

LIST OF TABLES

<u>Tables</u>	<u>Page No.</u>
1.1 Chronological order of the Various Geological formation	7
2.1 Morphometric and Related Variables, their Discussions and Symbols	31
2.2 Morphometric Variables of 24 Third-Order Basins in and around Darjiling Town	32
2.3 Frequency, Cumulative frequency, Relative Cumulative frequency and Relative frequency in Proportion	36
2.4 Measures of Central Tendency and Dispersions	38
2.5 Coefficients for Linear Regression Equations between some Morphometric Properties of 24 Third-Order Basins	40
2.6 Correlation Matrix for 14 Morphometric Variable for 24 Third-Order Basins	42
3.1 Rating Table for the Parametric Values of C.P.	61
3.2 Proposed Conservation Model for the Study Area	70
4.1 Intensity of Rainfall During Major Landslips in Darjiling Town	77
4.2 Major Events of Landslips in Darjiling Town and the sectors and human beings affected	79
4.3 Vane Shear Strength of Soil in Toongsoong busty	91
4.4 Mechanical Analysis of Soils in Toongsoong busty	92
4.5 Consistency Limits of Soils in Toongsoong busty	93
4.6 Nature of Slope Stability	96
4.7 Morphology of Tonga Rd. (New Road) Landslip	99
5.1 Geomorphic Limitations on Urban Landuse in Darjiling Town	114
5.2 Characteristics of Major Landslips in Darjiling Town (1899-1983)	116
5.3 Nature and Source of Materials used in different stages of Urban Development in Darjiling Town	125

TablesPage No.

6.1	Estimation of Water Resources of Darjiling Town	136
6.2	Water Supply from Senchal Lake During Lean Months	139
6.3	Average Monthly Water Supply and Average monthly Rainfall of Darjiling Town	140
6.4	Monthly Average Yield of Water From Vineeta Jhora During 1991-93	145
6.5	Rates of Infiltration at different sites	155
6.6	Rainfall Run-off Relation Near St.Paul's School Main Gate, Darjiling - 18th July 1991	158
6.7	Impact of Land-use Changes and Urbanization on the Hydrology of Darjiling Town	160
6.8	Hydrological Effects During the Different Stages of Urbanization in Darjiling Town	162
6.9	Urban Water Balance of Darjiling Town	164
6.10	Consumption of Water in Six Urban System (million m ³ /y)	165
7.1	Growth of Population and Changes of Land-use in Darjiling Town	171
7.2	Growth of Population in Darjiling Town (ward-wise)	179
7.3	Ward-wise Illiteracy and Population Enjoying Urban Amenities in Darjiling Town	190
7.4	Rating Table for the Estimation of Kc	191
7.5	Rating Table for the Estimation of Kr.	192
7.6	The Index Values of Potential-Anthropo-geomorphology (I) of Darjiling Municipality (1991)	193
7.7	Distribution of the Values of P.A.G. in Darjiling Municipality (ward-wise) for 1991	194
8.1	Parametric Rating Value of Different Types of Rocks in Darjiling Town	204
8.2	Rating Value and Recommended land-use for various Terrains of Darjiling Town	206
8.3	Rating value and Recommended land-use for various slopes of Darjiling Town	207

Tables

Page No.

8.4	Rating value and Recommended land-use for various soils of Darjiling Town	210
8.5	Rating value and Recommended land-use for various Drainage system of Darjiling Town	212
8.6	Rating Value and incidence of slope failures in case of Potential landslip Prone Area of Darjiling Town	216
8.7	Urban land-use Capability sub-class	221

LIST OF FIGURES

Fig. No.	Description
0.1	Location Map of the Study Area.
1.1	Geological Map of Darjiling District.
2.1	Slope Zone Map of Darjiling Town and its Environs.
2.2	Slope Map of Darjiling Town (Ward-wise).
2.3	Relative Relief of Darjiling Town and its Environs.
2.4	Major Jhoras of Darjiling Town
2.5	Drainage Density Map of Darjiling Town and its Environs.
2.6	Geomorphological Map of Darjiling Town and its Environs.
2.7	Frequency Distribution Curves for Various Parameters.
2.8	Various Drainage Parameters Plotted on Arithmetic Probability Paper.
2.9	Darjiling Third Order Basins Classified by Various Parameters.
2.10	Linear Regression for aspects of Basin Area, Stream Length, Number and Basin Geometry.
2.11	Groups of Highly Inter Correlated Variables found by resorting the data of Table 2.5.
3.1	Rain-Erosivity Map of Darjiling Town and its Environs.
3.2	Soil Erodibility Normograph.
3.3	Soil Erodibility Map of Darjiling Town and its Environs.
3.4	Topographic Erodibility Map of Darjiling Town and its Environs.
3.5	Biological Erosivity Map of Darjiling Town and its Environs.
3.6	Potential Erosivity Map of Darjiling Town and its Environs.
3.7	Predicted Soil Loss of Darjiling Town and its Environs.
3.8	Proposed Generalised Conservation Scheme for Darjiling Town and its Environs.

Fig.No.	Description
4.1	Intensity of rainfall during major landslips in Darjiling Town Since 1899.
4.2	Chronological Incidences of Landslips in Darjiling Town.
4.3	Generalised Map of Landslip - prone area in and around Darjiling Town.
4.4	Index Map of Toongsoong.
4.5	Geological Map
4.6	Topographica Map
4.7(a)	Geotechnical Map
4.7(b)	Diagrammatic Cross-section along the eastern face of St.Paul's School (Toongsoong)
4.8	Index and Geological Map of Tonga Rd. Landslip.
4.9	Contour Plan of Tonga Rd. Landslip.
5.1	Safe Zone Map of Darjiling Town.
5.2	Contour Plan and Geology of the Landslip opposite Glenery's.
5.3	Landforms of Accumulation and Removal in and around Darjiling Town.
5.4	Contour Plan and Cross-section of a man modified landform near St.Paul's School.
6.1	Location of Major jhoras and supply of water from Senchal and Sindhap Lakes to Darjiling Town.
6.2	Distribution of Drinking Water in Darjiling Town.
6.3	Comparision of Average Monthly Rainfall and Average Monthly Water Supply of Darjiling Town.
6.4	Diagram showing the Water Level at Senchal lake, St.Paul's and Rockville Reservoir.
6.5	Seasonal Yield of Water from the jhora near St.Paul's School, Darjiling since 1991-93.
6.6	Sewer System of Darjiling Municipality.
6.7	Distribution of rainfall of Darjiling Town (100 years).

Fig.No.**Description**

- 6.8 Infiltration Curves of 15 Sample sites in and around Darjiling Town.
- 6.9 Location of Field Site for rainfall run-off study.
- 6.10 Rainfall run-off relation at field site near St.Paul's School, Darjiling on 18th July 1991.
- 6.11 A Schematic representation of Urban Water Balance of Darjiling Town.
- 7.1 Decline of Forest Area and rise of Population and Urban Areas in Darjiling Municipality.
- 7.2 Stage-wise growth of Darjiling Town.
- 7.3 Density of Population of Darjiling Municipality (ward-wide) 1971, 1981, 1991.
- 7.4 Correlation between the percentage of illiteracy (Y) and the percentage of Urban Population enjoying Urban-Amenities (X) for 26 wards of Darjiling Municipality 1991.
- 7.5 Distribution of the values of P.A.G. (Potential Anthropo-Geomorphology in 26 wards of Darjiling Municipality).
- 7.6 Potential Anthropo-Geomorphology Index of Darjiling Municipality.
- 8.1 Geological factors of Urban Land-use Capability of Darjiling Town.
- 8.2 Topographical factor of Urban Land-use Capability of Darjiling Town.
- 8.3 Soil factors of Urban Land-use Capability of Darjiling Town and its Environs.
- 8.4 Hydrological factors of Urban Land Capability of Darjiling Town.
- 8.5 Slope Stability factors of Urban Land-use Assessment of Darjiling Town.
- 8.6 Urban Land Capability Class (Limitations) of Darjiling Town.

LIST OF PHOTOGRAPHS

Photo No.	Description
2.1	Panoramic View of Darjiling Town.
2.2	Dissected landscape of the western part of Darjiling Town.
2.3	Deep chemical weathering producing thick mantle of soil cover at Lebong.
2.4	Drains clogged with dirt and filth near Happy Valley tea garden.
2.5	Quarry near Batasia Loop.
2.6	Quarry near St. Paul's School, Jalapahar.
3.1	An example of well maintained, cemented sewage outlet.
4.1	Leaning trees showing the instability of the slope.
4.2	Unstable slope utilised for housing above the Lebong Cart Rd.
4.3	Along the Mall. Due to seepage pressure rocks are projecting out of the soil
4.4	Near the cemetery above the Lebong Cart Rd.
4.5	Digging out soil leads to the loss of basal support.
4.6	Water erosion in the subsoil leading to caving of roads.
4.7	Mud flow and debris slide near Lebong.
4.8	Tonga Rd. (New Rd.) Landslip.
4.9	Massive construction at upper Toongsoong (for commercial purpose)
4.10	Vulnerable slopes being utilised for construction in upper Toongsoong.
4.11	Landslips behind St. Paul's School above Tenzing N. Rd.
4.12	
4.13	The author standing near the Tonga Rd. landslip.

Photo No.	Description
4.14(a)	An example of well maintained revetment wall with weep holes.
4.14(b)	Slopes Covered by 'Welcome Ferns' along the Lebong Cart Rd.
4.15	Creeping slopes of the Botanical Garden with leaning trees.
4.16	Urban congestion dotted with Dhupi trees on the western spur of the Jalapahar - Birch Hill ridge.
4.17	An old septic tank with eroded out-lets above the Victoria Rd.
4.18	People carrying illegally felled woods in Tiger Hill.
5.1	Building of houses on terraced slopes following cut-and-fill process.
5.2	Extension of Bell-View Hotel disregarding the landslip scar at the back.
5.3	St. Joseph's School play ground Formed by cut-and-fill process
5.4	Lebong Race Course
5.5	Slope cut for widening of road.
5.6	Ground levelled for air-strip at Tiger Hill By cut-and-fill process.
5.7	St. Paul's School Tennis Court.
6.1(a)	Senchal reservoirs (3)
6.1(b)	A typical scene of water crices in Darjiling town.
6.2	Road side pipe leakage.
6.3	
6.4	Bazar Septic Tank between the Jail and the Slaughter house.
6.5	Recently built houses on steep slopes have no out-let for drainage.
6.6	A natural spring being polluted by a near by sewer out-let.

Photo No.	Description
7.1(a)	In 1878. Toy-train near Batasia loop.
7.1(b)	Recent 1993.
7.2(a)	In 1878. Railway station of Darjiling town
7.2(b)	In 1993.
7.3	Previous landscape around the Mall showing the Monestary on top of the Observatory Hill (1874).
7.4(a)	(1871). Changes in land use along the eastern spur of the Birch-Hill-Jalapahar-Katapahar ridge.
7.4(b)	(1993).
7.5(a)	In 1874 The Mall
7.5(b)	In 1993.
7.6(a)	In 1874. The Bazer
7.6(b)	In 1993. The Barrack has been replaced by the Super Market.
7.7	Way to Birch Hill showing people carrying logs felled illegally in 1874.
7.8	Hotels along the N.B. Singh Rd. Massive Constructions on the hilly terrain violating the mulicipality rules.
7.9	Telephone exchange Bhawan.
7.10	Another massive construction - Mahakal Hotel.
7.11	Slums with no drainage or sewage out-let at Mal Godwan.
7.12(a)	Debranching is a common practice of cutting down trees.
7.12(b)	A bare slope with no vegetation cover becomes prone to erosion and landslips.
7.13	Unscientific terrace cultivation mainly under root crops causes soil erosion.
7.14	Old buildings built by stones on ridge tops. St. Joseph's School with the majestic Kunchenjunga at the background.
7.15	Early tea plantation at Happy Valley without any erosion in 1875.