THE LANDSLIDE HAZARD IN INDIA

BY

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1. Introduction

The term "Landslide" is used to describe a wide variety of processes that result in the downward and outward movement of slope-forming materials composed of rocks,soils, artificial fill, or a combination of these. The materials may move by falling, toppling,sliding,spreading, or flowing [U.S. Geological Survey, 1981]. India has about 25% of its geographical area under mountanious terrain. The southern, central and western mountains namely the western ghats, satpura and vindhyan ranges and aravalis are geologically very old and stable formations as compared to the Himalayas and the Shwalik ranges in the north. These recent formations are geologically unstable, are in seismic zone and are still in the upheaval stage [Valdiya, 1975]. Recently there has been a very rapid increase in the developmental activities in whole Himalaya. These comprise large scale construction of mountain roads,mining activity, overgrazing, deforestation and opening up of steep land for agriculture. These activities cause severe erosion resulting in extensive slope failures. These are often termed as landslides ar slips. The probable landslides prone areas are shown in Fig. 1.

2. Factors and causes of landslides

The number of important factors effecting the hill slope instability directly or indirectly along or with combination to other factors are:

i] Geology - Structure,Lithology and tectonic history.

ii] Rainfall - Amount, intensity and duration.

iii] Geomorphology - Relief [absolute and relative]
Slope [amount, nature, slope morphology and aspect].

iv] Hydrology - Surface [Natural or artificial] and subsurface.

v] Landuse - Agriculture, settlement, forest, mining,quarring grazing and barren lands.

vi] Socio-economic - Population density, education, economic condition and developmental activities.

In nature, all these factors are lying in a natural state of equilibrium and any alternation in the system by natural or artificial means leads to unstability of hill side and landslide. In structurally deformed Himalayas, rainfall is one of the primary factor and most of the slide occur during rainy seasion.

3. Landslide occurrances

Some recent examples of extensive damages arising from landslides due to heavy rainfall are given below:

i] 1990 - Landslide occurred in Neelkanth area near Rishikesh.

ii] 1989 - Landslide ocourred on shimla highway [H.P.].

iii] 1986 - Landslide problems in Jammu & Kashmir area along NH-1A

iv] 1985 - Extensive landslides in hilly areas of Kerala.

v] 1983 - Wide spread incidence of landslides and damages in North Sikkim.

vi] 1983 - A major length of NH-17 in the Western Ghats was damaged by landslides.

vii] 1979 - Extensive landslides along NH-1A in Jammu & Kashmir and also on NH-21A in H.P.

viii] 1976- Landslides in Sikkim and Darjaleeing areas due to heavy rainfall and consequent floods in tista valley.

ix] 1973/72 Severe incidence of landslides in Jammu & Kashmir area.

x] 1971 - Heavy rainfall triggered extensive landslides incidence along Alaknanda Valley.

xi] 1969 - Tista Valley was the scene of catastrophic landslides that damaged large stretches of NH-31 as well as resulted in the washing out of the Tista bridge at sevoke.

4. Efforts towards landslide hazard reduction.

Landslide, a natural hazard in mountainous areas, can cause extensive damage to life and property. India has many areas which are prone to landslides. The most effected areas are: J & K, H.P. Garhwal Himalayas, North East Himalayas, Western Ghats and Nilgiri hills. So it was felt essential to take up detailed investigations to explore the origin and causes of landslides and to find out the mechanisms for prevention and monitoring on a national level from time to time. In order to study various aspects of landslides, the Department of Science & Technology, Govt. of India, has launched a coordinated multi-disciplinary and multi-agency programme during [1990/91]. As an effort towards concretising R&D programme, an expert committee on the study of landslides has been constituted in July 1990 with the following broad terms of reference:

i] Setting up of authentic database.

ii] Zonation of landslide prone areas.

iii] Monitoring of high risk zones.

iv] Development of models and prognostic systems.

vi] Design of suitable control measures.

vi] Training and dissemination of emerging technologies.

As a part of this programme, some intensive test sites have been chosen for detailed investigations . The various R&D agencies are associated in carrying out research work.

5. Landslide hazard zonation

Though there are various steps involved in minimization of landslide hazard, but here efforts are made to emphasise only landslide hazard zonation mapping. A landslide hazard zonation [LHZ] map depicts division of land surface into zones of varying degree of stability based on the estimated significance of the causative factors in inducing instability. The LHZ maps have an important role in planning and implementation of development schemes in mountainous areas [R.Anbalagan,1991].

6. Methodology for landslide hazard zonation mapping

LHZ mapping technique is a macro zonation approach showing the probabilities of landslide hazards of an area preferably on scales 1:25000 to 50000. The study involves the preparation of various types of maps on 1:50000 scale such as lithological map, structural map, slope morphometry map, relative relief map, soil map, landuse map and hydrological map. The procedures of

LHZ mapping technique has been outlined in the form of flow chart Fig.2

7. Landslide hazard rating:

To findout the relationship of landslide activity with various geo-enviromental factors ie. slope, lithology, structure, hydrology, relativerelief and land use pattern, a statistical analysis based on frequency of landslide in each caregory of these factors is carried out. To achieve this, area of different categories of each factor maps are first determined, followed by determination of number of landslide occurring in each category of the factor map one by one. The frequency of landslide per sq.km and percentage of landslide per sq. km for each category of thematic maps are calculated. Further, a numerical weightage called landslide susceptibility value (LSV) has to be assighed to each factor of the terrain according to its relative importance for landslide susceptibility,table 1.

Table - 1

Landslide Susceptibility Value (LSV) Rating

(1)	Lithology	---	25.
(2)	Structure	----	20.
(3)	Slope	----	25.
(4)	Landuse	----	10.
(5)	Relief	----	5.
(6)	Hydrology (D.D)	----	15.

Here, for example, the landslide hazard map of Imphal catchment along with the different factors maps are enclosed. The total area is approximately 920 sq.km. The major factors for landslides in this area are; the excessive rainfall, unconsolidated lithology and techtonically disturbed terrain. Maps (1 to 7).

8. Landslide susceptibility index (LSI)

The following values has been assigned to different factors as shown in tables 2-6 below;

Table -2

Soil thickness	(L S V 25)	L S I
Deep	-	7.5
Moderate	-	8.75
Shallow	-	8.75

Table -3

Slope	(L S V 25) in degree	L S I
0 - 7	-	7.5
7 - 14	-	6.25
14 - 21	-	11.25
21 - 28	-	-
28 - 35	-	-
> 35	-	-

Table -4

Landuse	(L S V 10)	L S I
Thick forest	-	-
Moderate forest	-	5.0
Sparse vegetation	-	1.0
Agriculture land	-	4.0
Barren land	-	-

Table -5

Drainage density	(L S V 15)	L S I
0 - 1.5	-	3.0
1.5 - 3.0	-	4.5
3.0 - 4.5	-	7.5
4.5 - 6.0	-	-
6.0 >	-	-

Table -6

Lithology	(L S V 25)	Structure	L S I
Alluvium	-	Thrust Zone	15
Barail	-	Lineaments etc.	-
Disang	-	Lineaments etc.	10

9. Landslide hazard Zonation on the basis of total estimated hazard

The final landslide zonation map gives a general picture of Imphal catchment area. This is useful for environmental planning and development of the region table 7. The class I indicates absence of landslide in the area. The class II gives very low possibility of landslides. The class III consists of moderate possibility of landslide. The class IV and V are the zones of active landslides areas. Table - 7.

Table -7

Sl.No.	Class	L S I Range	Landslide possibility
1.	Class I	< 10	No landslide
2.	Class II	10 - 20	Very low frequency of landslide
3.	Class III	20 - 30	Moderate (Old scars)
4.	Class IV	30 - 40	High frequency of active landslide
5.	Class V	> 40	Very high frequency of active landslide

10. Conclusions

The planning and implementation of developmental schemes in the study area should take into account the existing instabilities of slopes ; so that the disturbance to the environmental balance are kept to the minimum. Landslide Hazard Zonation maps have gained wide acceptance and use in many countries. These maps also serve as a tool in guiding and controlling the development in hill areas, in order to keep developmental work away from potentially hazardous zones.

11. Acknowledgements

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12. References

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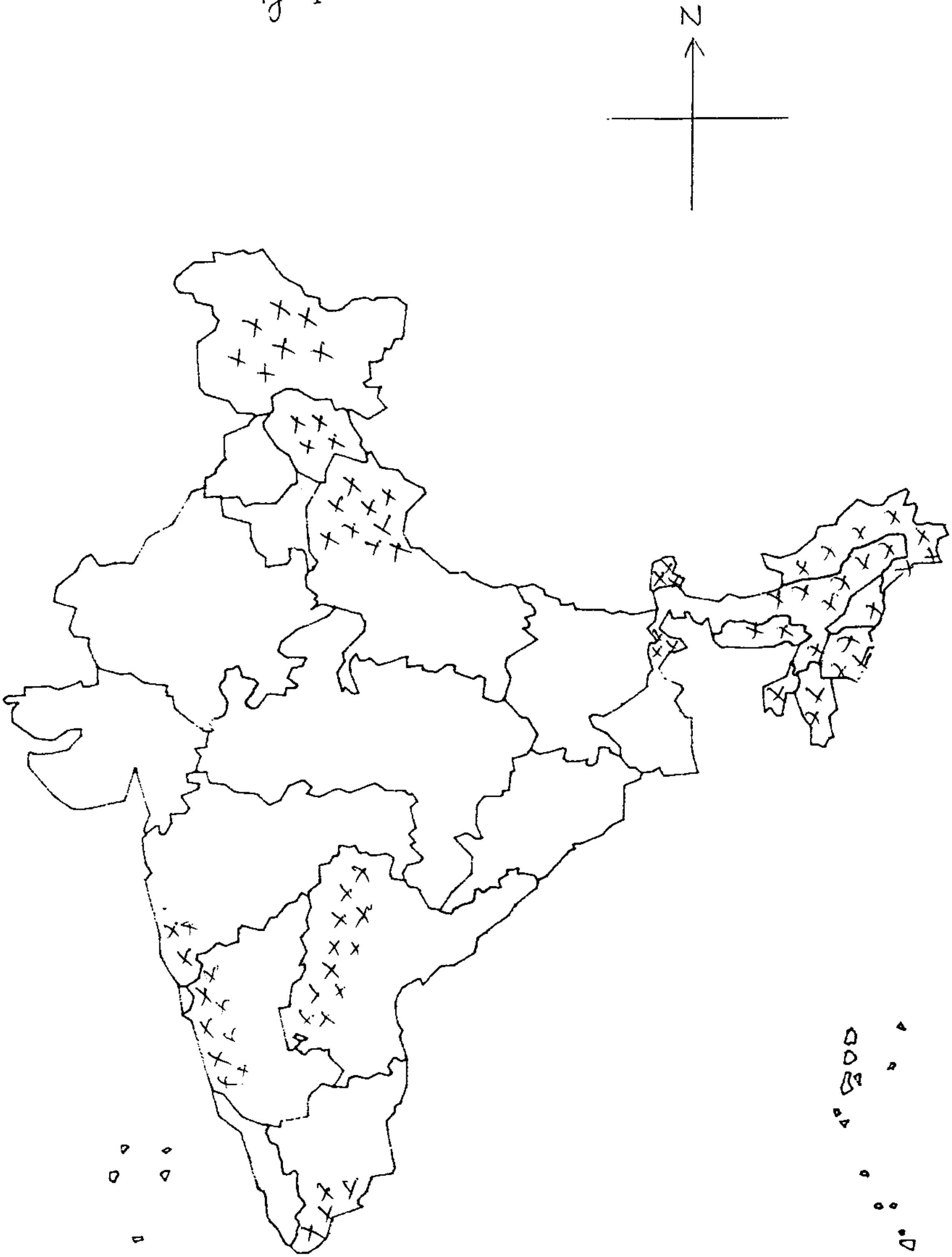
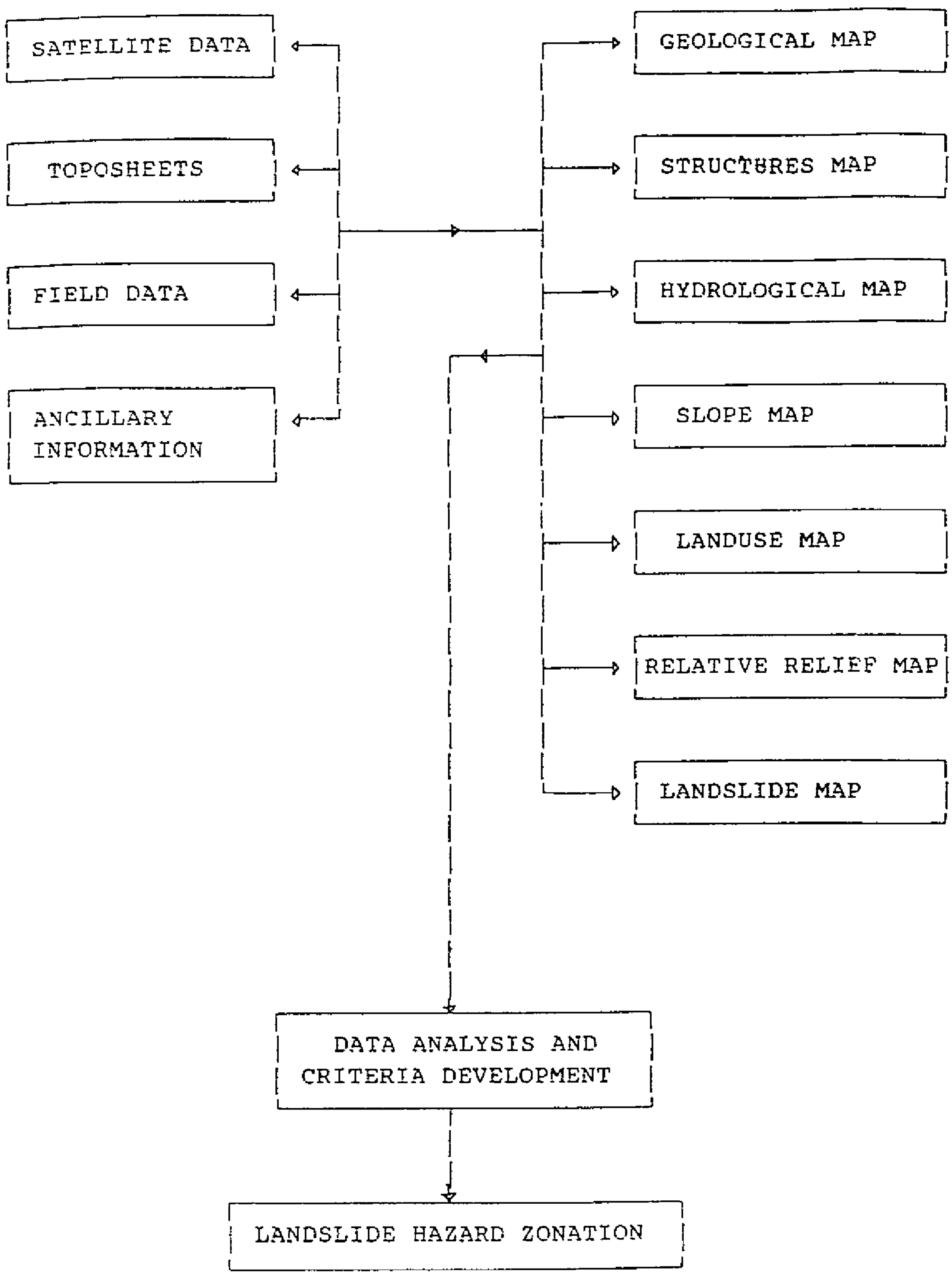
Fig. 1

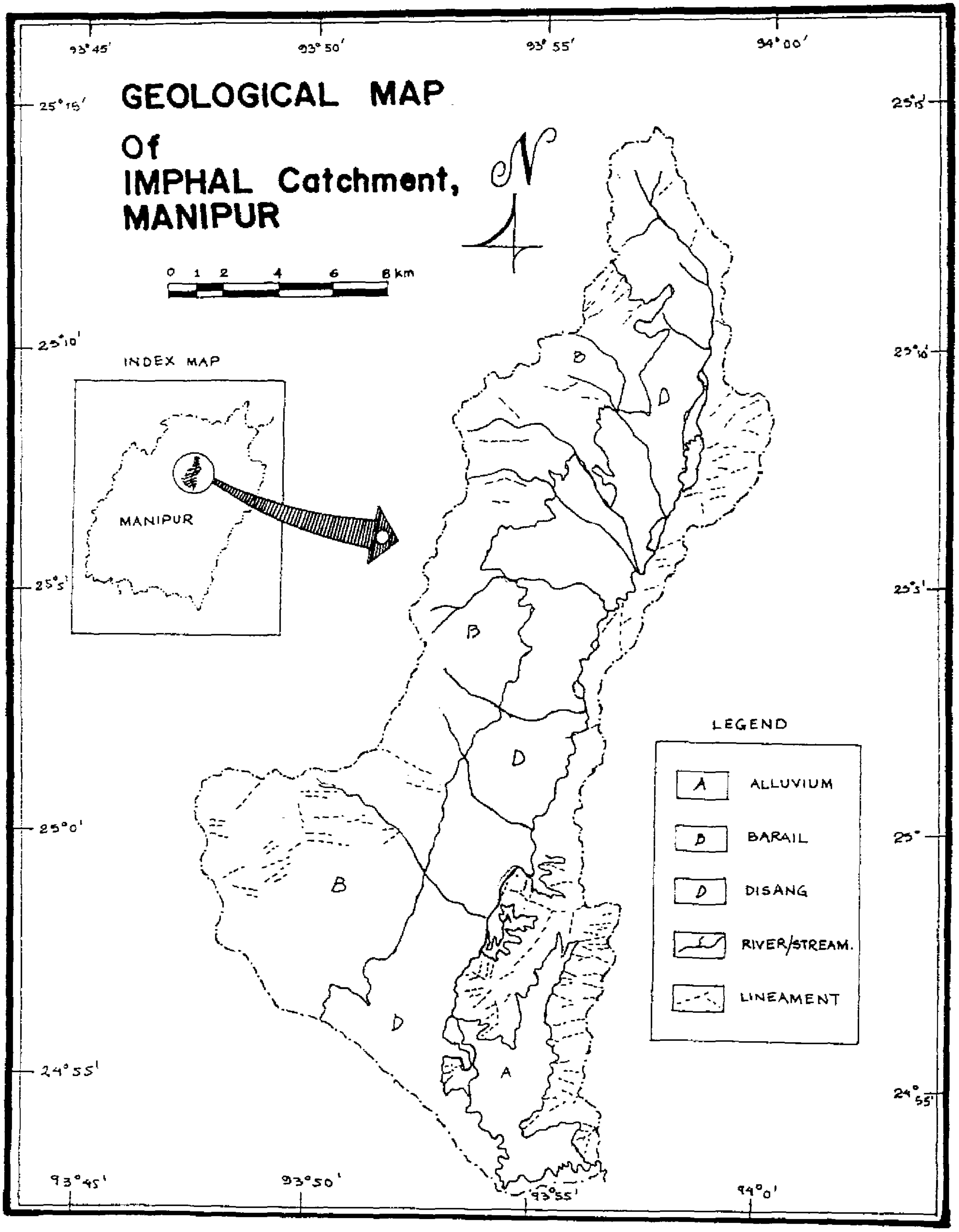


X - Landslide prone areas.

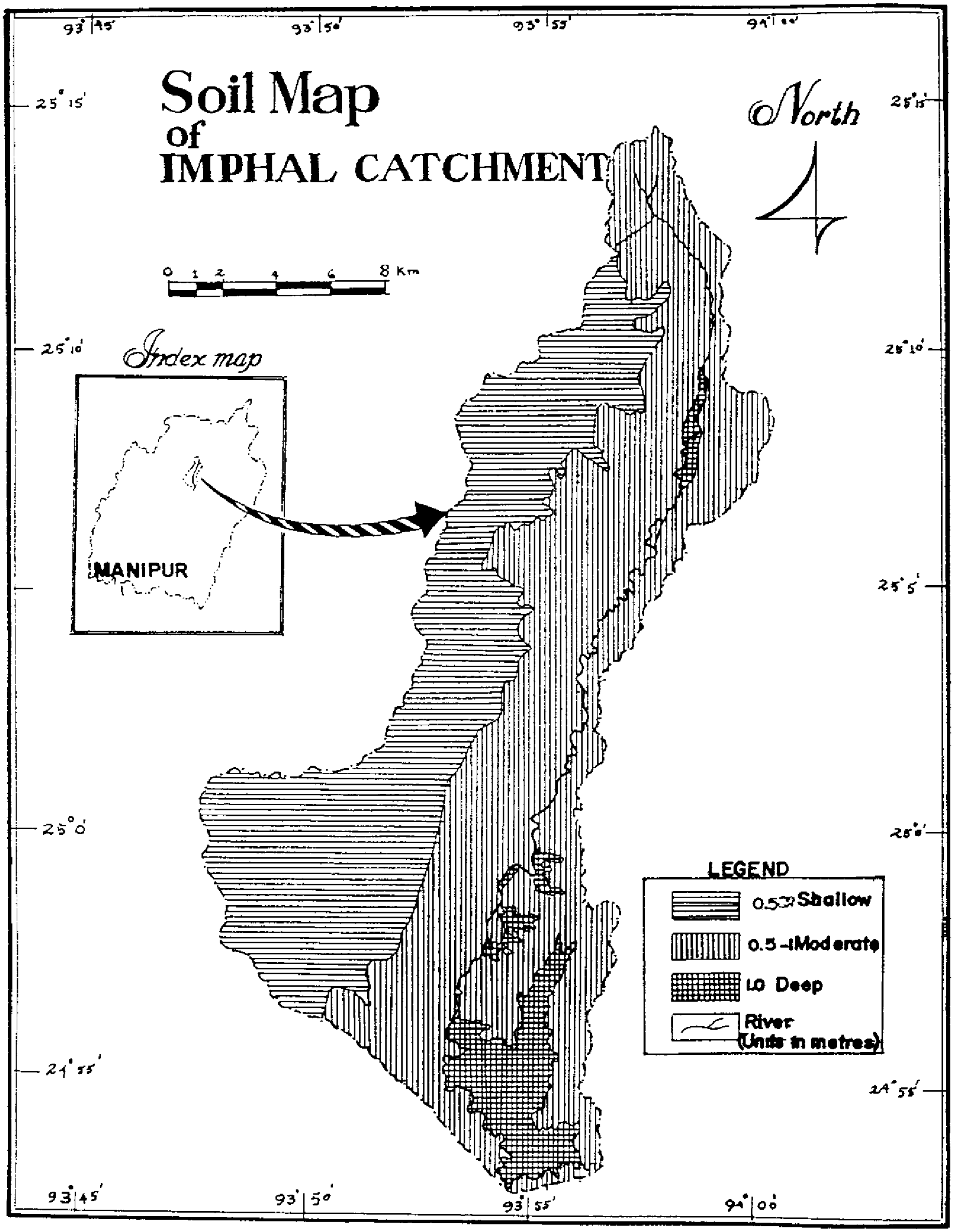
Fig-2

FLOW CHART FOR LANDSLIDE HAZARD ZONATION

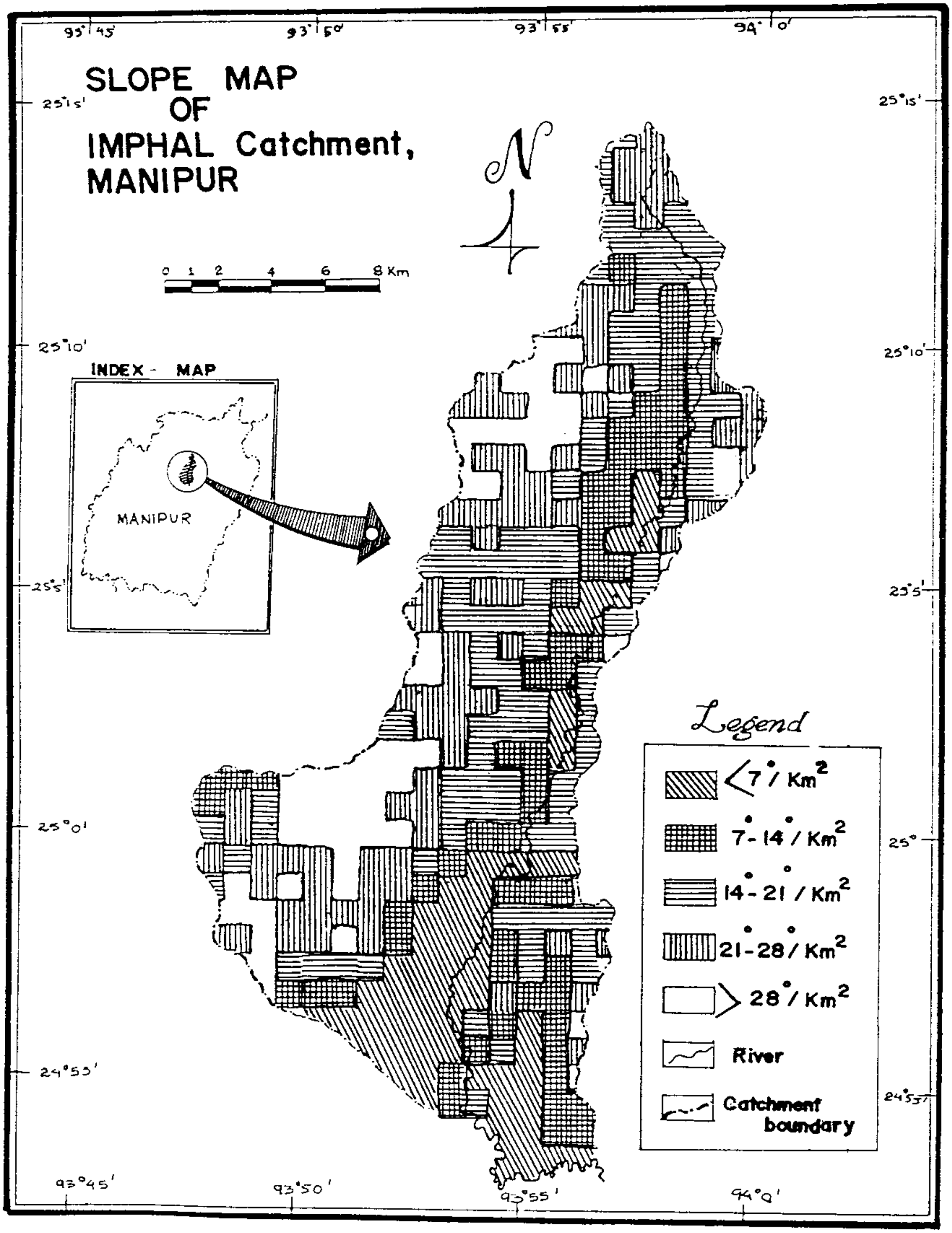



GEOLOGICAL MAP
Of
IMPHAL Catchment,
MANIPUR
0 1 2 4 6 8 km
INDEX MAP
MANIPUR
LEGEND
A ALLUVIUM
B BARAIL
D DISANG
RIVER/STREAM.
LINEAMENT
B
D
A
93°45'
93°50'
93°55'
94°00'
25°15'
25°10'
25°5'
25°0'
24°55'

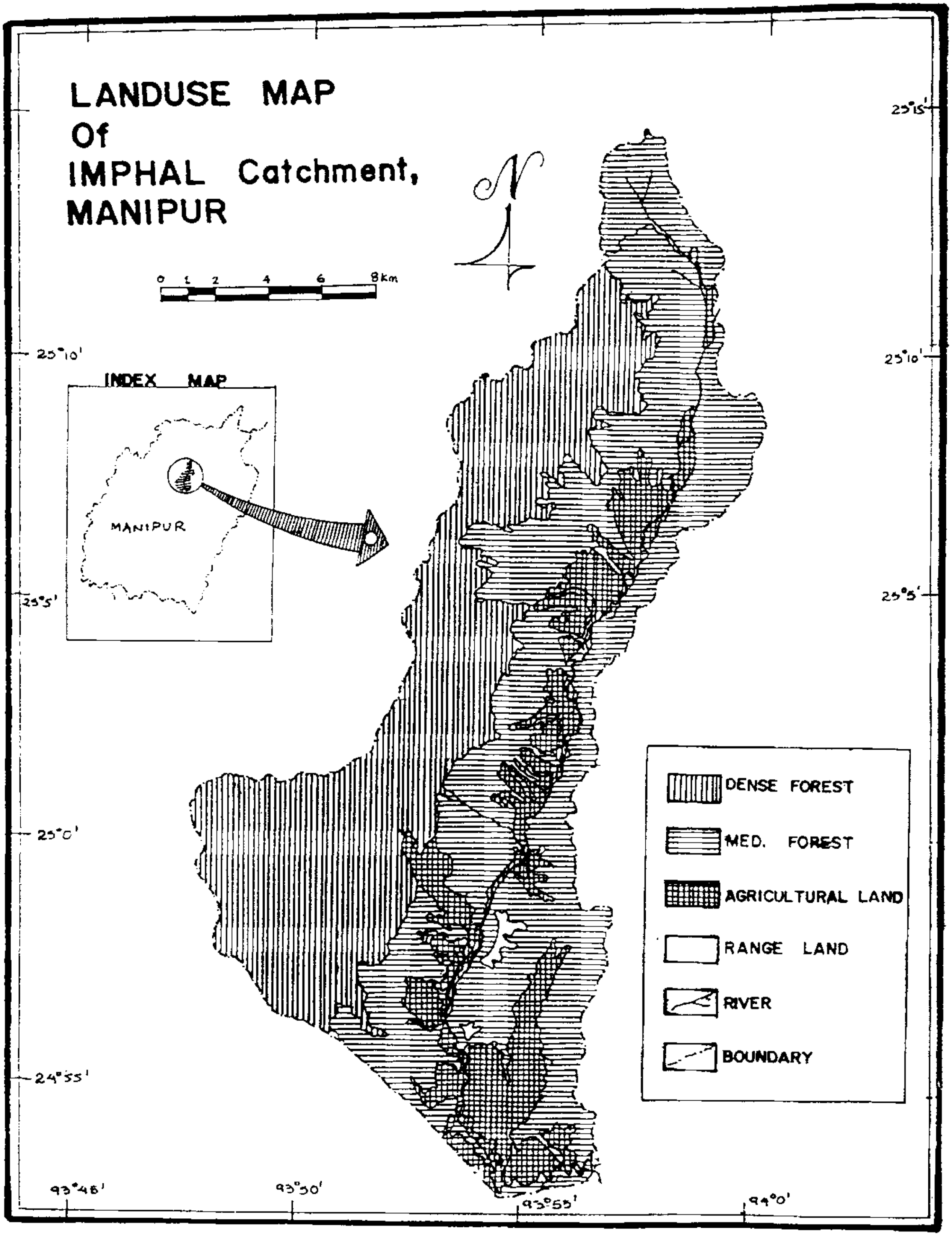
Map-1


Soil Map
of
IMPHAL CATCHMENT
North
0 1 2 4 6 8 Km
Index map
MANIPUR
LEGEND
0.5 Shallow
0.5 -1Moderate
1.0 Deep
River
(Units in metres)

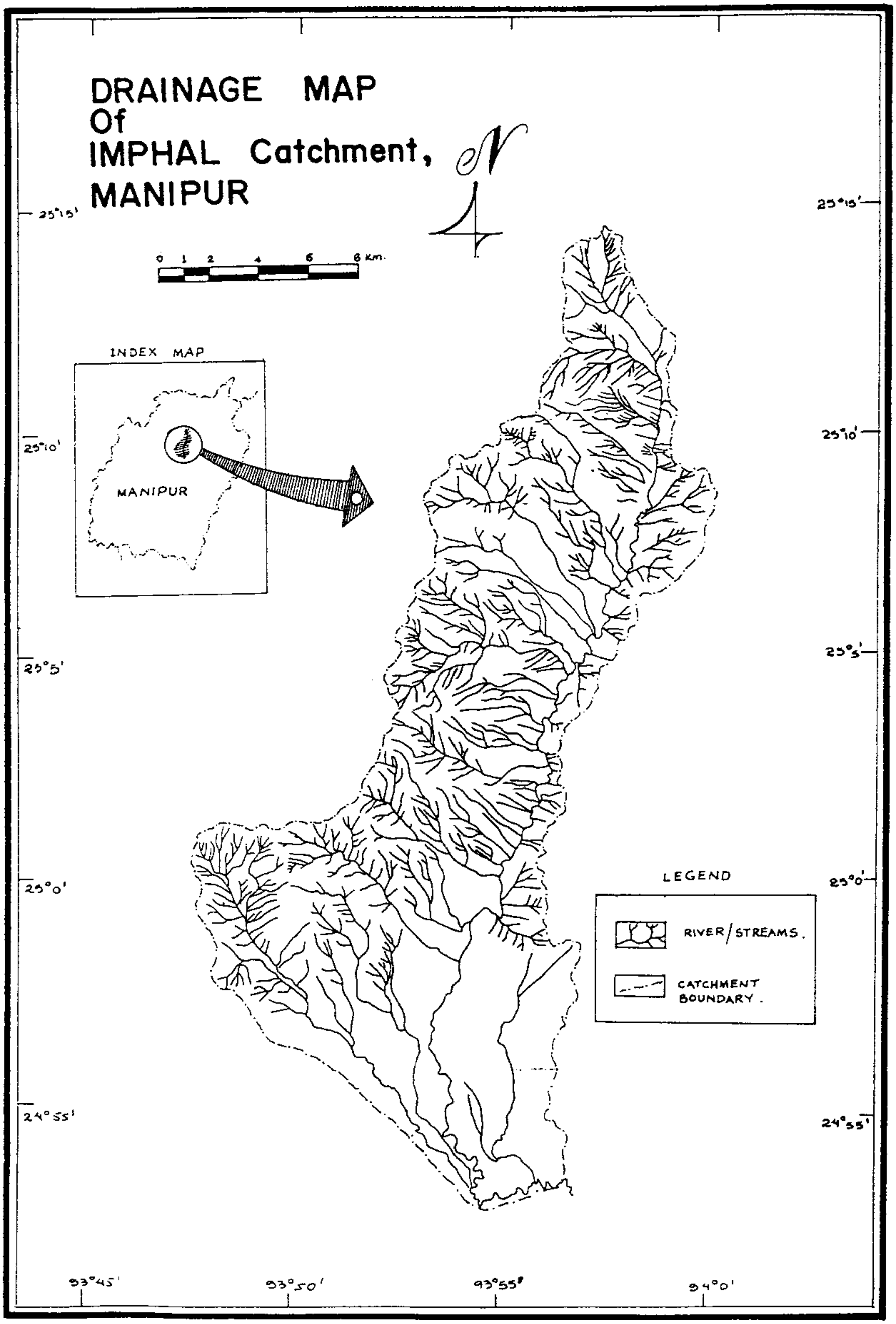
Map - 2


SLOPE MAP
OF
IMPHAL Catchment,
MANIPUR
N
0 1 2 4 6 8 Km
INDEX - MAP
MANIPUR
Legend
<7°/Km²
7°-14°/Km²
14°-21°/Km²
21°-28°/Km²
>28°/Km²
River
Catchment boundary
93°45'
93°50'
93°55'
94°0'
25°15'
25°10'
25°5'
25°
24°55'

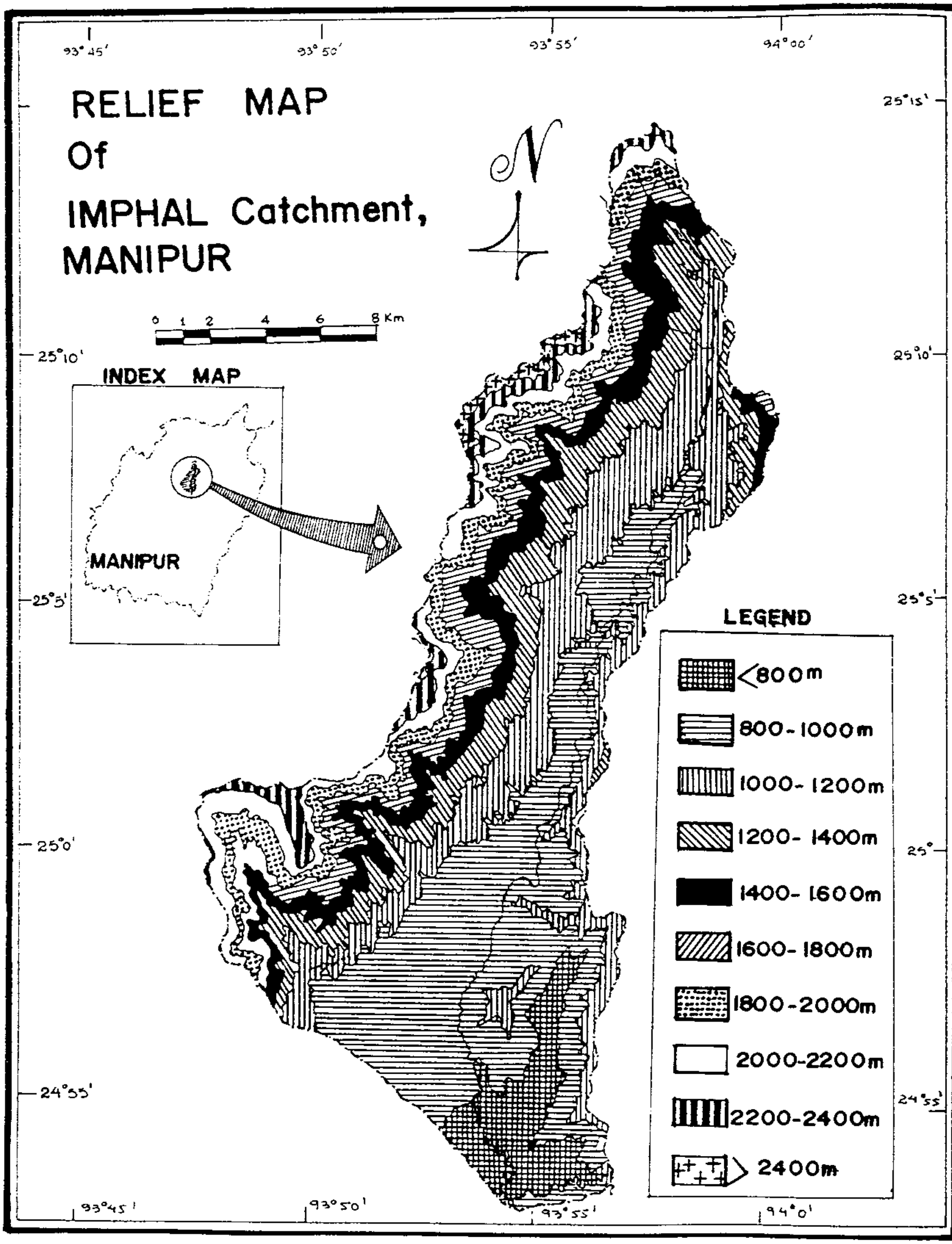
Map-3


LANDUSE MAP
Of
IMPHAL Catchment,
MANIPUR
0 1 2 4 6 8km
INDEX MAP
MANIPUR
DENSE FOREST
MED. FOREST
AGRICULTURAL LAND
RANGE LAND
RIVER
BOUNDARY
25°15'
25°10'
25°5'
25°0'
24°55'
93°45'
93°50'
93°55'
94°0'

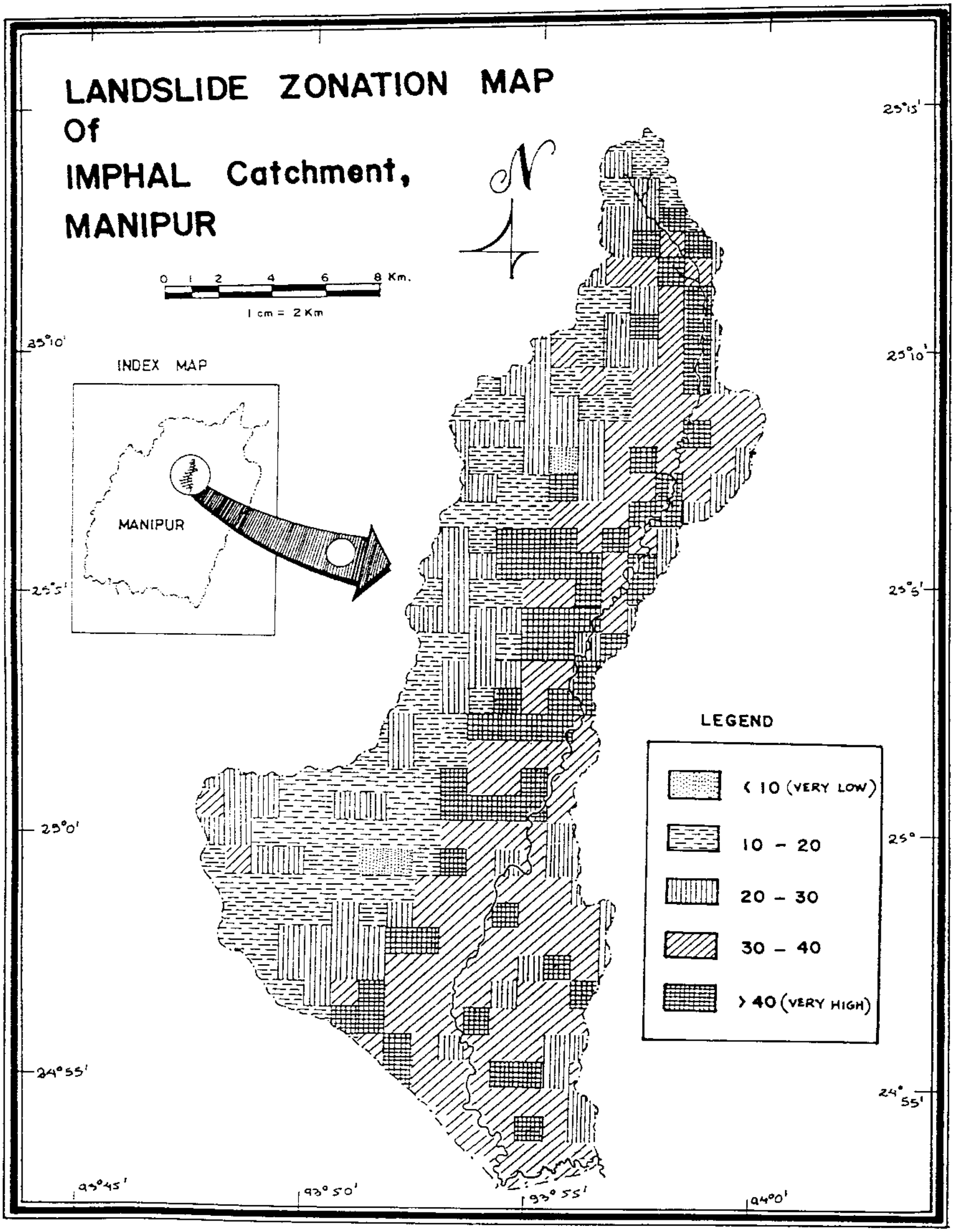
Map - 4


DRAINAGE MAP
Of
IMPHAL Catchment,
MANIPUR
N
0 1 2 4 6 8 Km.
INDEX MAP
MANIPUR
LEGEND
RIVER/STREAMS.
CATCHMENT
BOUNDARY.
25°15'
25°10'
25°5'
25°0'
24°55'
93°45'
93°50'
93°55'
94°0'

Map - 5


RELIEF MAP
Of
IMPHAL Catchment,
MANIPUR
0 1 2 4 6 8 Km
INDEX MAP
MANIPUR
LEGEND
<800m
800-1000m
1000-1200m
1200-1400m
1400-1600m
1600-1800m
1800-2000m
2000-2200m
2200-2400m
> 2400m
93°45'
93°50'
93°55'
94°00'
25°15'
25°10'
25°5'
25°0'
24°55'
94°0'

Map - 6


LANDSLIDE ZONATION MAP
Of
IMPHAL Catchment,
MANIPUR
N
0 1 2 4 6 8 Km.
1 cm = 2 Km
INDEX MAP
MANIPUR
LEGEND
< 10 (VERY LOW)
10 - 20
20 - 30
30 - 40
> 40 (VERY HIGH)
25°15'
25°10'
25°5'
25°0'
24°55'
93°45'
93°50'
93°55'
94°0'

Map - 7