APPLICATION OF GIS FOR SHIVAPURI WATERSHED PROJECT

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Abstract: The MENRIS programme of ICIMOD, in collaboration with the Shivapuri Integrated Watershed Development Project (SIWDP), conducted a comparative study of land-use changes in the SIWDP area using GIS as a tool. Maps of Kathmandu Valley, produced by E. Schneider, and the Indian Topographical Map Sheets were used to prepare a base map. Aerial photographs and other maps, supported by field verification, were used to prepare different thematic maps for digitisation. The changes in major land-use categories between 1981 and 1993 were determined through a land-use change map using GIS. The results indicated that there has been an overall gain of four per cent in the area under forest cover and losses in the areas under scrub and grasslands. About 94 per cent of agricultural land remained unchanged. A land-use adjustment map, based on present land use and land capability maps, was also produced using GIS.

1. INTRODUCTION

This case study was conducted by the Mountain Environment and Natural Resources' Information System (MENRIS) programme of ICIMOD in collaboration with the Shivapuri Integrated Watershed Development Project (SIWDP), supported by FAO. This case study made a comparative study of land-use changes in the SIWDP area using a Geographical Information System (GIS). Staff and consultants of the SIWDP were engaged in the preparation of thematic maps and the professional staff of MENRIS were involved in the GIS analyses. The objective of the study was to use GIS as a tool to carry out the following tasks:

- to prepare two sets of land-use maps, based on available information (aerial photographs and topographic base maps);
- to prepare land-use change maps (for the period between 1981 and 1993);
- to study and assess the condition of the major land-use categories in the watershed;
- to estimate the extent of land-use changes in agricultural, forest, and non-forest lands; and
- to establish land capability criteria and propose a rational land capability map and land-use adjustment map.

The above-mentioned tasks would facilitate the preparation of a management plan for SIWDP.

2. METHODOLOGY

Aerial Photographs and Topographical Base Maps

As a basis for the land-use comparison study, three sets of aerial photographs were used. All photographs were black and white with scales varying from 1:15,000 to 1:30,000. The first set with two scales, 1:20,000 and 1:30,000, was used to prepare historical land-use maps for the year 1981. The second (1989) and third (1991) sets, on a scale of approximately 1:15,000, were used to prepare the present land-use maps (1993). All the three sets were taken by the Survey Department of HMG/N.

Two sets of topographical base maps were used. The first set of map sheets, on a scale of 1:10,000 and with 10m contour intervals, was prepared by E. Schneider in 1977, based on 1971 aerial photographs. This covers the southern part of Shivapuri. The second set, prepared and published by the Survey of India between 1950 and 1969, on a 1 inch to 1 mile scale and with 100 feet contour intervals, covers the northern part.

Agricultural Land-use Classification

The classification system was designed to extract information from several sources in order to achieve the proposed objectives. The aerial photos, on scales between 1:15,000 and 1:30,000, provided general information. Details on cropping patterns were collected through field work, and when there were no visible indications of cropping patterns within a sample site, information from local farmers was obtained.

For practical reasons, and due to the cropping pattern diversity within cultivation units, a maximum of two cropping patterns had to be recorded. Recording was carried out in order of dominance of the crop, as observed in the field. The estimate of percentage coverage was determined by field verification and information from local farmers, as well as from air-photo interpretation based on tones, textures, and patterns of crops. Areas less than one hectare, i.e., one square centimetre on the base maps (1:10,000 scale) were not mapped, due to photographic distortions and cartographic problems.

Agricultural land was classified into two major sub-classes, namely, Hill Slope Cultivation and Valley Cultivation.

Hillslope Cultivation

Three distinct types of cultivation terraces were recognised, two for *bari* (rainfed) and one for *khet* (irrigated). Terraces were identified as level terraces *(khet)*, level terraces *(bari)*, and sloping terraces *(bari)* and designated as T, L, and C respectively. The first is a rice-based farming system, with irrigation for at least two seasons, and the latter two are maize-based farming systems. Farmers normally develop appropriate terraces for cultivation, depending on the geology, landform, soil type, aspect, elevation, climate, and amount of water available for irrigation. Over 97 per cent of the terraces observed in the watershed were level terraces. In addition, three intensities of cultivation were given, namely, intense (3), medium (2), and light (1). The intensities of cultivation for intense, medium, and light were eighty to a hundred, sixty to eighty, and forty to sixty per cent of the mapped unit respectively.

In the project area, level terraces (*khet*) and level terraces (*bari*) were found to be 832 and 4322ha in 1981 and 839 and 4120ha in 1993 respectively. Sloping terraces (*bari*) occupied only 135ha in 1981 and 136ha in 1993 (Table 1).

Table 1: Distribution of Cultivation Types (1981-1993)

Cultivation Types	1981		1993	
	Area (ha)	%	Area (ha)	%
1. Level Terrace *(Khet)*				
T2	107.9	1.4	108.4	1.4
T3	727.7	9.4	731.2	9.8
Sub-total	832.6	10.9	839.6	11.2
2. Level Terrace *(Bari)*				
L1	27.4	0.4	0	0
L2	1157.5	15.1	1082.9	14.5
L3	3137.1	40.9	3037.5	40.6
Sub-total	4322.0	54.4	4120.4	55.1
3. Sloping Terrace *(Bari)*				
C2	46.4	0.6	49.4	0.7
C3	88.9	1.2	86.6	1.1
Sub-total	135.3	1.8	136.0	1.8
4. Valley Cultivation				
F *(Khet)*	2367.3	30.9	2369.4	31.7
F *(Bari)*	11.5	0.1	11.6	0.1
Sub-total	2378.8	31.0	2381.0	31.8
Total *Khet*	**3199.9**	**41.7**	**3209.0**	**42.9**
Total *Bari*	**4468.8**	**58.3**	**4268.0**	**57.1**

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

Valley Cultivation

Valley cultivation, including tars, alluvial fans, lower footslopes, and/or valley floors, were classified into two categories. The first type, designated as F, included agricultural lands normally irrigated throughout the year for rice and wheat production. The second type, designated as F, included rainfed tars or alluvial fans that were used for maize and millet production. Valley cultivation occupied 2,378ha and 2,381ha in 1981 and 1993 respectively (Table 1).

Classification of Other Land-use Types

Grassland Classification

The lands designated as G in the project area included all types of grassland that could or could not be used for livestock grazing. Grasslands within the watershed boundary were also included in this category, although they were not open to livestock grazing. Grasslands outside the project boundary wall, i.e., the buffer zone, were generally communal lands and used for grazing.

The grassland category also included some small units of landslides/slips/gullies which were too small to be mapped separately.

Grasslands in the project area covered 1,032ha and 619ha in 1981 and 1993 respectively (Table 2).

Table 2: Overall Changes in Major Land-use Categories in the SIWDP Area

Land Use	1981		1993		Changes	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture	7668.8	36.16	7477.0	35.26	-191.8	-0.90
Forest	7771.4	36.65	8638.3	40.74	+866.9	+4.09
Shrubs	3412.2	16.09	3148.2	14.85	-264.0	-1.24
Grassland	1032.3	4.87	618.9	2.92	-413.4	-1.95
Grassland with Shrubs	850.8	4.01	555.6	2.62	-295.2	-1.39
Landslides	87.3	0.41	102.3	0.48	+15.0	+0.07
Settlements	166.6	0.79	187.6	0.88	+21.0	+0.09
Riverine Features	22.9	0.11	45.7	0.22	+22.8	+0.11
Abandoned Lands	191.9	0.91	430.6	2.03	+238.7	+1.12
					-	-
Total	**21204.2**	**100.00**	**21204.2**	**100.00**		

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

Grassland in Association with Shrubs / Scrubs

Units of land covered by more than 50 per cent of grassland, but associated with shrub/scrub species, were designated as GS. These units often included regenerating, severely-degraded, and planted tree species.

The total area covered by such lands in the project area was 851ha and 555ha in 1981 and 1993 respectively.

Abandoned Land

The term abandoned land, designated as A in the project area, covered terraced or non-terraced lands that had been previously under cultivation and which are presently no longer used for agricultural production. Lands within the project boundary wall, taken over from the farmers in 1981 for the Shivapuri Watershed and Wildlife Reserve (SWWR), were also included in this category. The SWWR programme was started by HMG/N in 1975, and, in 1992, it was renamed SIWDP.

Abandoned land in the project area covered 192ha and 431ha in 1981 and 1993 respectively (Table 2).

Riverine Features

These lands had riverine features, such as sand, gravel, and boulders, that can be associated with water. All these were designated as W on the maps.

Landslides / Slips / Gullies

Active landslides/slips/gullies (whether caused by natural processes or man-made) greater than one hectare in area were indicated on the

map. However, old scars of landslides covered by vegetation were classified under vegetation type rather than under landslides. Landslides were designated on the map as arrows.

Settlements / Built-up Areas

Settlement lands included conglomerate groups of buildings and/or houses and were denoted by R on the map. Large school areas, experimental farms (such as the Herbal Farm in Manichaur), factory areas, etc were also included in these units.

Forest Classification Systems

Basis of Forest Classification

Three major cover-type categories, namely, coniferous (C), hardwood (H), and mixed wood (M) (including all other combinations of tree species), were used for forest classification. All these categories were then further subdivided into species or species-group types.

Shrub / Scrub Lands

Land areas covered by more than 50 per cent of shrub/scrub vegetation were denoted by S. Shrub species are predominately less than five metres in height and are normally associated with various grass species. These lands often include regenerating, degraded, and/or planted tree species. It should be noted that land areas covered by less than 50 per cent of shrub/scrub vegetation were classified as 'Grassland in Association with Shrubs'.

The total area mapped as forest, including shrubs, was 52.7 per cent and 55.6 per cent in 1981 and 1993 respectively. These figures are summarised in Table 2.

The percentages of hardwood forest species in the project area were 64 and 67 in 1981 and 1993 respectively. The areas under coniferous forest and mixed forest were 522 and 8,008ha and 732 and 8,816ha in 1981 and 1993 respectively (Table 3).

Table 3: Distribution of Forest Types (1981 and 1993)

Land Use	1981		1993	
	Area (ha)	%	Area (ha)	%
Mixed Forest	94.0	0.84	45.1	0.38
Hardwood Forest	7207.4	64.45	7934.1	67.32
Coniferous Forest	470.0	4.20	659.1	5.59
Shrubs/Scrub	3412.2	30.51	3148.2	26.71
Total Forest Area	**11183.6**	**100.00**	**11786.5**	**100.00**

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

3. GIS APPLICATION

Maps are indispensable for watershed management planning. Analysing maps (or spatial analysis) necessitates overlaying many thematically different base maps and entails reclassification of land units based on mutually interacting spatial phenomena. To analyse these maps by conventional methods is, however, a cumbersome task.

The advancement of computer technology, particularly the invention of GIS, has made it possible to digitise, store, and overlay several

base maps and then, to create a new set of maps as per the requirement of the analysis. Morever, the capability of storing attribute data and relating them to spatial data has augmented and corroborated the application of GIS to watershed management planning. A temporal database, stored intermittently, facilitates the monitoring of changes in watershed (Thapa et al. 1992).

This study was based on information provided by the consultants of the SIWDP. The overall spatial database preparation and analysis functions were performed using a GIS called ARC/INFO. Maps showing 1981 and 1993 land use for north and south Shivapuri were digitised, using the topographic maps, and stored as separate layers. Likewise, the land capability and land systems' maps were digitised and stored separately. Simple overlay operations were carried out on 1981 and 1993 land-use information to examine the land-use changes between the two years. Likewise, the 1993 land-use map was overlaid on the land capability map to prepare a land-use adjustment map in order to provide information on different use conditions.

4. LAND-USE COMPARISON BETWEEN 1981 AND 1993

There have been significant gains in forested and abandoned lands and losses in agricultural lands, grassland, shrubland, and grassland in association with shrubs. Table 4 shows that forested land increased by 4.1 per cent, and that most of it was previously under shrubland and grassland associated with shrubs. The increase in forested land was the result of protection and conservation of the Shivapuri Watershed Area under the SWWR programmes. There has been a gain in abandoned land by 239ha (1.12%) within the project boundary wall. Most of the present abandoned lands within the project boundary wall were taken over by the SWWR in 1981-82. Table 4 shows a slight increase in the areas under landslides, settlements, and riverine features, but this is due to the errors and limitations of digitising. Overall, Table 2 suggests that deforestation has not taken place, which substantiates field information. It should also be noted that this analysis indicates that the forest quality (density, species' diversity, and so on) has changed and the area under forest has increased. When the changes in terms of forest types (Table 3) are compared it can be noted that mixed forest has not changed much, and this change is well within the accuracy limit of the survey. In contrast, coniferous and hardwood forests have increased by 189 and 727ha respectively, and shrubland has decreased by 264ha. It also indicates that the increase in coniferous forests is the outcome of new plantations (mostly pine species) carried out under the SWWR programme in the mid-eighties. The increase in hardwood forests suggests that forest cover has improved in terms of timber and fuelwood supply. This is partially due to the effect of reforestation inside the project boundary wall undertaken by the Shivapuri Watershed Management and Fuelwood Plantation Project.

Another way of documenting the land-use dynamics is in terms of actual areas gained and lost in each land-use category. Table 4 indicates that forests and agricultural lands are the most stable land-use categories, with more than 94 per cent of the area remaining under the same uses during the period between 1981 and 1993.

It should be noted that an insignificant percentage (0.4%) of forests has been converted into agricultural land, while almost 21 per cent of the gains in forest cover have come from shrubland and only two per cent of forestland has reverted to shrubland. This is once again an indicator that the situation in the forestry sector is improving.

Table 4: Detailed Land-use Changes Between 1981 and 1993

From 1981	To 1993	Area (ha)	%
Agriculture	Agriculture	7226.6	93.7
Agriculture	Forests	39.1	0.5
Agriculture	Shrubland	12.4	0.2
Agriculture	Grassland	4.4	0.0
Agriculture	Grassland with Shrubs	12.1	0.2
Agriculture	Abandoned	415.4	5.4
Forests	Agriculture	32.2	0.4
Forests	Forests	7599.8	97.3
Forests	Shrubland	139.3	1.8
Forests	Grassland	0.4	0.0
Forests	Grassland with Shrubs	30.2	0.4
Forests	Abandoned	5.3	0.1
Shrubland	Agriculture	8.7	0.2
Shrubland	Forests	703.5	20.8
Shrubland	Shrubland	2485.2	73.6
Shrubland	Grassland	40.2	1.2
Shrubland	Grassland with Shrubs	113.7	3.4
Shrubland	Abandoned	26.5	0.8
Grassland	Agriculture	170.1	15.9
Grassland	Forests	166.0	15.5
Grassland	Shrubland	139.3	13.0
Grassland	Grassland	523.0	48.7
Grassland	Grassland with Shrubs	49.3	4.6
Grassland	Abandoned	25.0	2.3
Grassland with Shrubs	Agriculture	26.5	3.4
Grassland with Shrubs	Forests	123.4	16.1
Grassland with Shrubs	Shrubland	227.9	29.7
Grassland with Shrubs	Grassland	22.0	2.9
Grassland with Shrubs	Grassland with Shrubs	365.1	47.5
Grassland with Shrubs	Abandoned	3.0	0.4
Abandoned	Agriculture	10.7	5.5
Abandoned	Forests	6.4	3.3
Abandoned	Shrubland	7.7	4.0
Abandoned	Grassland	33.1	17.1
Abandoned	Grassland with Shrubs	21.9	11.3
Abandoned	Abandoned	114.3	58.9

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

Grassland and grassland in association with shrubs are the most dynamic land use categories. An almost even proportion (approximately 16%) of grassland was lost to agriculture and forests, whereas the gains from these two categories have been very small.

5. LAND CAPABILITY MAP

Land capability is defined here as the inherent capacity of land to be productive and sustain a certain prescribed management (LRMP 1986a). As the landscape changes from gently sloping alluvial plains to an increasingly steep mountainous terrain, the options for sustained and productive management decrease. Lands with the greatest options are rated Class I; those with the fewest options, Class IV.

Land capability is a tool to assist basic resource data in land planning and management. The land capability map was thus prepared on a scale of 1:50,000. Capability classes were based mainly on LRMP's land capability maps (LRMP 1986b) and field visits.

The distribution of major land capability classes is given in Table 5. Classes I and II provide land for agriculture or forestry and Classes III and IV provide land for fodder production and grazing.

Table 5: Distribution of Major Land Capability Classes

	Slope Category	Area in Hectares	%
Class I	(slopes < 1°)	1210.0	5.7
Class II	(slopes 1 - 5°)	1907.3	9.5
Class III	(slopes 5 - 30°)	13301.3	62.7
Class IV	(slopes > 30°)	4785.6	22.6
	Total	**21204.2**	**100.0**

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

6. LAND SYSTEMS' MAP

In order to ensure environmental protection and sustainable management of the Shivapuri Watershed Area, it is essential to understand the land system of the area which provides an inventory of the land resource. The Land Systems' Map was thus prepared on a scale of 1:50,000, using available information. Land classification was based mainly on LRMP's Land Systems' Maps (LRMP 1986c) and field visits.

The map provides basic information on landform, soil types, dominant textures, depth of water tables, drainage patterns, geology, and climate. Moreover, it gives valuable information on specific management limitations and opportunities for sustainable use for each land unit. Four major land system units were identified in the project and were designated as A, B, C, and D on the map (Table 6).

7. LAND-USE ADJUSTMENT MAP

The Land-use Adjustment Map provides information on use conditions, e.g., overuse, underuse, or use within the land capacity but requiring soil conservation measures. Such information is, therefore, essential to

watershed planners in order to make decisions about future land use, adjustment needs, conservation measures, and/or possible resettlement on public lands.

The land-use adjustment map was prepared on a scale of 1:50,000 by superimposing the present land-use map on the land capability map, with the help of GIS.

The criteria for Land-use Adjustment and the areas under different use conditions are shown in Tables 7 and 8 respectively.

Table 6: Distribution of Major Land System Classes

	Land System Unit	Area in Hectare	%
A	Alluvial Plains and Fans (Depositional)	1525.7	7.2
B	Ancient Lakes and River Terraces (Erosional Tars)	1520.3	7.2
C	Moderately to Steeply Sloping Mountain Terrain	13440.1	63.4
D	Steeply to Very Steeply Sloping Mountain Terrain	4718.1	22.2
	Total	**21204.2**	**100.0**

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

Table 7: Criteria for Land-use Adjustment

	Present Land Use	Land Capability Classes			
		I	II	III	IV
T	Terraces (*Khet*)	W	W	W	O
L	Terraces (*Bari*)	W	W	W	O
F	Alluvial Plan (*Khet*)	W	W	W	O
A	Abandoned Land	W	W	W	O
G	Grass	U	U	U	U
Gs	Grassland with Shrubs	U	U	W	O
R	Settlements	U	U	W	O
->	Landslides	O	O	W	W
C	Coniferous	O	O	O	O
H	Hardwoods	U	U	W	W
M	Mixed-woods	U	U	W	W
S	Shrubs	U	U	W	W

Source: SIWDP Consultant

W: Use within land capacity; soil conservation treatment necessary
W: Use within land capacity; soil conservation treatment not necessary
O: Seriously overused
O: Overused
U: Underused

Table 8: Areas under Different Use Conditions

Use Conditions	Area (ha)	%
W	11165.9	52.7
W	6234.9	29.4
O	354.2	1.7
O	1445.8	6.8
U	2003.4	9.4
Total	**21204.2**	**100.0**

Source: SIWDP Surveys and MENRIS/ICIMOD Analyses

8. RECOMMENDATIONS

A number of recommendations for better planning and management of the SIWDP area are given below.

i. For smaller project areas, such as the SIWDP area (total area approximately 212sq.km.), it is recommended that land-use comparison studies should be carried out with large-scale photographs and base maps, preferably on a scale of 1:5,000. Large-scale photographs and maps would improve the accuracy of the results and would provide better resolutions also.

ii For the present land-use study, the project should obtain new photographs on a scale of 1:5,000, covering the entire watershed area, including the buffer zone. Such large-scale photographs would be desirable not only for the land-use comparison study, but also for the other natural resource studies such as land capability, land systems, hydrology, geology, erosion hazard analysis, etc. It is also advised that a new set of topographic maps, based on the new photographs on a scale of 1:5,000, should be prepared. The recommended contour intervals are one metre for hilly areas and five metres for flat areas. The new set of topographic maps should contain all the administrative boundaries, including Village Development Committee and Ward boundaries.

iii. If the new set of base maps is prepared, the present problems of data interpretation, data transfer, orientation, and area measurement would be reduced significantly, thereby improving the accuracy of the results. Moreover, this would save a considerable amount of time and expedite the project activities.

iv. During field visits, it was found that the SIWDP boundary followed neither definite geographic features nor administrative boundaries. It is, therefore, recommended that the project boundary (especially the buffer zone boundary) should be demarcated on the basis of geographic features and/or the administrative boundary. This would facilitate planning, monitoring, management, and implementation of project activities.

9. CONCLUSIONS

Land use is dynamic in the Shivapuri Watershed Area and significant gains and losses were observed in all major land-use categories. The most important are described here.

i. The area under forest cover has increased significantly, but the increase has occurred exclusively in shrubland, grassland, and grassland in association with shrubs. This is an indication of improvement in the total biomass reserve and is also likely to have benefits in terms of slope stability.
ii. About 94 per cent of all agricultural land has remained in the same class. However, there has been a significant loss in level terraces *(bari)* to abandoned land, especially in the area within the boundary wall of the project.

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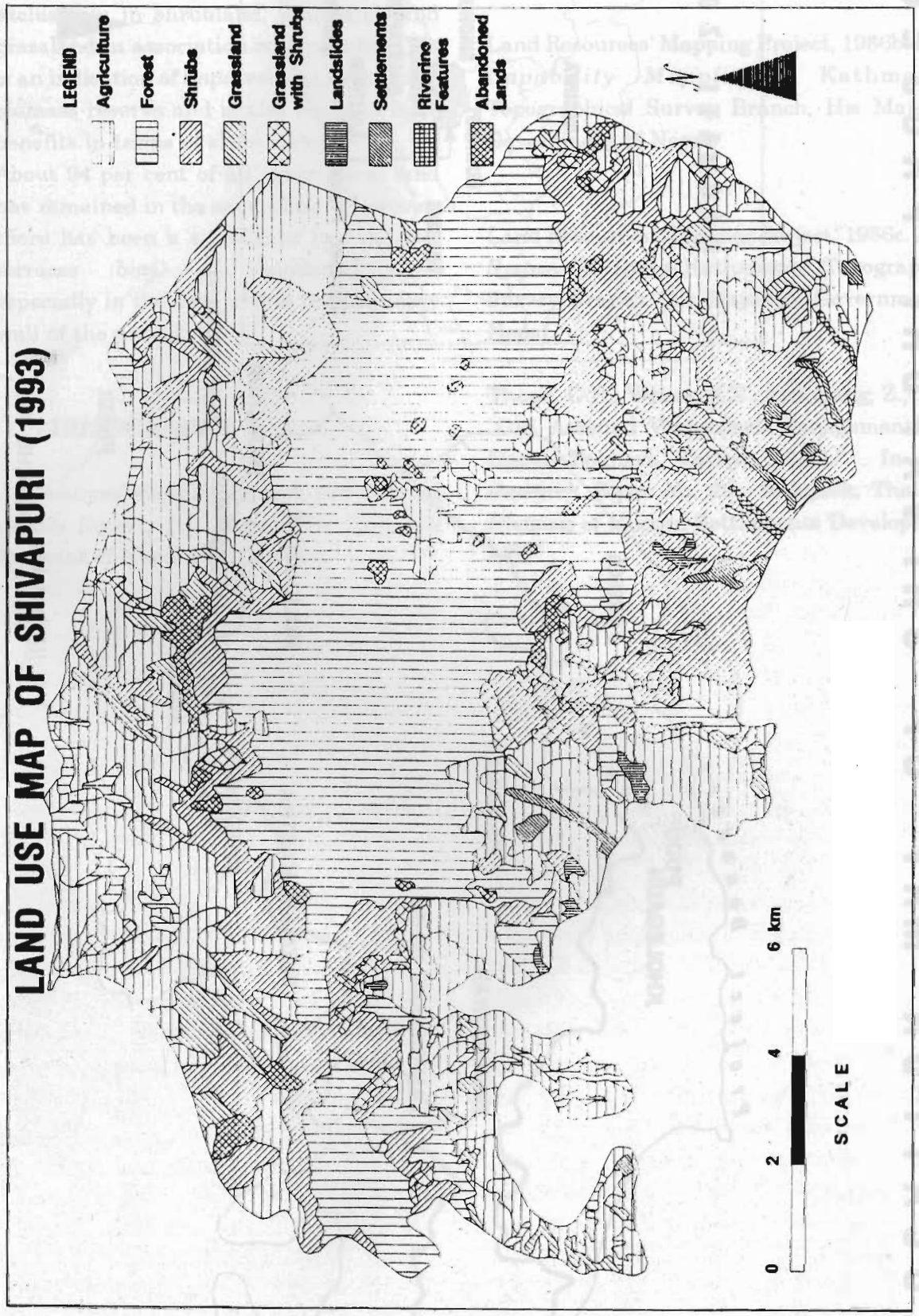
LOCATION MAP OF SHIVAPURI PROJECT

ICIMOD
MENRIS '94


LAND USE MAP OF SHIVAPURI (1993)
LEGEND
Agriculture
Forest
Shrubs
Grassland
Grassland with Shrubs
Landslides
Settlements
Riverine Features
Abandoned Lands
N
SCALE
0
2
4
6 km

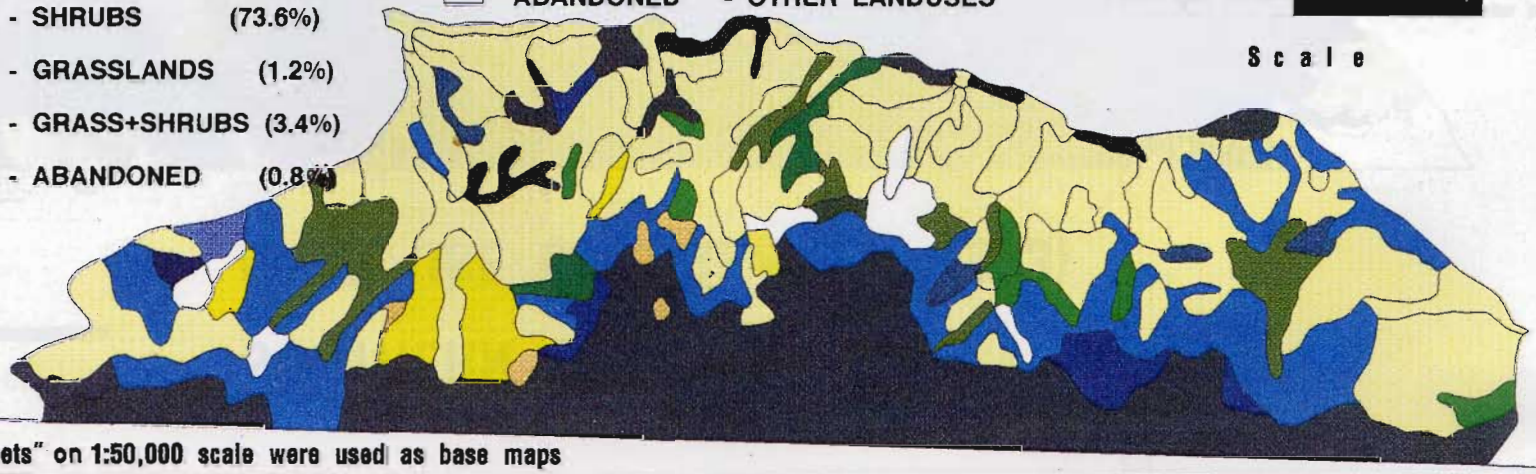
NORTHERN SHIVAPURI
LAND USE CHANGE (1981-1993)

From 1981 - To 1993

- AGRICULTURE - AGRICULTURE (93.7%)
- AGRICULTURE - FORESTS (0.5%)
- AGRICULTURE - SHRUBS (0.2%)
- AGRICULTURE - GRASSLANDS (0.0%)
- AGRICULTURE - GRASS+SHRUBS (0.2%)
- AGRICULTURE - ABANDONED (5.4%)
- FORESTS - AGRICULTURE (0.4%)
- FORESTS - FORESTS (97.3%)
- FORESTS - SHRUBS (1.8%)
- FORESTS - GRASSLANDS (0.0%)
- FORESTS - GRASS+SHRUBS (0.4%)
- FORESTS - ABANDONED (0.1%)
- SHRUBS - AGRICULTURE (0.2%)
- SHRUBS - FORESTS (20.8%)
- SHRUBS - SHRUBS (73.6%)
- SHRUBS - GRASSLANDS (1.2%)
- SHRUBS - GRASS+SHRUBS (3.4%)
- SHRUBS - ABANDONED (0.8%)
- GRASSLANDS - AGRICULTURE (15.9%)
- GRASSLANDS - FORESTS (15.5%)
- GRASSLANDS - SHRUBS (13.0%)
- GRASSLANDS - GRASSLANDS (48.7%)
- GRASSLANDS - GRASS+SHRUBS (4.6%)
- GRASSLANDS - ABANDONED (2.3%)
- GRASS+SHRUBS- AGRICULTURE (3.4%)
- GRASS+SHRUBS- FORESTS (16.1%)
- GRASS+SHRUBS- SHRUBS (29.7%)
- GRASS+SHRUBS- GRASSLANDS (2.9%)
- GRASS+SHRUBS- GRASS+SHRUBS (47.5%)
- GRASS+SHRUBS- ABANDONED (0.4%)
- ABANDONED - OTHER LANDUSES

0.0 2.5 5.0 km

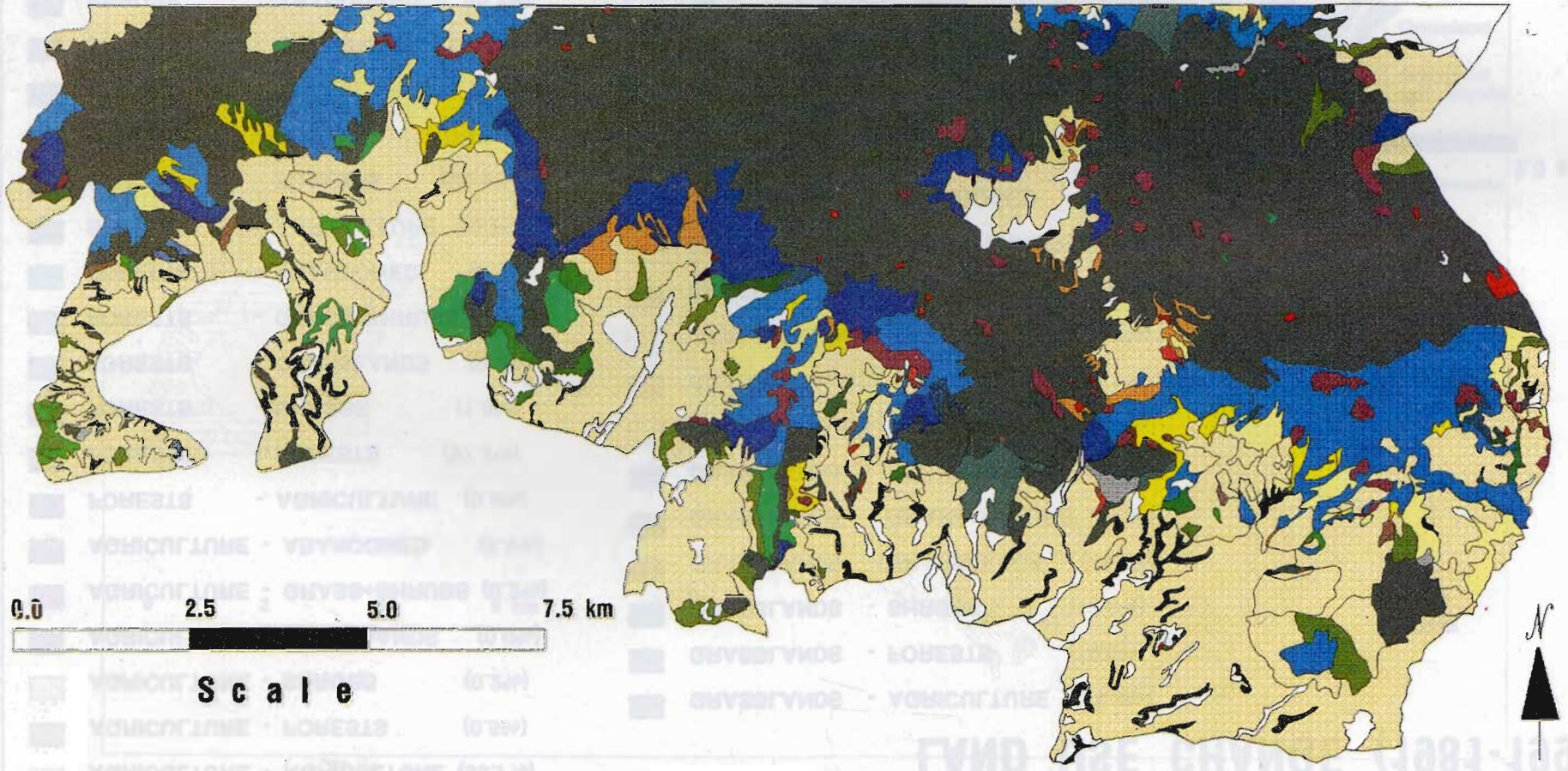
Scale



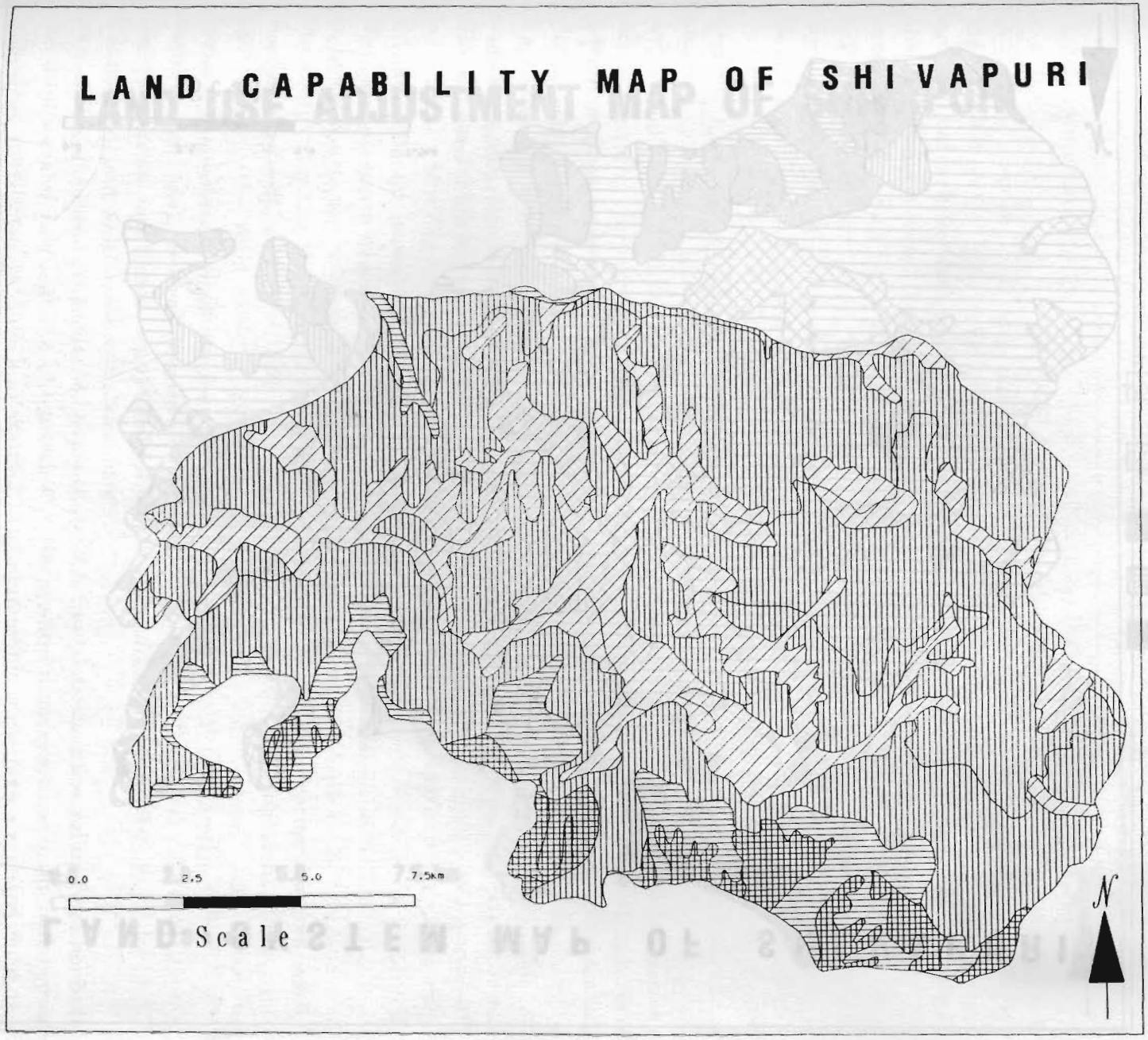
NOTE- "Indian Topo Sheets" on 1:50,000 scale were used as base maps

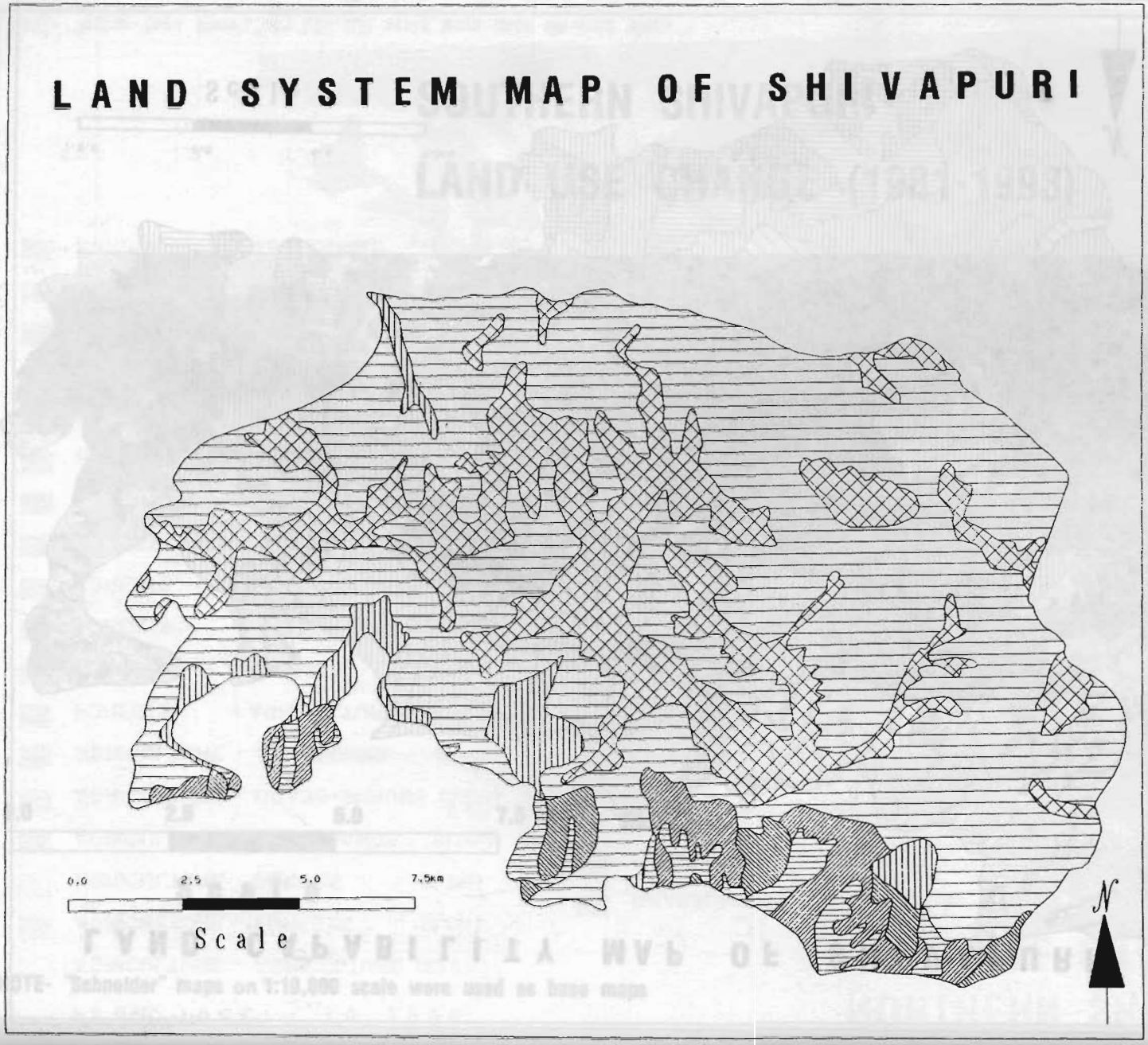
SOUTHERN SHIVAPURI

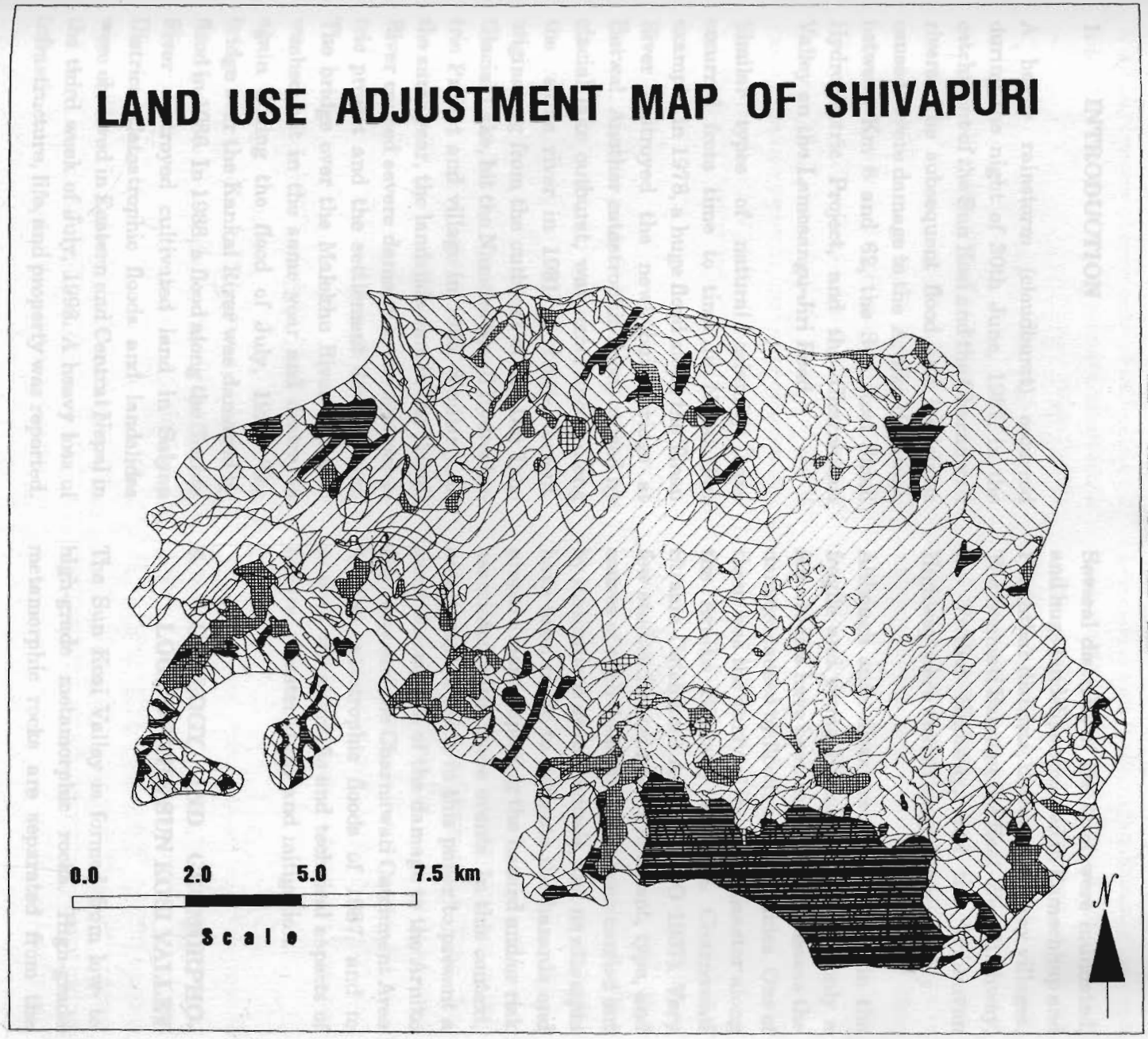
LAND USE CHANGE (1981-1993)



NOTE- "Schneider" maps on 1:10,000 scale were used as base maps


LAND CAPABILITY MAP OF SHIVAPURI
LEGEND
Class I = Slope <1 deg.
Soils are deep.
Few Limitations to agri./forestry
Class II = Slope 1-5 deg.
Soils deep and well drained.
Terracing necessary for agri.
Class III = Slope 5-30 deg.
Soils 50-100 cm deep.
Land for fodder prod./grazing
Class IV = Slope >30 deg.
Soils > 20 cm deep.
Land for fuelwood/fodder/timber prod
0.0
2.5
5.0
7.5km
Scale
N


LAND SYSTEM MAP OF SHIVAPURI
LEGEND
A1: River Channel
A2: Alluvial Plains
A3: Alluvial Fans
B1: Non-Dissected Erosional Tars
B2: Dissected Erosional Tars
C: Moderately/Steeply Sloping Mnt. Terrain
D: Steeply/V. Steeply Sloping Mnt. Terrain
0.0
2.5
5.0
7.5km
Scale
N


LAND USE ADJUSTMENT MAP OF SHIVAPURI
LEGEND
Use witin capability; Soil conserv. necessary
Use within capability; Soil conserv. not necessary
Seriously over used
Over used
Under used
0.0
2.0
5.0
7.5 km
Scale
N