CHAPTER 9

ENVIORNMENT IMPACT ASSESSMENT

9.1. Introduction

Every environmental system, whether natural or man-made, is unique, and is the outcome of the interrelationships and interactions between the biotic and abiotic factors. In some man-made environment, in addition to these physical, chemical and biological factors, the cultural factors may be involved, within which the system is composed. It has of late been realized, that man is but a part of his environment and he can never be outside or above it, and any human intervention, on whatever scale, exercises an influence – positive or negative on the environmental system.

With man trying to improve the quality of life, utilizing the various natural resources, an impact in the form of the degradation of the natural environment occurs. It is realized that an approach has to be made which is to be cautious, after a careful understanding of the environment, if the development is to be sustainable. Any exercise without proper understanding can lead to unforeseen calamities which can be disastrous, endangering not only the other countless life forms but even man himself. Thus, the promotion of the quality of man's environment, should involve the estimation of the carrying capacity, a sustainable and balanced use of natural resources, cautious management of the changes, conservation and promotion of biological and cultural diversity.

The overall impact, that the developmental activities in the Balason region has had on the environment, is an explicit form of degradation, which the region has undergone over the years, like in the other parts of the Darjeeling hills. Scars from landslides, loss of fertile top soil due to soil erosion, loss and changes in the species diversity of plants and animals have resulted in developmental works without proper understanding and planning. These natural and unnatural interactions, between the soil, water, vegetation and man in the region have led to drastic changes in the environment. Thus, the main objectives of the environment impact assessment is to understand:

- The important factors responsible for contributing to the environmental degradation of the region,
- The intensity and magnitude of the environmental degradation so caused and
- The significance, effects and repercussions of the impact on man and the environment.

9.2. Impact Identification

9.2.1. Aims and methods :

Impact identification brings together various developmental project characteristics and baseline environmental characteristics with the aim of ensuring that all potentially significant impacts (adverse or favourable) are identified and taken into account in the EIA (Environment Impact Assessment) process. Among the different states of EIA processes i.e., impact identification, impact prediction, impact evaluation, impact communication, impact mitigation, impact presentation, impact monitoring and impact auditing, the investigator of the present study has decided only to perform impact identification, as through this, she will be able to locate the places of impact magnitude of various degree within the Balason basin.

A wide range of methods has been developed (Stover, 1972; Munn, 1979; Lee, 1987; Wood & Lee, 1987). Soresen and Moss (1973) note that the present diversity, '*should be considered as a healthy condition in a newly formed and growing discipline*'. The methods are divided into the following categories:

- Checklist
- Matrices
- Quantitative methods
- Network and
- Overlay maps

Among the different methods, matrices are the most commonly used method of impact identification in E.I.A. Matrices are, essentially, expansions of checklists that acknowledge the fact that different components of development projects have impacts. Placing a cross in the appropriate cell identifies actions likely to have an impact on an environmental component. The main advantage is the incorporation of *cause-effect relationships.*

The best-known type of quantified matrix is the Leopold matrix (1971). This matrix is based on a horizontal list of 100 project activities and a vertical list of 88 environmental components. In the present study ,the quantified Leopold matrix has been used for the Environmental Impact Assessment of the study area with minor modifications (Table 9.1). This is based on a horizontal list of 39 developmental activities under 9 broad headings and a vertical list of 58 environmental components under 4 broad and 12 sub-headings that are applicable for the study area.

The scope of possible interaction between the developmental activities and the environmental components is wide, as the overall impact is being considered from the time development started to date, and therefore, the assessment could aid in future planning. In each appropriate cell, two numbers are recorded. The number on the left of the back slash represents the impacts magnitude from +10 (very positive) to –10 (very negative). That on the right represents the impact's significance from 10 (very significant) to 1 (insignificant). The modified Leopold Matrix as applied for the said purpose is represented along with a "unit example of Mirik region in table 9.1. To establish a quantitative value of such impact from the matrix, this investigator has applied the following simple calculation:

$$\textit{Impact Magnitude} \quad \frac{\Sigma P - \Sigma N}{TP} x100 \qquad 9.1.$$

$$\textit{Impact Significance} = \frac{ES}{TP} x100 \qquad 9.2.$$

Table No. 9.1.
Impact identification in Mirik area

	A. Modification of Regime: a. Exotic Fauna/Flora Introduction	b. Modification of Habitat	c. Alteration of Ground	d. Alteration of Ground water Hydrology	e. Alteration of Drainage	F. Irrigation	g. Weathering Modification	h. Burning	I. Surface or Paving
A. 1.Earth Mineral Res. Soils Landform	-3/4	-3/4	-2/3		-2/3		-1/1	-3/4 -2/3	-3/3 -3/4
2.Water Surface Underground Quality Recharge	-3/3 -3/3	-2/3 -2/3	-2/3	-2/2			-3/4 -3/3 -3/4	-2/3 -1/2 -1/2	-3/4 -2/3
3.Atmosphere Atmosphere Quality Rainfall Temperature								-1/1	-3/4
4. Process Flood Erosion Deportation Compaction Stability Earthquakes			-2/2	-3/3 -2/2 -2/2					-1/1
B. 1.Flora Trees Shrubs Grass Crops Microflora Aqiatic Rare species	-3/3 -3/3 -4/5 -2/2 -3/3	-3/3 -3/3 -3/3 -2/2 -3/3	-3/3 -3/3 -4/4 -2/2 -3/3						
2.Fauna Birds Mammals Fish Insects Microfauna Rare Species	-2/2 -3/3 -3/3 -3/3 -2/2	2/2 -3/3 -3/3 -3/3 -2/2	2/2 -3/3 -3/3 -3/3 -2/2	-2/2				-3/3 -3/3 -3/3 -2/2	

	B. Land Transformation & Construction: a. Urbanisation	b. Industrial sites and Buildings	c. Highways, Bridges, Roads and Rails	d. Transmission and Pipe lines	e. Barriers including fencing	f. Channel Revetments	g. Recreational structures	h. Blasting and Drilling	I. Cut and Fill
A. 1.Earth Mineral Res. Soils Landform	-1/2 -1/2	-6/7 -5/6	-1/2	1/1		1/2	-2/1 -1/1	-5/6 -5/4	-2/3 -3/3
2.Water Surface Underground Quality Recharge							-1/1		-3/3
3.Atmosphere Atmosphere Quality Rainfall Temperature	-1/1								
4. Process Flood Erosion Deportation Compaction Stability Earthquakes	-3/3 -3/3	-2/2 -2/2	-6/6 -3/3 -5/5			1/1 1/1 1/1		-2/3	-3/3 -2/2 -2/2
B. 1.Flora Trees Shrubs Grass Crops Microflora Aqiatic Rare species	-3/3 -3/3 -2/2 -1/1	-1/1 -1/1 -1/1	-2/2 -2/2 -2/2						
2.Fauna Birds Mammals Fish Insects Microfauna Rare Species	-3/3 -4/4 -2/2	-2/2 -1/1	-3/3						

	C. External: a. Surface excavation	b. Clear Felling & Lumbering	D. Processing: a. Farming	b. Hunting and Grazing	c. Lumbering	E. Alteration: a. Erosion Control / Terracing	b. Landscaping
A. 1.Earth Mineral Res. Soils Landform	-5/6 -5/3	-1/2 -2/3	-4/5	-1/2	-4/5	3/3 -5/6	-1/1 -1/2
2.Water Surface Underground Quality Recharge	-2/3	-4/5 -3//2	-2/2 -2/3 -2/2		-3/3 -3/3	-3/3	-1/1
3.Atmosphere Atmosphere Quality Rainfall Temperature							
4. Process Flood Erosion Deportation Compaction Stability Earthquakes		-4/4 -5/5 -3/3 -4/4	-4/4	-1/1	-3/4 -4/4 -3/3 -3/3	4/4 5/5	
B. 1.Flora Trees Shrubs Grass Crops Microflora Aqiatic Rare species		-3/3 -3/3 -2/2 -2/2			-4/4 -3/3 -2/2		
2.Fauna Birds Mammals Fish Insects Microfauna Rare Species		-4/4 -4/4 -3/3 -2/2		-3/3 -3/4 -4/4			

	F. Renewal: a. Reforestation, Wildlife, Stocking & Management	b. Fertilizer Application	c. Waste Disposal	G. Traffic: a. Railway, Automobile & Trucking	b. Trails	c. Communication	d. Pipeline	H. Waste Disposal: a. Emplacement of Spoils / Overburden	b. Municipal Waste & Junk disposal	c. Septic Tank	d. Smoke and Exhaust Emission	e. Spent Lubricants	I. Chemical: a. Fertilization	b. Weed & Insect Control
A. 1.Earth Mineral Res. Soils Landform	4/5	-3/4	-3/3	-2/2	-3/3	-4/5	-1/1	-3/4 -1/1	-2/3	-2/2	-1/1	-1/1	-2/3	-3/4
2.Water Surface Underground Quality Recharge	4/5 5/5	-2/2	-2/2		-1/2	-4/4		-4/4 -1/2	-4/4 -4/4	-3/3		-2/3	-3/3	-4/5
3.Atmosphere Atmosphere Quality Rainfall Temperature				-4/5										
4. Process Flood Erosion Deportation Compaction Stability Earthquakes								-1/1 -4/5 -4/4 -3/3						
B. 1.Flora Trees Shrubs Grass Crops Microflora Aqiatic Rare species	4/4 4/4 -4/4 2/2 3/3													-3/3 -2/2
2.Fauna Birds Mammals Fish Insects Microfauna Rare Species	3/3 3/3 3/3													-4/4 -4/4 -3/3

.... continued....

	A. Modification of Regime									B. Land Transformation & Construction								
	Exotic Fauna/Flora Introduction	Modification of Habitat	Alteration of Ground	Alteration of Ground water Hydrology	Alteration of Drainage	Irrigation	Weathering Modification	Burning	Surface or Paving	Urbanisation	Industrial sites and Buildings	Highways, Bridges, Roads and Rails	Transmission and Pipe lines	Barriers including fencing	Channel Revetments	Recreational structures	Blasting and Drilling	Cut and Fill
	a	b	c	d	e	F	g	h	i	a	b	c	d	e	f	g	h	i
C 1.Landuse																		
Open Space.	-2/3	-3/3	-3/3							-2/3	-1/1	-3/3						
Wet Lands		-2/2	-2/2	-3/3	-2/2					-2/2	-1/1	-2/2	-1/1					-2/3
Forestry	-4/5	-3/3	-3/3							-3/4	-1/1	-3/3				-1/1		
Agriculture	-3/3									-3/3	-1/1							
Grazing	-3/3	-3/3	-3/3							-3/3	-1/1	-3/3		1/1				
Residential																		
Commercial																		
Industrial																		
Mining/ Quarrying																		
2.Recreation																		
Camping/	2/2																	
Picnicking	2/2															4/4		
3.Aesthetic																		
Scenery	3/3									-4/4	-1/1	-2/2						
Wilderness																		
Landscape																		
Reserves	-3/3	-3/3	-3/3							-3/3	-1/1	-4/5	-1/1			-1/1		
4. Cultural Status																		
Health										-3/3								
Employment	5/5									5/5	3/3	4/4						
Population																		
density	7/7									5/6	2/2	3/3						
5. Man made Structures																		
Transport													8/8					
Utility																		
Waste											-5/5	-2/2						
D Diseases											-3/3							
Food chain	-2/2	-3/3	-2/2					-3/3			-3/3	-1/1	-2/2					
Others																		

	C. External		D. Processing			E.Alteration		F. Renewal			G. Traffic				H. Waste Disposal					I. Chemical	
	Surface excavation	Clear Felling & Lumbering	Farming	Hunting and Grazing	Lumbering	Erosion Control / Terracing	Landscaping	Reforestation, Wildlife, Stocking & Management	Fertilizer Application	Waste Disposal	Railway, Automobile & Trucking	Trails	Communication	Pipeline	Emplacement of Spoils / Overburden	Municipal Waste & Junk disposal	Septic Tank	Smoke and Exhaust Emission	Spent Lubricants	Fertilization	Weed & Insect Control
	a	b	a	b	c	a	b	a	b	c	a	b	c	d	a	b	c	d	e	a	b
C 1.Landuse																						
Open Space.			-2/2																			
Wet Lands		-3/3		-4/4	-3/3	3/3		2/2														
Forestry		-4/4	-1/1			4/4		6/6														
Agriculture		-3/3	1/1					4/4							-3/3							
Grazing								-3/3														
Residential																						
Commercial																						
Industrial																						
Mining/ Quarrying																						
2.Recreation																						
Camping/								3/3				3/3										
Picnicking																						
3.Aesthetic																						
Scenery																						
Wilderness																						
Landscape																						
Reserves		-4/4				3/3		5/5														
4. Cultural Status																						
Health																			-4/4		-3/3
Employment			4/4		3/3						5/5										
Population																					
density			3/3																		
5. Man made Structures																					
Transport																					
Utility																					
Waste																					
D Diseases																-3/3	-3/3	-2/2			-3/3
Food chain				-3/3					4/4												-4/4
Others																					

A= Physical and Chemical Conditions B= Biological Conditions C= Cultural Condition D= Biological Relations *where P = positive impact; N = negative impact; TP = total parameters and S = significance.*

The matrix has been applied as a 'check list' in 45 different sites within the study area for gaining an idea on the spatial distribution of environment impact of the various developmental activities in the Balason basin..This helps in producing two maps:

(i) impact magnitude

(ii) impact significance

9.2.2. Impact magnitude :

Figure 9.1. depicts the different zones of the magnitude of environmental impact of development activities. Impact magnitude are found to vary from highly positive (300) to highly negative (-300). In general various magnitude of positive impacts have been found to be more wide spread in the northern half of the study area; while the negative impacts of different magnitude predominated the southern foothills of the study area. The present investigator with the help of the following classes has attempted a more specific distribution of the different kinds of impact magnitude.

Class I. High positive impact occurs in two very narrow strips bordering the extreme north-western (along Simana) and north eastern peripheries of the study area. These areas are still under virgin forest cover and hardly affected by adverse developmental impact on environment.

Class II. Moderate positive impact has been identified in the southern sections of the former zone, extending through Pubong and arching further east, culminating just above Kalej Valley. A wedge like protuberance extends south-eastwards. A small wedge occurs in and around Panighatta. These tracts are still under natural forest cover of different species. Positive impact of silviculture activities can also be observed.

MAGNITUDE OF ENVIRONMENTAL IMPACT IN THE BALASON BASIN

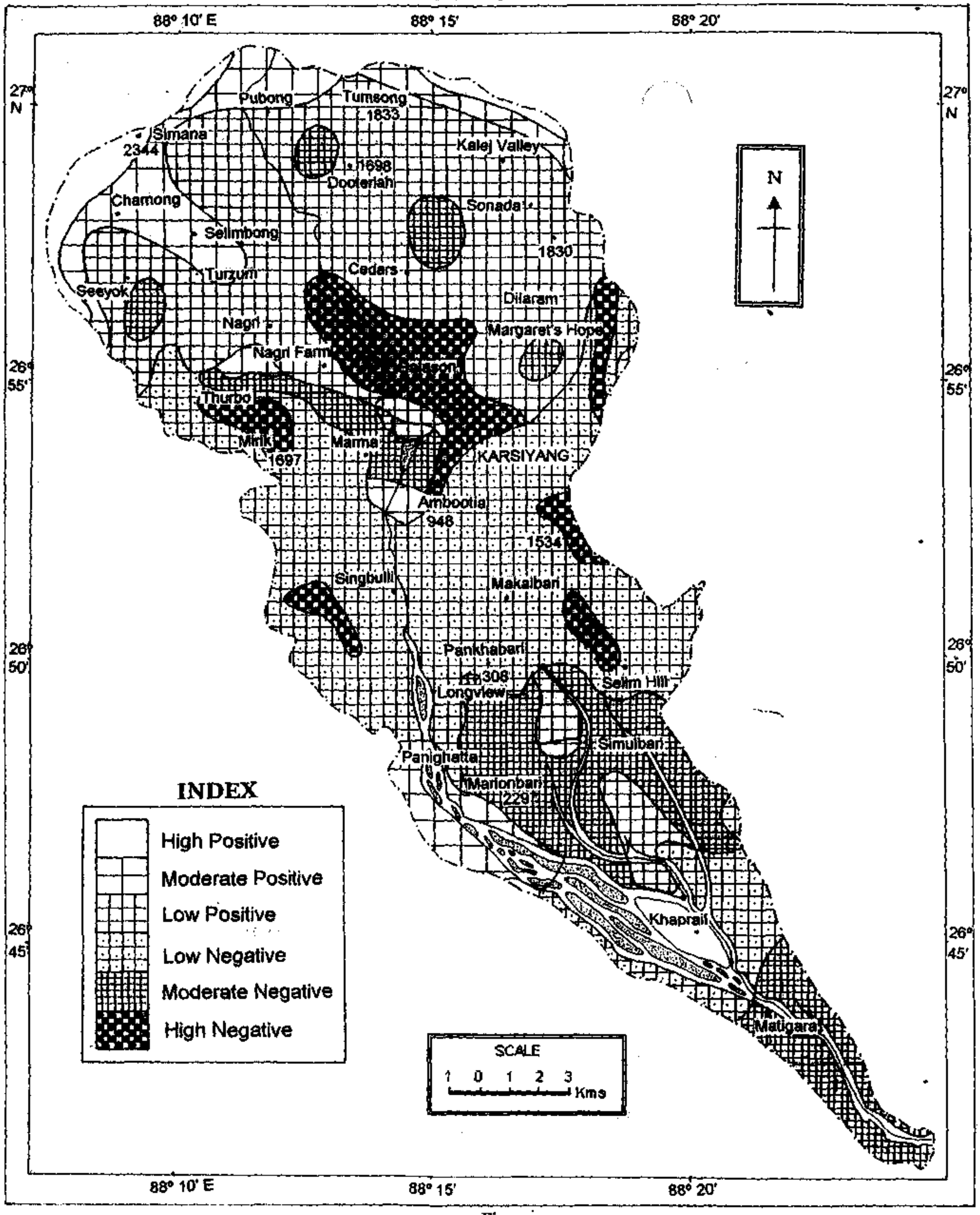


Figure 9.1

Class III. Low positive impact predominates over the northern half of the study area from Seeyok in the west to Tumsong in the north, through Kalej valley, Sonada and Dilaram in the east and as a narrow elongated strip along Nagri farm in the southern section of this zone. These tracts are dominated by tea plantations and forested areas. Although, the large scale plantations have detrimental effect on biodiversity, these plantations also have a beneficial impact on landscape and soil-water management since soil erosion is checked and ground water aquifers are recharged. Consequently, a low degree of positive impact is attained.

Class IV. Low negative impact covers an extensive section in the central region of the study area from Mirik through Karsiyang, Ambootia and then to Singbuli, Makaibari and Selim Hill. The Khaprail region also exhibits low negative impact. In this zone human settlements and large scale cultivation and arable farming along with the introduction of tea gardens have destroyed the regional biodiversity, thereby exerting a negative impact on the environment.

Class V. Moderate negative impact spreads throughout the study area. In the northern sections, they are found in small pockets around the Dooteriah, Cedar, Seeyok and Margaret's hope tea gardens. A narrow strip occurs just north of Thurbo and extends eastwards into Marma. In the southern half of the study area, more extensive regions are marked from Longview and Simulbari into Marionbari. Another wedge occupies the southern extremity along Matigara. These zones are mostly tea garden areas.

In the northern hilly areas large scale destruction of forest in the steep slopes have induced many unfortunate environmental repercussions like landslides and soil erosion. In the plain areas surrounding Matigara, the presence of Chandmoni tea garden (recently converted to a township) and dense human settlements with associated human activities like rock quarrying and road blasting, arable farming etc. have had a negative impact on this region.

Class VI. High negative impact are found scattered in pockets in the central section of the study area. The most noteworthy is in a broad wedge east of Nagri Farm along the Balason tea garden. This area is characterized by the highest degree of deforestation and excessive human settlements. Consequently, haphazard constructions, inadequate drainage and unsystematic landuse have established a vicious circle of degradation leading to a high to very high negative impact of the 'developmental activities' on the environment.

9.2.3 The impact significance :

The spatial distribution of environmental impact significance has been identified based on modified Leopold matrix (table 9.1.). Such semi-quantitative rating value has been obtained from 45 sites chosen randomly and plotted on the map. The impact significance map thus prepared based on interpolation method (figure 9.2). It has been found that the impact significance varies from very high (8) to insignificant (1). The following significant classes have been identified:

Class I. Highly significant impact has been identified along a few elongated tracts i.e., along the Dilaram-Karsiyang areas, Mirik-Thurbo-Soureni areas, east of Singubuli, a large area engulfing the Nagri, Nagri Farm and Balason tea garden, Ambootia, Makaibari-Selim Hill region . These areas experienced most devastating impact of development activities on environment. Ever increasing population growth and unplanned developmental activities are also found responsible for such high significance of environment impact.

Class II. Moderately significant impact is most widespread and has been identified in most of the tea garden areas. Large scale destruction of hill slope biodiversity exerts tremendous stress on the delicate hill ecosystem. Use of fertilizers, pesticides and herbicides to augment tea production also have detrimental effects on the quality of land, water and atmosphere of the area. Innumerable

ENVIRONMENTAL IMPACT SIGNIFICANCE IN THE BALASON BASIN

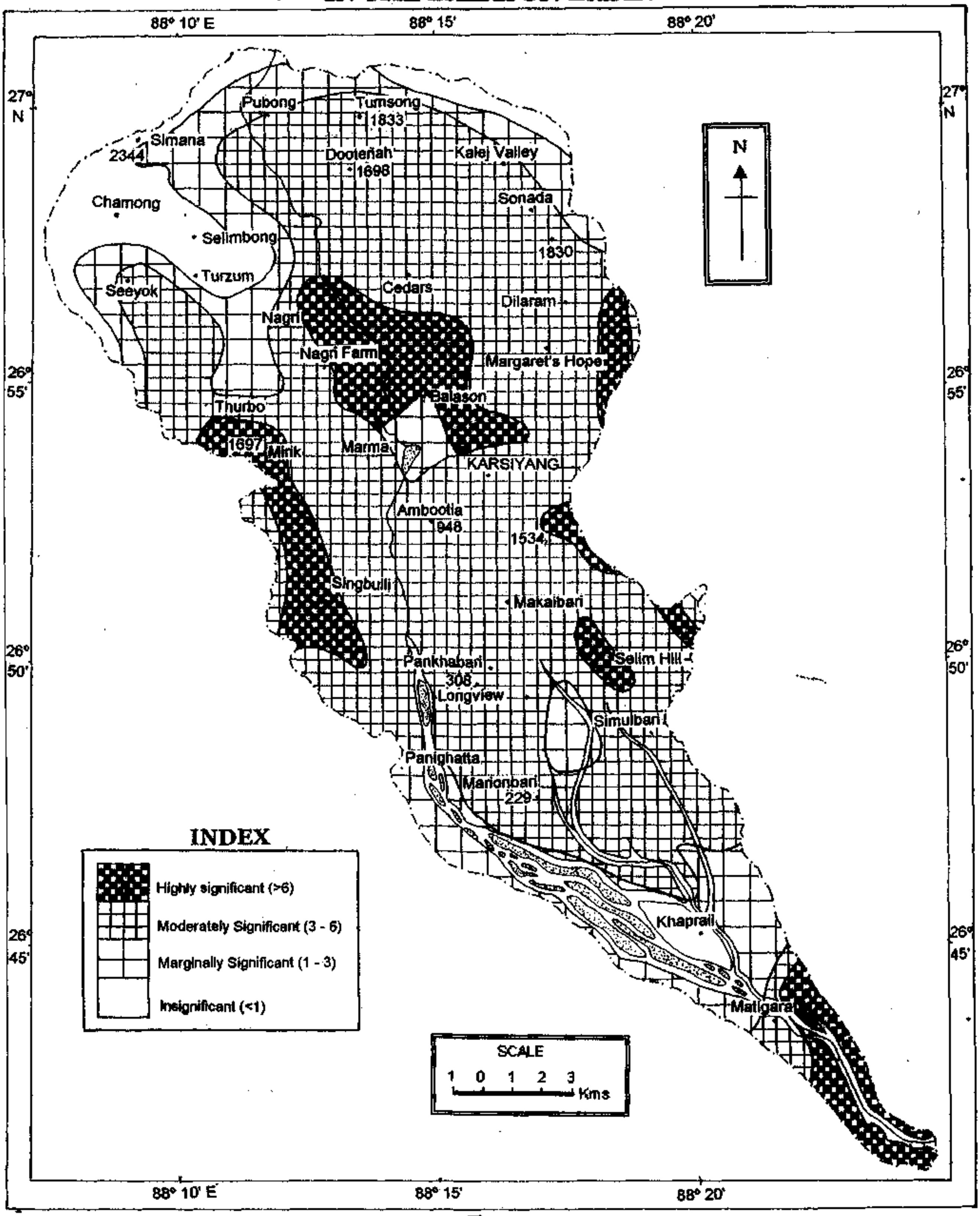


Figure 9.2

unprotected roads, footpaths and trails cause heavy loss of surface soil and often invite landslides.

Class III. Marginally significant impact has been noticed in degraded forested areas and in plantation tracts. Reduction of biodiversity and natural regeneration, coupled with marginal development activities, have exerted such adverse impact.

Class IV: Insignificant environmental impact has been noticed in the north western part of the study area around Simana Busty, Chamong, Selimbong and Turzum and in the Panighatta and Khaprail area in the southern part of the study area. These areas are still free from any significant development and/or modification impact and are largely covered by dense natural forests. An overview of the matrix suggests high interactions between the components under modification of regime with those of flora, fauna and land-use. The modification of regime brought about by the introduction of new species and management practice has negative impact on the environmental components, particularly flora and fauna and is quite significant.

The impacts of such interactions are best comprehended in the following case studies on vegetational analysis of plantations of exotic species. The other development activity having high interaction is land transformation and construction, which has influenced the processes like flood, soil erosion and landslide, with high magnitude, the impact of which is very significant. This has been clearly revealed in the specific case study on landslide caused by construction activity.

9.3. Case Studies

9.3.1. The impact of *Cryptomeria japonica* (Dhupi) plantation on the environment :

With the advent of the tea plantation in the British era, *Cryptomeria japonica* was introduced primarily to make tea boxes. However, due to certain environmental factors the fibers of this plants were thickened and thus unsuitable for such use. However, due to its quick growing characteristics, it was soon adopted for commercial forestry. Now it has been more or less understood, that the introduction of this exotic species has had a negative effect on the local vegetation.

To understand the impact of the effects of dhupi plantation, the investigator carried out vegetational analysis in the middle hill areas near Mirik to determine the impact of growing monocrop of dhupi on the biodiversity with particular reference to the plant species (photo 9.1). A similar investigation had been earlier carried out in Mahaldiram block of Kurseong Forest Division, one having natural forest consisting of miscellaneous species and the other of pure dhupi plantation of 1929-31 (Bhutia, 2000).

Vegetational analysis were carried out by utilizing quadrats of different sizes for trees, shrubs, climbers and sampling and the herbaceous cover (Santra, Chatterjee and Das, 1989). For the trees 30 randomly placed quadrats of 20 x 20m were utilized in each of the forest types i.e. the natural mixed forest and the dhupi monoculture forest. Within each of these two 5 x 5m quadrats were placed for the study of the saplings, under trees, shrubs and climbers. Within each 5 x 5m quadrat a 1 x 1m quadrat was placed for the study of the herbaceous ground cover.

The different data obtained, showing the number of quadrats has been represented in which, the total count relative frequency, relative abundance and the importance value of each species has been calculated (appendix 9.1a, 9.1b, 9.1c) Analysis of the data has been carried out to come to the conclusion of the effect that the dhupi plantation has on the overall detrimental effect on the vegetation of the region. Frequency class diagram (figure 9.3) of the natural forest and dhupi plantation were prepared and compared with the Raunkiaer's frequency class diagram. Raunikiaer's frequency class is given in the table 9.2.

The Mirik natural forest was found to comprise of 41 different tree species, while only 15 species were found in association with the *dhupi* plantation. Moreover the number of trees, in the natural forest was greater, the total number being 663 as compared

Photo 9.1 Mirik-site of impact analysis of *Cryptomeria Japonica*

Photo 9.2 Flattened Mirik Dome : note the deep gully formation

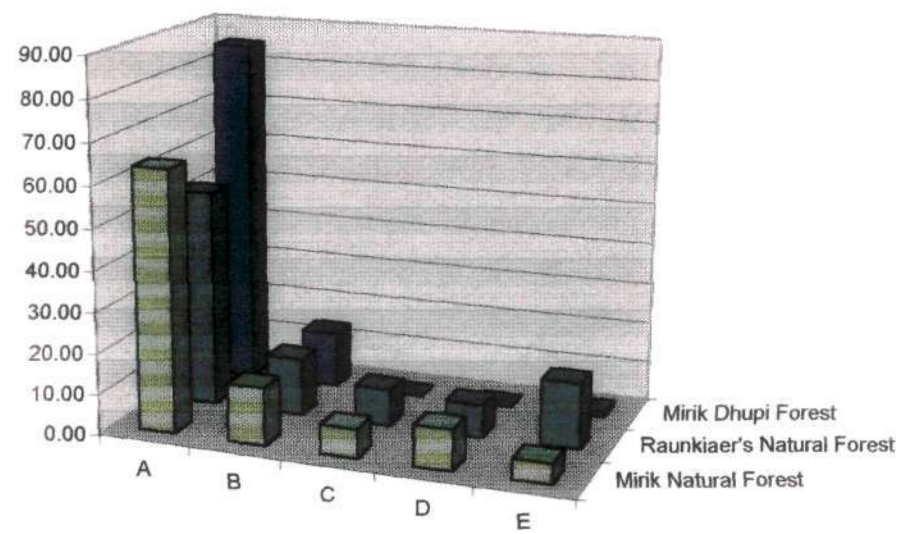
Photo 9.3 A dumping ground for construction refuge- a future hazard

Table 9.2

Raukiaer's frequency class

Frequency class	% of the Frequency
A	0-20%
B	21-40%
C	41-60%
D	61-80%
E	81-100%

FREQUENCY CLASS DIAGRAM



	A	B	C	D	E
Mirik Natural Forest	63.83	14.18	7.09	9.93	4.96
Raunkiaer's Natural Forest	53.00	14.00	9.00	8.00	16.00
Mirik Dhupi Forest	85.00	13.75	0.00	0.00	1.25

Figure 9.3

to 487 in the *dhupi* plantation, with the number of *dhupi* alone being 362. The upper storey in the natural forest chiefly comprised of trees like *Acer campbellii, Castanopsis indica, Engelhardia spicata, Symplocus theafolia, Tetractum fraxinifolia, Brassiopsis hainla* etc., the middle storey was occupied by smaller trees like *Eurya* *acuminata, Ehertia wallichiana,* with *Alnus nepaulensis* occurring along the steep slopes.

The lower storey of shrubs chiefly were *Osbeckia nepalensis, Urtica dioica, Girardina palmate, Eupatorium adenophorum,* and climbers like *Cuscuta reflexa, Stephania elegans, Ipomea tumifolia* etc.; the understorey in the *dhupi* plantation was less dense with the more open spaces being occupied by exotic shrubs like *Lantana camara, Eupatorium adenophorum, Artemesia indica.* The effects on the lower layers were more pronounced, with respect to both the number of species and the total number of individual species. While 39 species were recorded in the natural forest with 28 being shrubs and 11 climbers, the number of shrubs and climbers were 18 and 4 respectively in the plantations.

The ground cover in the natural forest comprised of 41 species as compared to 28 found in the dhupi plantation. Regeneration of trees were also found to be much lower in the dhupi plantation with seedlings of 11 species recorded in the natural forest as compared to only 7 species in the plantation. Thus, the dhupi plantation, which was initiated during the British era has been shown to have a detrimental effect on the natural vegetation of the region. The thick dense canopy does not allow penetration of sufficient light thus checking the growth of the lower tiers and the ground cover.

Moreover the acidic secretion of its roots have allelopathic effects and does not allow the growth of the lower storey (Sarkar,1985). The absence of undergrowth in such plantations may also increase the surface run-off leading to more soil erosion, particularly where slope gradient is more.

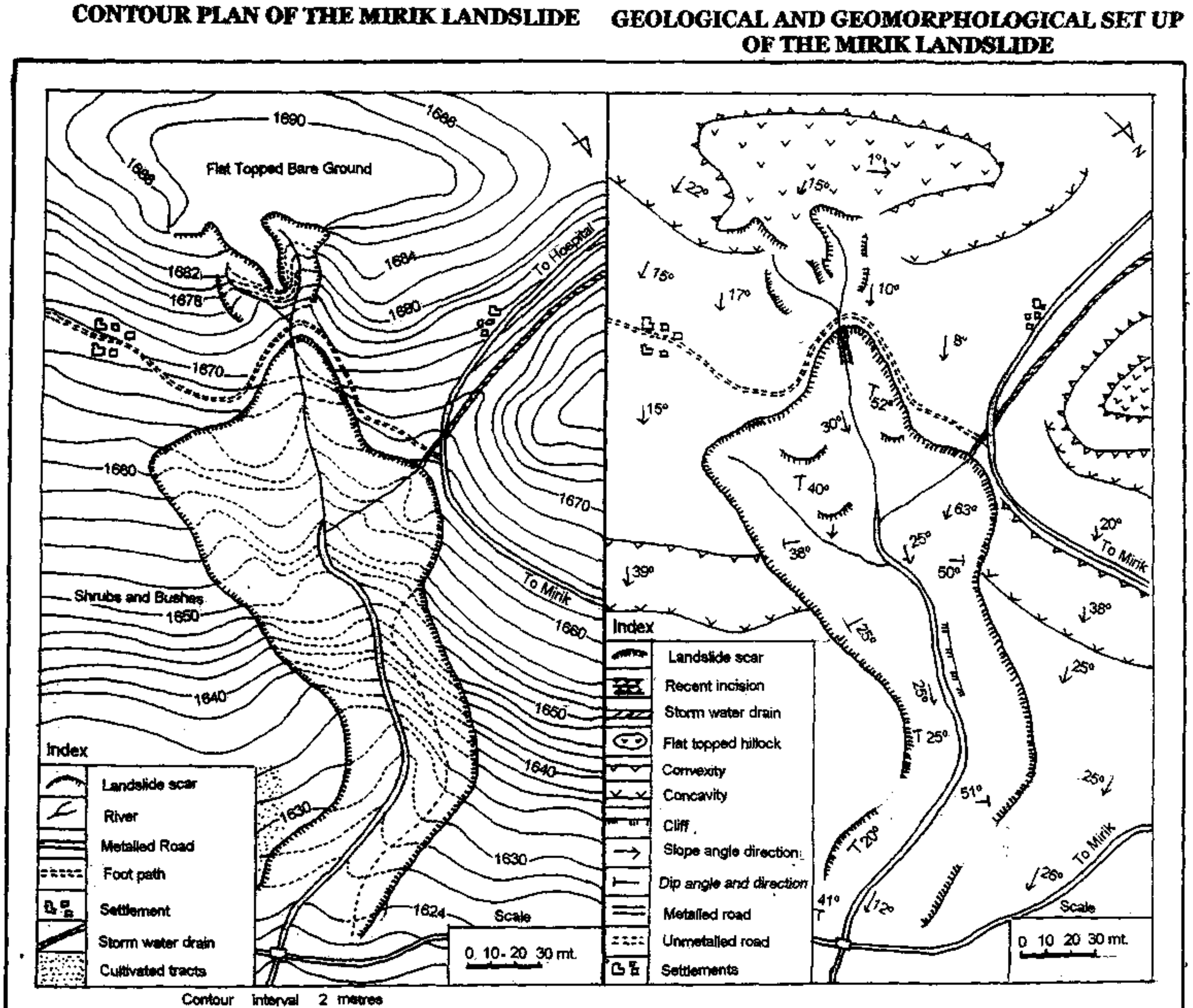
A similar situation can be observed in the lower reaches of the study area where monoculture of *Tectona grandis* (teak) are being carried out in large scales along the lower parts of the hills and the foot hills. This includes regions like Pankhabari and Simulbari. The teak plant also does not support the growth of the under storey like the dhupi plant. The overall ecological impact of such mono-cultural practices need to be studied in greater depths although it can be said that introduction of exotics have always had detrimental effects on the natural vegetation of any region.

A comparative analysis based upon Raunkiaer's Frequency Class of the two types of forests (figure 9.3) shows that the dhupi plantation deviates widely from that of Raunkiaer's normal forest thus, indicating that it constitutes biotically a highly disturbed site. The natural forest is close to the Raunkiaer's normal forest, but here too slight deviation can be observed, which shows that group with the highest relative frequency i.e. Class E of Raunkaer's Class is effected. This may be due to removal of some of the plants of commercial importance, grazing by domestic animals and removal of forest products and produce.

9.3.2. Impact of ridge-top cutting and throwing of talus material downhill :

The disposal of talus materials, resulting from the excavation of hill slopes and hill tops for so called development purposes, and in many cases into jhoras and kholas is a common practice in the study area. This particular case exemplifies how such an action has initiated a series of landslides that have affected the road communication, agricultural fields and threatened the fluvial environment of the river Marma, an important tributary to the river Balason (photo 9.2).

The Darjeeling Gorkha Hill Council in 1995, undertook an ambitious project of constructing a helipad in Mirik area to boost tourism. The Mirik Dome was selected for the purpose and operations to cut the dome and level the area started in a war footing by engaging heavy bulldozers and hundred of labourers, (Bhutia, 2000). The excavated materials was thrown downhill into the area which formed the source of Marma Khola ignoring the consequence of such heedless action. The project was abandoned in 1996 for certain reasons but the damage was already done, as landslides occurred immediately during the monsoons resulting in the disruption of



CONTOUR PLAN OF THE MIRIK LANDSLIDE
GEOLOGICAL AND GEOMORPHOLOGICAL SET UP OF THE MIRIK LANDSLIDE
Flat Topped Bare Ground
1690
1688
1686
1684
1682
1680
1678
1670
1660
1650
1640
1630
1624
To Hospital
To Mirik
Shrubs and Bushes
Index
Landslide scar
River
Metalled Road
Foot path
Settlement
Storm water drain
Cultivated tracts
Scale
0 10 20 30 mt.
Contour interval 2 metres
Recent incision
Flat topped hillock
Convexity
Concavity
Cliff
Slope angle direction
Dip angle and direction
Metalled road
Unmetalled road
Settlements

Figure 9.4

Table 9.3

Morphology of Mirik Landslide

Pre-slided conditions	Post slided conditions (1997)*	Post slided conditions (2000)**	Remarks
1.Rocks: Moderate to highly decomposed jointed granite, gneiss interbedded felspathic veins. The rocks are dipping at an angle of 20°– 60° towards NE-SW, NNE-SSW and EES-WWN. A number of joints have been identified.	1.Length of the scar: 270 meter. 2. Width of the scar: Max. 95 meter Min: 10 meter Ave: 52.5 meter 3.Depth of the scar: Max. 5.1 meter Min: 0.3 meter Ave: 2.7 meter	1.Length of the scar: 340 meter. 2.Width of the scar: Max.:15 meter Min: 12 meter Ave:63.5 meter 3.Depth of the scar: Max. 7.2 meter Min: 0.3 meter Ave: 3.75 meter	Within a short period the link between Mirik and hospital will be affected. Immediate proper storm water draining system and protective walls are recommended.
2. Altitude: 1620 to 1690 meter	4. Shape: Triangular	4.Shape: Triangular	
3. Slope: Convex (25° – 30°)	5.Total area affected 14,175 sq meters. 6.Total volume of materials displaced: 38,272.5 m³	5. Total area affected 21,590 sq meters. 6. Total volume of materials displaced: 80962.5 m³	
4.Natural vegetation: Scattered shrubs. Land use: Tea garden is situated just below the threatened area. Mirik to Hospital road passes through this affected area. Shrubs are found scattered here and there.	7. Process responsible for the landslide: Removal of basal support by toe cutting makes the stage ready for the slide. Spontaneous liquefaction due to heavy rainfall and cutting of the ridge tops for helipad has actually provided the so-called trigger mechanism.	7. Process responsible for the landslide: Removal of basal support by toe cutting makes the stage ready for the slide. Spontaneous liquefaction due to heavy rainfall and cutting of the ridge tops for helipad has actually provided the so-called trigger mechanism.	Ridge top cutting materials were thrown away along the natural stream down slope. These unconsolidated materials have undergone massive gully erosion during the monsoon months. Such stream action along with continuous toe cutting has actually invited disastrous landslides along the upper landslides al9ng the upper valley of the river Marma, a tributary of Balason
5. Soil Colour Top: 10 YR 4/4 (Dusky red) Mid: 2.5 YR 4/4 (Reddish Brown) Base: 5YR 4/3 (Reddish brown)	8.Modified slope: Concave and irregular (12° – 60°) 9.Type of slide: Debris flow 10. Special features: A number of gullies have developed, incisions have also been noticed.	8.Modified slope: Concave and irregular (12° – 65°) 9.Type of slide: Debris flow 10. Special features: A number of gullies have developed, incisions have also been noticed.	

*Based on Bhutia and ** field observation by the investigator.

communication and loss of agricultural areas along the banks of the jhora. Bhutia (2000) has excellently documented the causes and effects of landslide that has taken place during the monsoon of 1997 (figure 9.4). The follow-up study reveals how unscientific and irrational activities of man can cause irrevocable damage to the environment. The dumping of excavated materials into the source of Marma Khola has initiated landslides along the entire tract of the entire tract of the khola, causing a series of chain reaction leading ultimately into deterioration of the hydrological regime of the river Balason.

9.4. Conclusion

From the above studies, it can be concluded that unscientific developmental activities, without taking into consideration the fragile nature of the Himalayan ecosystem can lead to serious environmental degradation. The impact of such activities have been adverse and if not heeded, could lead to extensive damage to both human life and environment.

It has thus become necessary that extensive studies be carried out and analysis of the impact of development activities be made, before undertaking any such activities in this region. Under the prevailing conditions of environmental degradation in the study area, it has become absolutely necessary to have a comprehensive plan to offer every remedial measure, for each and every kind of adverse environmental effect of development project. This would also help to adopt precautionary measures that are pertinent and need to be followed, before undertaking any development activity. These have to be taken up seriously and followed carefully if the development activity is to have the minimal adverse effect on the ecology of the region.

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