CHAPTER 2
GEOMORPHOLOGY OF THE BASIN

2.1 Introduction

Drainage basin is the most convenient unit for the study of environmental problems and its management. These basins form the natural backdrop for hill slope processes and river channel behavior, within which, most fluvio-geomorphological processes operate. The drainage network and the basin morphology are measures of fluvial processes operating in the basin. It has been established that river flows are related to the topographic and climatic characteristics of a drainage basin, which in turn control the amount, time and space distribution of the stream flow. The stream-flow reflect the precipitation variations and surface and sub-surface characteristics. To make a geomorphic study, it is thus necessary to obtain quantitative expressions of landform characteristics and then to develop quantitative relations between geomorphic and hydrological variables.

2.2. Slope

'Slope' may be defined as 'an angular inclination between different elevations and the slope gradient defines the stage of development of a landscape'. Terrain morphology is characterized by slope conditions, which are governed by a number of factors – climatic, geologic and tectonic. There is a close relationship between slope conditions and morphometric attributes of terrain viz. absolute relief, relative relief, dissection index and drainage density. An attempt has been made here to analyze the slope morphology of the Balason basin (figure 2.1).

The Balason basin displays a spectacular association of different slope and its inclination. The slope morphology map is thus, prepared based on topographical maps (figure 2.1). The major break of slope is identified along the southern margin which separates the study area into two broad segments : northern hilly area and the southern undulating terrain. Both convexity and concavity in slope form are

SLOPE MORPHOLOGY OF THE BALASON BASIN

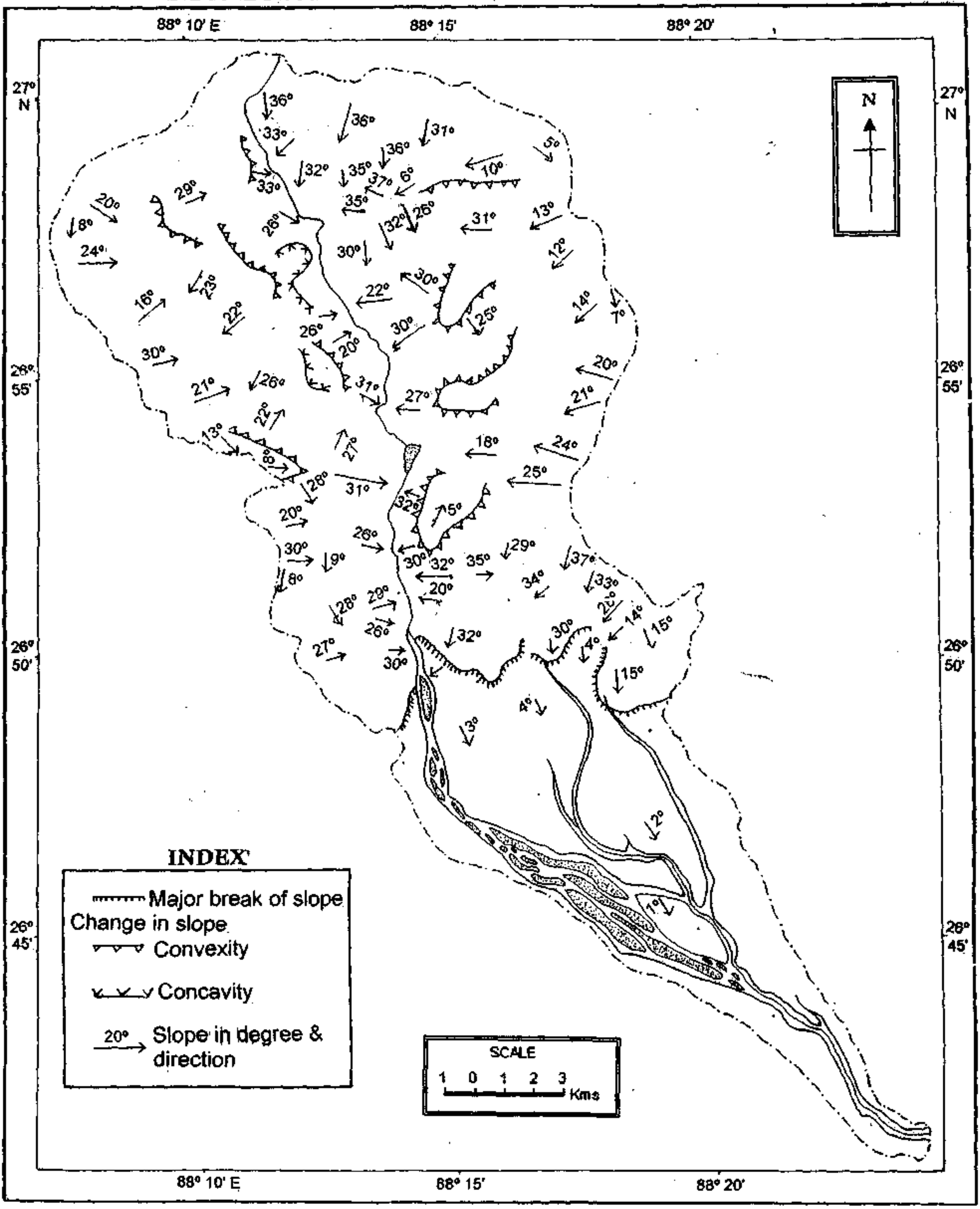

Figure 2.1.

found everywhere in the northern hilly section. However, concavity is more pronounced along the mid-slope due to massive mass movements.

Slope inclination is measured from the topographical map along with the field verification. Based on slope angle, the following slope class have been proposed:

Class I. Very steep slope zone (>30°) lies in a small wedge right across the center of the region around Phuguri and Gayabari and extending in a narrow strip away from Makaibari towards the eastern periphery. A small section in the north around Milling and Rungmook also exhibits steep slopes of >30°.

Class II. Steep slope zone (20° - 30°) is found to be the most widespread zone in the study area with a very large section in the north having slope between 20° to 30°. Steep slopes are noticed in Gopaldhara, Pubong, Tukvar, Kalej Valley, Margaret's Hope and Phulbari tea gardens. Slope inclination range between 20° to 30° also in the north western section of the region, extending from Pubong, Selimbong, Seyok, Nagri, Nagri Farm, Simripani, Dilaram, Rington, Soureni and Phuguri to the west..

Class III. Moderate slope zone (10° -20°) is found in a broad undulating wedge towards the north and northwest around Thurbo, Nagri farm, Nagri and Dhajia. A narrow strip occurs across the central portion of the study area below Panihatta and in and around the ridges i.e. Mahaldiram, Lepchajagat, Ghoom – Simana etc.

Class IV. Moderate to gentle slope zone (below 10°) are found around Mirik dome, Lepchajagat, Longview tea estate, Panighatta, Marionbari, Phulbari and Khaprail area.

Thus, from the above analysis it can be seen that most of the northern part of the study area is characterized by steep to moderately steep slopes, which is an indicator of youthful stage, where the moderately active erosional processes have not yet been able to turn the steep slope into gentle categories.

2.3. Relative Relief

Relative relief represents the difference in elevation between the highest and lowest points falling within a unit area. It is also termed as 'local relief' or 'amplitude of relief' (Hammond, 1958). Relative relief is closely associated with slope and is more expressive and useful in understanding the morphogenesis.

The relative relief of the Balason basin has been prepared, based on one sq. km. grid, from the relevant topographical maps of the Survey of India (1:50,000). The relative relief map of the Balason basin (figure 2.2) broadly divides the study area into two zones: i) high relative relief and ii) moderate to low relative relief. For a better understanding of the spatial distribution of different relative relief zone, the following classes have been identified:

Class I. Very high relative relief zone (> 500 metres) is found in very isolated patches towards the western, eastern, northern sections and central section of the study area around Ambootia.

Class II. High relative relief zone (400 – 500 metres) is concentrated in the entire northern section and the north eastern section.

Class III. Moderately high relative relief zone (300 – 400 metres) is predominant in the central region running in a broad belt from west to east in the north western of the study area .

Class IV. Moderate relative relief zone (200-300 metres) runs parallel to Class III towards the south, in a narrow strip mostly around the foothill zones.

Class V. Moderately Low relative relief zone (100-200 metres) runs parallel to the Class IV zone in a narrow strip running from west to east.

Class VI. Low relative relief zone (<100 metres) engulfs the entire southern section.

RELATIVE RELIEF OF THE BALASON BASIN

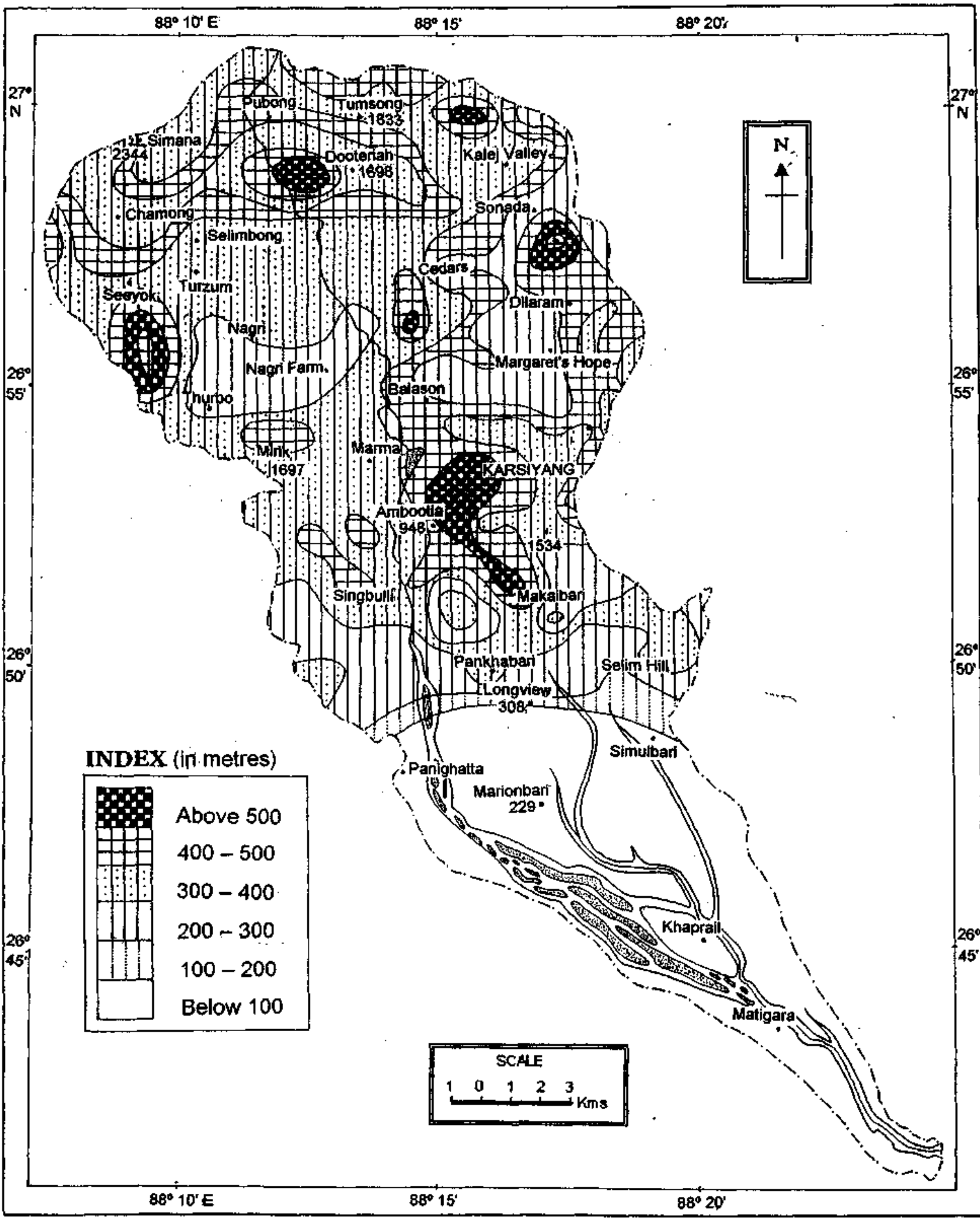

Figure 2.2.

Thus, it can be seen that the northern half of the study area is covered by high to moderately high relative relief. Hills with high altitudes and steep slopes are responsible for the development of this particular pattern of relative relief found. Structural disturbances and selective weathering in the normal course of the sculpturing processes, particularly along the boundary zones of different geological formation have played a decisive role in the attainment of such variation, in the amplitude of relief. The high amplitude of relief over the hill portion explains the possibility of high, degree of valley-side slope along the river course, which indicates that the rivers are associated with high intensity of erosion in the hilly area. Thus, it can be said that the landform of the hilly region of the basin is in the youthful stage in its erosional processes.

2.4 Dissection Index

The dissection index is a ratio between relative relief and absolute relief, and it gives a better understanding of the landscape. Dov Nir (1957) states, '*as a criterion of relative energy, the concept of relative height is not entirely satisfactory. Equal relative heights are not always of equal importance since their absolute altitudes may vary. The picture gained from relative altitudes only is static, because it fails to take into account the vertical distance from the erosion base i.e. the dynamic potential of the area studied*'. Thus, relief, in terms of the ratio between absolute relief and relative relief can be obtained by the following method of dissection index:

$$\textit{Dissection Index (DI)} = \frac{\textit{Relative Relief (RR)}}{\textit{Absolute Relief (AR)}} \qquad \ldots\ldots\ldots\ldots 2.1$$

From the calculated values, the following six dissection categories have been identified (figure 2.3):

Class I. Very high dissection index (>0.5) forms isolated peaks in the central part of the study area around Marma and Balason.

DISSECTION INDEX OF THE BALASON BASIN

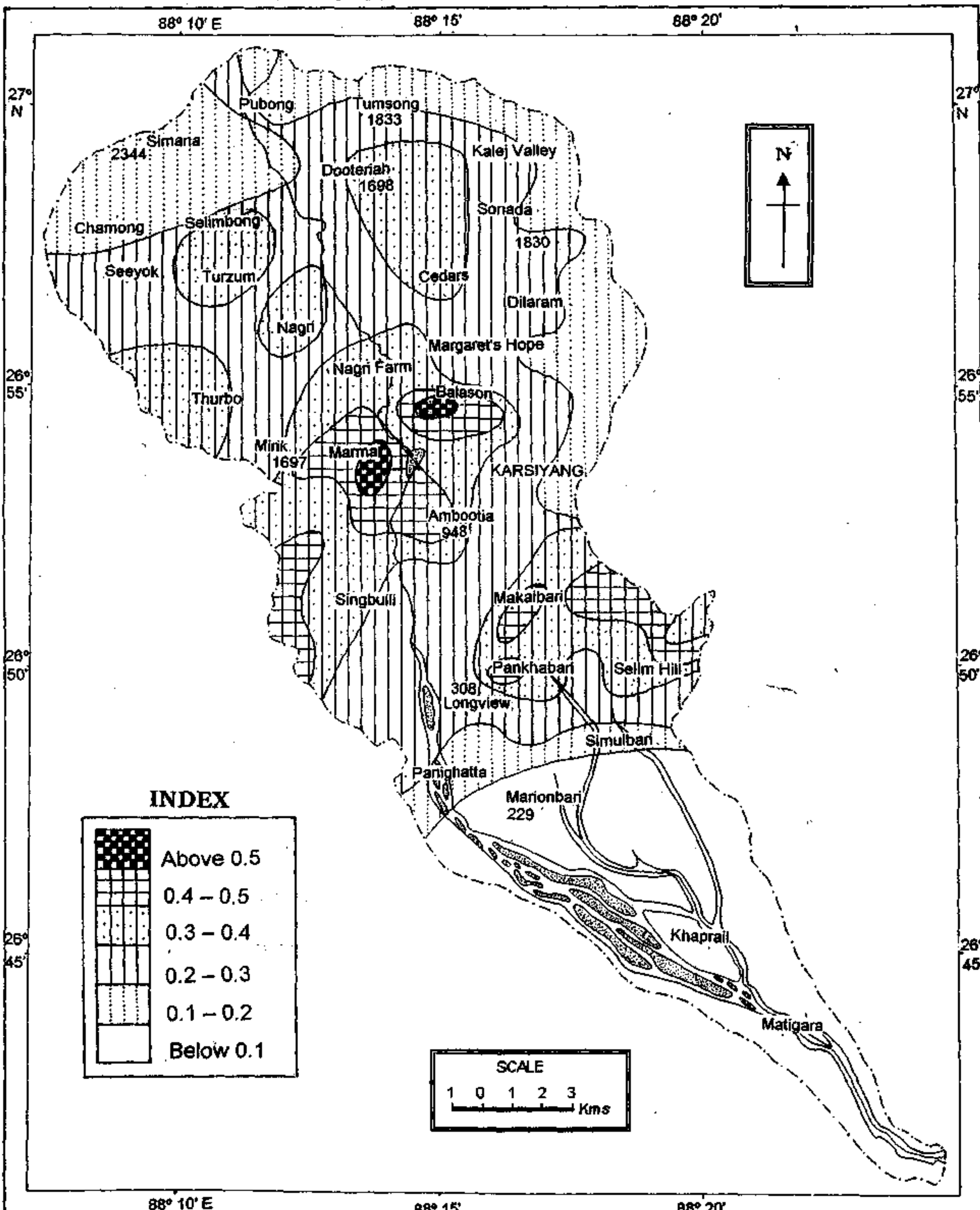

Figure 2.3.

Class II. High dissection index (0.4 – 0.5) is found in small isolated patches encircling very high dissection zone in the central eastern part of the basin around Tilndharia, above Makaibari and above Manjwa.

Class III. Moderately high dissection index (0.3 – 0.4) is found in the extreme eastern section of the central region around Makaibari. Towards the northwest a smaller irregular patch is found extending from Manjwa eastward towards Ambootia and in smaller pockets in the north around Nagri, Thurbo, Selimbong and Turzum and around Dooteriah and Cedars.

Class IV. Moderate dissection index (0.2–0.3) is found as a broad wedge in the central, north western and north eastern section of the study area extending from Gayabari and ending just short of Kalej Valley, and Tumsong in the north. A broader area in this class is found encompassing Seyok, Phulbari and winding down to Karsiyang, Singubuli and extending upto Panighatta.

Class V. Low dissection index (0.1 –0.2) lies north of moderate dissection index zone below Longview in a narrow strip running west to east, from south of Panighatta to Simulbari.

Class VI. Very low dissection index (< 0.1) occurs in a tapering wedge south of Panighatta and Simulbari across Khaprail and towards Matigara and further south.

The dissection index map of Balason basin (Fig.2.3) reveals high dissection ratio in the northern parts, due to varied nature of slope, relative relief, vegetation growth and distribution of rainfall which exhibits relatively youthful stage in morphological evolution. Low dissection index over the lower southern part of the basin shows lack of structural differences as well as instability over the terrain and conforms with the low categories of other morphometric attributes.

2.5. Drainage Density

Drainage density is defined *as the total length of stream segments per unit area.*

DRAINAGE DENSITY OF THE BALASON BASIN

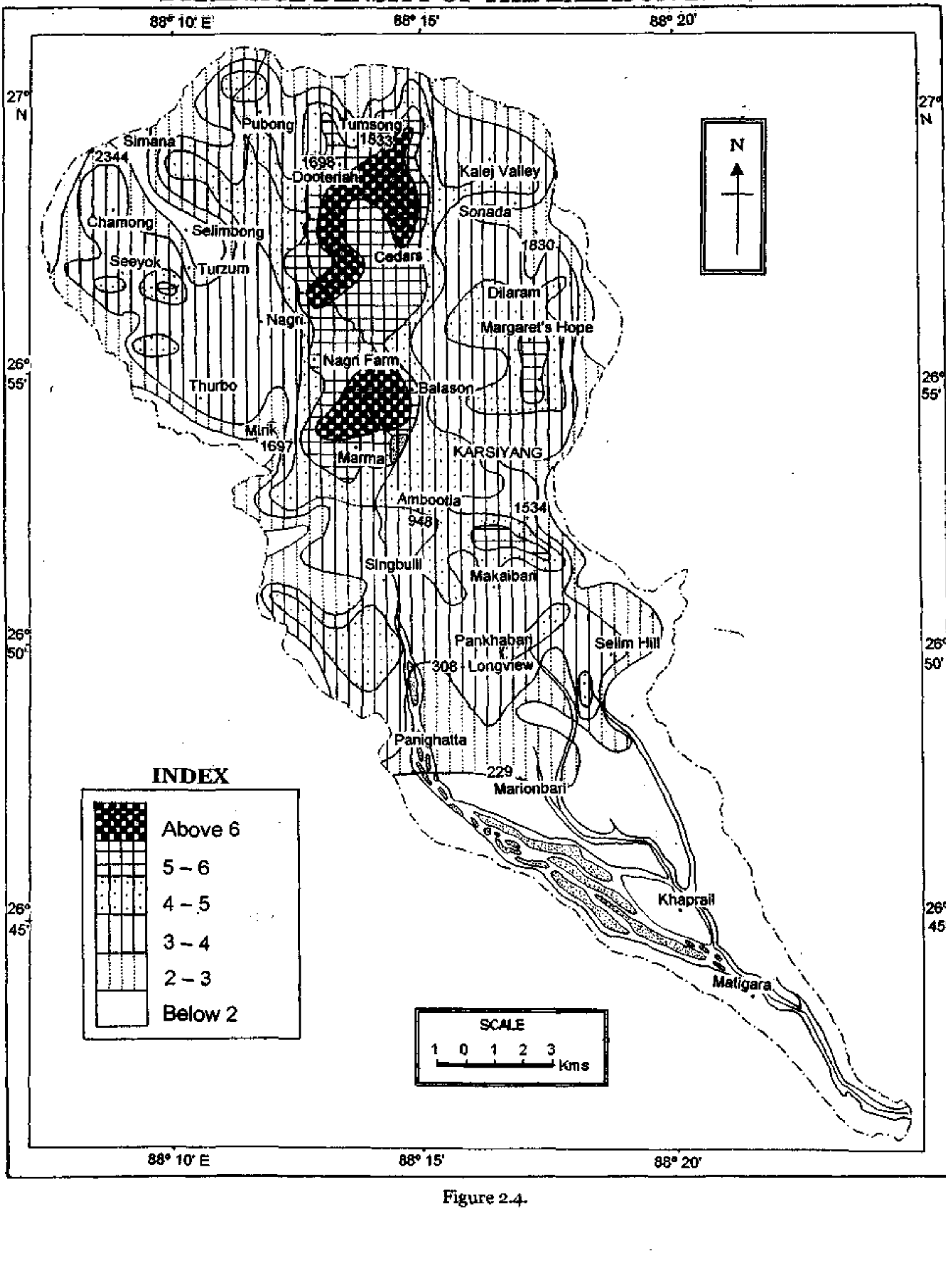

Figure 2.4.

It is a function of the intensity of run off, erosion, relief, density and absolute viscosity of the fluid. Drainage density is given by the quotient of the cumulative length (El) of the stream and total drainage area (Ad).

$$\textit{Drainage Density} = \frac{El}{Ad} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2.2$$

Drainage density has been calculated in one square grid and isopleths have been drawn with different values (figure 2.4) The following drainage density zones are identified in the Balason basin:

Class I. Very high density (> 6 km/km^2) are found in two isolated pockets, in the northern and central portion of the study area. The northern pocket forms an arching loop, just south of Dooteriah; while the second pocket lies between Nagri Farm and Marma.

Class II. High density (5-6 km/km^2) surrounds the Class I zone in a broad belt, and are also found in isolated patches around Margaret's Hope and Castleton.

Class III. Moderately high density (4-5 km/km^2) extends in a narrow strip, almost throughout the entire hilly section of the study area. This class seems to predominate over the central portion, extending from just south of Tumsong in the north, running through Nagri, Karsiyang and Ambootia and ending just above Makaibari. Isolated patches are also found in the western side near Seeyok and Singbulli and further south in the foothill zones around Pankhabari, Longview and Simulbarie.

Class IV. Moderate density (3-4 km/km^2) completely surrounds the three previous zones, right from the higher reaches of the hilly section, to the undulating foothills.

Class V. Low density (2-3 km/km^2) is found in a very narrow strip fringing the boundary of the study area in a wide arch, starting from the west of Singbulli, and extending northwards through Mirik, passing through Tumsong in the extreme north of the basin and running southwards through the eastern periphery from Sonada to Selim Hill. A bigger triangular wedge is seen in the undulating plain, between Longview, Panighatta and Marionbarie.

Class VI. Very low density (< 2 km/km²) is restricted, essentially, to the southern extremity of the basin which is the zone of the southern alluvial fan. However very narrow isolated patches are also found in the western, northern and eastern section of the study area.

The drainage density map of the study area shows a higher degree of consistency with the spread of other morphometric attributes and reflects the nature of variation in relief, soil, rock, vegetation etc. along with the changes of infiltration rate of different segments. It is concerned mainly with the alignment and frequency of streams. Lower values of drainage density are also found along the ridges of the Balason basin.

2.6. The Major Geomorphic Units

The Balason basin of the Darjeeling Himalaya exhibits a wide variety of geomorphic forms and indeed a complex geomorphic area. Among the processes, the fluvial is of paramount importance although, slope wash, mass movement along with the continual high degree of weathering process are found to be responsible for the evolution of fascinating assemblage of landforms. Extreme events including extreme flood also modified and produce a great variety of geomorphic forms. Geomorphology of the Balason basin may broadly be sub-divided into the following 3 major units (figure 1.2).

2.6.1. The Southern Alluvial Fan:

Gently undulating plains lie on the south of the basin, where the Balason river and its tributaries have deposited huge amounts of eroded materials that are transported from upstream. The sudden decrease in velocity as the river enters

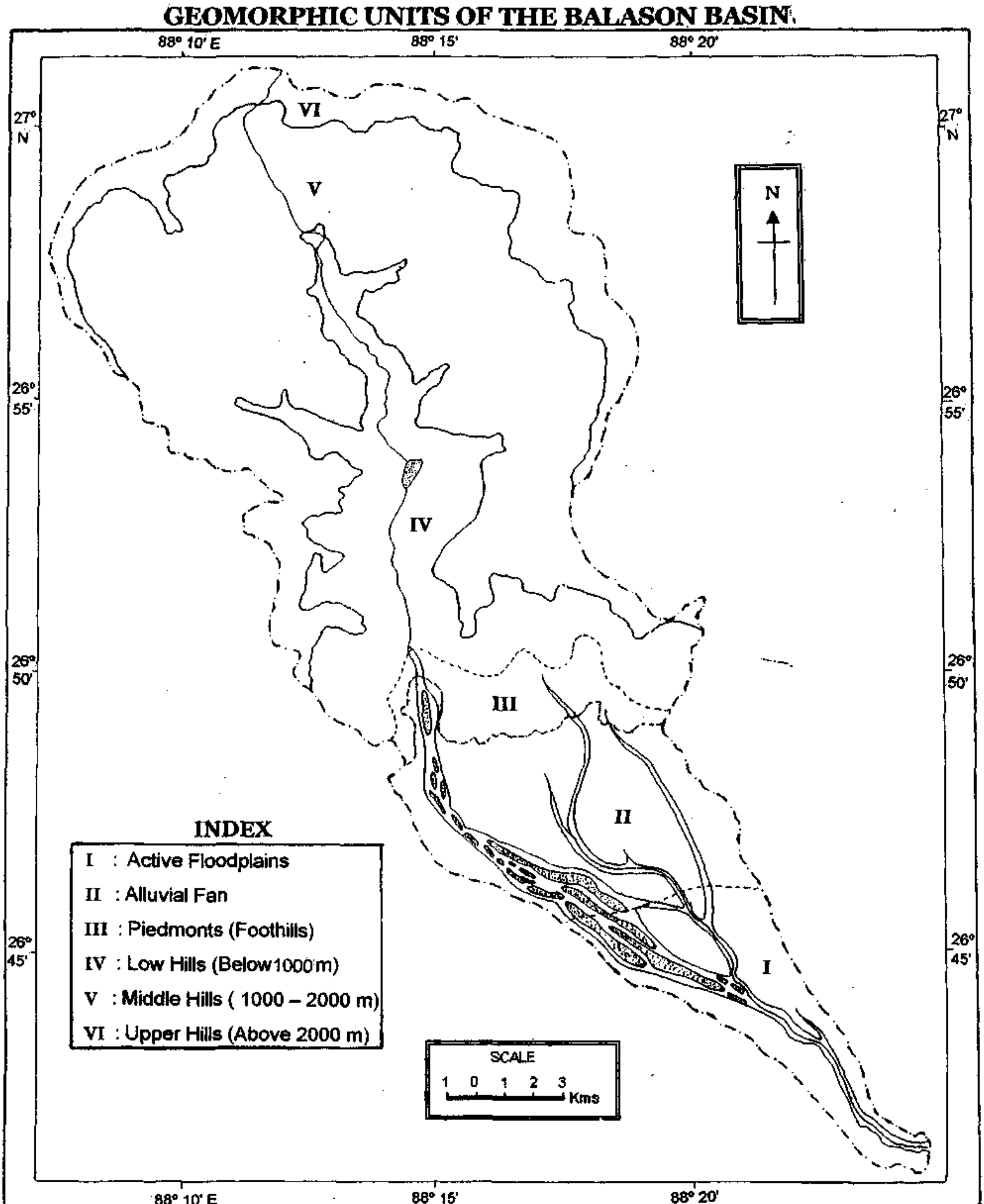
GEOMORPHIC UNITS OF THE BALASON BASIN
88° 10' E
88° 15'
88° 20'
27° N
26° 55'
26° 50'
26° 45'
N
VI
V
IV
III
II
I
INDEX
I : Active Floodplains
II : Alluvial Fan
III : Piedmonts (Foothills)
IV : Low Hills (Below 1000 m)
V : Middle Hills (1000 – 2000 m)
VI : Upper Hills (Above 2000 m)
SCALE
1 0 1 2 3
Kms

Figure 2.5

the flat lands results in an increase in deposition. Thus, the sudden fall in slope results in the development of a series of alluvial fans that occur mainly between 120 m to 400 m covering about 97.53 sq. km. approximately, over the entire alluvial plain area of the present basin of study. A piedmont zone is formed when the alluvial fans coalesce (photo 2.1). This piedmont zone exhibits some textural diversities and different sediment patterns. These alluvial fans fall on the right bank of the river Tista, the main river system of the region.

2.6.2. The Foothills / Piedmonts:

Immediately above the gently undulating plains lies the dissected foothill topography. A higher dissection is noted in this region, in comparison to the plains, which is chiefly associated with the active exogenetic process and geological disturbances which have extended upto the sheared, thrusted and folded transition zone of the Damuda series. A series of ridge and valley forms characterize the landform of the foothill areas. These features are the result of fluvial process and slope acting on the litho-techno structure of the Darjeeling Himalaya. The region is associated with the Siwalik-Damuda sandstone and shale with occasional coal bearing seams of the Permo-Carboniferous periods, distinct thrusts have been depicted between the Siwalik-Damuda and Damuda-Daling series contacts and the resultant sheared, crushed and folded litho-techno set-up prevails over the area. The occurrence of the sandstone and shale in the area facilitates a greater degree of incision giving rise to prominent valley side slopes and ridges. This geomorphic unit is characterized by steep mass wasted slopes, eroded fault scarps etc. which can be considered to be related to the manifestations of the regional episodic uplifts (Kar, 1962; Nakata, 1972). Thus, this geomorphic unit exhibits highly dissected land surface confined between 400 to 800 metre elevation.

2.6.3. The Rugged middle and upper hill tract :

A rugged zone, which however, is comparatively less dissected than the foothills, characterizes the middle and upper hill tracts. These hill tracts are composed of

Photo 2.1 The foothills overlooking the coalescing alluvial fans

Photo 2.2 The rugged upper catchment

the harder rocks of the Daling series and of Darjeeling gneiss with comparatively low amplitude of relief (photo 2.2). This zone is clearly separated from the foothills by a distinct break of slope at 800 metres. This zone is characterized by comparative lesser steep valley-side slopes and widely spaced ridges, since the Daling series and the Darjeeling gneisses of the area exert better resistance to the drainage incision. Moreover, the episodic uplifts that have been so effective in the foothills have exerted little influence on these harder rocks of the Archean period. Hence, geological deformities have been much restricted in this region, where relatively low amplitude of relief and dissection prevail.

2.7. Major Geomorphic Forms

The Balason basin in the Darjeeling Himalaya exhibits a unique assemblage of multifaceted landform. Numerous geomorphic processes produce these landforms. An attempt has been made to map the great variety of landforms (figure 2.5) found in the Balason basin. The geomorphological map provides information, which is relevant to management needs. The geomorphological map thus produced also includes information about the nature and location of features formed by denudation, fluvial action as well as those features created by slope wash. The map is prepared based on intensive field survey and topographical maps (1:50,000 and 1:25,000) using conventional symbols (Demek, 1972).

2.7.1. Landforms created by destructive action of denudation agents:

- **Denuded outliers** are found on the ridge tops of Mahaldiram range, Mirik dome, and Selim hills. These are generally, erosional remnants of the Lesser Himalayan ranges.

- **Dome like summits** are common along the Mechi-Balason interfluves. Mirik dome is the most significant example of such landform

- **Broad ridges** consist of major ridges like Simana (2355m), Mahaldiram (2061m), Giddapahar (1803m), Manjha (970 m) and Selim Hills (540 m).

GEOMORPHOLOGICAL MAP OF THE BALASON BASIN

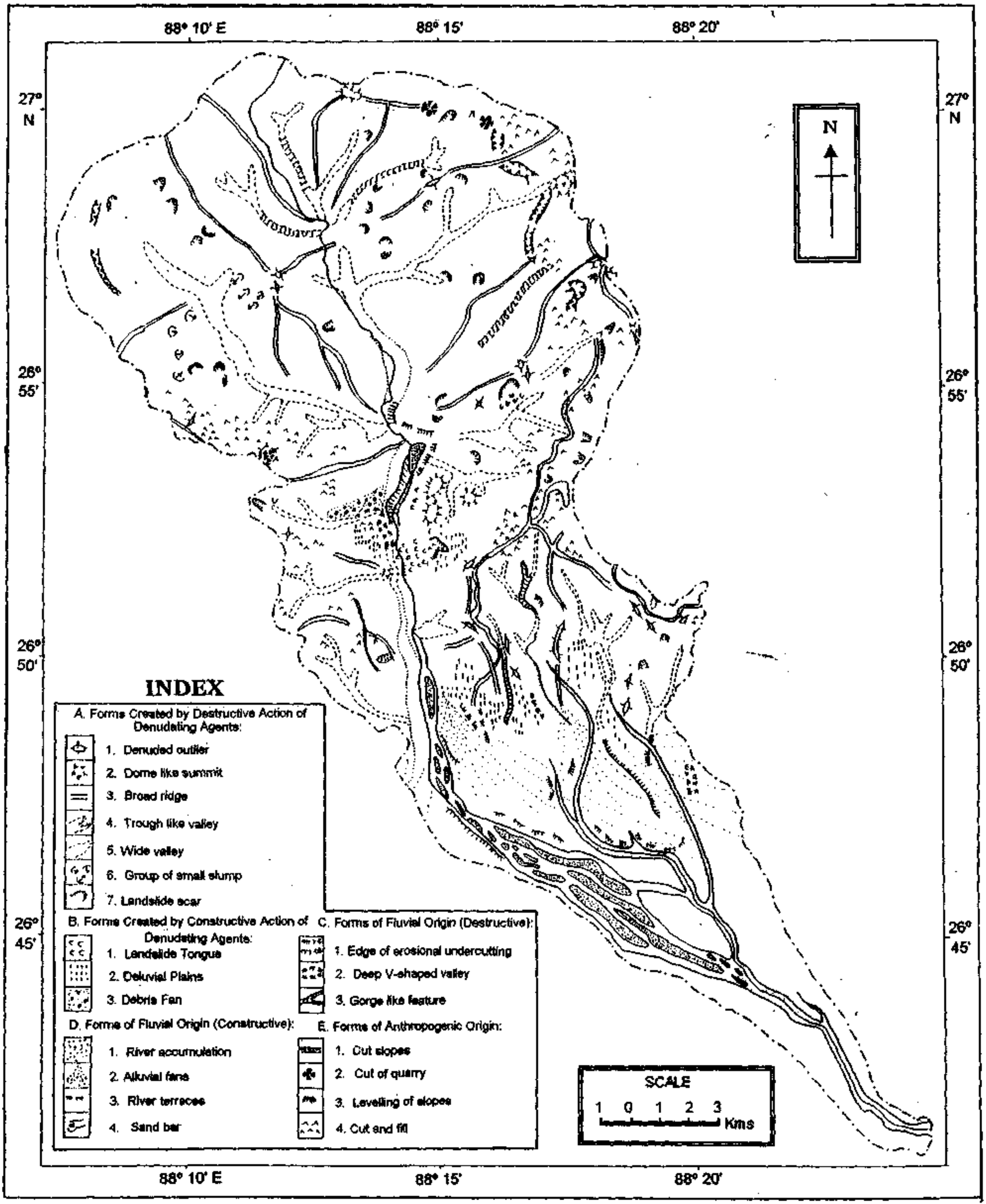

Figure 2.6.

- **Trough like valleys** are found along the right bank tributaries to Balason (Marma, Manjwa, Dudhia, Rangbang) and left bank tributaries of Balason (Rinchingtong, Rakti, Rohini, Rungsung, Pacchim, Rangmuk, Bhim Khola).

- **Wide valleys** are found along the extreme southern part of the study area, Here, broad valley with terraces have also been identified which is perhaps the product of massive aggradations due to major landslide in and around Ambootia (Starkel et al, 2000).

- **Landslide scar** is the most common form of micro-landform produced by the destructive processes. Landslide scars are very common along the Pankhabari-Mirik area. However, the biggest landslide has been found near the Ambootia tea garden, which is the biggest active landslide within the study area.

2.7.2. Landforms created by the constructive action of denuding factors:

- **Landslide tongues** are found mostly in association with landslide scars. The detached materials move down slope and are deposited at the break of slope. Such deposition looks like tongue of a landslide.

- **Debris fans** formed by paleo catastrophic events i.e. mass wasting are found in two distinctive separate zones: along the foothills and lower slopes i.e. near Bamanpokhri-Pankhabari area and the upper part of the hill slopes i.e. Bunkulung, Ambootia Tea Garden, Nagri farm, Pubong, Phuguri-Mirik area. Such landforms are the product of slope wash and exhibit moderate slope (4° - 6°) surrounded by steeper slopes (>15°). An case study of the Bunkulung debris fan is presented in the following section.

2.7.3. Landforms of fluvial origin (Destructive):

- **Edges of erosional undercutting** are the landforms of very recent origin and mostly found along the southern margin of the study area i.e. piedmont slopes and in the Balason alluvial fan. The Balason, Rohini and Rakti rivers are found noteworthy for such undercutting which varies form 6 meters to 50 meters in height. Such undercutting may be treated as an indication of post-pleistocene upliftment i.e. Neo-tectonic activities (Nakata, 1972).

- **Gorge like features** are very common along the valleys of the Balason and its tributaries along the hilly section of the study area. However, it is more common in the valleys of Marma Khola, Rinchintong, Rangbang Khola, Pacchim Khola, etc.

- **Deep V-shaped valleys** are found in the northern hilly part of the study area. Such valleys are identified in Rinchintong Khola near Singell tea garden and near Balason Pacchim confluence.

2.7.4. Landforms of fluvial origin (Constructive):

- **River accumulative** landforms are mostly found along the valleys of the Balason in the southern part of the study area. The river borne sediments are deposited in the area as a typical undulating landscape.

- **Alluvial fan plains** are perhaps the most typical landforms found along the piedmont plains. Alluvial fans are very well developed and well preserved in these areas, and are identified in between Balason and Tista rivers (Basu & Sarkar, 1990).

- **River terraces** are not very well developed in the study area. They are identified along the foothills in between Balason and Mahanadi rivers.

2.7.5. Anthropogenic landforms :

- **Cut slope** is common all over the hilly terrain of the study area, particularly along the roads and railway lines. Such cut slopes are often found to be prone to slope instability.

- **Cuts of Quarry** are common mostly around the towns like Karsiyang and Mirik from where the building materials and stones were collected for construction.

- **Leveling of slopes** is very common in most towns and tea gardens.

- **Cut and fill** for urban use along hillslope is perhaps the commonest of anthropogenic landform. Most land-use in hilly terrain needs cut of upper hill.

2.8. Case Study of Bunkulung Debris Fan

The steep slopes of the Balason basin, Darjeeling Himalaya, with considerable and uneven gradients are particularly sensitive to precipitation of a catastrophic type. Records since 1850 reveals 3 such major events (1899, 1950 and 1968) caused considerable change in topographic form on hill slopes and valley bottoms (Starkel, 1972).

Such extreme rainfall events normally induced massive mass movements (landslides as it happened in 1968 when the gigantic Ambootia landslide initiated. In the valley bottoms incision and lateral erosion lead to the removal of masses of the order of several hundred thousand m^3 per sq km of the course of a river. Accumulation of landslide debris at the base of slopes is also common and thereby, forming a fan likes landform.

Such catastrophic events are also found to have occurred during the recent geologic past i.e. the Holocene. There exist numerous evidences of such paleo events in the Balason basin. However, the investigator has selected the Bungkulung debris fan for detail analysis (figure 2.6).

The Bungkulung debris fan has been identified at the Bungkulung DGHC Rest House near the river Balason at an elevation from 450 meter to 650 meter a.s.l.

and to the west of the river Marma Khola, covering an area of 400 hectares. The average thickness of debris deposits has been estimated to be 45 metre (maximum 81 metre near Balason valley and minimum of 3 metre near the apex of the fan).

2.8.1. Genesis and morphology of the Bunkulung debris fan

Incessant high intensity rain induced gigantic landslides in the upper Marma catchment along with many other parts of the lower Darjeeling – Sikkim Himalayas during the beginning of Holocene (Sarkar, 2000). Such paleo-scars are still clearly visible in many areas (photo 2.3). The huge amount of slided materials (debris) amounting to over 20 billion m^3 (conservative estimated based on present deposition), deposited along the lower Marma valley i.e. Marma-Balason confluence and infact chocked the river Balason temporarily. Recent incision of the Balason valley into the bedrocks of the opposite site proves such contention.

The Bungkulung debris fan is a triangular shaped deposit with the maximum basal width of about 3250 metre and the maximum length of 3750 metre. The thickness of the deposits varies from 81 metres near the Balason valley to only 3 metres to the apex (figure. 2.7). Generally, the lower fan segments have greater depth. Along the eastern margin of the deposit, the river Balason cut deep gorge with an altitude varying from 70 to 90 metres, with very steep slope scar (45°–50°). The gradient of the Marma valley, near its confluence with the Balason suddenly increased from 15 to 30 %. Valley head segments dissecting slopes with a gradient of 20°–30°, constitute furrows in which material of all size were transported. Headcuts with waterfalls formed on hard bed rocks (often 5 – 10 metre high). At the outlet, valley fan was not formed, since the removed mass often eroded and was transported away by the water of the river Balason.

The Bungkulung fan is composed of materials of different size from gigantic gneissic boulders (7 metres diameter) to fine sand fragments (photo 2.4 & 2.5). An assessment of debris size was made by the investigator during field survey. A good number of large gneissic boulders of over 4 meter diameter are found to

CONTOUR PLAN OF THE BUNGKULUNG DEBRIS FAN

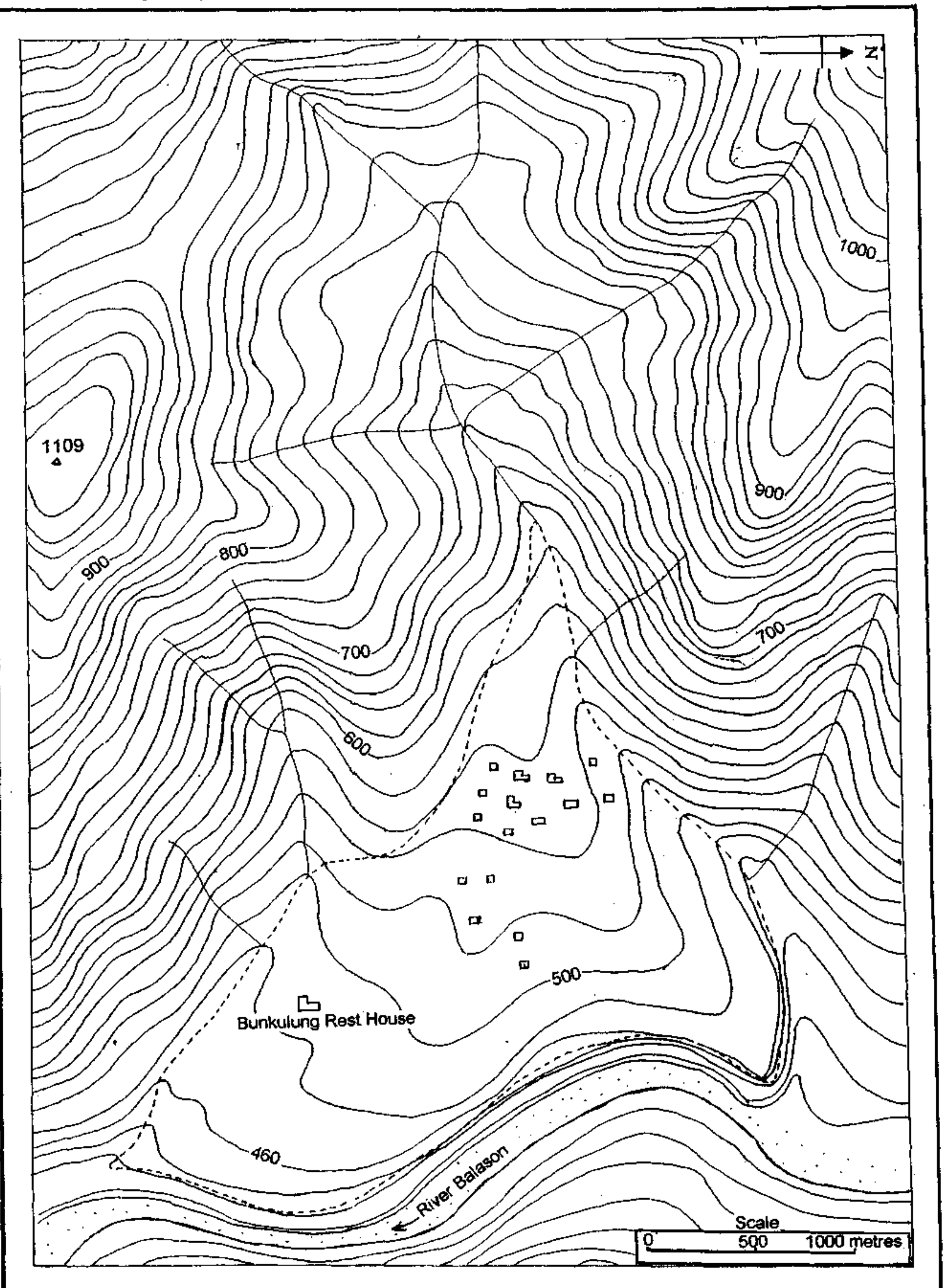

Figure 2.7

GEOMORPHOLOGICAL MAP OF THE BUNGKULUNG DEBRIS FAN

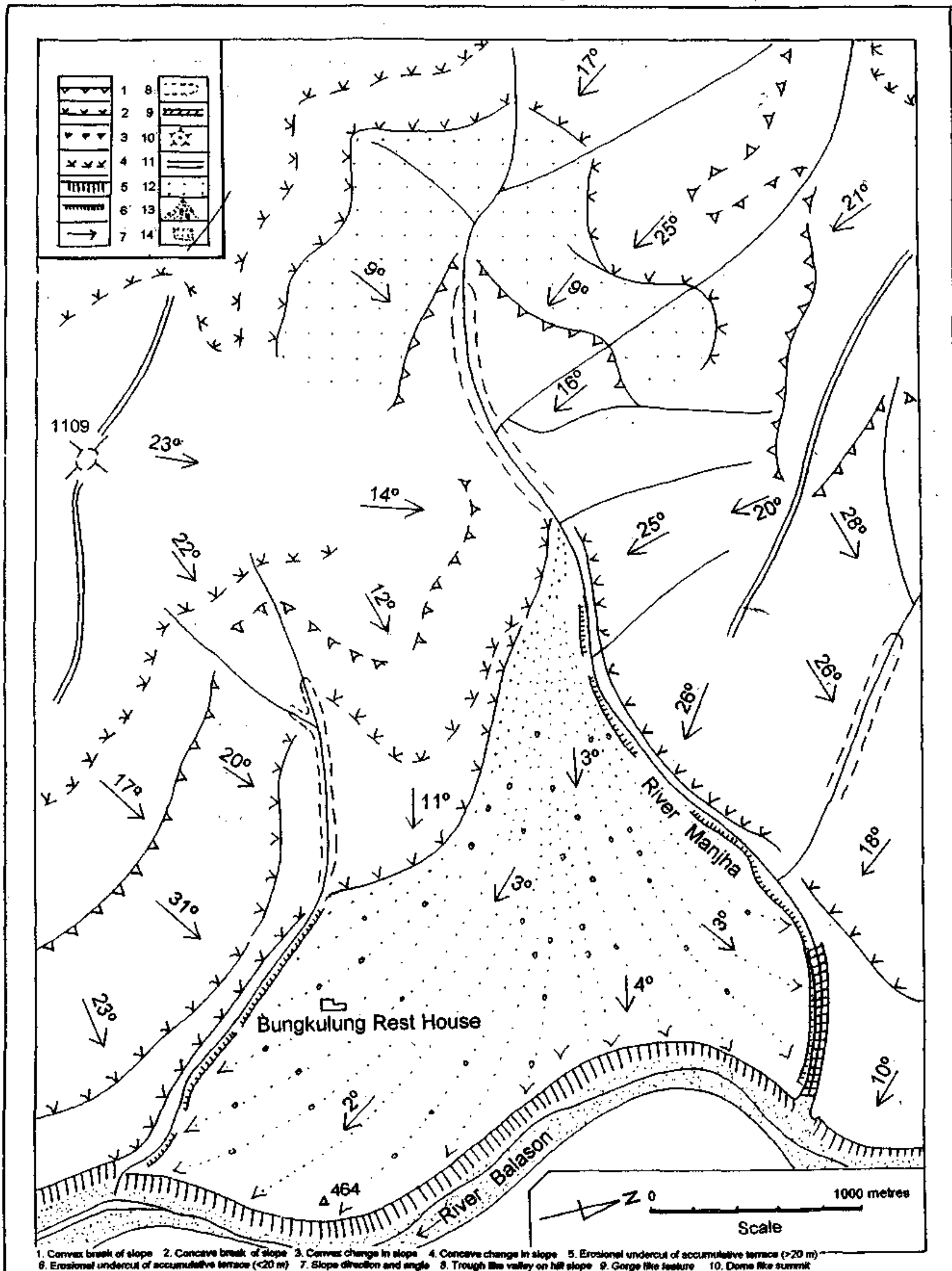

Figure 2.8

Photo 2.3 The Bungkulung debris fan : note the Palaeo scars

Photo 2.4 Gigantic gneissic boulders on the lower Bungkulung debris fan

Photo 2.5 Gigantic gneissic boulders on the lower Bungkulung debris fan

occur on the fan. However, a visible concentration of large boulders are noticed in the upper segments of the fan and along the channel of former waterways. Sample survey conducted at 3 different sites reveals some interesting features regarding the grain size composition of the fan deposits and are shown in the following table (table 2.1).

Table 2.1

Grain-size composition of the Bunkulung fan deposits.

	Occurrence in percentage to the total			
Grain size in metre	*Upper fan segments*	Middle fan segments	Lower fan segments	Mean
Above 1	15.3	10.4	4.3	10
0.5 – 1	19.7	23.1	9.4	17.4
0.1- 0.5	28.0	25.6	15.9	23.2
0.01-0.1	18.4	19.2	30.7	22.7
0.001 – 0.01	10.1	8.1	21.6	13.3
Below 0.001	8.5	13.6	18.1	13.4

It is thus revealed that the Bungkulung debris fan is composed of materials having all size. However, there found a definite concentration of material having diameter between 1 to 50 centimeters. The materials are also found very poorly sorted throughout the fan deposit. This conclusively proves that the Bungkulung fan materials are the product of a gigantic paleo mass movement.

Geomorphic forms of the Bungkulung debris fan have been depicted in the figure 2.8 which reveals that the slope of the upper fan segment is between 4° – 5°, in the middle fan segment the slope has been estimated in between 3° to 4° and that of the lower segment has been in between 2° to 3°. Thus, a gradual decreasing of slope gradient is noticeable from the upper to lower fan segment. Approaching to the Balason valley, the fan deposits form an impressive scarpment of 40° to 50° slope caused by the toe erosion of the river Balason. Minor incision of 1 to 2 meter by the Bungkulung jhora has also been noticed along the western margin of the deposits. The fan area is separated from the surrounding hills by a distinct break

CROSS SECTION ACROSS THE BUNGKULUNG DEBRIS FAN

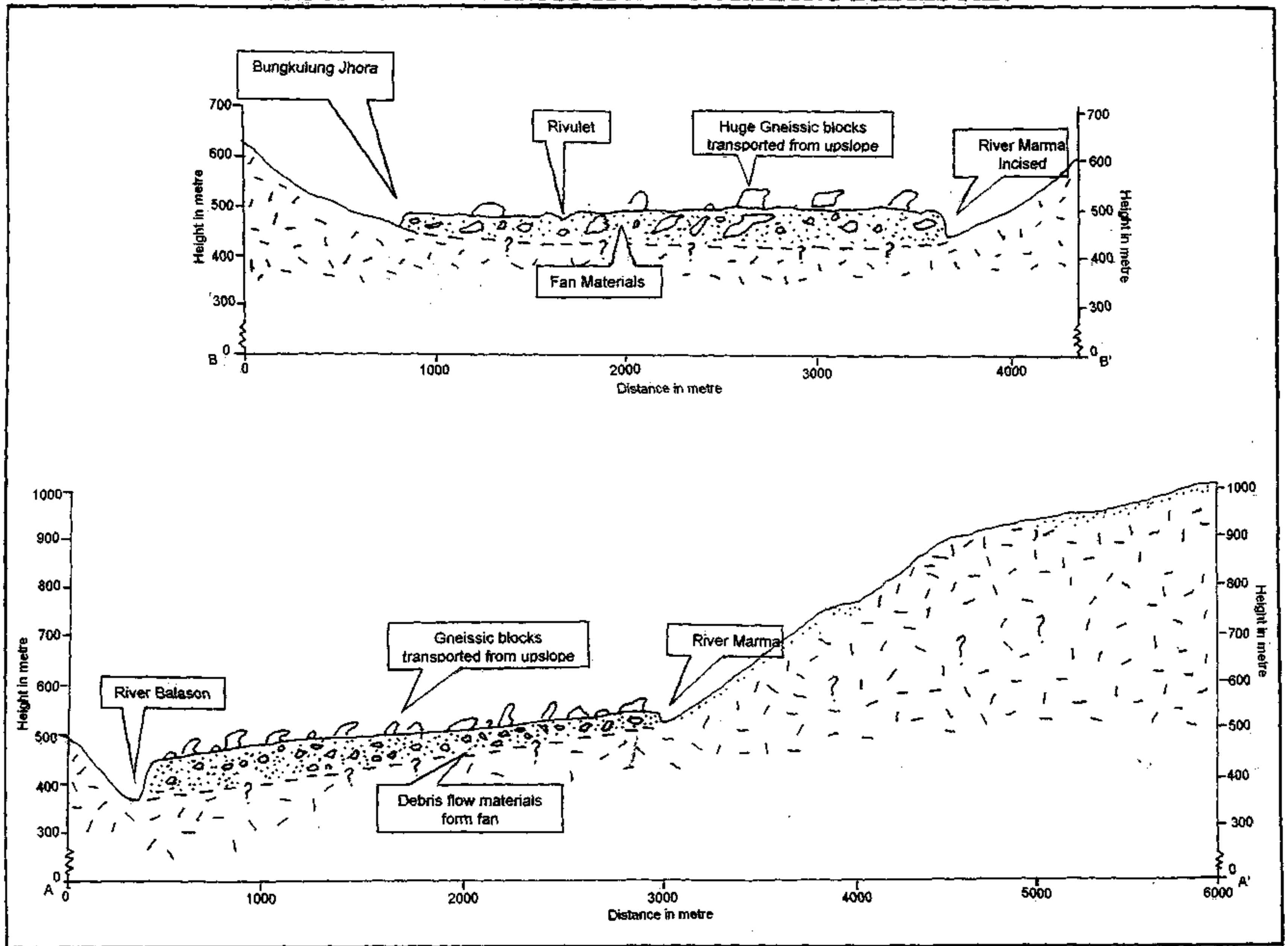

Figure 2.9

of slope, (figure 2.9) beyond which the slope varies in between 11° – 23° towards the southern side and between 16° – 28° towards the west northern side.

Excavation for the construction of development work in the area helps the investigator to reconstruct longitudinal and transverse profiles of the deposits (figure 2.9). The figures 2.7 & 2.8 depict the thickness of the debris fan deposit which varies from 80 to 3 metre. The deposits are found thicker both near Balason and Marma valley and is found to be thinning out towards the apex and the break of slope towards both the sides.

The Balason catchment of the Darjeeling Himalaya is one of the most heavily degraded on a global scale. The phenomenal rate of soil erosion and mass movements in conjunction with the deforestation and land-use transformation has already been noticed and reported in this report. In this backdrop of the catastrophic events i.e. large scale mass movements followed by very high intensity rainstorms as it was reported in 1899, 1950 and 1968, often transformed the topographic form as well as the slope pattern of hill slope and valley. Catastrophic lowering of hill slopes often takes place at the expenses of huge aggradation along the hill margin and break of slope area. Catastrophic process producing contacts and disturbing the equilibrium of forms are the motive power of transformation of the relief.

2.9. Conclusion

From the above analysis it can be concluded that the Balason basin can be geormophologically classified into two broad zones: while the northern hilly part forms the erosional zone the lower southern peidmont zone constitutes the accumulative form. Each of these zones may be further sub-divided. Whilst the Northern erosion zone can be subdivided into the ridge, upper hills and the lower hills; the southern accumulative zone can be sub-divided into the alluvial fan and the deluvial plains. The most important geomorphic process that is operative upon the area of study is fluvial, but denudational slope wash and mass movement too, have an important role in the overall shaping of the lower regions. A number of geomorphic forms were identified in the area of study chief amongst which were: denudation outlier, dome like summit, broad ridge, landslide scars, landslide tongue, deluvial and solifuxion plains, erosional cuttings, trough like valleys, gorge, river accumulation, alluvial fan, river terrace etc. The convex form of the ridges, along with the gentler slopes towards the upper segments being steeper towards the foot, show that the region is still young and active. Active down cutting is evident in a number of places along the Balason valley. The numerous geomorphic forms that occur in the study area have also definite relevance to tectonic disturbances and neo-tectonic activities.

References

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