CHAPTER IV

SOIL EROSION : HAZARD ASSESSMENT & STRATEGIES FOR CONSERVATION

4.1 INTRODUCTION

Soil erosion is probably the most destructive process that acts to reduce production from land. Top soils generally contain most of the nutrients and best structure for plant growth and materials eroded from the upper part of soil profile have detrimental effect upon crop yield and plant growth. The Kurseong Sub-Division of Darjeeling district was truly a nature's domain till the British occupation. With a very scanty population (below 1 person/square kilometre), this hilly tract was densely covered by natural forest and had no major soil erosion problem. The cutting of trees to create open land for tea plantation, cultivation, settlement and road construction curtails transpiration and the unspent water feeds the run-off and infiltration. It invites drying up of jhoras, accelerated soil erosion and mass movements. Few measurements of soil erosion have so far been made in the area (Sarkar, 1987 & 1991) and the data available are derived mainly from studies of sediment concentrations in the rivers (Photo. 4.1 & 4.2).

The aim of this chapter is to make a quantitative assessment of erosion hazard through the study of its processes and mechanisms. A number of diagnostic criteria have also been apprehended. Finally, a formula for proposed conservation plan has also been presented to protect the extremely vulnerable soil against erosion.

4.2 ASSESSMENT OF SOIL EROSION HAZARD

The assessment of erosion hazard is a specialised form of land resource evaluation, the objective of which is to identify those areas of land where the maximum sustained productivity from a given land-use is threatened by excessive soil loss. The assessment aims at dividing a land area into regions with similar intensity of erosional hazard, as a basis for planning soil conservation work. The potential soil loss is the diminution of current or potential productivity, resulting in the action of physical factors such as climate, soil and topography but without the intervention of biotic factors. Biological activities, however, modify the natural/potential soil erosion and lead to the actual rate of soil erosion which is often known as the predicted soil loss (Requier, 1980).

4.2.1 DIAGNOSTIC CRITERIA

There are many factors that control the rate of soil erosion. Quantification of some of them can readily be done while, in case of others, quantitative assessment seems to be difficult. However, when a criterion or factor is lacking, it is possible to substitute it by another (FAO/UNEP, 1978) in the present study the following diagnostic criteria have been assessed quantitatively.

- Climatic/Rainfall erosivity (R);
- Soil factor/erodibility (K);
- Topographic factor/erosivity (L.S.);
- Biological factor/erosivity (C.P.)

4.2.2 METHODOLOGY

Detail soil erosion hazard assessment of the Kurseong Sub-Division of Darjeeling district has been done through the 4 above mentioned diagnostic criteria, based on the existing standard literature and rating tables (Wischmier and Smith, 1965, 1978; Fournier, 1972; FAO/UNEP, 1978; Arnoldus, 1980, Requier, 1980 and Sarkar, 1987 & 1991) with necessary modifications. Rating value for crop practice and management factor for soil erosion (biological erosivity or *C.P*), is assigned in such a way that it can influence the final result according to their respective importance (FAO/UNEP, 1978). A detailed assessment of potential and predicted soil loss has been put forward as an example of "unit area". The site

Photo. 4.1 Sediment Concentration – in a tributary to Balason

Photo. 4.2 Sediment Concentration in Upper Mahananda in contrast to clear water of Sivakhola

near Tindharia Tea Garden has been chosen for this purpose and the following diagnostic criteria have been employed for the hazard assessment:

a) **Climatic erosivity** or R

$$R = \sum_{1}^{12} Pr^2{}_{10mm} / P \text{-------------------} 4.1$$

where, $Pr^2{}_{10mm}$ is the average monthly rainfall of months having >10 millimetres rain in a single rainfall event i.e. 305.6 millimetres and P is the annual rainfall in millimetres i.e. 2763 and hence,

$$R = 270.40$$

b) **Soil erodibility** or K, has been estimated based on the Universal Soil Loss Equation (USLE) nomograph, where, sand (0.10-2.00 millimetres) content is 30.6%, silt and very fine sand (0.002-0.10 millimetres) content is 48.51%. Organic matter content is 2.56%, soil structure has been identified as coarse granular, soil permeability is rapid and hence, the K value has been calculated to be 0.24 (Fig. 4.2).

c) **Topographic erosivity** *(L.S)* has been estimated based on USLE model such as :

$$L.S = \sqrt{L/100}\ (0.136 + 0.0097.S + 0.0139.S^2 \text{---------} 4.2$$

where, L is the the length of the dominant slope in meter, i.e. 630 meter, S is the slope gradient in percentage, i.e. 46% and $L.S$ is the topographic erosivity i.e. 72.82.

d) **Biological factor** *(C.P)* has been calculated based on the parametric rating value (modified FAO/UNEP, 1978 model) i.e. 0.32.

Two types of erosion hazard have been assessed by the investigator:

i) The **Potential Soil Loss** by water erosion has been assessed from the first three diagnostic criteria i.e.

$$Pe = R \,.\, K \,.\, L.S \text{-------------------------------------} 4.3$$

i.e. 4725.73 tons/h^{-1}/y^{-1}

and ii) The **Predicted or Actual Soil Loss** has been estimated based on the following :

$$E = R\,.\,K\,.\,LS\,.\,CP \text{-----------------------------------} 4.4$$

i.e. 1512.23 tons/h^{-1}/y^{-1}

4.2.3 CLIMATIC/RAIN EROSIVITY

Soil erosion is closely related to rainfall, partly through the detaching power of raindrops striking the soil surface and partly through the contribution of rain to run-off (Morgan, 1986). The erosivity of a rainstorm event is thus, a function of its intensity and duration, mass, diameter and striking velocity of raindrops. Based on the work of Laws and Pearsons (1943), Weischmeir & Smith (1958) obtained the equation:

$$K.E = 13.12 + 8.78\ Log.10^{I} \text{--------------------} 4.5$$

where, I is the rainfall intensity (mm/h^{-1}) and K.E. the kinetic energy (Jm^{-2}/mm^{-1}). For tropical rainfall, Hudson, (1965), gives the equation:

$$K.E = 29.8 - 127/I \text{----------------------------} 4.6$$

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

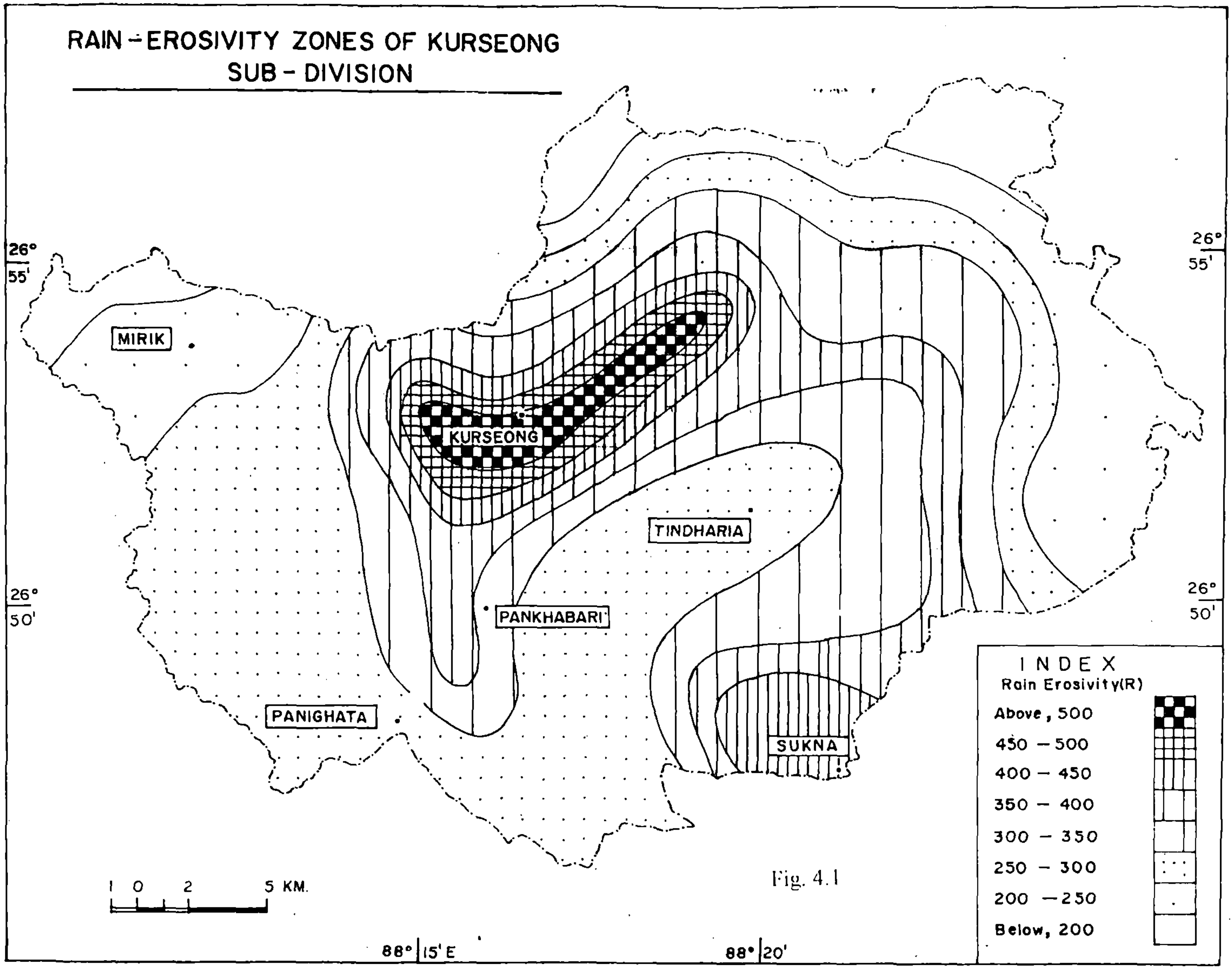
$$K.E = 9.81 + 11.25\ Log.10^{I} \text{------------------} 4.7.$$

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) :

$$R = Pm^2/P \text{-----------------------------------} 4.8$$

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

This index is very popular due to its simplicity, but correlation study between it (Equation 4.8) and $K.E$ (Equations 4.5, 4.6 and 4.7) 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 index (Equation 4.9) 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:


RAIN - EROSIVITY ZONES OF KURSEONG SUB - DIVISION
MIRIK
KURSEONG
TINDHARIA
PANKHABARI
PANIGHATA
SUKNA
26° 55'
26° 50'
88° 15' E
88° 20'
1 0 2 5 KM.
INDEX
Rain Erosivity(R)
Above, 500
450 — 500
400 — 450
350 — 400
300 — 350
250 — 300
200 — 250
Below, 200
Fig. 4.1

$$R = \sum_{1}^{12} p^2/P \text{ ---} 4.9$$

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

The investigator has tried to correlate the R value of Equation 4.9 and that of $K.E$ (Equations 4.5, 4.6 and 4.7) , through the data available from Dilaram and Nagri recording station. The result has not been found satisfactory, probably due to the fact that the FAO/UNEP model (Equation 4.9) only average monthly rainfall is the criteria leaving the intensity of rainstorm untouched. Sarkar (1988) in his study of rainfall intensity study of Darjeeling Himalaya has modified the FAO/UNEP model in the following manner:

$$R = \sum_{1}^{12} Pr^2_{10\ mm} / P \text{ ------------------------------} 4.10$$

The present investigator has found that the Equation 4.10 suits best as an effective alternative of 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 (Fig. 4.1). The highest rain erosivity (696.5) has been recorded at the Ambutia Tea Garden and the lowest (281.0) at the Sittong Cinchona Plantation. Generally speaking the southern slope of the Mahaldiram - Ghoom range show a higher (above 500) value of rain erosivity. The southern piedmont zone (foothills and Terai) also show high (>400) rain erosivity. The inner valley and eastern part of the Kurseong Sub-Division show moderate to moderately low erosivity (<300). However, for better understanding of geographical distribution of rain erosivity the following classes have been recognised (Fig. 4.1).

Class I: Very high rain erosivity (>500), has been recognised along a narrow east - west elongated belt extending form Mahaldiram to Ambutia Tea Garden. These are the areas located along the southern windward side of the Mahaldiram range.

Class II: High rain erosivity (400-500) zones are found in two distinct areas:

a) along the northern part of the study area i.e. around the valleys of Mahananda and Balason and b) in a narrow east - west belt along the foothills i.e. from Longview to Gulma Tea Gardens.

Class III: Moderately high rain erosivity (300-400) has been identified in the most central part of the study area. This erosivity class covers over one half of the study area.

Class IV: Moderately low rain erosivity (< 300) zones are to be noticed along the extreme western and eastern part of Kurseong Sub-Division i.e. Mechi - Balason and Mahananda - Tista interfluves.

4.2.4 SOIL ERODIBILITY

Erodibility defines the resistance of soil to both detachment and transport. Although, soil resistance to erosion depends in part on topographic position, slope steepness and nature of disturbance created by man, yet, the properties of soil are more important determinants. Soil erodibility varies with soil texture, aggregate stability, shear strength, infiltration capacity and organic and chemical properties. A good number of research work have so far been done for the approximation of soil erodibility index, since 1930 (Morgan, 1979). The Dynamic Field Oriented Methods of Wischmeir and Mannering, 1969, seems to be the best representative. The assessment of soil erodibility risk (*K*) of the Kurseong Sub-Division has been calculated from the Soil Erodibility Nomograph (Fig. 4.2) of the USLE (Wischmeir, 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 percent,

iii) the structure and

iv) the profile permeability.

It has been found from the analysis that the *K* value varies from 0.15 to 0.61 in the study area. A soil erodibility map has been prepared based on the available K value. Low

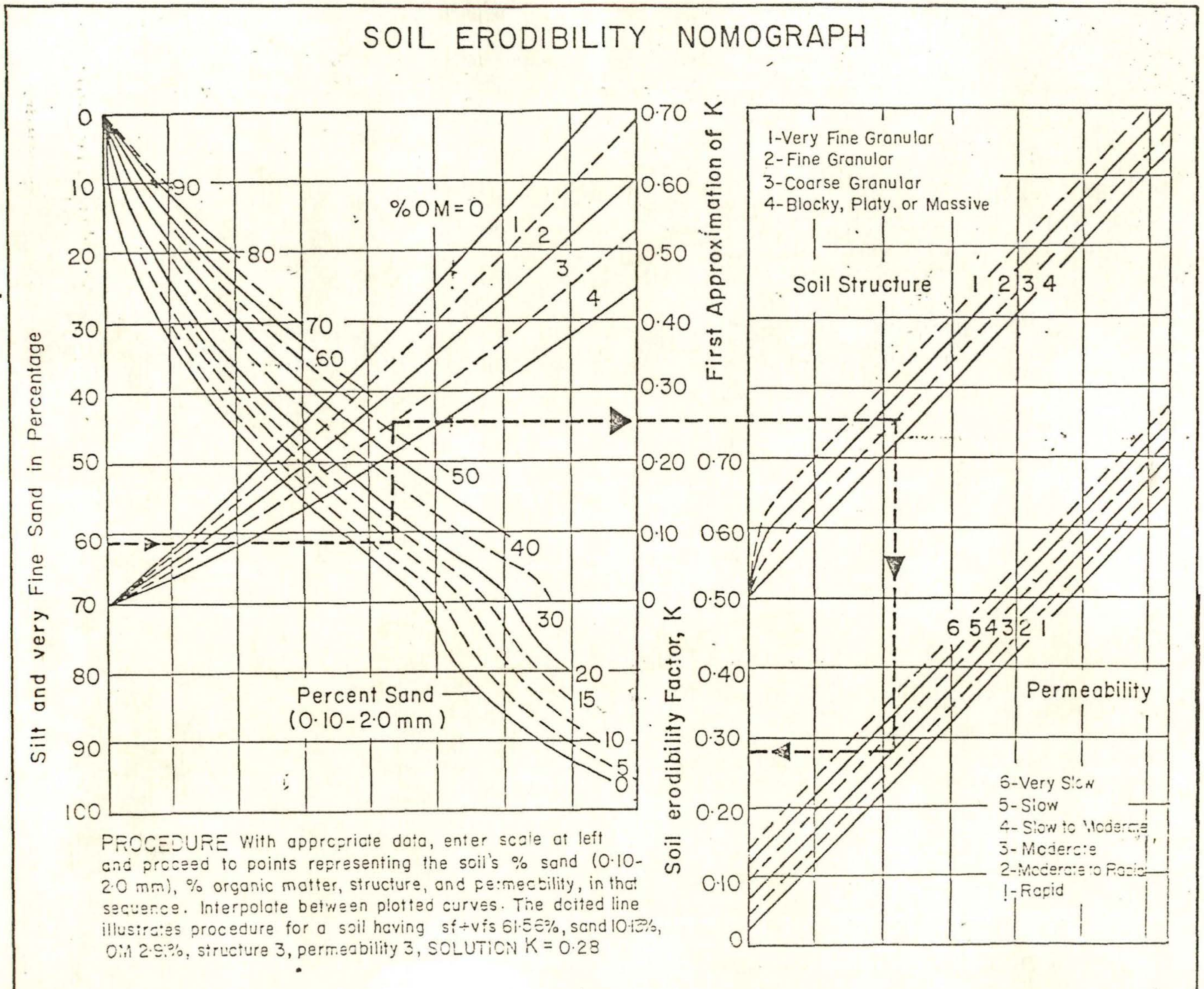
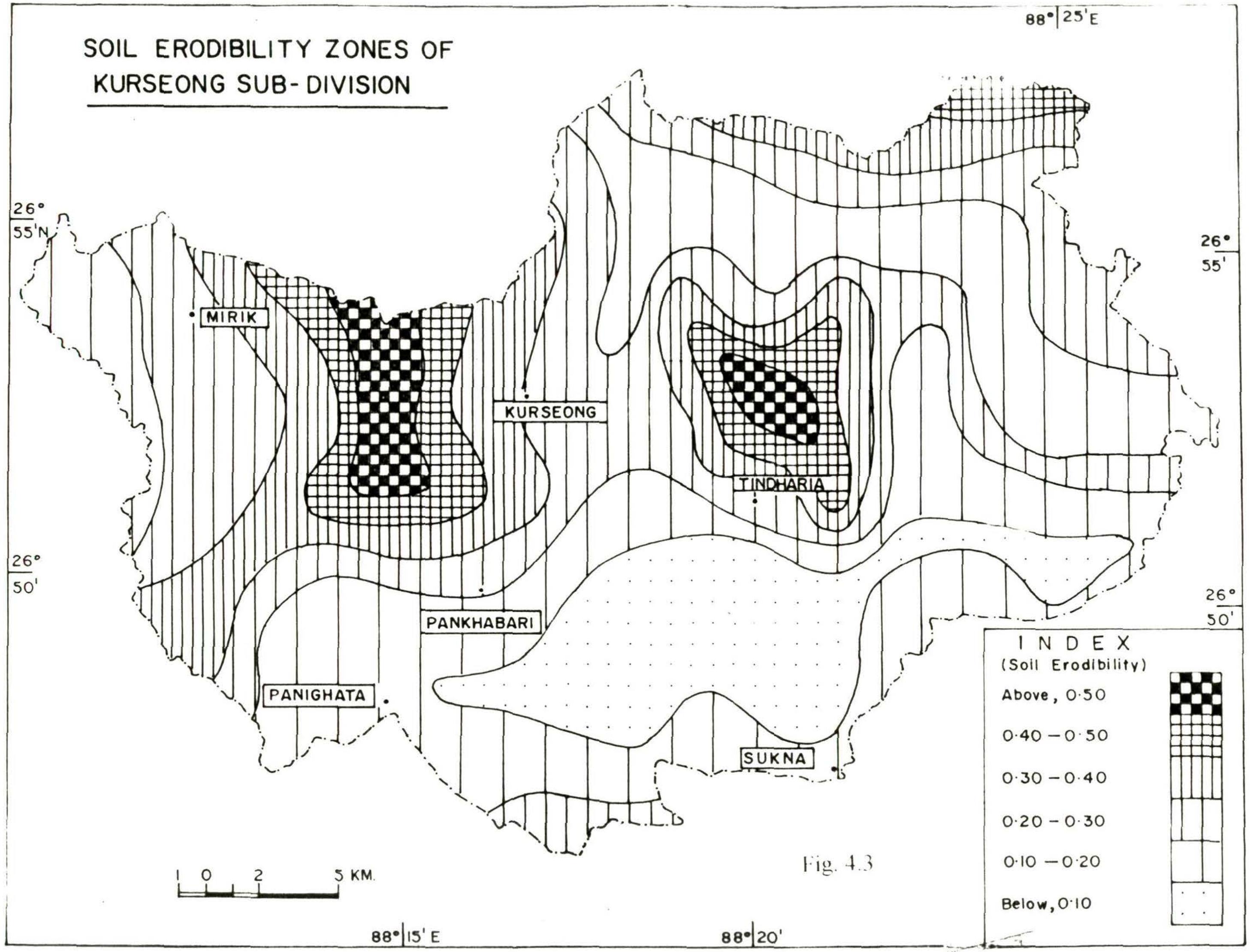


Fig. 4.2 Based on Wischmeier, Johnson and Cross (1971)


SOIL ERODIBILITY ZONES OF
KURSEONG SUB-DIVISION
88°|25'E
26°
55'N
26°
55'
MIRIK
KURSEONG
TINDHARIA
26°
50'
26°
50'
PANKHABARI
PANIGHATA
SUKNA
INDEX
(Soil Erodibility)
Above, 0·50
0·40 – 0·50
0·30 – 0·40
0·20 – 0·30
0·10 – 0·20
Below, 0·10
1 0 2 5 KM.
88°|15'E
88°|20'
Fig. 4.3

erodibility (<0.2) has been detected around the Mahaldiram - Ghum ridge, Okaiti - Simana Basti ridge and along the eastern part of the Mahananda basin. The north central, Mahananda and Balason basins and the southern Terai possess moderate to high rate of soil erodibility (> 0.4).

The following erodibility classes have been identified (Fig. 4.3):

Class I: High soil erodibility (K = > 0.5) has been identified in a number of narrow and elongated tracts, along the major valleys and cliff surfaces.

Class II: Moderately high soil erodibility (K = 0.4-0.5) has been identified in and around very steep hill slopes and around valley floors.

Class III: Moderate soil erodibility (K = 0.3-0.4) is perhaps the most common in the study area and is found in almost everywhere in the Kurseong Sub-Division.

Class IV: Moderately low soil erodibility (K = 0.2-0.3) is found around two areas:

a) along the gently sloping ridges and b) southern forest covered foothills.

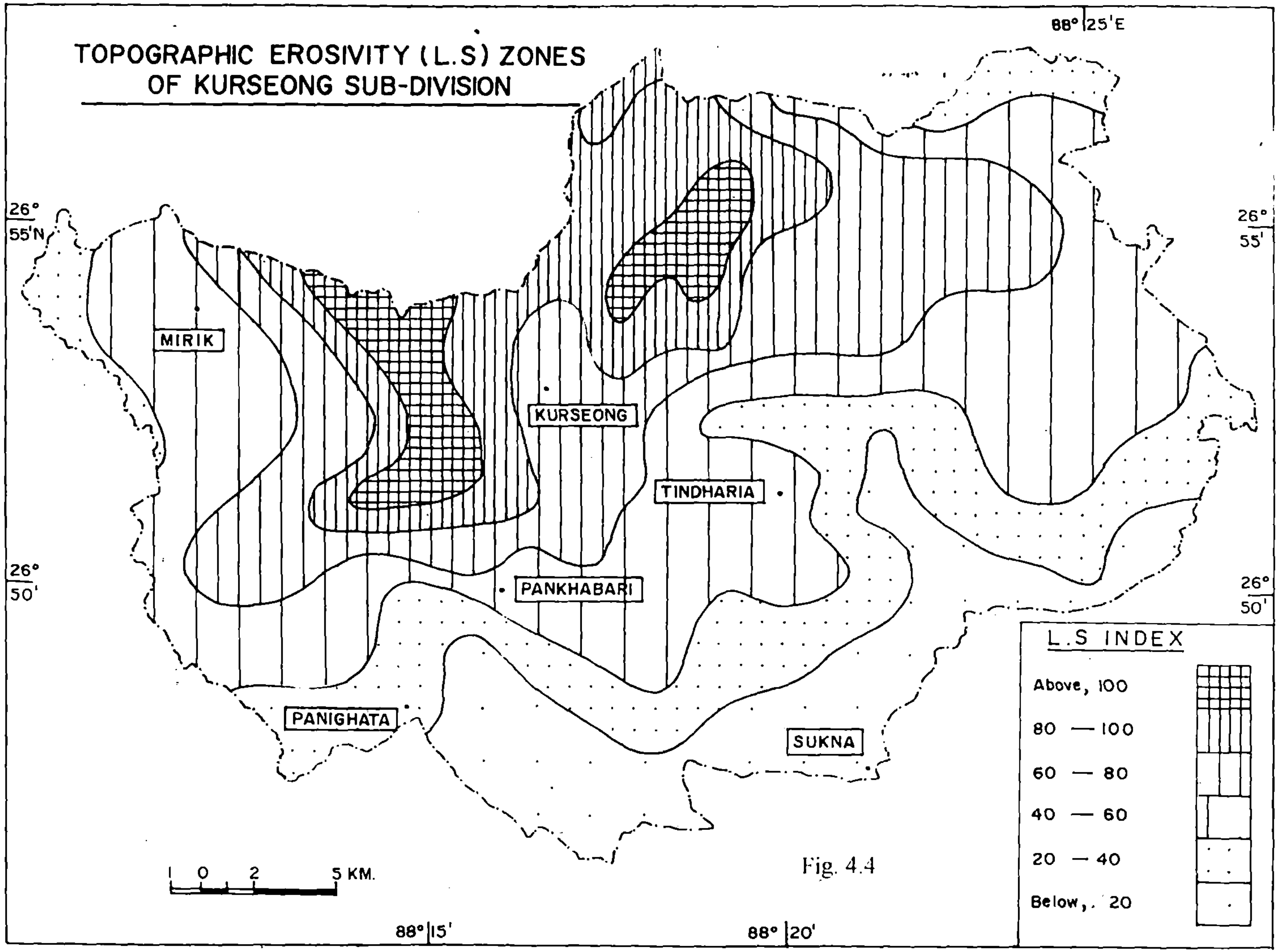
Class V: Low soil erodibility (K = 0.1-0.2) has been encountered mostly along the densely forested foothills i.e. Tista - Mahananda interfluves, and some tracts along Mahananda - Balason interfluves.

4.2.5 TOPOGRAPHIC EROSIVITY

Soil erosion would normally be expected to increase with the increase of slope steepness and of slope length as a result of respective increase in velocity and volume of surface run-off. The relationship between erosion and slope can be expressed by the following equation:

$$Qi \ \alpha \ tan^m \theta . Ln \quad \text{(Morgan, 1979)} \text{ ——————— } 4.11$$

where, θ is the slope gradient angle and L is slope length.



TOPOGRAPHIC EROSIVITY (L.S) ZONES OF KURSEONG SUB-DIVISION
88° 25'E
26° 55'N
26° 55'
26° 50'
26° 50'
MIRIK
KURSEONG
TINDHARIA
PANKHABARI
PANIGHATA
SUKNA
L.S INDEX
Above, 100
80 — 100
60 — 80
40 — 60
20 — 40
Below, 20
1 0 2 5 KM.
88° 15'
88° 20'

Fig. 4.4

Many researches have so far been done on the effect of slope in erosion based on the data obtained from experimental station (Mayer & Wischmeir, 1969; Gabriel, Powels & De Boodt, 1975 and D'Souza & Morgan, 1976). The assessment of topographic erosivity *L.S* in the study area has been carried out based on the model of the USLE (Equation 4.2). Based on the calculated *L.S* value, a topographic erosivity map has been drawn (Fig. 4.4). The topographic erosivity (105.43) has been found to be the highest along the southern slope of the Mahaldiram ridge, while, very low topographic erosivity (below 5) has been estimated along the ridges and southern piedmont areas. It has been found from the analysis that the entire northern and central part of the study area possess high *L.S* (> 50.0) while the southern foothills and alluvial fans and along some very small pockets on the ridge tops exhibit low to moderately low topographic erosivity *L.S* < 10.0). The remaining area have moderate erosivity value ranging form 10 to 50.

4.2.6 BIOLOGICAL EROSIVITY

Biological factor, particularly land-use, soil management and cultural practice have many and varied effects and the generalisation and quantification of these effects of an area are often difficult and complicated (FAO/UNEP, 1978). The biological erosivity or *C.P* of USLE, in the study area has been assessed based on the parametric rating value of each of the different types of land-use (Table 4.1), because, the land-use types and patterns ultimately depend on the complex physico-biological processes and it reflects, the human level of interference in the natural ecosystem (Sarkar, 1989). A biological erosivity *C.P* map has been prepared (Fig. 4.5) from the available *C.P* index, which includes *C* and *P* coefficients of the USLE. It has been found from the map (Fig. 4.5) that the biological erosivity is mostly dependent on the existing land-use pattern. Very high *C.P* value (0.5 to 0.8) has been identified in several pockets along the north-central part of the Mahananda and Balason basins, and low to very low *C.P* has been noticed in the forested ridges, eastern part of the Mahananda basin and in the foothill areas. The following biological erosivity classes have been identified from the Figure 4.5:

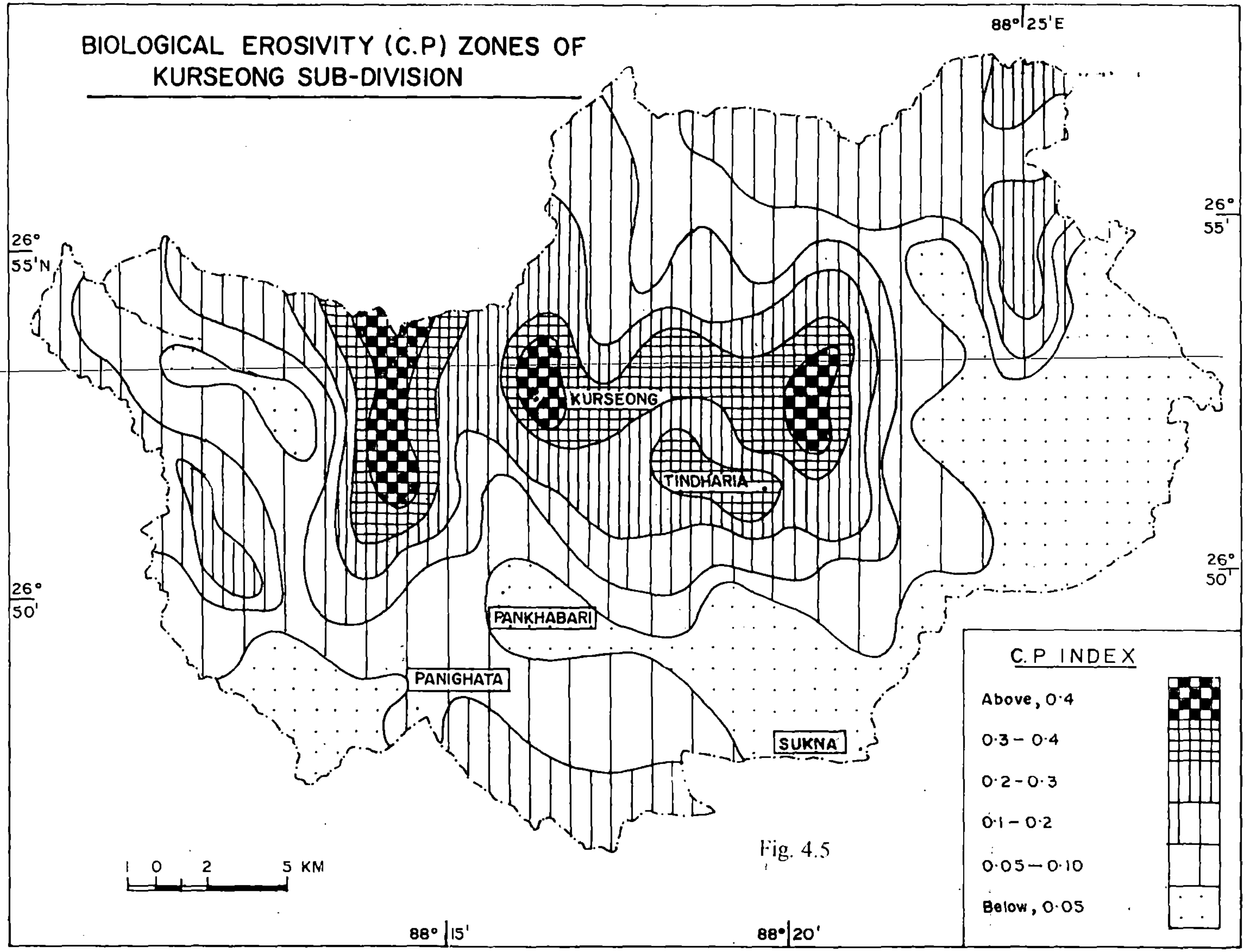

BIOLOGICAL EROSIVITY (C.P) ZONES OF
KURSEONG SUB-DIVISION
88° 25'E
26° 55'N
26° 55'
26° 50'
26° 50'
88° 15'
88° 20'
KURSEONG
TINDHARIA
PANKHABARI
PANIGHATA
SUKNA
1 0 2 5 KM
C.P INDEX
Above, 0·4
0·3 – 0·4
0·2 – 0·3
0·1 – 0·2
0·05 – 0·10
Below, 0·05

Fig. 4.5

Class I: Very high biological erosivity ($C.P$ = > 0.6) has been found in two distinct zones : a) in the hilly north-central part of the Mahananda and Balason basins, due to extensive human interference i.e. heedless deforestation, unscientific slope cultivation of root crops like ginger, cardamom, potato, onion, etc., which are highly vulnerable to soil loss (Sarkar, 1987) and b) the southern Terai due to near complete destruction of natural vegetation.

Class II: High biological erosivity ($C.P$ = 0.4 to 0.6), has been identified along the major river valleys and in some degraded tea garden areas.

Class III: Moderate biological erosivity ($C.P$ = 0.2 to 0.4), is perhaps the most common class found in the study area mostly identified in and around tea gardens.

Table 4.1

Parametric Rating Value for Different Land-use 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 gardens (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, intertilled 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

Class IV: Low biological erosivity ($C.P$ = 0.01 to 0.2) has been encountered in densely forest covered upper slopes i.e. around ridges and b) forested mid slopes and small valleys.

Class V: Very low biological erosivity ($C.P = < 0.01$) has been notice over the south-eastern and south central foothills which is still under dense vegetative cover.

The biological erosivity $C.P$ constitute the most important and the ultimate factor for the quantitative assessment of the predicted or actual soil erosion from a given area, over a given period, such as, a highly vulnerable zone of potential erosion hazard may have insignificant amount of predicted or actual soil loss, if the region is under the cover of dense natural forest.

4.2.7 THE POTENTIAL SOIL EROSION

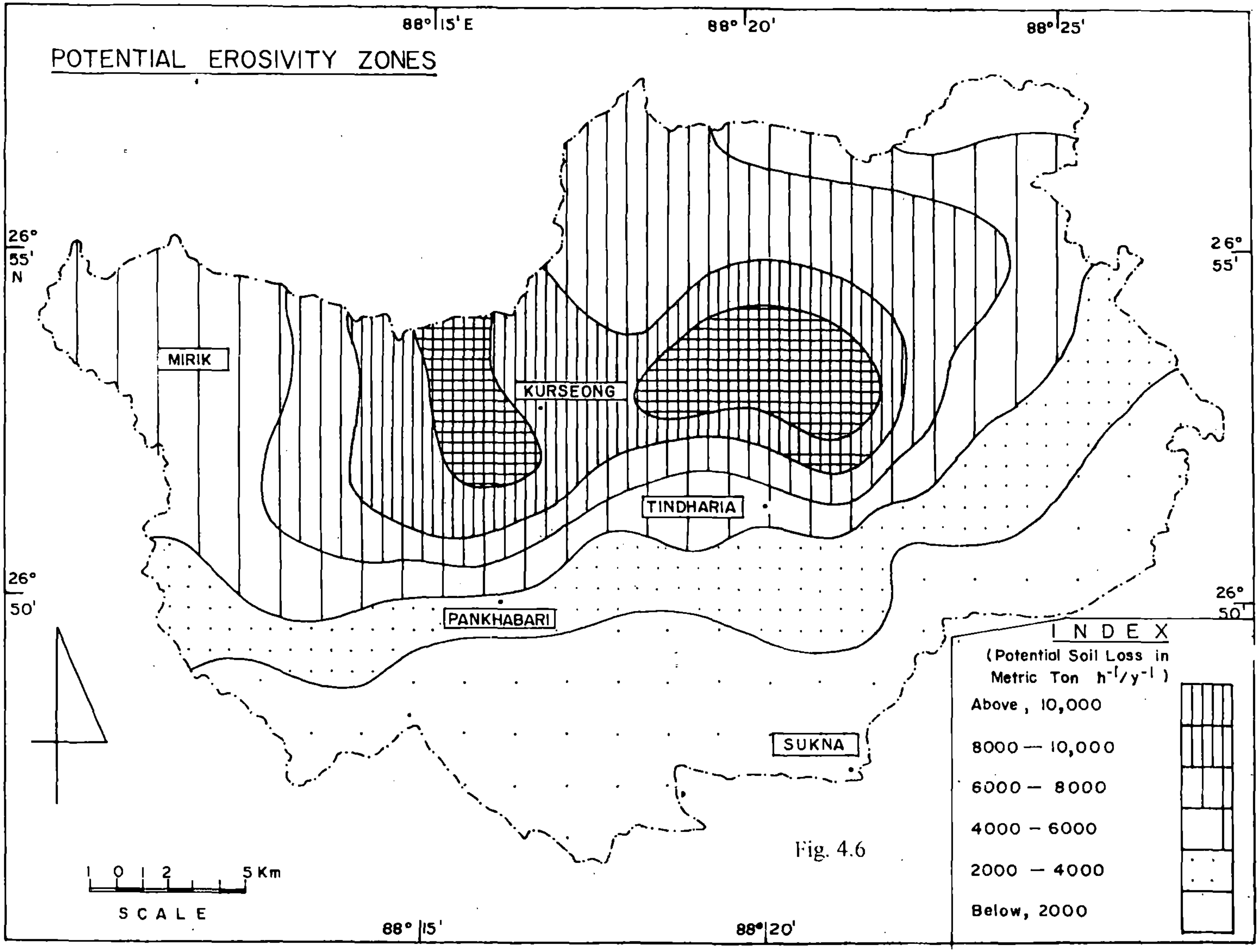
The potential soil degradation is the diminution of current or potential productivity or suitability which results from the action of physical factors without the intervention of biological factors (Requier, 1980). A potential erosivity map (Fig. 4.6) of the Kurseong Sub-Division and its environs has been prepared form the available quantitative information, based on the following equation:

$$Pe = R \times K \times L.S \text{ ------------------------------------ } 4.12$$

It has been found that most of the study area except southern piedmont zone, show high degree of potential soil erosion due to its topographic configuration. But, its spatial variation seems to be striking and for a better description, the following gradation have been put forward:

Class I: Exceptionally high potential erosivity zone, where the potential soil loss has been estimated to be more than 15,000 tons/h^{-1}/y^{-1} or, 600mm/y^{-1}, found along the southern and western steep slopes or Mahaldiram range, western and eastern spur of Selim hill.

Class II: Very high potential erosivity zones (Pe = 10,000 to 15,000 tons/h^{-1}/y^{-1} or 400-600mm/y^{-1}) are noticed along the south-eastern slope of Kurseong-Pankhabari ridge, southern spur of Mirik dome, western spur of Latpanchor ridge and western spur of Kurseong-Sonada ridge.


POTENTIAL EROSIVITY ZONES
88° 15' E
88° 20'
88° 25'
26° 55' N
26° 55'
26° 50'
26° 50'
MIRIK
KURSEONG
TINDHARIA
PANKHABARI
SUKNA
0 1 2 5 Km
SCALE
88° 15'
88° 20'
INDEX
(Potential Soil Loss in Metric Ton h^{-1}/y^{-1})
Above, 10,000
8000 — 10,000
6000 — 8000
4000 — 6000
2000 — 4000
Below, 2000
Fig. 4.6

Class III: High potential zones, with the rate of soil loss varying from 5000 to 10,000 tons/h^{-1}/y^{-1} or, 200-400mm/y^{-1}, are found to be the most common potential erosivity class in the study area. Most of the central part of Kurseong Sub-Division falls under this category.

Class IV: Moderate erosivity zones (*Pe* = 2000 to 5000 tons/h^{-1}/y^{-1} or 80 to 200mm/y^{-1}) are encountered around the major tea garden areas of western Balason river, around Mirik dome, and in some upper slope of the Mahaldiram range.

Class V: Low erosivity zones with the potential soil loss estimated to be in between 1000 to 2000 tons/h^{-1}/y^{-1} or 40 to 80mm/y^{-1}, and have been identified in and around the major ridges, wide valleys and along the southern foothills.

Class VI: Very low erosivity zones (below 1000 tons/$h^{-1}y^{-1}$ or below 40mm/y^{-1}) has been noticed in a very narrow east-west elongated zone along the extreme southern part of the Kurseong Sub-Division i.e. Panighata-Longview-Sukna-Gulma area.

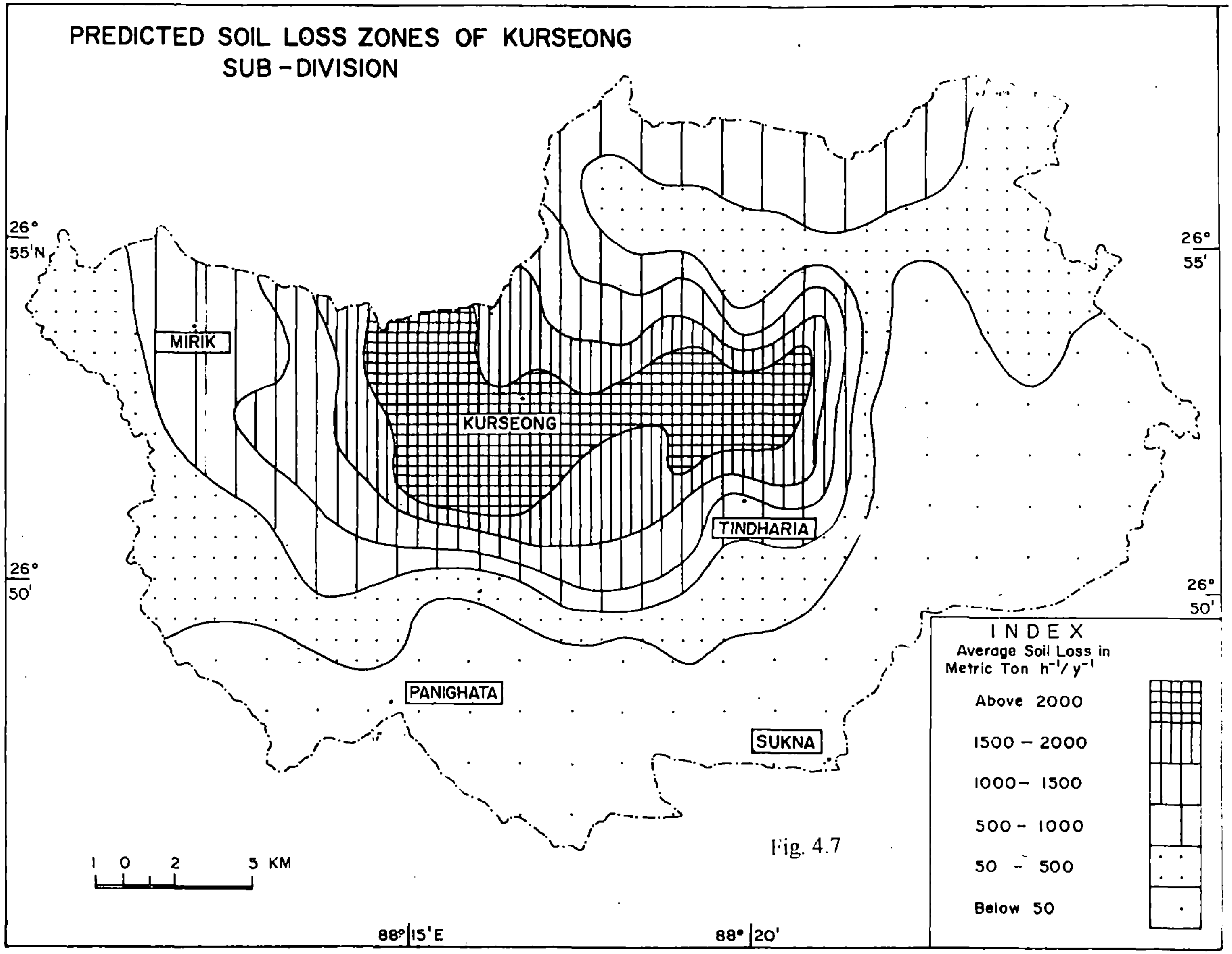
The potential erosivity map (Fig. 4.6) of Kurseong Sub-Division provides a basic inventory for estimating the actual or predicted soil erosion hazard. This may also provide an appropriate tool for the future land-use planning and conservation practice.

4.2.8 THE PREDICTED SOIL EROSION HAZARD ASSESSMENT

The predicted or actual soil erosion hazard has bee assessed based on the potential erosivity and the biological erosivity by using the equation :

$$E = R \times K \times L.S \times C.P \text{ --- } 4.13$$

An isoerodent map has been prepared by interpolating the E values of different sites (Fig. 4.7). It has been found that the north central parts of the Mahananda and Balason basins (Photo. 4.3) show exceptionally high rate of soil loss (> 2500 tons/h^{-1}/y^{-1}), while very low rate of soil loss (< 5 tons/h^{-1}/y^{-1}) has been estimated along the southern piedmont area and



PREDICTED SOIL LOSS ZONES OF KURSEONG
SUB - DIVISION
26°
55'N
26°
55'
26°
50'
26°
50'
MIRIK
KURSEONG
TINDHARIA
PANIGHATA
SUKNA
INDEX
Average Soil Loss in
Metric Ton h^{-1}/y^{-1}
Above 2000
1500 – 2000
1000 – 1500
500 – 1000
50 – 500
Below 50
1 0 2 5 KM
88° 15'E
88° 20'

Fig. 4.7

Photo. 4.3 High Soil Erosion Zone, near Tung

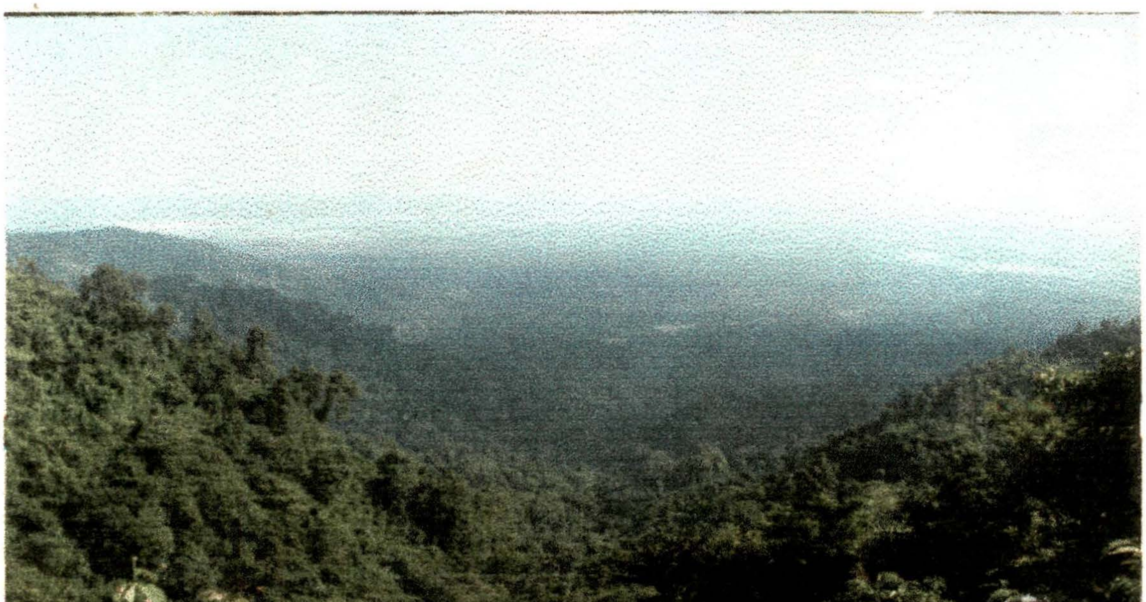


Photo. 4.4 Low Soil Erosion Zone, the foothill area

the northern forested ridges (Photo. 4.4). However, for a better understanding of the geographical distribution of erosion hazard zones, the following susceptibility classes have been identified (Fig. 4.7).

Class I: Exceptionally high susceptibility zones, where the soil loss have been estimated to be above 2500 tons/h^{-1}/y^{-1}, are identified along a few pockets around the valleys of major rivers and along some highly disturbed hill slopes, particularly around Tindharia-Paglajhora area.

Class II: Very high erosion hazard zones (E = 1250 to 2500 tons/h^{-1}/y^{-1} or 75 to 150mm/y^{-1}), have been noticed in some settled and cultivated tracts around Chunabhati-Mahanadi belts, Central Mahanada-Balason interfluves, around Selim hills and along the western spur of Kurseong-Tung ridge.

Class III: High erosion hazard zone (E = 250 to 1250 tons/h^{-1}/y^{-1} or, 15 to 75mm/y^{-1}) has been concentrated in the Mahananda-Balason interfluve. This is the most extensive erosion hazard zone found in the study area (Photo. 4.3).

Class IV: Moderate susceptibility zones (E = 50 to 250 tons/h-1/y^{-1} or, 3 to 15mm/y^{-1}), are identified in two areas: a) the Mechi-Balason and b) the Mahananda-Tista interfluves.

Class V: Low susceptibility zones (E =5 to 50 tons/h-1/y^{-1} or, 0.3 to 3mm/y^{-1}), have been identified around the Mirik dome, gently sloping upper slope of the Mahaldiram range and along the lower Balason valley.

Class VI: Very low erosion hazard zones where the rate of soil loss have been estimated to be in between 1 ton to 5 tons/h^{-1}/y^{-1} or, 0.06 to 0.3mm/y^{-1} are encountered a) on the ridge tops and b) along the southern margin of the foot hills (Photo. 4.4).

Class VII: None to negligible susceptibility zone where the E value have been estimated to be below 1 $ton/h^{-1}/y^{-1}$ or < $0.06mm/y^{-1}$, is found along a narrow belt on the extreme south of the study area i.e. the Mechi-Balason-Mahananda-Tista alluvial fans.

Thus, the erosion hazard zone map as produced in the Figure 4.7 coincides very well with the quantitative assessment of susceptibility and hazard done earlier, based on the evaluation of the *R, K, L.S and C. P* factors independently.

4.3 STRATEGIES FOR SOIL EROSION CONTROL

The aim of soil erosion control vis-à-vis soil conservation is to maintain erosion below a threshold level which theoretically permits natural soil erosion (Morgan, 1986). The maximum acceptable rate of erosion is known as the soil loss tolerance, which is very difficult, if not impossible to estimate. Soil loss tolerance has been estimated by Scientists, varying from 0.01 in semi desert environment to as high as $1.5mm/y^{-1}$ in certain tracts of humid tropics and humid temperate environments (Boul, Hole & Mc Mracken, 1973, Kirkby, 1980, Zacher, 1982, etc.). Considering the available information in this regard, Sarkar (1993) has proposed a target of $0.3mm/y^{-1}$ soil loss as the uppermost limit for soil erosion control in the Darjeeling Himalaya.

It has been found in the study area that water is the single most important agent of soil erosion. Among the mechanisms of erosion, rainsplash and run-off are found to be more important. 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 4.2). Soil conservation schemes must be well designed if they are to reduce erosion effectively. Their ultimate success depends on how well the nature of the erosion problem has been identified and on the suitability of the conservation measures selected.

Table 4.2

Impact of Conservation Measures in Soil Erosion Mechanism

	Rainsplash		Run-off	
Conservation Measures	D	T	D	T
A. Agronomic Measures				
i) Covering soil surface	0	0	0	0
ii) Increasing surface roughness	*	*	0	0
iii) Increasing surface depression storage	+	+	0	0
iv) Increasing infiltration	*	*	+	0
B. Soil Management				
i) Fertiliser application	+	+	+	0
ii) Manuring	0	0	0	0
iii) Drainage	+	+	0	0
C. Mechanical Measures				
i) Contouring	*	+	+	0
ii) Terraces	*	+	+	0
iii) Shelterbelts	*	*	*	0
iv) Waterways	*	*	*	0

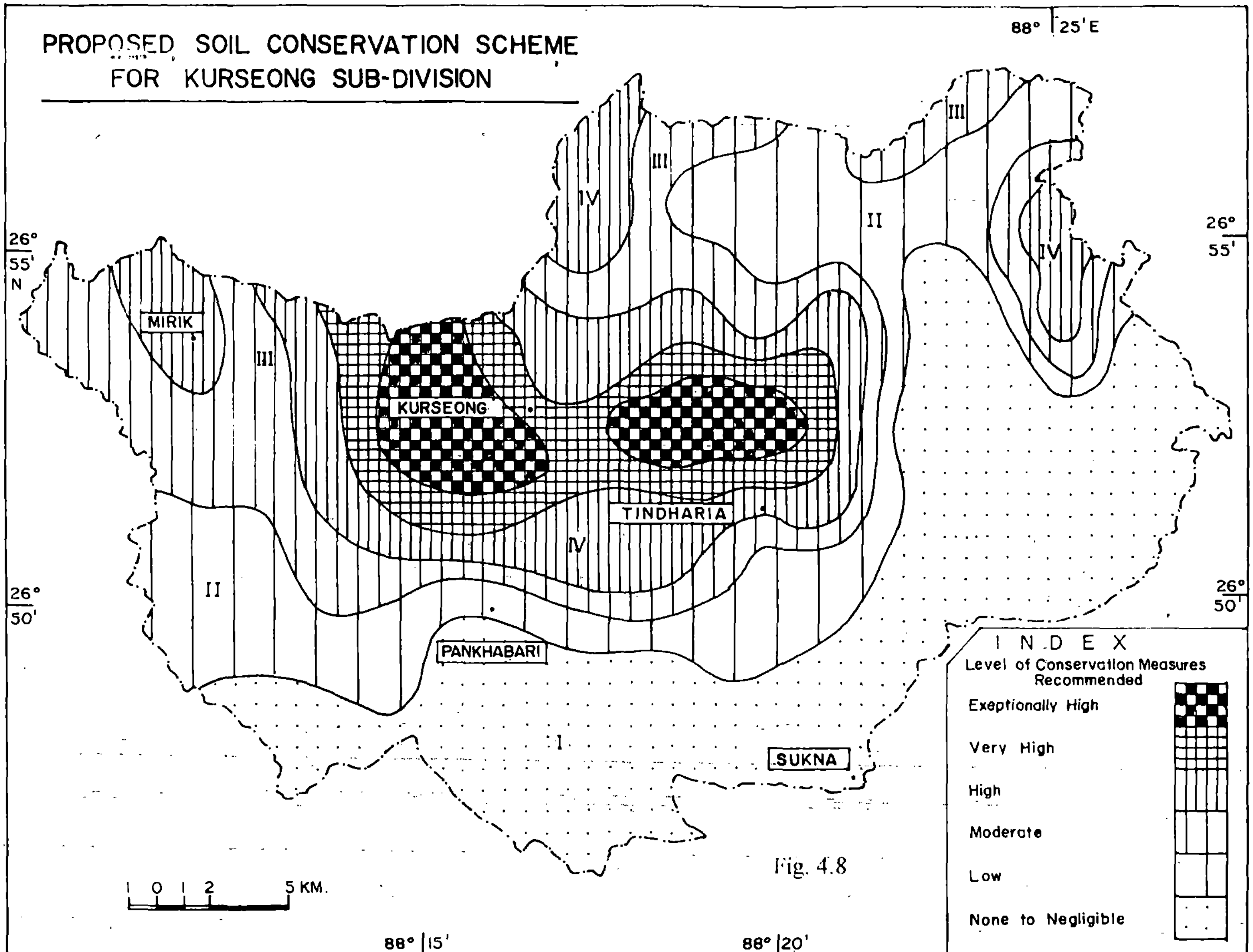
* = no control; + = moderate control; 0 = strong control, D = detachment; T = transport.

Modified from Voetberg, 1970; Morgan, 1980.

4.3.1 PROPOSED CONSERVATION PLAN FOR THE STUDY AREA

The assessment of soil erosion in Kurseong Sub-Division reveals that the soil of the area is highly erodible. This coupled with favourable environmental conditions often yield very high rate of soil loss. The climatic conditions also help in rapid decomposition of parent rocks which, ultimately help in rapid soil formation. Keeping these two points in mind, the investigator has been proposing a target of $0.5 kg/m^{-2} y^{-1}$ or 5 $tons/h^{-1}/y^{-1}$ of soil loss be accepted as the permissible limit.

Although, the entire study area possess high erosion risk, yet the investigator has identified some highly vulnerable areas which need immediate conservation measures. The Figure 4.8 shows the proposed level of conservation measures required to protect soil against erosion.


PROPOSED SOIL CONSERVATION SCHEME
FOR KURSEONG SUB-DIVISION
88° 25'E
26° 55' N
26° 55'
26° 50'
26° 50'
MIRIK
KURSEONG
TINDHARIA
PANKHABARI
SUKNA
I
II
III
IV
1 0 1 2 5 KM.
88° 15'
88° 20'
INDEX
Level of Conservation Measures Recommended
Exeptionally High
Very High
High
Moderate
Low
None to Negligible
Fig. 4.8

The various erosion classes their respective level of conservation and the recommended measures are given in tabular form in the Table 4.3.

Table 4.3

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
VII	Below 1	None	-
VI	1 to 5	None to Negligible	No immediate specific conservation measure is needed except careful crop management.
V	5 to 50	Low	Crop rotation, cover crops, strip cropping, contour bunds, along with suitable waterways.
IV	50 to 250	Moderate	Cover crops, mulching, organic matter management, retention and bench terraces, channel diversions, terrace channels, grass waterways, etc.
III	250 to 1250	High	Cover crops, mulching, ladder and bench terraces, waterways, storm water disposal systems along with slope stabilisation.
II	1250 to 2500	Very high	Here, all possible agronomic, mechanical and soil management methods should be adopted simultaneously, suitable cover crops, mulching, adequate retaining wall and grass and /or masonry waterways.
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 forests.

4.4 CONCLUSIONS

The forest clad mountains with high precipitation of Kurseong Sub-Division of Darjeeling

Himalaya reveals man's heedless activities, which elevate the average soil erosion manifold. Complete severance of the topsoil and forest from bedrock is visible in these areas and this once lush green mountains and rolling foothills are becoming barren and less suitable for human habitation.

The worst affected north-western and north-central parts of the upper Balason and upper Mahananda basin are mostly deforested along with skeletal soil and very steep slope ($>30^0$), need immediate conservation measures as mentioned in Table 4.3. Special attention should be taken along the roads, railways, tea gardens, agricultural terraces and in and around the existing settlements. Large scale afforestation with suitable terracing and drainage facilities become necessary to check massive soil loss. While, the southern and south-eastern parts have revealed very low to negligible amount of soil loss (below 5 tons/h^{-1}/y^{-1}). This amount is below the upper limit of the permissible soil erosion and thereby, no immediate conservation measures are required.

High to very high level of conservation measures are also required in many areas of northern and central parts of the study area, where, the amount of soil loss has been estimated to be in between 250 to 2500 tons/h^{-1}/y^{-1}. These are the areas of extensive tea plantation and terrace cultivation. Moderate level of conservation has been proposed for the areas located along the ridges and the southern margins of the study area. While, low level of conservation measures has been recommended for the southern piedmont slopes and the northern ridges. Although, these regions have no immediate visible degredational problems, yet need to be brought under the conservation measures, keeping in mind long term consequence of soil erosion.

Among the various soil conservation measures, agronomic measure should be given preference because it is less expensive and deals directly with reducing raindrop impact, increasing infiltration, reducing run-off volume and decreasing water velocity. It is also easy to fit them into an existing farming system. The conservation schemes must be well designed and their ultimate success depends on how well the measures are implemented.

The willingness and the socio-economic background of the farmers and others to adopt the techniques required by a particular strategy is also very important.

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