CHAPTER 5

SOIL EROSION: ASSESSMENT AND STRATEGIES FOR CONSERVATION

5.1. Introduction

The extremely dynamic nature of the geological, geomorphologic and fluvial processes operating in the Balason basin provides unrivalled possibilities for the study of soil erosion in the region. Mass movement and gullying are rampant on most slopes and soil loss is widespread over the basin, which is of increasing concern to the inhabitants (Photo 5.1 & 5.2).

This chapter aims at making a quantitative assessment of the soil erosion hazard by apprehending a number of diagnostic criteria, culminating, in the proposal of a soil conservation plan, to protect the extremely vulnerable region against extensive soil loss.

5.2. Assessment of Soil Erosion Hazard

The assessment of soil erosion hazard is a specialized extension of land resource evaluation, whereby areas of land are identified where the maximum sustained productivity from the given landuse is threatened by excessive soil loss. The assessment aims at classifying the area into regions with similar intensity of erosion hazard, as a basis for planning soil conservation work (Requier, 1980). Such an assessment of soil erosion is concerned with measuring and comparing the variables that determine forces like soil erosivity and soil erodibility in order to predict the likelihood of erosion and soil loss.

5.2.1 Diagnostic criteria

Soil erosion is controlled by a number of factors (figure 5.1), some of which can be easily quantified while it becomes more difficult to make a quantitative

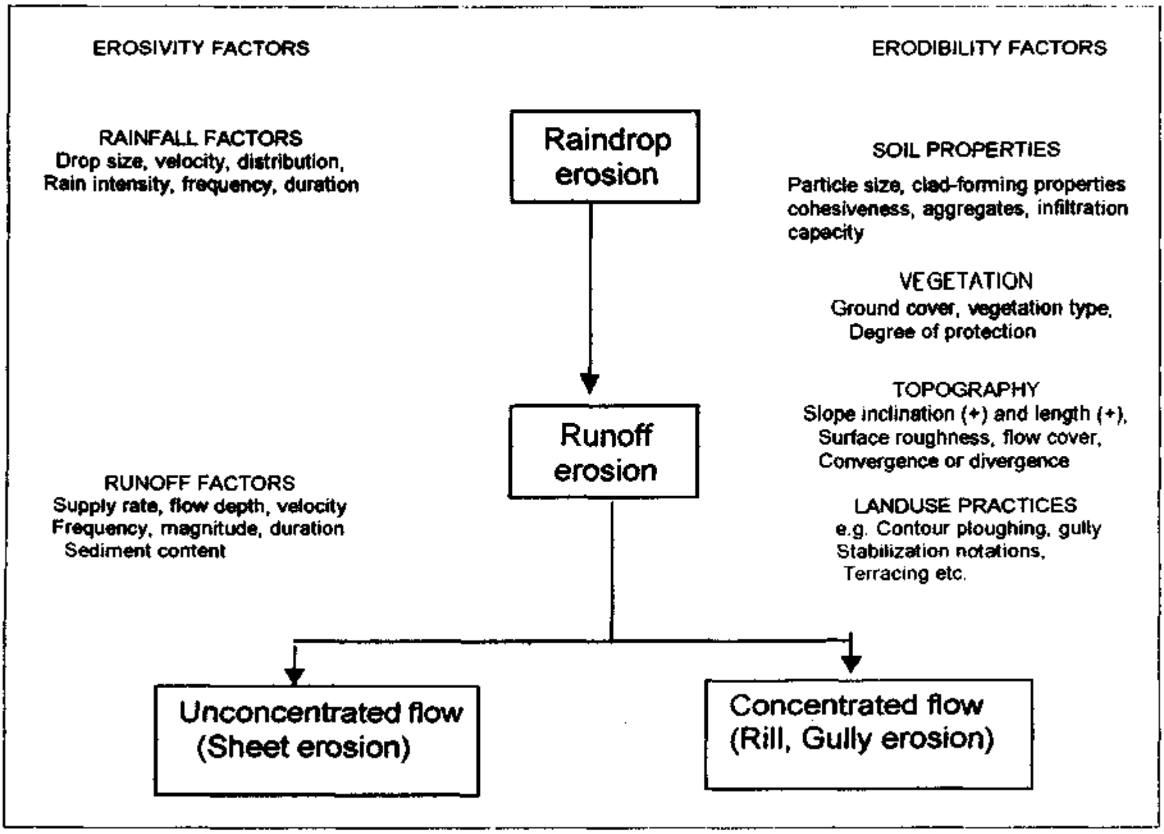
Photo 5.1 Top soil removal in the Northern hilly part : note the indigenous conservation measures

Photo 5.2 Bank erosion - rampant in the Southern piedmont zone

assessment in the case of other factors. In the present study, the following diagnostic criteria have been assessed quantitatively:

1. Climatic / Rain erosivity (R)
2. Soil factor/ erodibility (K)
3. Topographic factor / erosivity (LS)
4. Biological factor (CP)

FACTORS IN SOIL EROSION BY WATER



Based on Cooke and Doornkamp.1990

Fig.5.1

5.2.2. Methodology :

A detailed soil erosion hazard assessment of the Balason basin has been attempted based on the diagnostic criteria mentioned above with necessary modification using the existing standard literature and rating tables (Wischmier and Smith 1978; Fournier 1972; FAO/UNEP, 1978; Arnoldus 1980; Requier, 1978 and Sarkar 1987, 1989 a, 1989 b, 1991 & 1997). A rating value is assigned to each group of the factors in such a way that each group can influence the final result according to its own importance (FAO/UNEP, 1978). The index value of all the above criteria have been calculated on the basis of field data collected from various stations at regular intervals within the basin area. Details of assessment of soil erosion has been put forward as an example of "unit area". The site near Makaibari tea garden has been chosen for this purpose and the following diagnostic criteria have been employed for the assessment:

1. Climatic / Rainfall erosivity or R

$$R = \sum_{1}^{n} Pr_{10mm}^{2} / P \qquad \text{..............................5.1}$$

where Pr_{10mm} is the average monthly rainfall of months having >10 mm rain in a single rainfall event i.e. 463.8 mm and P is the annual rainfall in mm i.e. 4030.72 mm and hence R = 426.94.

2. Soil erodibility (K) has been calculated, based on the USLE Nomograph (figure 5.2); where sand (0.10 – 2.0 mm) content is 66.71%, silt and very fine sand (0.002 – 0.10 mm) content is 9.09%. organic matter content is 2.31%; soil structure has been identified as coarse granular to crumby; soil permeability is moderate to moderately rapid and hence, the K value is calculated to be 0.34

3. Topographic erosivity (LS) has been estimated based on USLE model such as:

$$LS = \sqrt{L/100}\ (0.136 + 0.0097.S + 0.0139.S^{2}) \qquad \text{...............5.2}$$

where L is the length of the dominant slope in metre, i.e. 450 metre, S is the slope gradient in percentage i.e. 47% and L.S is the topographic erosivity i.e. 66.39.

4. Biological factor (C.P) has been estimated, based on the parametric rating value (modified FAO/UNEP, 1978) i.e. 0.08.

SOIL ERODIBILITY NOMOGRAPH

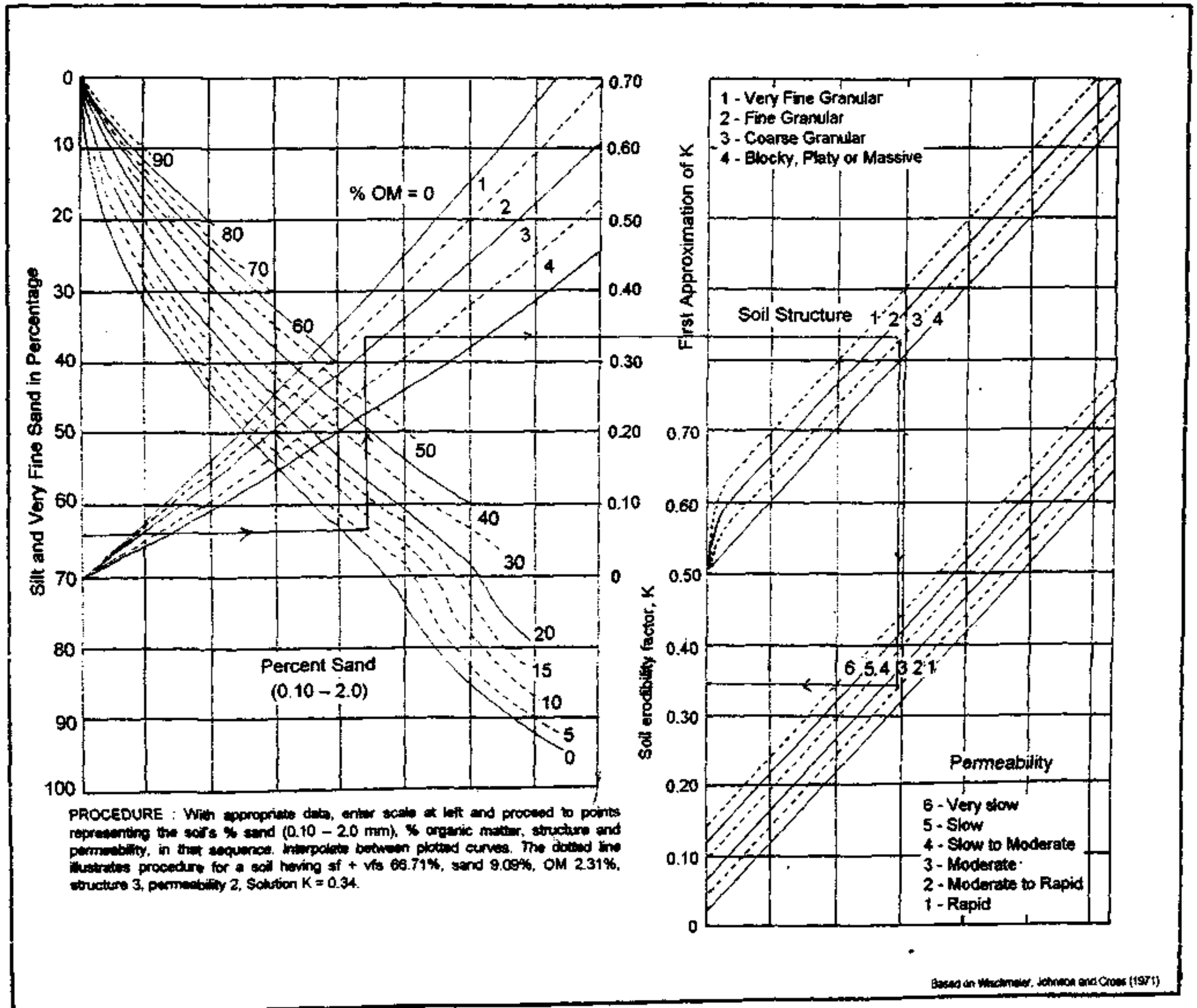


Figure 5.2

The potential (natural vulnerability) soil loss and predicted or actual soil loss have been assessed from the following empirical formula:

a). The Potential soil loss by the water erosion has been assessed from:

$$Pe = R.K.L.S. \qquad (5.3)$$
$$= 9637.15 \text{ tons} / h^{-1} / y^{-1}$$

b). The Predicted or Actual soil loss has been estimated based on the following equation:

$$E = R.K.L.S.CP \qquad (5.4)$$
$$= 770.97 \text{ tons} / h^{-1} / y^{-1}$$

5.2.3. Climatic / Rain Erosivity :

It has been increasingly realized that the amount of soil in runoff increases rapidly with the increase of raindrop energy, and it has also been noted that erosion can be greatly reduced by preventing raindrop impact (Morgan, 1986). Thus, climatic erosivity is essentially a function of the intensity of rainfall, its duration, the mass diameter and the impact of raindrops. Based on the works of Laws and Pearsons (1943), Wischemeier and Smith (1958) obtained the equation:

$$KE = 13.12 + 8.78 \log. 10^{I} \qquad (5.5)$$

where, I is the rainfall intensity (mm / h^{-1}) and K.E is the Kinetic energy (Jm $^{-2}$ / mm^{-1}).

For tropical rainfall, Hudson (1965), gives the equation:

$$K.E = 29.8 - 127 / I \qquad (5.6)$$

Based on measurements of rainfall properties in Zimbabwe, Zanchi and Torri (1980) carried out similar research in Italy and obtained :

$$K.E = 9.81 + 11.25 \log^{I} \qquad (5.7)$$

But all the methods require a continuous rainfall data, which is not generally available from the present recording stations of the study area. However, the

Fournier's Index (1972):

$$R = Pm^2/P \quad \text{.......} 5.8$$

where *Pm is monthly rainfall having highest rainfall and P is the mean rainfall in mm*, can easily be calculated within the limitations of insufficient rainfall records.

This index is very popular due to its simplicity, but correlation studies between it and equation nos. 5.5, 5.6 and 5.7 show that the Fournier's Index can hardly be used to approximate the R factor (Arnoldus, 1980). Thus, the FAO/UNEP experts (1978) have tried to modify the Fournier's equation (Eq.5.8) in such a way, that not only the month that receives the highest rainfall but also the average monthly rainfall can affect the evaluation of the R factor:

$$R = \Sigma p^2 / P \quad \text{.......} 5.9$$

where p is the average monthly rainfall and P is the annual rainfall in mm.

The result again has not been found satisfactory, probably because in the FAO/UNEP model, the average monthly rainfall is the only criteria and the intensity of the rainstorm is left untouched. Sarkar (1989 b) in his study of rainfall erosivity of Darjeeling Himalaya has modified the FAO/UNEP model in the following manner:

$$R = \sum_{1}^{n} Pr^2 \, 10 \, mm / P \quad \text{.......} 5.10$$

The present investigator has found that the above equation suits best as an effective alternative to the existing standard index for the evaluation of rain erosivity (R) for the study area. An iso-erodent map of the study area has been prepared based on interpolation method. Classes have been recognized for a better understanding of the geographical distribution of rain erosivity. (figure 5.3)

Class I: Very high rain erosivitiy (R = >550) : has been recognized along a narrow wedge extending in the center of the Balason basin, starting at Ambootia and moving in a narrow strip to the eastern extremity of the basin.

Class II : High rain erosivity (R = 450 – 550): zones are found bordering the

RAIN EROSIVITY ZONE OF THE BALASON BASIN

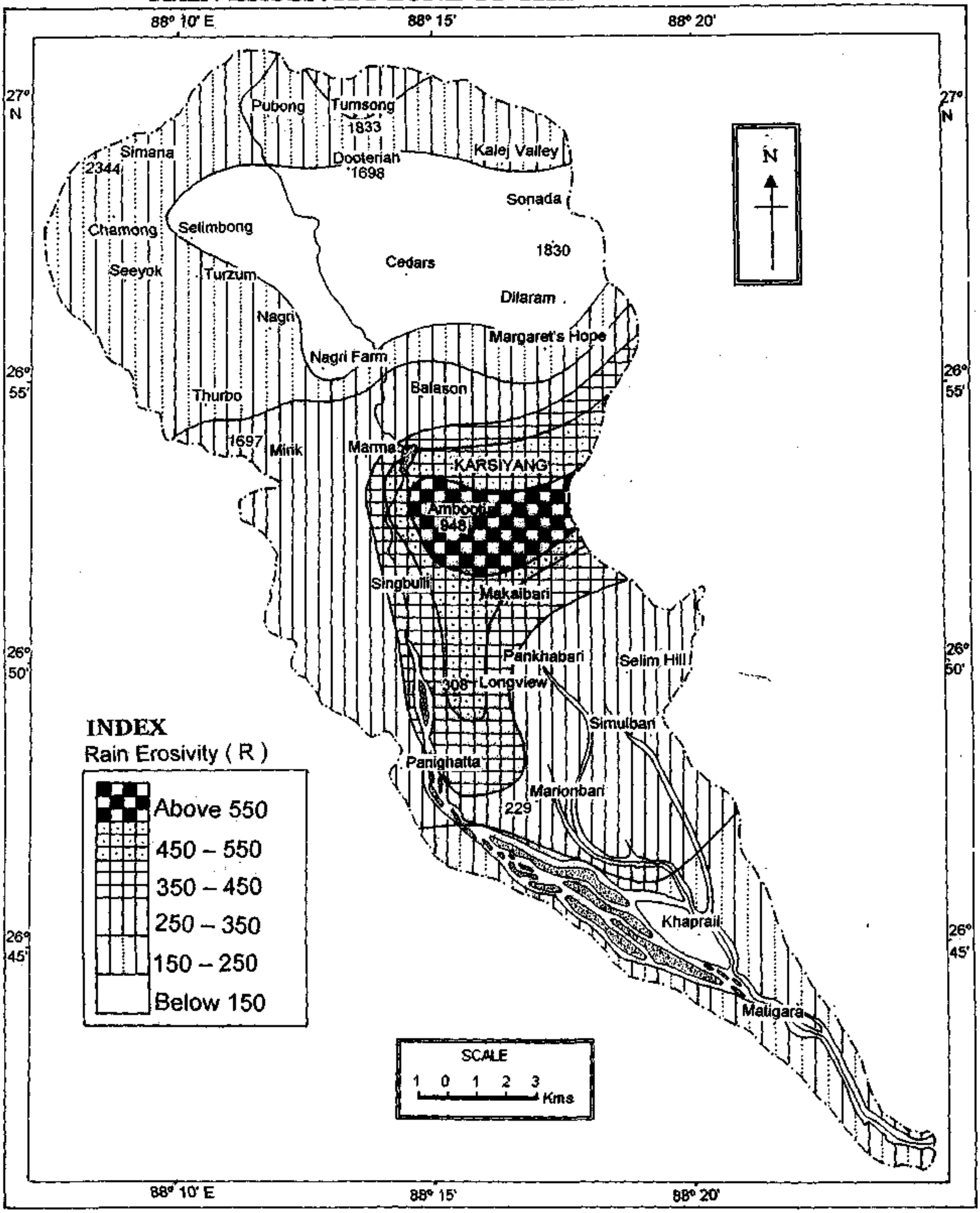


Figure 5.3.

class I zone on all sides and forms a broader wedge engulfing the former.

Class III: Moderately high rain erosivity (R = 350-450): forms the outer boundary, engulfing the former zones on all sides, with a marked extension towards the Panighata and Longview in the south.

Class IV: Moderate rain erosivity (R = 250-350): zones are observed towards the northwestern and southern parts of the basin.

Class V : Moderately low rain erosivity (R = 150-250) : zones are found in the north western, northern and extreme southern part of the basin, engulfing Chamong, Thorbu, Mirik, Soureni, Seyok in the north western part, Pubong, Tumsong, Takdah in the extreme north and Matigara and Khaprail in the south.

Class VI : Low rain erosivity (R = <150) : is centered around the north eastern part of the basin around Kalej Valley, Doteriah, Selimbong, Cedars and Dilaram tea gardens.

The Longview tea estate records very high rainfall (5116.50 mm), the erosivity remains moderately high in the order of class III, whereas Ambootia that falls in the very high erosivity zone (class I) records a lesser annual rainfall of 3922.51 mm. The high steep slopes of Ambootia along with the high intensity of rainfall in the region within a short period probably accounts for this observation.

5.2.3. Soil Erodibility :

Erodibility defines the resistance of soil to both detachment and transport. Soil properties are the more important determinants of erodibility, although topographic position, slope steepness and nature of disturbances created by man also have decisive role Soil erodibility varies with soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical properties. The dynamic field oriented methods of Wischemeier and Mannering (1969), seems to be the best available method in this regard. The assessment of soil erodibility (K) of the

Balason basin has been calculated from the soil erodibility Nomograph (figure 5.2) of the USLE (Wischemeier, Johnson and Cross, 1971) based on the following:

i). the percentage of sand, silt and very fine sand (USDA, 1951),

ii). the organic matter content in %,

iii). the structure and

iii). the profile permeability.

It has been found from the analysis that the K value varies from 0.1 to 0.5 in the study area. A soil erodibility map has been prepared based on the available K value (figure5.4). The following erodibility classes have been identified:

Class I. High soil erodibility (K = >0.5): has been identified along a narrow elongated tract running almost longitudinally between the central and northern hilly part of the basin, extending through the major valleys and cliff surface, from Simripani to south of Dooteriah enclosing Ambootia en route. The high erodibility of this belt can be attributed to the coarseness of texture and less organic matter content in the soil of the region.

Class II. Moderately high soil erodibility (K = 0.4 – 0.5): has been identified in an area engulfing the former zone on all side, surrounding Balason, Singbuli, Marma and Nagri Farm.

Class III. Moderate soil erodibility (K = 0.3 - 0.4): are found on the fringe areas belonging to class II, which includes Tumsong, Pubung, Dooteriah in the northern side, Cedars, Margaret's Hope, Karsiyang on the eastern side, Nagri, Turzum, Selimbong on the western side, and Makaibari, Rington, Dhajia on the southern side. A small pocket is found centered around Matigara.

Class IV. Moderately low soil erodibillity (K = 0.2- 0.3): occur in the north western region around Chamong, Seeyok and Thurbo, around the north eastern extremity in Kalej Valley, Sonada and Dilaram. A small section is found in the southern side of the basin around Khaprail.

Class V. Low soil erodibility (K = 0.1- 0.2): has been identified in a small tract

SOIL ERODIBILITY ZONES OF THE BALASON BASIN

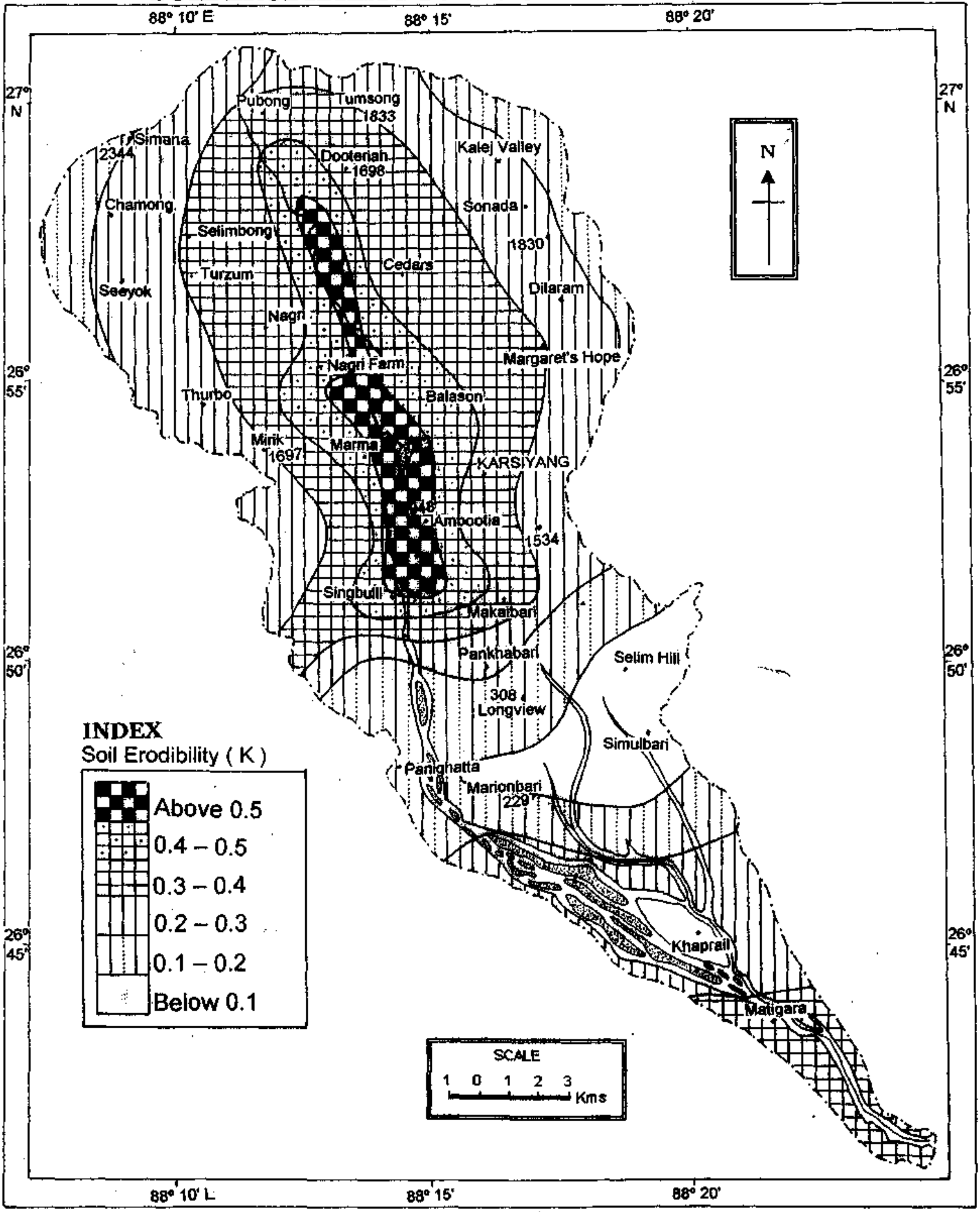


Figure 5.4.

around Simulbari, Marionbari, Panighatta and Longview area.

Class VI. Very low erodibility (K = <0.1): lies around the foothill and forested tract. The low to very low soil erodibility can be attributed to the vegetation cover that account for a very high organic matter content.

5.2.4. Topographic Erosivity:

The topographic erosivity L.S of the Balason basin has been determined with the help of the following equation which is based on USLE model:

$$LS = \sqrt{L/100}\ (0.136 + 0.0097.S + 0.0139.S^2) \qquad \text{....5.2}$$

where S is the slope gradient in % and L is the slope length in metre.

The highest topographic erosivity (>120) remains confined in a narrow V shaped wedge in the center of the region around Ambootia, and in small pockets on the north eastern part of the study area. High topographic erosivity of 80 and above extends in a similar wedge around Nagri farm, Marma, as well as in the northwestern part of the study area around Simana, Chamong, Seeyok and Thurbo. Moderate topographic erosivity with values extending from 20 to 80 encircles the high topographic erosivity class from all sides. The low topographic erosivity with values less than 20 is confined to the southern and southeastern tip of the Balason basin in the region lying south of Marionbari.

It is evident from the above analysis that topographic erosivity is directly related to the nature of the terrain. The higher topographic erosivity values indicate hilly terrain as opposed to the low values, which indicate the gently undulating *terai* plain. Thus, the lower LS values (figure 5.5) are confined to the southern and south eastern part of the basin while the rugged hilly areas of the northern, north western, north eastern central and east central parts of the study area exhibit high to very high L.S values. In the remaining area moderate topographic erosivity occurs, where the slope steepness is less. LS factor, thus provides an inventory of computation for both the potential and predicted soil loss of an area, but does not play any critical role in soil erosion mechanism (Hudson, 1971).

TOPOGRAPHIC EROSIVITY ZONES OF THE BALASON BASIN

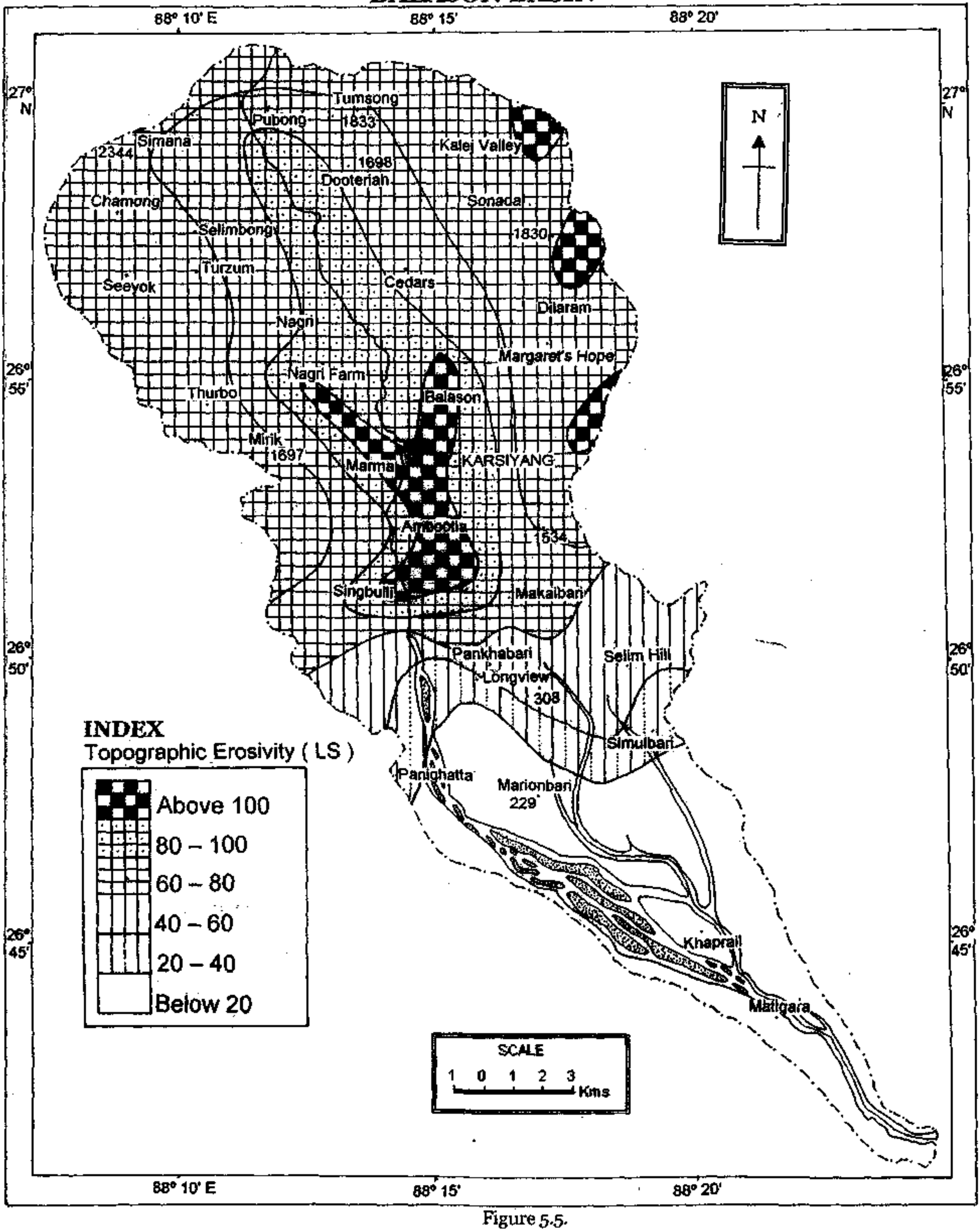


Figure 5.5.

5.2.5. Biological Erosivity :

The combined effects of land cover, land productivity, various landuse, over a particular area contribute to the biological erosivity (C.P) of the basin.The biological erosivity (C.P) in the study area has been assessed based on the parametric rating value as shown in table 5.1 which has been prepared based on FAO/UNEP, 1978 model with necessary modifications (Sarkar, 1989 a). A biological erosivity map has been prepared (figure 5.6) from the available C.P values which also includes C and P co-efficient of the USLE. The following biological erosivity classes have been identified:

Class I. Very high biological erosivity (C.P = >0.4) : occurs in three distinct places of the study area; a). in a narrow central wedge around Ambootia, b). around Dilaram, and c). around the Kalej Valley. Heedless deforestation, unscientific slope cultivation and other extensive human interferences make the region highly vulnerable to soil erosion.

Class II. High biological erosivity (C.P = 0.2 – 0.4) : encircles the very high biological erosivity area along the western fringe with a marked increase as one progresses towards the eastern section of the basin and a small strip in the southern section around Khaprail and Matigara.

Class III. Moderate biological erosivity (C.P = 0.1-0.2) : follows more or less the same pattern fringing the class II area but there is a broad extension of this zone towards the northern and eastern section extending from Takdah to Dajia and Phulbari and in the southern section running parallel to the southern strip of the previous class between Simulbari and Marionbari. This extension can be broadly attributed to moderate zones in and around the tea gardens.

Class IV. Low biological erosivity (C.P = 0.01 – 0.1) : almost forms a complete arc around the previous zones extending across the western, central northern and a narrow strip along the southern margin of the study area.

BIOLOGICAL EROSIVITY ZONES OF THE BALASON BASIN

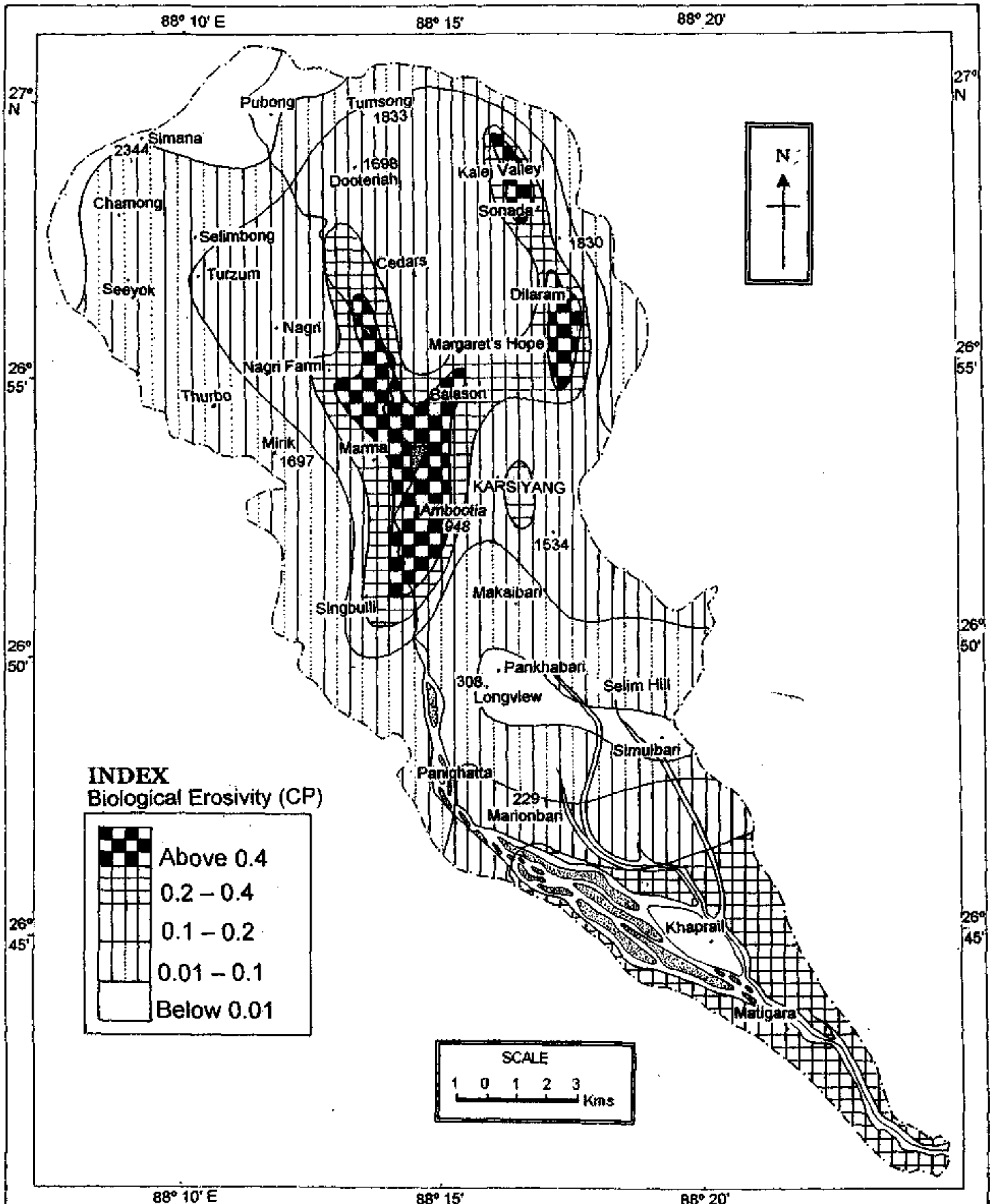


Figure 5.6.

Class V. Very low biological erosivity (C.P = <0.01) : is confined to a small central wedge around Pankhabari and a very narrow arc extending across the western and northern part of the basin around Sukhia Pokhri-Simana busty and Pubong. This is primarily due to the dense vegetative cover. Biological erosivity is considered to be the most important parameter in quantitative assessment of predicted or actual soil erosion in a given area over a given period, because a highly vulnerable potential erosion hazard may have insignificant amount of predicted or actual soil loss if the region is under the cover of dense natural forests.

Table 5.1

Parametric rating value for different landuse patterns

Sl No.	Major land use type	Percentage coverage	Rating value
1.	Virgin forest with a thick vegetal matter in the forest floor	100%	0.0005
2.	Natural vegetative cover, i.e. forest, bush, permanent grasslands	100%	0.001-0.0005
3.	Natural vegetative cover i.e. forest, bushes, permanent grasslands	50-100%	0.05-0.001
4	Tea garden (well stocked)	100%	0.05-0.1
5.	Degraded forests, rough permanent grasslands and other perennial cover	25-50%	0.05-0.1
6	Degraded to semi-degraded tea garden	25-50%	0.1-0.2
7.	Row crops, inter tilled crops	20-80%	0.2-0.8
8.	Terraced cultivated field	10-50%	0.2-0.8
9.	Root crops such as ginger, potato, cardamom	50%	0.8
10.	Bare soils, cultivated fallow cover	0	1.0

Based on FAO/UNEP, 1978 & Sarkar, 1987, 1993.

5.2.7. Assessment of soil erosion:

The assessment of soil erosion has been based on the quantitative estimation of the physical factors like the climatic erosivity (R), the soil erodibility (K), the topographic erosivity (L.S) and the biological factors (C.P). two kinds of assessment have made: i). potential soil erosion based on the equation 5.3 and ii). Predicted soil loss based on equation 5.4.

5.2.7.1. The potential soil erosion

The potential soil loss is the natural vulnerability of land to erosion, which results from the action of physical factors without the intervention of biological factors Requier, 1980). A potential iso-erodent for the Balason basin has been prepared based on equation no. 5.3.

The highest potential soil loss is confined to the central hilly tract around Ambootia where the potential soil loss has been estimated to be above 10,000 tons h^{-1} y^{-1}. This excessively high potential erosivity is due to factors, including very high gradient, large slope length, high rainfall, low organic matter content and coarse texture of the soil. As one moves away from the Ambootia region the potential soil loss diminishes very rapidly on all sides attaining a moderate potential soil loss ranging from 500 to 8000 tons/h^{-1}/y^{-1}. However there is a marked decrease towards the southern plains as one moves away from the foothills around Simulbari and Longview. The main factors for the low potential soil loss (< 1000 tons/h^{-1}/y^{-1}) are the very gentle gradient over the part of this basin, very fine textured soil and a comparatively high organic matter content (figure 5.7).

5.2.7.2. The predicted or actual soil erosion hazard assessment

The predicted or actual soil loss has been assessed, based on the potential erosivity and the biological erosivity by using the equation no. 5.4. An isoerodent map has been prepared by interpolating the soil loss values of different sites (figure 5.8). The east central part of the basin have experienced an exceptionally high rate of erosion (> 1000 tons/h^{-1}/y^{-1}), while, the extreme northern and south central parts of the study area have experienced low predicted soil loss (< 250 tons/h^{-1}/y^{-1}). However, for the better understanding of spatial distribution of soil erosion, the following classes of erosion susceptibility have been put forward.

Class I. Exceptionally high susceptibility zone (>1000 tons/h^{1}/y^{1}) : is centered around Ambootia with a slight extension towards the north. This exceptionally high value of predicted soil loss can be attributed to a large number

POTENTIAL SOIL LOSS OF THE BALASON BASIN

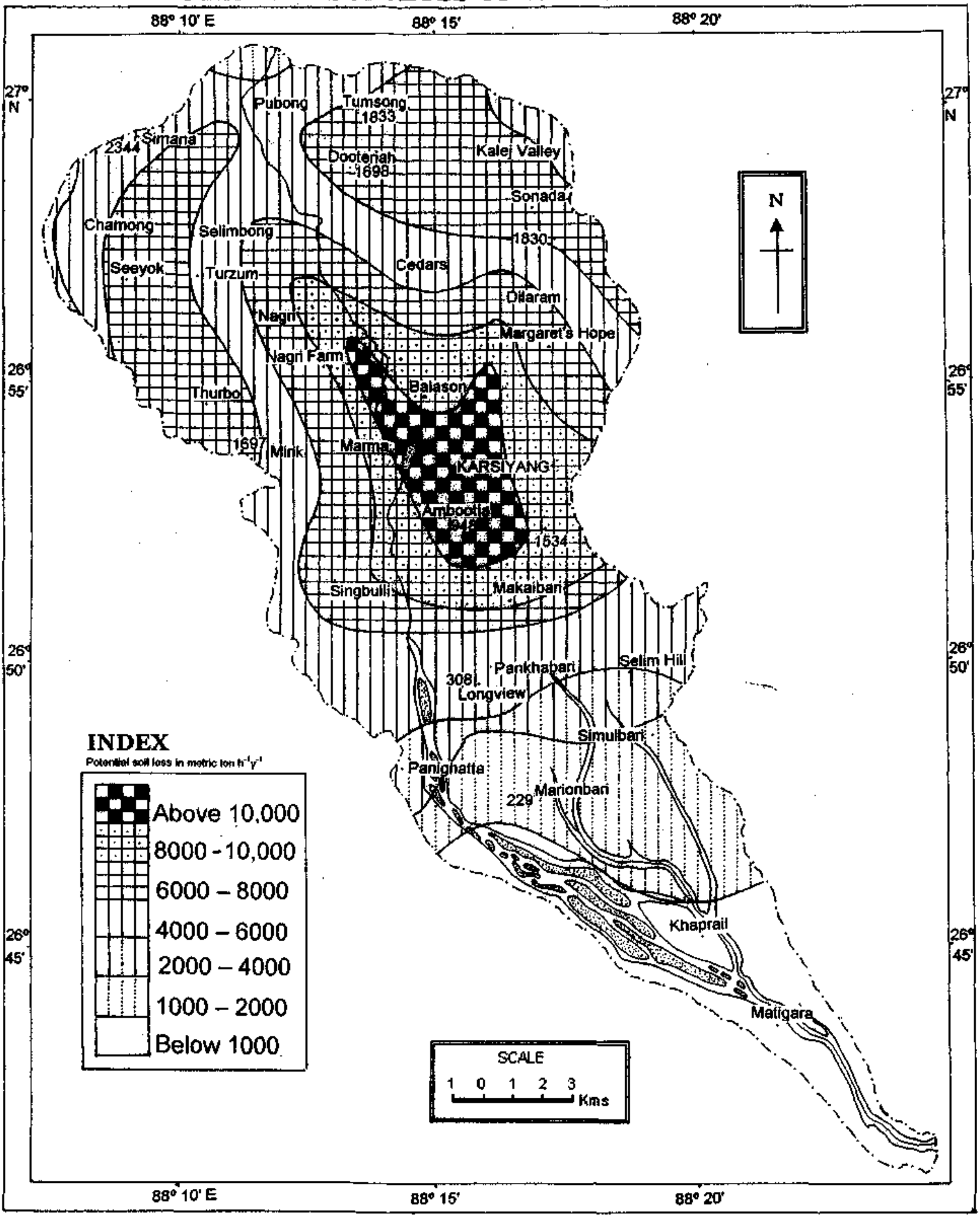


Figure 5.7.

PREDICTED SOIL EROSION OF THE BALASON BASIN

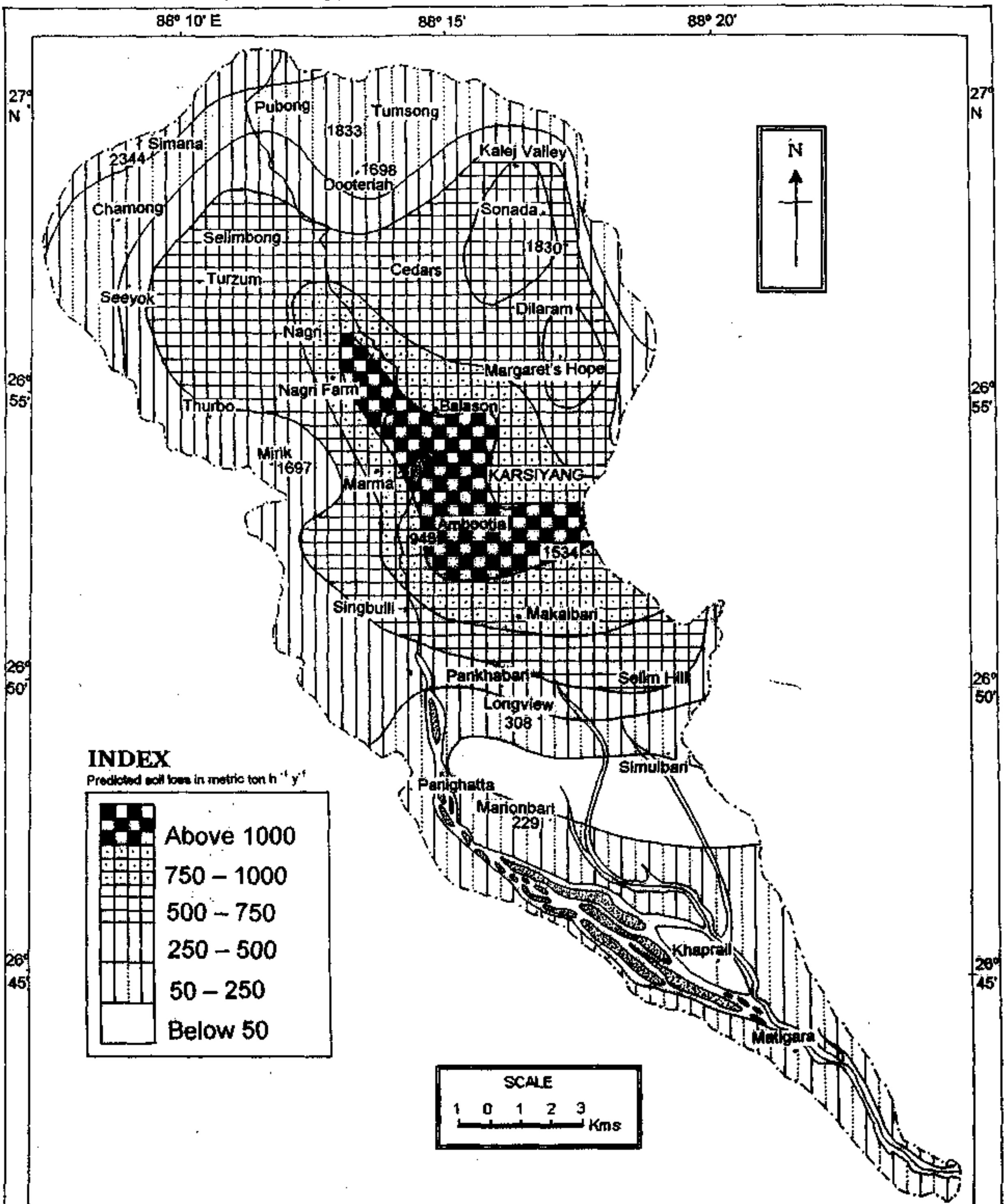


Figure 5.8.

of landslides, prevalent in the area of which the Ambootia landslide has earned the notoriety of being one of the largest in India, covering an area of about 2.06 sq.km. This problem has been further aggravated by the unscientific landuse, accelerated deforestation and coarse textured soil with less organic matter content.

Class II. Very high soil loss zone (750 - 1000 tons/h^{-1}/y^{-1}) : surrounds class I on all sides extending from Nagri farm in the north to Makaibari in the south.

Class III. High soil loss zone (500 - 750 tons/h^{-1}/y^{-1}) : surrounds class II areas on all sides with a broad extension towards the eastern and western fringe of the basin. The northern projection goes beyond Turzum, Selimbong, Rungmook, Cedars and in the south it extends till Singubulli.

Class IV. Moderate soil loss zone (250 - 500 tons/h^{-1}/y^{-1}) : forms a narrow strip around class III on the southern, eastern and western side.

Class V. Low susceptibility zone (50 - 250 tons/h^{-1}/y^{-1}) : forms an arc in the western, northern and a very narrow strip in eastern section of the region, that is from Chamong, Pubong, through Takdah and beyond Dilaram. A narrow band also occurs in the southern section running in a west to east alignment through Panighatta to Khaprail and Matigara.

Class VI. Very low soil loss zone (< 50 tons/h^{-1}/y^{-1}) : has been identified along a broad wedge in the south eastern section of the basin around Longview and Simulbari, covering the foothills. The soil loss is less due to gentle undulating slopes with a dense vegetation cover.

5.3 Strategies for Soil Erosion Control

Soil conservation aims at obtaining the maximum sustained level of production from a given area of land while maintaining soil loss below a threshold level

(Morgan 1979 &1986).The maximum acceptable rate of erosion is known as the soil loss tolerance, which has been estimated by various scientists as ranging between 0.01 in semi desert environments to as high as 1.0 mm / y^{-1} in certain areas of humid tropics and humid temperate environments. (Douglas, 1976; Holeman, 1968; Zacher, 1982). Sarkar (1991) has estimated 0.3 mm/y^{-1} soil loss as the uppermost limit for permissible soil erosion in the Darjeeling Himalaya.

Table 5.2

Impact of conservation measures in soil erosion mechanism

Conservation measures	Rainsplash		Runoff	
	D	T	D	T
A. Agronomic measures				
i). Covering soil surface	o	o	o	o
ii). Increasing surface roughness	*	*	o	o
iii) Increasing surface depression storage	+	+	o	o
iv). Increasing infiltration	*	*	+	o
B. Soil management				
i). Fertilizer application	+	+	+	o
ii). Manuring	o	o	o	o
iii). Drainage	+	+	o	o
C. Mechanical measures				
i). Contouring	*	+	+	o
ii). Terraces	*	+	+	o
iii). Shelterbelts	*	*	*	o
iv). Waterways	*	*	*	o

** = no control; + = moderate control; o = strong control; D = Detachment; T= transport.*

Modified from Voetberg, 1970, Morgan, 1986.

The strategies for soil conservation must be based on covering the soil to protect it from raindrop impact, increasing the infiltration capacity and increasing surface roughness to reduce the velocity of transport phases of erosion (table 5.2).

Soil conservation schemes must be well designed if they are to reduce erosion effectively. Their ultimate success depends on how well the nature of erosion problem has been identified and suitable conservation method selected. The various soil conservative measures effective for the present purpose may be sub-divided into three major groups: i) agronomic measures, ii) soil management and iii) mechanical methods.

5.3.1 Agronomic measures :

Plants differ in their effectiveness in protecting soil from erosion because of differences in their density and morphology. Generally, row crops are least effective and give rise to the more serious erosion hazards. In designing a conservation strategy based on agronomic measures, row crops must be combined with protection effective cover crops in a logical cropping pattern. Of the various agronomic measures, cover crops, strip cropping and mulching are important and are recommended as protective measures against soil erosion in the Balason basin.

5.3.2. Soil management :

The aims of soil management are to maintain the fertility and structure of the soil because fertile soil results in high crops yield, good plant cover and therefore, in conditions which minimize the erosive effects of raindrop and runoff. In the study area, good soil fertility can be achieved by applying organic matter because it improves the cohesiveness of soil, increases water retention capacity and also promotes a stable aggregate structure.

5.3.3. Mechanical methods :

The mechanical methods are used widely to control the movement of water and the decision which is to be adopted, depending on whether the objectives is to reduce the velocity of run-off and increase surface water storage capacity or safely dispose off excess water. All mechanical should be employed in conjunction with agronomic measures. Of the various mechanical methods, contouring, contour bunds, terraces and waterways are recommended in the study area.

5.3.4. Proposed conservation scheme

The assessment of soil erosion in the Balason basin reveals that the soil is highly erodible and when environmental factors are conducive, very high rates of soil

PROPOSED SOIL CONSERVATION SCHEME FOR THE BALASON BASIN

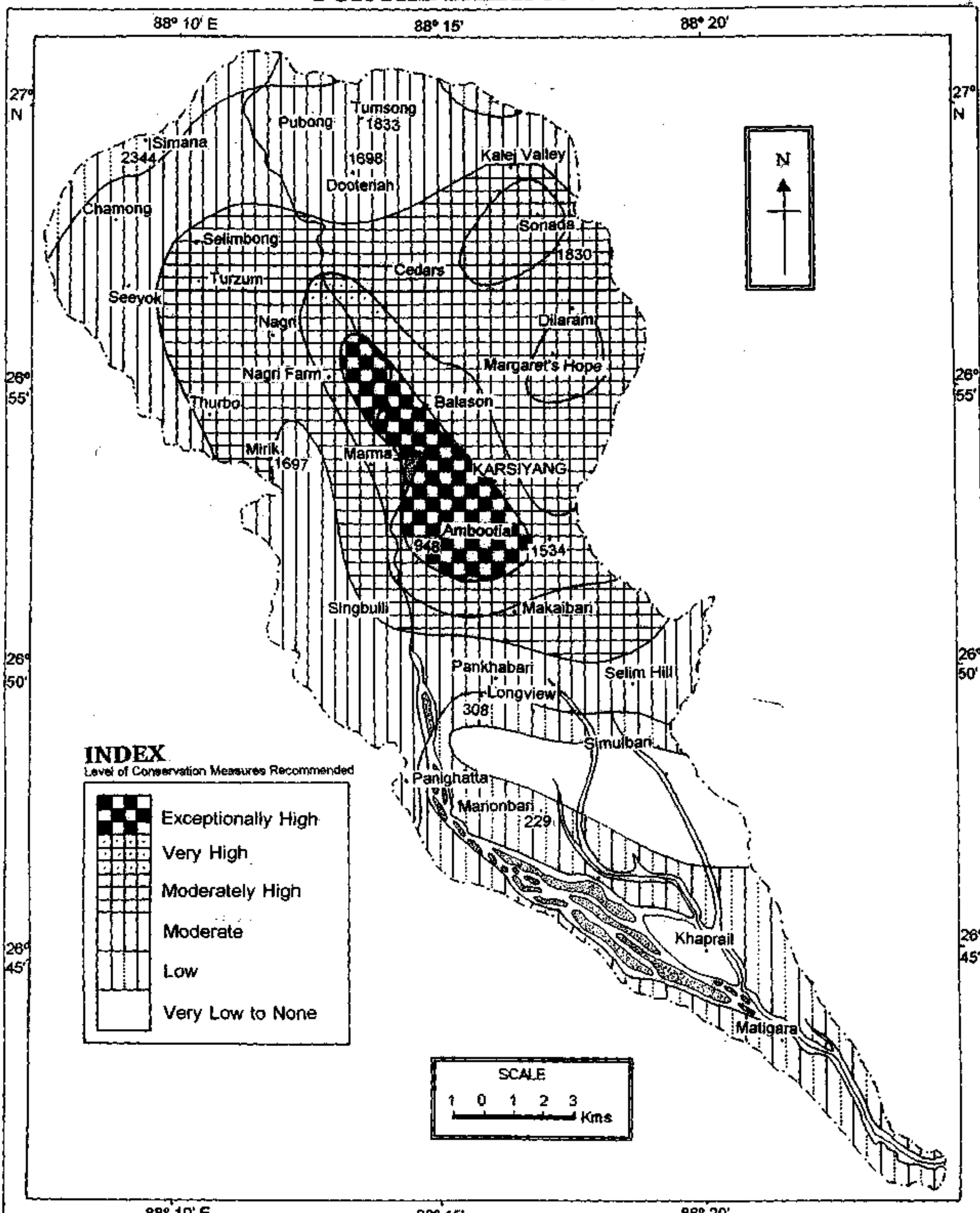


Figure 5.9.

erosion occur. Moreover, the climatic conditions of the region is such, that a rapid decomposition of parent material has taken place which also accelerate soil formation. Keeping these two factors in mind, the present investigator has proposed a target of 0.5 kg/m^{-2}/y^{-1} or 5 ton / h^{-1}/y^{-1} or 0.3 mm/y^{-1} of soil loss be accepted as the permissible limit (table 5.3).

Table 5.3

Conservation measures proposed for different soil erosion classes

Major erosion classes	Rate of soil loss in tons / h^{-1}/y^{-1}	Level of conservation	Recommended conservation measures to be taken
VI	Below 5	None to negligible	No immediate conservational measure is needed except careful crop management.
V	5 to 50	Low	Cover crops, crop rotation, strip cropping, contour bunds along with suitable waterways
IV	50 to 250	Moderate	Cover crops, mulching organic matter application, retention and bench terracing; diversion channel and cross waterways are required
III	250 to 1250	High	Cover crops, mulching, ladder and bench terraces, waterways, storm water disposal systems along with slope stabilization
II	1250 to 2500	Very high	Here all possible agronomic, mechanical and soil management methods should be adopted simultaneously. Plantation of quick growing plants and intensive root spreading grasses, mulching, bench terraces, application of geo-wire , suitable waterways along with slope stabilization works should be applied
I	Above 2500	Exceptionally high	Agriculture should not be allowed in such areas. They should be kept under natural cover i.e. permanent grass or forest.

5.4. Conclusion

The Balason basin, surrounded by forest-clad hills attracted human settlements. As these settlements grew, the acute human interference through the heedless destruction of the forest cover has had its toll on the natural landscape. The degradation of the forest cover with increasing population pressure has elevated the natural soil erosion manifold. The complete severance of the fertile topsoil has gradually led to the loss of fertility and the natural regeneration of the forest cover has dwindled. Thus, the compactness of the soil of the study area has been lost and this has led to various environmental hazards.

The worst affected area lie in the central parts of the Balason basin. This area is deforested and characterized by skeletal soil and very steep slope (>30°); and needs immediate conservation measures recommended in table 4.4. Special attention must be given to areas along the roads, railways, tea gardens, agricultural terraces and existing settlements. Large-scale afforestation, with suitable tree species, along with terracing and drainage facilities is necessary to check massive soil loss. The southern parts have shown very low to negligible soil loss, below 5 tons/ h^{-1}/y^{-1}. This amount is below the upper limit of the permissible soil erosion, thereby, no immediate conservation measures are required.

Agronomic measures should be given a priority over all other measures, as it is less expensive and deals directly with reducing raindrop impact, increasing infiltration, reducing run-off volume and decreasing water velocity. Other measures, mentioned above, should then be implemented without further delay, to save the basin from massive destruction.

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