CHAPTER - 3

CATCHMENT AREA TREATMENT PLAN

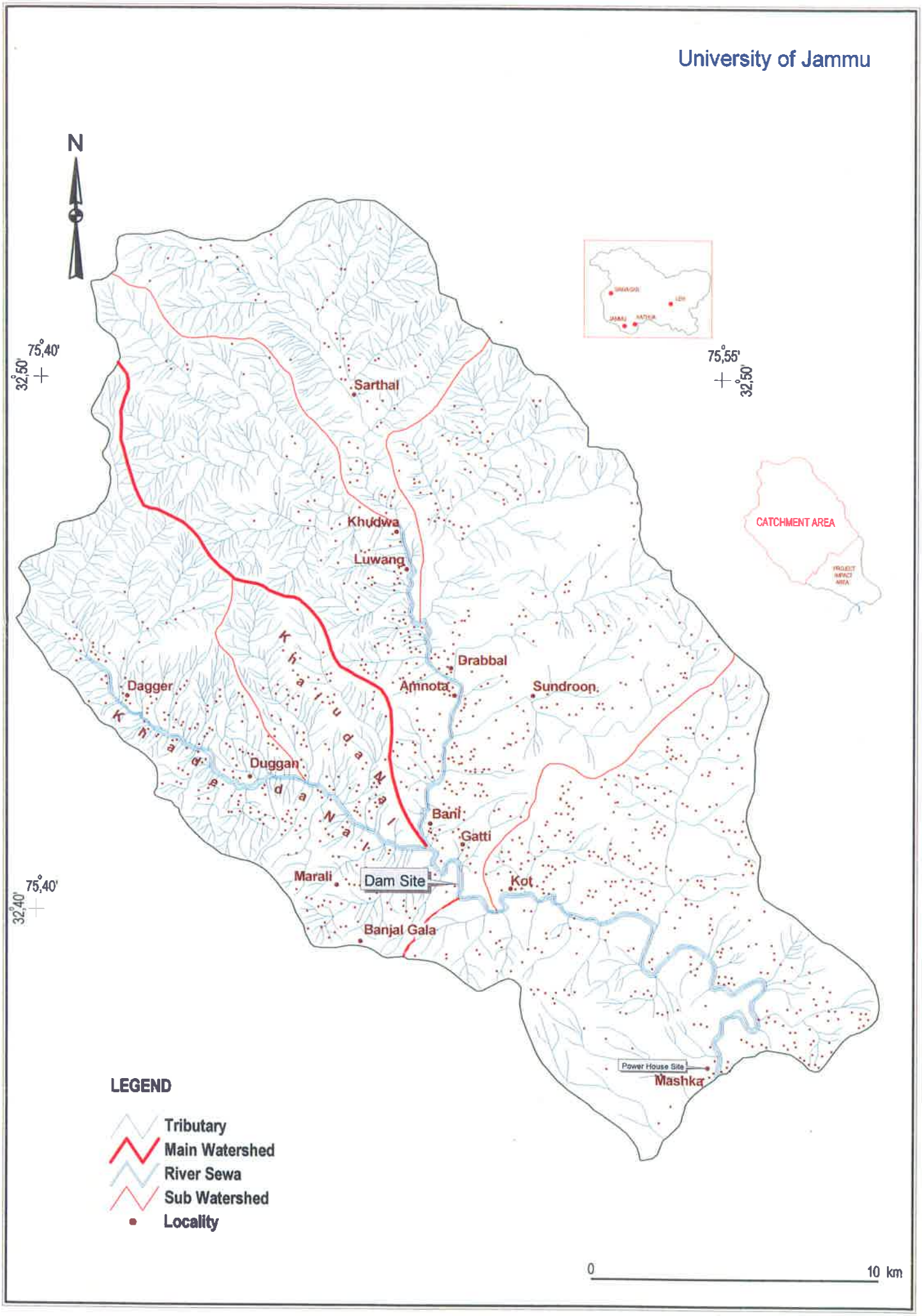


Fig 3.1 - Drainage Map of Sewa river basin

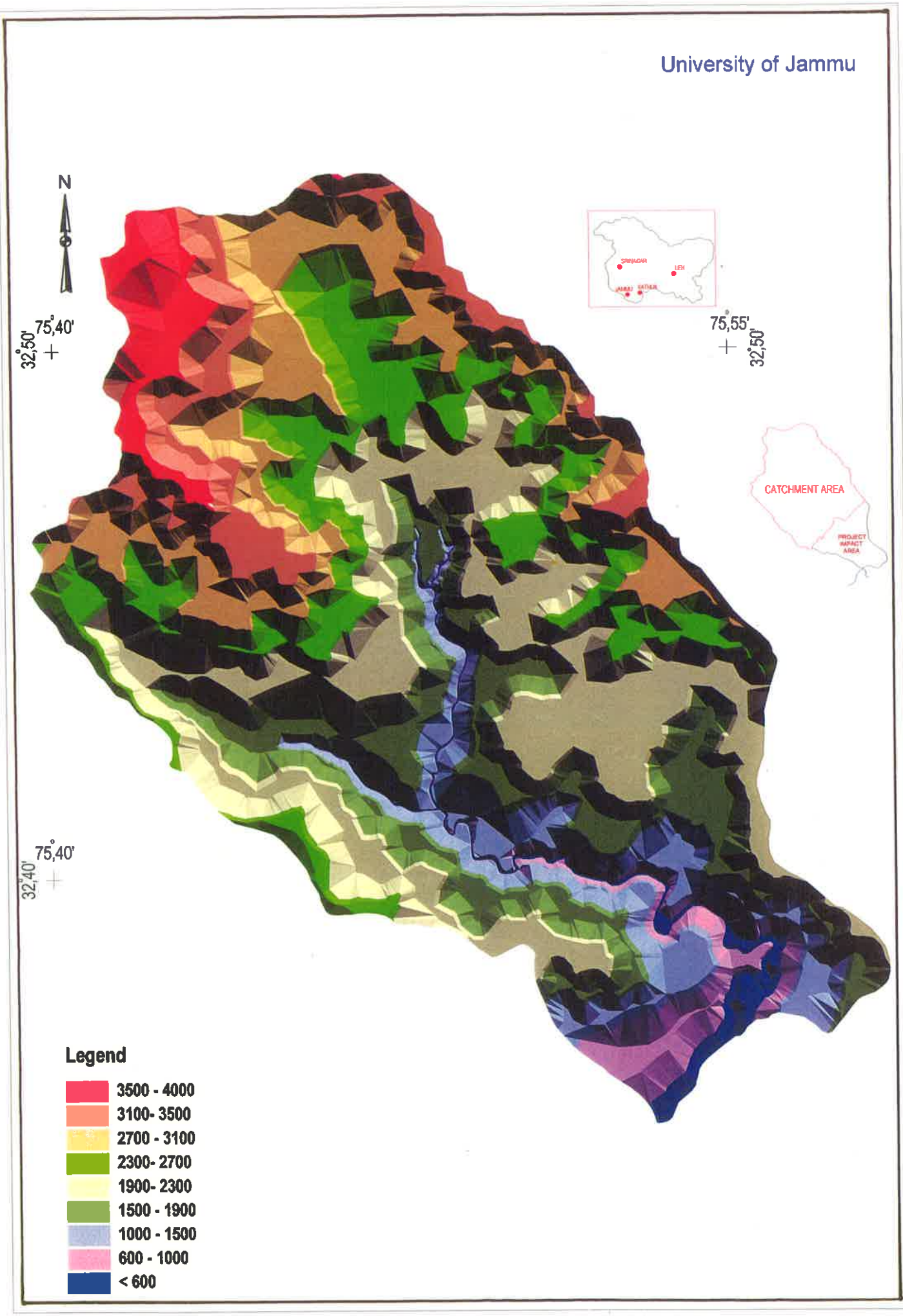


Fig 3.1a Digital Elevation Model of Sewa River basin

3: CATCHMENT AREA TREATMENT PLAN

3.1: INTRODUCTION

The issue of environmental concern and protection caught the attention of the world nations since the United Nations Human Environment Conference (UNHEC) was held at Stockholm (Sweden) in 1972. Most of the nations particularly the developed ones including India have adopted the issue as a basic state policy, linking economic and social construction to synchronise with it both the planning and implementation stages.

The ever-increasing world population, urbanisation and industrialisation are incrementally exerting constraints on the natural resources. As most of the easily accessible mineral, fossil fuel, geothermal and biological resources are near depletion; the man's focus has shifted to the ocean floors, the polar continents and the deep-seated resources in the earth's crust. Besides, focus has also shifted to the exploitation of water resource to cater to the increased demands of energy, irrigation and water supply. Consequently a number of hydroelectric projects are coming up in different parts of the country. These developmental projects lead to urbanisation and industrialisation in the country imposing social and physical strains, and subsequently disturb the delicate local and regional ecological equilibrium; resulting in floods, land subsidence, ground water pollution, induced seismicity, landslides, sinkholes, soil degradation, etc. Some of these processes active in the catchment area of a project ultimately exert pressure on the reservoir capacity by producing and supplying the sediments through drainage network. Associated with this menace is a series of problems e.g., depletion of flow capacity, steady loss of storage capacity, consistent drop in hydroelectric power generation and frequent floods, which incur heavy economic losses. In order to increase the life span of the reservoirs and reduce the economic losses, watershed management and soil conservation plans need to be formulated for the catchment areas.

For the catchment area treatment and soil conservation programmes watershed is chosen as the basic unit for implementation of the plan. Watershed is a natural hydrological and geographic unit of specific spatial extent characterised by surface run-off confined to a defined course at a particular point. The boundary of the watershed is delineated by the line of water divide in a basin with reference to specific point drainage. The pre-requisite for a watershed management is the collection of multipronged data e.g., geology, geomorphology, topography, soil, landuse/landcover, climate, hydrology, drainage pattern, etc. The catchment of the Sewa Hydroelectric Project, Stage II consists of six watersheds having 36 micro-watersheds covering an area of 36,475 ha. The multipronged data generated from various published sources and actual data collected from these micro-watersheds on the above-mentioned parameters forms the basis of the Action Plan for Catchment Treatment Plan presented here.

3.2: AIMS AND OBJECTIVES

The main aim of the Catchment Area Treatment Plan is to rejuvenate various potential and degraded ecosystems in the catchment area (Fig. 3.1 & 3.1a) for longevity of the reservoir storage capacity. For this purpose the Action Plan has been prepared with the following objectives:

1. To facilitate the hydrological functioning of the catchment and to Augment the quality of water of the river and its tributaries.
2. Conservation of soil cover and to arrest the soil erosion, floods and siltation of the river and its tributaries and consequent reduction of siltation in the reservoir of the project.
3. Demarcation of the priority of watersheds for treatment on the basis of soil erosion intensity in the catchment area.
4. Rehabilitation of degraded forest areas through afforestation and facilitating natural regeneration of plants.
5. Mitigation of landslide, landslip and rock falls.

3.3: Methodology

Detailed field survey was conducted for study of soil characteristics, and erosion prone areas and landslides in the catchment area. The vulnerable and problematic areas were identified in different physiographic zones (Fig. 3.2) in the entire catchment area. The data was generated on physiography, landuse/landcover, lithology, structure, drainage pattern, slope characteristics, landslides/slips, etc. These data sets were used for preparation of the thematic maps, calculation of sediment yield index and Erosion Intensity Units in the catchment area according to the following procedures:

3.3.1: Preparation of Thematic Maps

Landuse and landcover (Fig. 3.3) mapping was carried out by standard methods of analysis of remotely sensed data and followed by field data collection, and visual interpretation of satellite data. The Survey of India toposheets at 1:50,000 scale were used for the delineation of watersheds of the Sewa River catchment (Fig. 3.4). These sub-watersheds were then interpolated on the drainage, physiographic and landuse/landcover maps of the catchment area in order to extract the drainage and landuse of the respective sub-watersheds. The different thematic layers of Sewa River catchment i.e., base map, physiographic, drainage and landuse/land cover maps were then transferred to Geographic Information system (GIS) using 'Arc View GIS 3.2 a' software for further analysis.

3.3.2: Sediment Yield Index

Methodology for the calculation of sediment yield index developed by All India Soil & Land Use Survey (Department of Agriculture, Govt. of India) was followed in this study. Each element of erosion intensity unit is assigned a weightage value. The cumulative weightage values of the erosion intensity units represent approximately the relative comparative erosion intensity within the watersheds. A basic factor of K = 10 was used in determining the cumulative weightage values. The

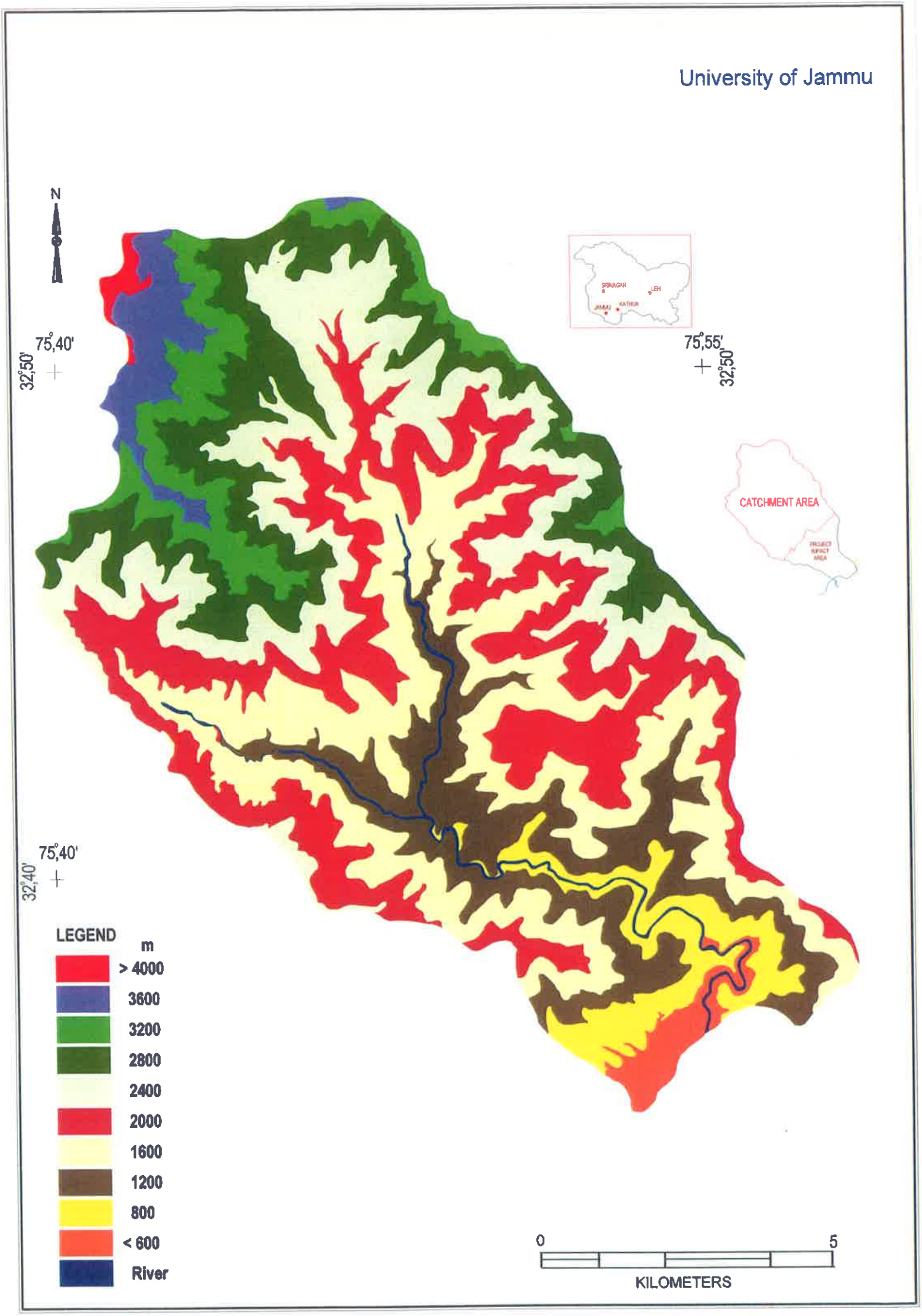


Fig. 3.2- Physiographic Map of Sewa river basin

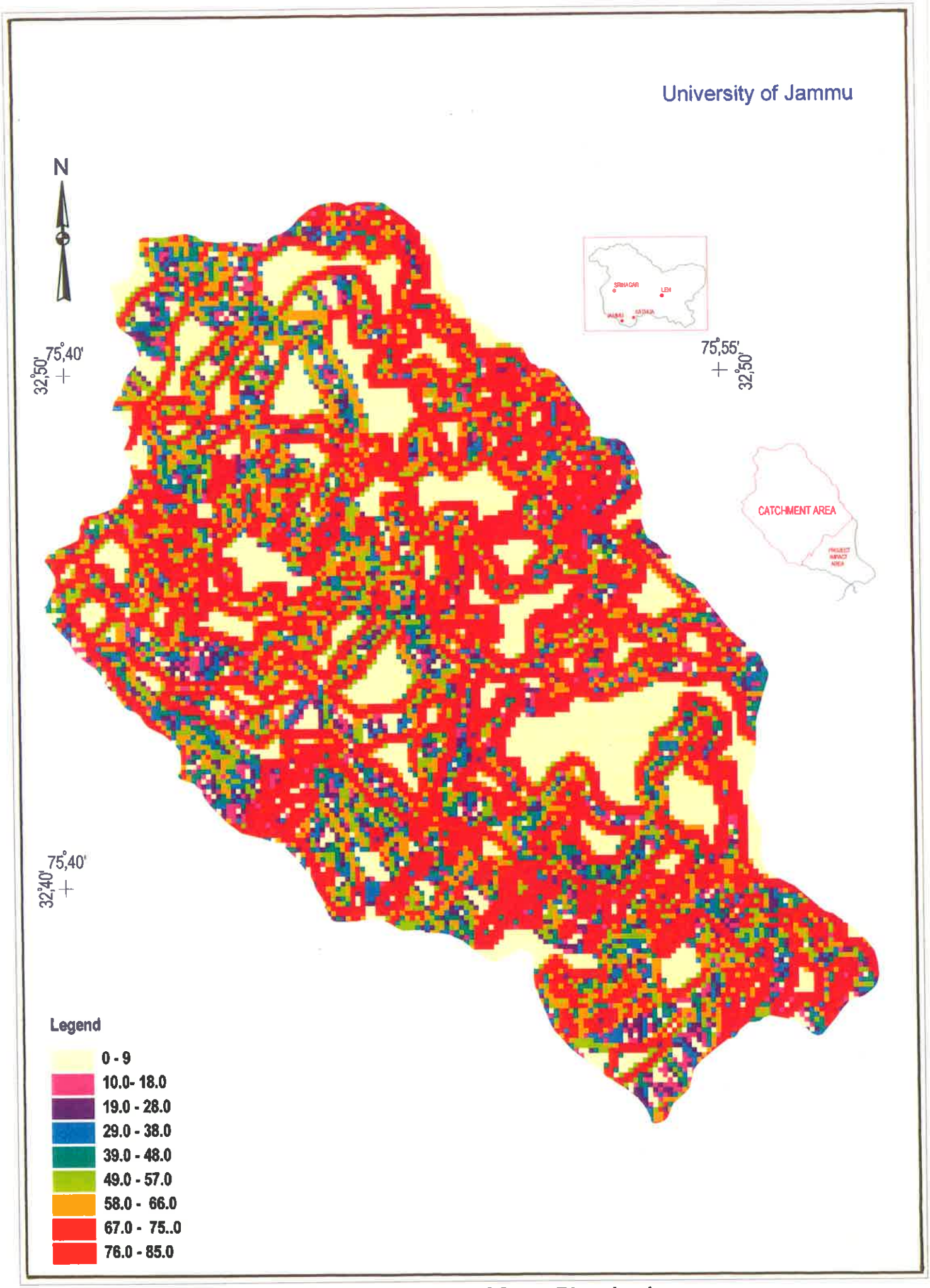


Fig 3.2a Slope Index Map of Sewa River basin

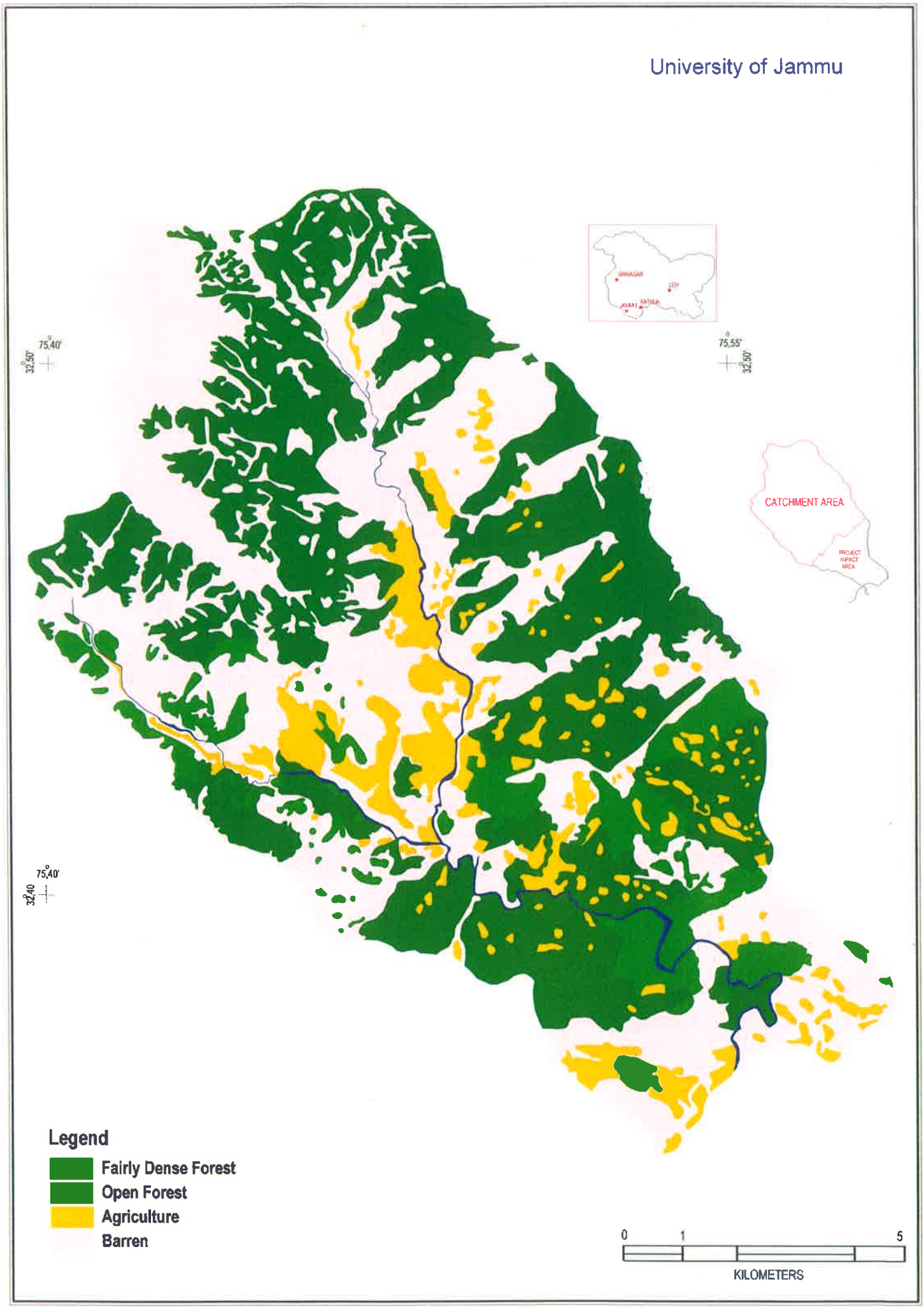


Fig.3.3 - Landuse / Landcover Map of Sewa river basin

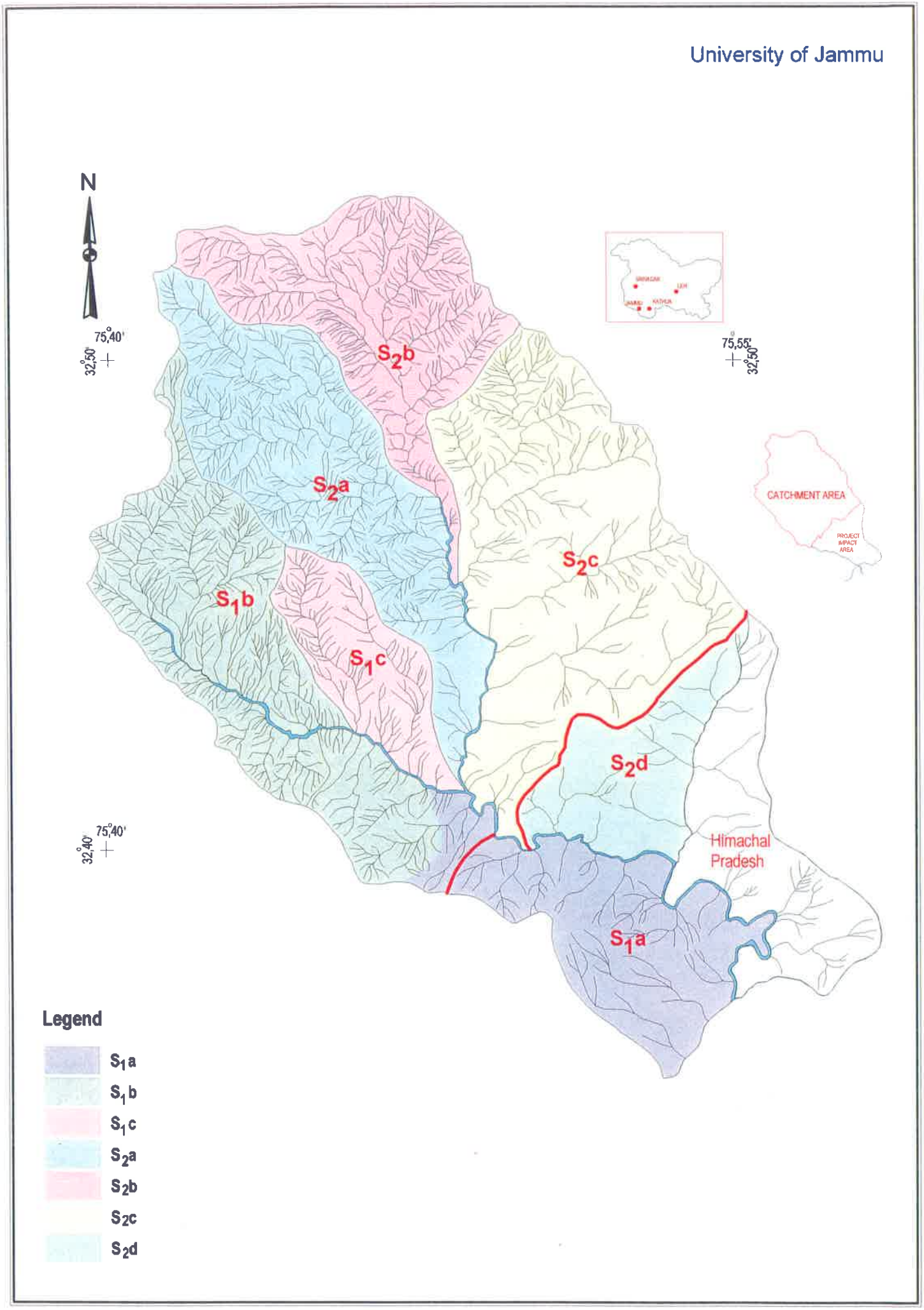


Fig. 3.4 - Watershed Delineation Map of Sewa river basin

value of 10 indicates an equilibrium condition between erosion and deposition. Any value of K (10+X) is suggestive of erosion intensity in an ascending order whereas the value of K (10-X) is suggestive of deposition intensity in descending order.

The delivery ratios were calculated for each composite erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into the reservoir or river/stream. Total area of different erosion intensity classes (composite erosion intensity unit) in each watershed was then calculated.

Sediment yield index (SYI) was calculated using the following empirical formula.

$$SYI = \frac{E(A_{ei} \times W_{ei} \times DR)}{AW} \times 100$$

Where,

SYI = Sediment yield index

A_{ei} = Area of composite erosion intensity unit

W_{ei}= Weightage of composite erosion intensity unit

DR = Delivery ratio

AW = Total area of the watershed

3.3.3: Erosion Intensity and Delivery Ratio

Determination of erosion intensity unit is primarily based upon the integrated information on soil characters, physiography, slope, landuse/landcover, lithology and structure. This is achieved through super-imposition of different thematic map overlays. Based upon the field data collected during the field survey and published data, weightage value and delivery ratio were assigned to each erosion intensity unit. A complete legend for composite erosion intensity mapping unit is given in the following pages: -

The delivery ratio is generally governed by the type of material, soil erosion, relief length ratio, cover conditions, distance from the nearest stream, etc. However, in the present study the delivery ratios to the erosion intensity units were assigned

upon their distance from the nearest stream (being the most important factor responsible for delivery of the sediments) according to the following scheme.

Nearest Stream	**Delivery Ratio (DR)**
0 - 0.9 km	1.0
1.0 - 2.0 km	0.90
2.1 - 5.0 km	0.85
5.1 - 15.0 km	0.70
15.1 - 30.0 km	0.50

Accordingly the sediment yield Index (SYI) was calculated for 6 watersheds and were categorized into five erosion ranking classes i. e., very severe (VS), 'severe (S), moderate (M), slight to moderate (SM) and negligible (N) according to priorities (Fig. 3.5). These prioritised watersheds would require treatment according to their priority ranking for soil conservation measures.

Ranks of different elements responsible for degradation of the catchment area

Rank	Lithology	Landuse/Landcover	Slope Range	Structure
1	Granite/Quartzite	Dense Forest	$<15^0$	Foliation
2	Sandstones	Open Forest	$15\text{-}30^0$	Joints
3	Limestones	Cultivated area	$30\text{-}45^0$	Master joints
4	Slate	Barren	$45\text{-}60^0$	Shear Zones
5	Shale	Landslides/Land slips	$> 60^0$	Faults

Criteria adopted for assigning the delivery ratio

Distance	**Delivery Ratio**
0-0.9	1.0
1.0 – 2.0	0.95
2.1 – 5.0	0.90
5.1 – 15.0	0.80
15.1 – 30.0	0.70

Legend for Composite Erosion Intensity Unit

Erosion **Intensity Unit**	Slope	Landuse/ **Landcover**	Weightage

Very Severe (VS)	$>60^0$	Degraded forest, open forst, scrub	20/0.95
Severe (S)	$45\text{-}60^0$	Degraded forest, open forest, scrub cultivation	18/0.90
Moderate (M)	$30\text{-}45^0$	Dense forest, open forest, cultivation	15-16/0.90
Slight to moderate (SM)	$30\text{-}15^0$	Dense forest, open forest	13/0.85
Negligible (N)	$<15^0$	Dense forest, open forest, cultivation	11/0.70

Computation of Silt Yield Index

Watershed code	Erosion intensity	Area (Ha)	Weightage	Area x Weightage	DRY	Gross Silt	Sediment yield Index
S1a	VS	-	-	-	-	-	-
	S	175	18	1350	0.90	1215	-
	M	572	15	7830	0.90	7047	-
	SM	574	13	7137	0.85	6066	-
	N	1129	11	10769	0.70	7538	-
Total		**2450**				**27086**	**1275**
S1b	VS	-	-	-	-	-	-
	S	84	18	1512	0.90	1361	-
	M	1844	15	27660	0.90	24893	-
	SM	1224	13	15912	0.85	13525	-
	N	3273	11	36003	0.70	25202	-
Total		**6425**				**64961**	**1011**
S1c	VS	-	-	-	-	-	-
	S	-	-	-	-	-	-
	M	228	16	3648	0.90	3283	-
	SM	1328	13	17264	0.85	14674	-
	N	1394	11	15334	0.70	10734	-
Total		**2950**				**28691**	**973**
S2a	VS	524	20	10480	0.95	9956	-
	S	83	18	1494	0.90	1345	-
	M	1782	16	28512	0.90	25661	-
	SM	481	13	6253	0.85	5315	-
	N	4655	11	51205	0.70	35844	-
Total		**7525**				**78121**	**1038**

S2b	VS	39	20	780	0.95	741	-
	S	1495	18	26910	0.90	24219	-
	M	688	15	10320	0.90	9288	-
	SM	768	13	9984	0.85	8486	-
	N	3210	11	35310	0.70	24717	-
Total		**6200**				**67451**	**1088**
S2c	VS	1213	20	24260	0.95	23047	-
	S	728	18	13104	0.90	11794	-
	M	259	16	4144	0.90	3730	-
	SM	3591	13	46683	0.85	39681	-
	N	5134	11	56474	0.70	39532	-
Total		**10925**				**117784**	**1078**

3.4: Slope

The slope of a watershed plays an important role in controlling the soil and water retention thereby affecting the landuse capability. The percentage of the slope in a watershed determines the soil erosion susceptibility and forms the basis for classifying different segments of the watershed into suitable capability classes for formulating suitable soil erosion conservation measures. Broadly the following slope classes and ranges as per norms of All India Soil & Land Use Survey were adopted for the present study.

Slope Rank	Slope Range	Description
1	$<15^0$	Gently Sloping
2	$15\text{-}30^0$	Moderately Sloping
3	$30\text{-}45^0$	Steeply Sloping
4	$45\text{-}60^0$	Very Steeply Sloping
5	$> 60^0$	Very Very Steeply sloping

The slope model for entire Sewa HE Stage II Project area was generated from the contours of survey of India toposheets at 1:50,000 scale following a 100 m contour interval. The contours were traced from the toposheets and then scanned and digitised using GeoVec. From the digital data, Digital Elevation Model (DEM) for the entire project area along with other catchments was also generated using Intergraph MGE Terrain Analyst. Thereafter the TIN models for all the constituent catchments of the project area were generated. Similarly thematic maps for

elevation-relief and aspects were also generated. The area for each slope category was calculated for all the constituent catchments. More than 50% of the constituent catchments of the Sewa HE project area fall under steep to very steep slope categories (Fig. 3.2a).

3.5: Aspect Map

The Digital Elevation Model (DEM) formed the basis for generation of aspect map. Majority of the mountain slopes and tops are flat and account for about 30% of the aspects. The north facing slopes between $0\text{-}22.5^0$ and $337.5\text{-}360^0$ constitute about 5% of the slopes. The northeast aspect between $22.5 - 67.5^0$ cover about 10% of the slopes, while the east aspect between $67.5\text{-}112.5^0$ form about 15%, the southeast aspect bounded by $112.5\text{-}157.5^0$ covers about 7%, the south aspect between $157.5\text{-}202.5^0$ covers about 13% of the slopes, the southwest aspect between 202.5-247.50 covers about 8% of the lopes, the west aspect between $247.5\text{-}292.5^0$ covers about 7% of the slopes and the remaining 5% of the slopes is covered by the northwest aspect between 292.5-337.50. The different aspects of the catchment area are given in Figure 3.5a.

3.6: PHYSIOGRAPHY AND RELIEF OF THE SEWA BASIN

Physiographically the area is hilly and rugged mountainous terrain with narrow inter-mountains valleys (Fig. 3.2). The tract forms a part of Lesser Himalayan Mountains. The ridges have sharp summits and steep slopes.

The prominent physiographic feature of the area is the rugged, snow covered mountain ranges, cut into precipitous ridges and deep defiles. The general trend of the ranges is NW-SE. The elevation ranges from 578m at Mashka to above 4200 m Kaplas peak. The young and immature topography conform to the Himalayan orogeny. Raised terraces, deep gorges and rocky cliffs are the characteristic features of the area. The Sewa River rising from the southeastern slopes of the mountain ranges around the Chattar Pass area is fed by a number of perennial streams on

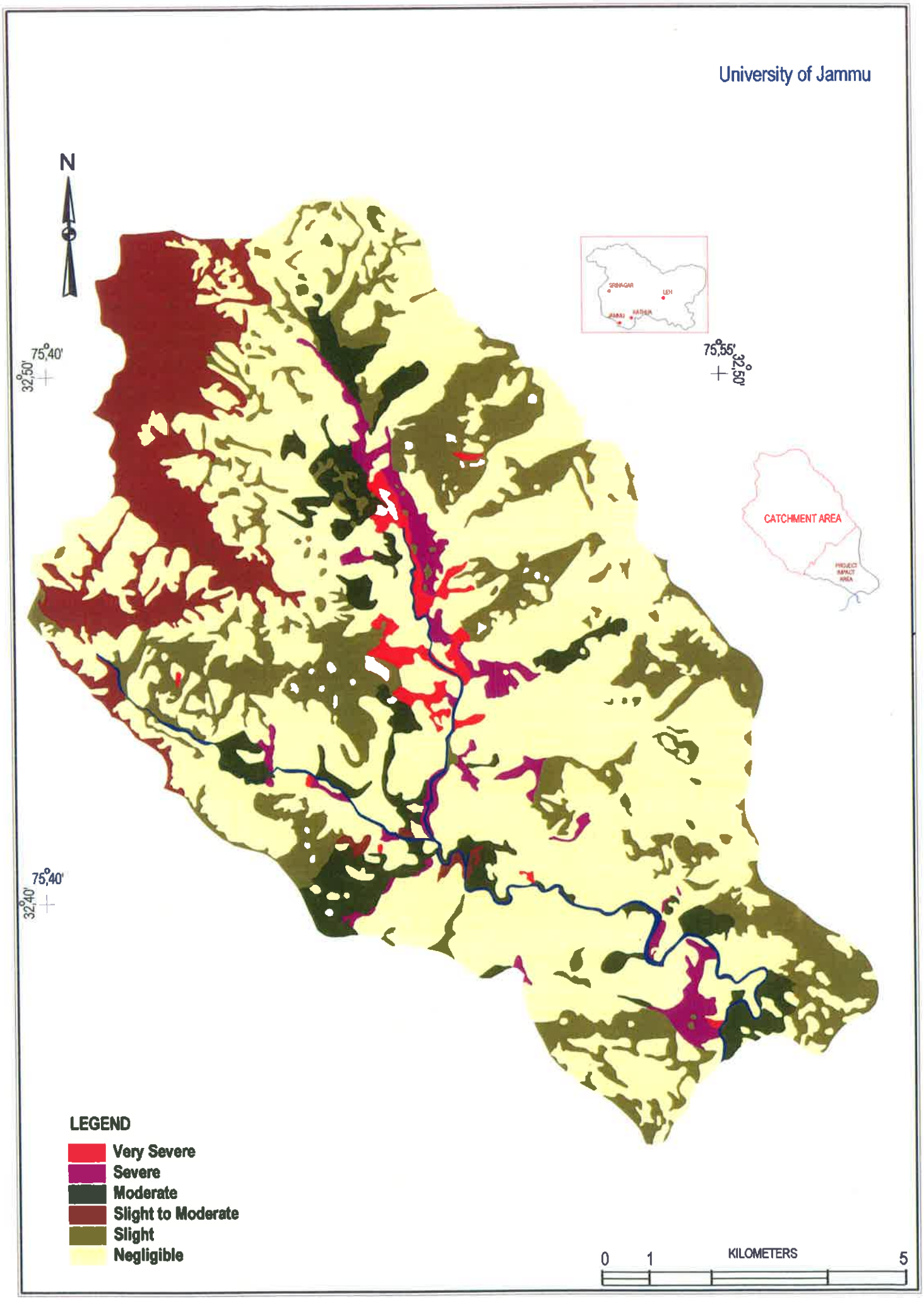


Fig. 3.5 Degradation / Erosion Intensity Catogary Map of Sewa river Basin

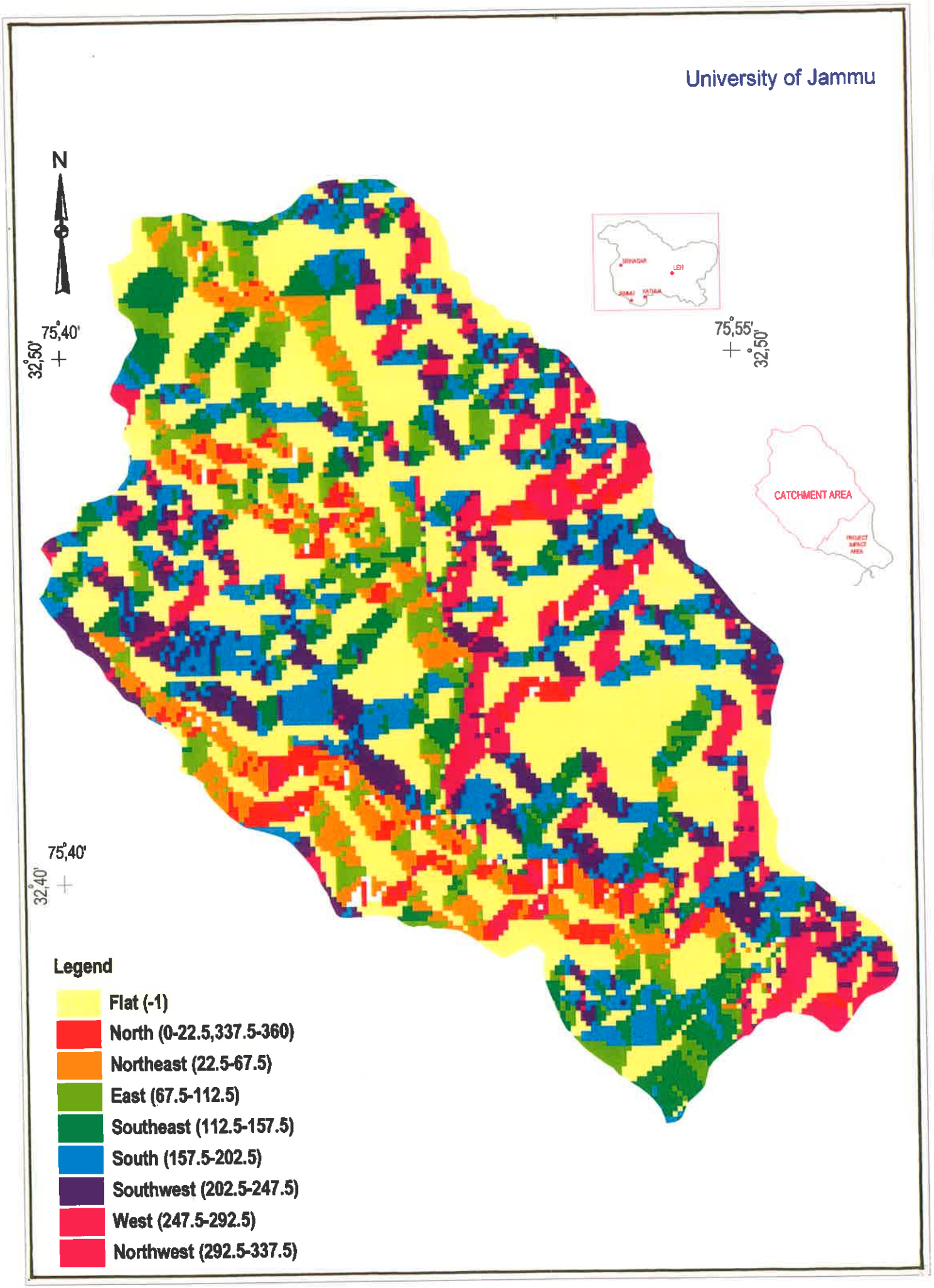


Fig 3.5 a Aspect Map of Sewa River basin

either side through its 53.36 km course. On either side of the river topography is divergent. The banks of the river are characterised by steep, rocky and vertical escarpments. The gentle slopes on either side of the river are covered with overburden and slope wash deposits. The colluvial and alluvial deposits are gently sloping towards the valleys of the Sewa River and its tributaries. River terraces are present intermittently all along the river course and its tributaries. Overall the whole area is topographically rugged and cut into deep ravines and deep gorges at places. The high hills have slopes more than 50^0 and sometimes reach upto 85^0.

The entire catchment area of river Sewa is mountainous with rugged terrain and undulating topography. The area in general stores evidence of recent tectonics expressed by topographic features of prominent relief. The roughly N-S trending steep, mostly longitudinally anticlinal hill ranges and synclinal valleys with a series of topographic highs impart the physiographic expression of the area. The other geomorphic elements include ridges with the formation of deep gorges and spur, which have developed due to intensive erosion during isostatic adjustments. The Sewa River is perennial, of which initial 23 km have a steep slope of 1: 8 while the remaining part has a mild slope of 1: 40.

Geologically the rocks of the catchment area are of contrasting lithologies, structure, geomorphology and competence. The mass denudation of these rocks is governed by freeze-thaw mechanism on the one hand and erosion. The streams and the river during the rainy season transport these materials and the ones produced by landslides and avalanches. Another important factor at work seems the neotectonics which destabilise the already vulnerable slopes and which get accentuated by the percolation of rainwater and lead to the slides and slips in the catchment area. Because of inhomogeneity of lithology and structure sediment yield is considerably high and therefore the sediment transport s is also high in the catchment. The river has ferocious and torturous flow and has escarps and gorges in its course. The catchment area is hilly undulating with steep to very steep slopes and depressions. Few flat areas are there along the stream and the river courses. Few high-dissected ridges with deep gorges have developed due to erosion and the catchment area is covered with rills and

gullies of various lengths and sizes. The drainage and contour maps have been prepared.

3.7: RAVI BASIN

The Ravi River is one of the main tributaries of the Indus Water Resource Region. It rises in the mountains of the Bhangahal basin draining northern slopes of the Dhauladhar Range and southern slopes of the Pirpanjal Range. It leaves the basin through an inaccessible gorge with perpendicular sides and flows through Chamba in the northwesterly direction parallel to the Dhauladhar Range cutting through that range in a few kilometres to the northwest of Dalhousie. It leaves the mountains of Basoli after a course of 210 km during which it drops by 4570 m in altitude (22 m/km). It finally joins the Chenab at 30 31; 71 51 the total length upto this junction being 720 km. The river drains Panjab, J&K and Himachal Pradesh. The main tributaries contributing the run-off in this basin are Basantar, Tarnah, Ujh, Biani, Chiril and Sewa. These tributaries have mostly steep slopes and bring flash floods during the rains and remain dry for rest of the year.

3.8: SEWA RIVER DRAINAGE

The All India Soil and Landuse Survey Organisation, Govt. of India has divided the Sewa River catchment into two sub-catchments. The two sub-catchments 1CS1 and 1CS2 have been further dived into 3 and 8 watersheds respectively out of which seven watersheds fall in the State of Jammu and Kashmir (Fig. 3.4). These seven watersheds have been further divided into 47 micro-watersheds.

The Sewa Hydroelectric Project envisages utilisation of discharge of the Sewa River by constructing a dam near village Gatti ($42^0\ 31'\ 25''$; $75^0\ 44'\ 23''$), a 10.02 km tunnel, a surge shaft and a surface PH on the right bank of the river near the village Mashka ($32^0\ 37'\ 18''$; $75^0\ 55'\ 00''$). Sewa River rising from the southeastern slopes of the mountain ranges around the Chattar Pass area is fed by a number of perennial streams on either side through its 53.36 km course. Sewa River is a major right bank

tributary of Ravi draining a catchment of 381-km2 upto the dam site (Fig. 3.1). It originates at an altitude of 4200 m on southwestern slopes of the Chattar watershed and flows for about 53.36 km to meet the Ravi River at an elevation of 578 m. The major drainage pattern having different bifurcation ratio follow the north-south trending depression and gorges in the low level topography separated by highland topography in between them. The tributaries and river forming angular, sub angular, sub-parallel and dendritic drainage patterns run along the topographic depressions. The slopes of the tributaries, main nallas and the main river course are moderate to steep.

The Total catchment of the Sewa River has been divided into two sub-catchments (1C1 & 1C2), seven watersheds (S1a–S1c and S2a-S2d) and forty-seven micro-watersheds (S1a1, S1a2, ..., etc). The code numbers are in conformity with the All India Soil and Landuse Survey Organisation, Government of India. The bed level at the dam axis is 1178 m. The initial 23 km has steep slope of 1:8 while the remaining part has a slope of 1:40. The catchment is almost square shaped and the river flows diagonally through it. The catchment is located in hilly areas having steep to moderate basin slopes. The higher reaches of the catchment area are snow bound. In the upper region the area is partly covered with forests and remaining part represents bare rocky mountains. The slopes of the lower reaches are under the sporadic type of cultivation. The general climate of the catchment area varies from temperate to extreme cold.

The rocks are marked by a number of prominent master joints and foliation. Some joints cutting across the foliation have resulted in the formation of blocky structures at most of the places. The instability in the entire area has been activated by percolation of water during monsoons and toe cutting by the Sewa River. In addition steep slopes around the discontinuity planes are potential sites for landslides and rock falls in the area. Micro-folds and drag folds and shear zones have been noticed in the rocks suggesting disturbed rock conditions. Due to turbulent flow of the river and its tributaries during rains and flash floods,

boulders of large size are brought down along their courses forming pseudo-rapids.

The main tributaries of the Sewa catchment area are Khade da Nal flowing in the NW-SE direction and confluence at Sarthali with the Sewa. The Khade da Nal is fed by a number of perennial and ephemeral streams rising on either side of the mountain slopes all along its course. The prominent among them are the Tre Nali, Bari the Nal, Lorig nala, Duggan the Nal and Duggar the Nal emanating from the mountain ranges on the left bank catchment (watershed S1a). While the main streams arising on the slopes of the right bank catchment (watershed S1b and S1c) include Chiroge da Nal, Kothi da Nal and Daui da Nal. The right bank catchment area of the Khade da Nal is covered by thick vegetative cover while the left bank catchment is barren and is mostly under cultivation of rice and maize.

Two important streams which directly confluence with the Sewa River near the dam site are Gwar nala (micro-watershed S1a6) and Jaura da Nal (micro-watershed S1a5) which originate in mountain ranges of Ramrachan and Jaura. Thalangal and Naika nalas (micro-watershed S2c2) feed into the reservoir site at Gatti and Sarthali respectively. These nalas originate from the mountain range east of Bani town. Either slope of this mountain range is covered with vegetation. However, a number of patches have been cleared for agricultural purposes and has resulted in degradation of the slopes particularly the slope facing the east that is drained by the Naika nala.

The main nalas and khads that feed the river at Bani on the right bank include Khalu nala, Rolaid, Kaphoi nala and Kankhor nala. Two nalas Kotharu and Kakan drain western slopes around Bani and feed the Sewa particularly during the rainy season. Another important tributary of the Sewa river is the Ghat da Nal (micro-watersheds S2c2 and S2c3) which rises in the mountain ranges of Satsanani da Ghat and Bhulak in the form of Sera da Nal and Balak da Nal that confluence at the village Dandi upstream of the confluence of the Ghat da Nal

with the Sewa River near the village Halanu. A 40 m Dhuncho waterfall at an altitude of 1800 m is the characteristic feature in the watershed at Kudel that falls through the Batnal nala slates.

Mandar da Nal and Suthaun da Nal (micro-watershed S2a2) streams confluence with the Sewa at Drabbal and Amnota (micro-watershed S2c4) respectively. The important tributaries of the river rising from the Mandi Hill range include those rising from Chatter Pass (micro-watershed S2b2) and Daggar (micro-watershed S2a7) that confluence upstream of Khadwa. The tributaries of the main Sewa rising from Chatter Pass include Newa, Sawaj, Neun nala, Goraunt Pari nala, Sarthal, and Khori nala. The tributaries rising from other side include Akhru nala, Nok-Malla (Kinson nala) that join at Mathotha and downstream join with Sewa at the upstream point at Khadwa. Overall the whole catchment area is degraded with varying intensity with watersheds (Fig. 3.5)

3.9: NOMADIC CULTURE AND GRAZING AND BROWSING

The Sewa catchment area is thinly populated in the higher reaches and fairly populated along the main Sewa River course even in its higher reaches. The nomadic graziers invade the whole catchment area during the summer months. The pressure of grazing in the area is for beyond the carrying capacity of the forest, which result in degeneration and subsequent degradation of the soil cover. The cattle population, which depend on these forests for grazing shows an ever-increasing trend. The data on nomadic cattle grazing in the area since 1981 has increased from 24,396 to 67, 618. The projected population of these cattle in 2002 is 1,37,000. However, under the law the Forest Department can utilise 25% of the forest area by rotation protecting it under different closures for regeneration and rehabilitation.

Grazing destroys the forests slowly but completely and is one of the potent causes of degradation of forests and subsequent soil erosion. Grazing prevents regeneration to establish and sets in the process of degradation by killing the micro-

fauna and flora in the soils. Browsing is another adverse factor, which upsets the delicate balance between the soil and vegetation. Every year a few lac goat population browse in the catchment area during summer months. Besides, migratory Bakerwals axe numerous trees in the area, whose adverse impact on the forests is more that of goat browsing. Grazing, browsing and other anthropogenic activities, along with the natural denudation processes operative in the Sewa catchment has rendered the whole area severe to very very severely degraded.

3.10: FOREST FIRES

The catchment area of the Sewa River is prone to forest fires which when occurs destroys everything around, e.g., vegetation, wild animals, birds, micro-organisms in soils, humus, etc. very quickly and completely. The forest fires set in environmental and ecological disorder in it area of occurrence and hamper regeneration to establish. Chir forests are most susceptible to fire because the people intentionally put them on fire for improving grasses and reducing slipperiness on the slopes.

3.11: DELINEATION OF WATERSHEDS

Using the above mentioned data, the sediment yield Index (SYI) was calculated for 6 watersheds and was categorized into 'very high', 'high', 'medium' 'low' and 'very low' priorities. These prioritised sub-watersheds would be treated according to their priority ranking for soil conservation measures.

3.11.1: Landuse/landcover

Classification Scheme

The Sewa River catchment has been subjected to large-scale traditional practice of clearing the forest areas for cultivation. Most of the natural forests in the catchment have experienced varying degree of disturbance for centuries due to this

practice. However, this has simultaneously resulted in the development of small-scale sporadic horticulture in the entire catchment. On the basis of field survey in the catchment area and published literature the following landuse/landcover classification scheme has been adopted and watershed wise maps have been prepared on 1:50,000 scale. Key image elements from the satellite imageries like texture, tone, shape, location, pattern, etc. were used for interpolation with the field data and toposheets for the demarcation of the landuse/landcover pattern.

Landuse/Landcover type	**Explanation**
Dense forest (Semi-evergreen & Mixed deciduous forest)	Crown density > 40%
Open forest	Crown density 40 - 20%
Cultivated and settlement area (mainly Maize, rice cultivation, and horticulture and fuel and fodder trees)	Crown density < 20%
Degraded area	Rocky/landslide areas and devoid of any vegetation

The landuse of the catchment area mainly consists of mixed evergreen and deciduous trees, conifers, shrubs, grasslands, etc. The lower reaches have mainly scrub forests, grasslands and agricultural lands, while upper reaches of the catchment are covered by conifer and mixed evergreen deciduous forest. The factors influencing the vegetation are elevation, aspect, ecological and climate, rainfall and human interference.

3.11.2: Soil erosion and Sediment Profile:

Soil erosion is the most important process of degradation in the hills. Steep slopes with high rainfall are often subjected to soil loss by water erosion, landslides and landslips. The turbidity of water increases downstream as a result of soil degradation and soil erosion rise from human interference. The silt generation in the catchment area is expected from landslides, slips, and soil

erosion along with the network of roads. Suitable conservation measures in the catchment area would reduce the rate of siltation in the reservoir.

The project has been designed as a run-of-the river scheme. As a consequence of the high erosion rate in the catchment area resulting in extremely high rate of sediment inflow during the monsoons, the reservoir is likely to get filled up within a short span of time. Therefore, flood flushing shall have to be restored to, to obtain a sustainable reservoir live capacity. During such flush flooding, a flushing channel has to be provided upstream of the dam at the point of slope break of the river. Prediction of the shape of this flushing channel is important as it can provide permanent long-term reservoir capacity. To maintain the live capacity the project requires an effective and efficient flushing arrangement through the low level spillway. Overall the whole catchment area of the Sewa River above the reservoir site is highly degraded and prone to erosion and landslides. Slumps and debris flows are expected particularly along the river course and its tributaries, and along the road cuts. These processes would bring down heavy sediment load in the form of traction, saltation and suspension and is likely to add to siltation problem at the reservoir. The situation is most likely to accentuate during heavy rains and cloud bursts. Therefore, appropriate remedial measures need to be taken to overcome this menace and the consequent siltation problem in the reservoir.

3.12: CATCHMENT AREA TREATMENT PROCEDURES

Degraded areas in the Sewa River catchment have been delineated on the basis of the composite erosion intensity in the watersheds. Only those areas that fall under severe and very severe erosion intensity category in the six watersheds analysed would be taken up on priority basis for protection measures. Different engineering and biological measures have been suggested to be taken up in these six watersheds covering an area of about 3256 ha for treatment.

3.12.1: Bioengineering Protection Measures

Different engineering measures like training with sausage wall, catch water drainage, retaining walls etc. will be required at all the potential sites in the catchment area. The contour stagger trench and pit works are also essential in the forest areas on the vulnerable steep slopes. For different sized landslides and slips in the catchment area, Gabion structure can prove effective besides, being treated for water percolation by controlling and guiding the surface run-off. These measures would be taken up priority wise in the different watersheds as per the following scheme :

Landslides Control

Rainfall pattern of the area and seepage of surface run-off coupled with lithology govern the landslides. Water plays an important role in triggering of landslides and mass wasting processes along with other factors such as slope and nature of soil, landcover and landuse. In addition to these natural factors, human activities in the form of road construction, overgrazing of hill slopes, felling of trees for timber, fuel and fodder and upslope extension of cultivation further contribute to landslides. All the streams and watercourses must be diverted around the crown of the slide or the potentially hazardous area through properly lined drains. By slope modification, the slides can be reduced. The deep rooted Cotoneaster falcorni is the suitable shrub to be planted on the steeper slopes for stabilisation in the area. The landslides prone areas identified in the project area would be taken up for the following treatments.

Seepage Control

As the main cause of initiation of mass-movements is water, this agent has to be prevented from entering into the affected area. For this purpose divert surface water away from the site, prevent entry of water into open joints, tension cracks etc. and ensure sealing of cracks if possible. Blanket the slope with free draining materials providing filters where necessary. Use gravel filled trench drains aligned directly down slope and supplement by shallower drains arranged in a herringbone pattern. Use gravel filled counterfeit drains in which the invert surface is located

beneath the slip surface, thus providing mechanical support in addition to drainage. Use cut-off drain trenches (interceptor drains), gravel filled, running across the slope above the upper most scarp of the landslide. These drains are useful in intercepting surface run-off.

Use horizontal drains by drilling into slope and using porous or perforated liners. In large slides horizontal drains may be used in combination of vertical drainage shafts leading to gravity drainage flow.

Use of soil and rock anchors generally with pre-stressing and with or without retaining structures may be used for translation slides. Use of vegetation cover on slopes not only reduces erosion but also improves evapotranspiration and consequently reduces pore pressure. Grouting and strengthening slip zones by injecting cement grout in the jointed rocks would reduce percolation and groundwater movement.

Contour Bunds

The contour bunds may be erected to control the erosion on steep slopes as is done in the neighbour of the project in the village of Baggi (H. P.). Before afforestation of a ravaged slope, it is necessary to stabilise it by constructing walls by stones or wooden, steel and concrete poles. It is always a package of measures that has to be taken up for successful control of the slope erosion. Creep movements over a long period of time precede many landslides. This natural warning system can be used to ensure that preventive and ameliorating measures are taken in time.

Crown Load Reduction

One important method is to reduce the load at the head of the slide and/or strengthening the base by enlarging the toe. It has been observed that by removing 4% mass from the head and placing the same amount at the toe reduces instability by 10% (Zaruba and Mancl, 1969). Retaining walls and buttresses can be used wherever possible and feasible. However, it is always desirable to put a polyfilter before emplacing the retaining wall. These filters prevent loss of solid material of the

structure. A very effective, fast and economical method is the installation of pre-stressed anchor pads at the toe of the slope. These are arranged in a grid pattern in three rows each and connected with one another by crossbeams (Upadhyay, 1980).

Control on Soil Erosion

An effective method of arresting erosion and protecting damage subsurface material is to cover it with a net of coir jute or synthetic yarn of about 2.5 to 1.5 cm opening which will allow quick growth of vegetation. A number of grasses and plants can be useful for soil erosion control in the area. Some of the species that can mitigate soil erosion in the area include:

nara (Arundo donax),
lemongrass (Pennisetum,
napier (Pennisetum purpureum),
Kikiyu (Pennisetum clandestinum),
gorda (Chrysopogon fulvus),
C. nepalensis, etc.

The legume Pueraria hirsute (P. thunbergiana) with deep roots would be found promising. Among the scrubs recommended for the area are:

beshram (Ipomoea carnea),
shamalu (Vitex negundo)
Jatropha curcas,
poplus, birch,
salix,
adlar, and
oak

Reduction of loss of soil can be best achieved by planting trees, shrubs and grasses together, like sheesham (Dalbergia sissoo), Khair (Acacia catechu) and A.

arabica together with fodder grass Dicanthium annulatum. This can reduce the peak discharge of run-off and reduce gully erosion.

Contour Trenches and Plantation Pits

Contour trenches of 1.5 x 0.4 m in cross-section at the row and column interval of 1 m each following the contours with intervening plant pits of 0.3 x 0.3 m cross-section is recommended for all the vulnerable slopes. Four trenches in an area of 16 m^2 forming a single trench and pit unit will surround each plantation pit. This is a most effective measure to trap the silt and slope run-off. It would also facilitate the fertile base for plantation on the vulnerable slope in the area.

Stream Bank Protection

Stream bank erosion is one of the major causes of degradation of the catchment areas. The processes responsible for stream bank erosion include loss of vegetative cover, mass movement on unstable bank slopes, undermining of top portion of the lower bank by turbulent flow, sliding of the slopes, etc. Toe cutting by the river an its tributaries induce landslides in the project area. Therefore, the stream bank protection works including wire crates and development of vegetative spurs are necessary to be taken up. For this purpose the flow in the river and its tributaries is to be confined to the main channel and protection of the concave bends from torrents by constructing spurwalls and retards. In the sediment load deposits at the spurwalls, Salix spp., Populus ciliata, Ipomoea carnea, Vitex negundo, Alnus nepalensis, local grasses, etc. can be planted.

Gully control

The gully erosion enhances the instability of the already vulnerable slopes by deepening by the surface run-off. This process is one of the most active agents of soil erosion particularly on the steep slopes. Therefore, appropriate gully protection measures need to be taken in the catchment area of the project. Wherever possible gullies should be plugged at appropriate locations on the slopes particularly at the slope break points where check dams can also be constructed. In addition suitable

plantation may be developed on the slopes to check further deepening of gullies and erosion. The effect of erosive velocity of the surface run-off can be minimised by confining the water from different gullies to a major one and treat the main gully by training work.

In addition to the vegetative measures used for stabilization of gullies, temporary and/or permanent mechanical measures will be used as supplementary measures to prevent the washing away of young plantations by large volume of run off. The gullies get stabilized over a period of time with the establishment and growth of vegetation cover. With the passage of time mechanical structures weaken and vegetative measures get strengthened. For mechanical measures following types of checkdams are suggested.

Check Dams

Different types of check dams would be required for different conditions comprising different materials depending upon the site conditions and the easy availability of material at local level. The Brushwood checkdams for the catchment area are recommended:

The conservation measure in the river and its tributaries involves plugging them by constructing a series of check dams at the regular intervals particularly at the slope break sites. In the construction of these chechdams, stakes of self regenerating trees like poplar, willow (Salix tetrasperma), Ficus cunia, Pangara or mandar (Erythrina suberosa), Phyragmites kaka, Lannea grandis, beshram (Ipomea carnea), nara (A. donax), Ganthi (Boehmeria regulosa), semal (B. ceiba), B. retusa, B. ceina, Sapium insigne, Woodfordia fruticosa, Wenlandia excreta, L. oromandalis, Moringa pterygosperma, etc. are can be used. The stakes are driven in staggered rows across the gullies, which are then partly filled with straw and bush to trap the sediment.

Diversion drains/Catchwater Drains

Diversion drains intercepts the storm water, which could otherwise flow from higher ground on to the arable land. It is the first line of defence and vital for protection systems and structures low down as it effectively controls the run off from outside the arable land and conducts it safely to natural outlet. It is one of the most effective, practical and least expensive measures. All the streams and minor water courses would be diverted around the crown of the slide or the potentially hazardous area through catch water drains with adequate gradient. The catch water drain avoids the run off to pass over vulnerable areas and water is guided through the drain provided on foothill or along the Kaccha/Pucca roads. The ground surface of the threatened area would be leveled to eliminate all depressions where water can accumulate. The soil excavated from the diversion drain shall be deposited on lower side of the drain, leaving a berm of 0.3 m and sectioned in a trapezoidal shape with side slopes not steeper that 1:1. In order to protect the bed and sides of the diversion drain from scour and erosion, suitable type of grasses would be planted.

Slope modification by stepping/Bench Terracing

Bench terracing is one of the most popular mechanical soil conservation measures in practice in the country. The slopes are converted in step-like fields along contours by half cutting and half filling resulting in the conversion of the original slope into level terraces. In the catchment area unplanned agricultural practice is being done on the slope, which are already degraded. Such sloping crop fields are prone to heavy rates of soil erosion particularly in the form of sheet, rill and gully erosion. These cultivation fields require leveling and formation of terraces having a slope of 10^0 in hill. The ploughing and tilling of these sloping should be done in hill.

In the catchment area most of the slopes under agriculture need to be converted into terraces by cutting and filling and supported by retaining stonewalls. While doing so care should be taken not to disturb the topsoil. The vertical intervals between the terraces should not be more than 1.5 m and cutting depth at

0.50 m. The minimum average width of the terrace may vary from situation to situation and at the best can be maintained between 4 to 5 m. The stability of the terraces can be maintained by providing shoulder bunds of 30 x 15 cm and staggered drain channels to flush out the excess water from the terraces.

Activities to be undertaken

Considering the topographic factors, soil type, climate, landuse/vegetation cover in the catchment area following works have been proposed to be undertaken with the aim to check the soil erosion, prevent/check siltation of reservoir and to maintain its storage capacity in the long run.

Watersheds-wise Treatment Measures

The amount of area and type of treatment to be undertaken is based upon the stream drainage pattern, extent of forest cover, accessibility of the area, landuse, soil profile and slope. The areas with very severe erosion intensity having very slopes and which are inaccessible would be left alone for natural rejuvenation. In some of the sub-watersheds some areas under high erosion intensity category also have been earmarked for treatment owing to local conditions and degradation factors. The details of sub-watershed-wise treatment measures are described below.

Preventive Measures

It is always better to undertake preventive measures than to mitigate the factors that ultimately lead to soil erosion. Such preventive measures will indirectly help to conserve soil in the long run and arrest the degradation processes and events. The approach followed here is two-pronged which will keep in view the importance of integrating eco-restoration strategy with socio-economic needs of the local community. The preventive measures that are suggested for the project area have been discussed below.

3.12.2: Biological Protection Measures

Afforestation

For conservation of soil and ecosystem vegetative cover plays a pivotal role particularly in hilly region, like the present proposed Project area. For the catchment area of the present project afforestation programme would be taken up in the moderately, severely and very severely degraded areas on prioritisation criteria. In very severely degraded areas, plantation of locally useful, diverse and indigenous plant species would be undertaken. Plantation to be undertaken under afforestation programme according to the established methodology with plant density of 1600 per ha is recommended. In order to conserve soil and to enhances the moisture content and reduce the adverse effect of surface run-off contour plantation should done. The afforestation programme in the catchment area is planned according to the local factors like altitude, aspect, biotic pressures, soil depth, moisture, etc. Besides, enormous pressure of cattle grazing in the entire catchment area and need for fuel wood by the local people have also been taken into consideration in the afforestation plan. The following species have been recommended for plantation in the catchment area:

Conifer Plantation

All chir forests of the catchment area lack regeneration and those at the lower reaches and adjoining the habituated areas are badly damaged and degraded. Soil erosion is the common phenomenon in the area. These areas need immediate attention. In areas lacking advance growth necessary preparatory measures should be taken up so that fresh seed can come in direct contact with the soil cover enabling them to germinate at the onset of monsoon. In comparatively in less degraded cooler aspect areas, patch sowing should be practised. In either case the seeds should be treated for fungal spores and cutworm applying fungicide and insecticide. On the eroded and blank areas nursery raised chir seedlings should be planted at a spacing of 2 x 3 m at the onset f monsoon. The casualty replaced should be done during following monsoon period. The following species of conifers are suitable for plantation in the catchment area:

Deodar (Cedrus deodara),
Kail (Pinus wallichiana), and
Cedar (Cupressus torulosa).

Broad Leaved Species

The broad-leaved patches in the catchment area should be protected and the damaged patches should be tended and provided with proper protection. The economically important species wherever exist in the catchment should be protected and promoted.

Forest Roads and Inspection Paths

All existing bridle paths and inspection roads in the catchment area should be maintained in order to serve as fire lines. In addition, new bridle and inspection paths should be constructed to facilitate easy inspection and fire protection. These paths would also serve as communication links to other places in the region and facilitate the easy movement of the nomadic people migrating to the higher reaches during summer months for grazing of their cattle.

Watch and Ward and Fire Protection

Protection of plantation would be a greatest challenge in the catchment area particularly due to invasion by nomadic cattle in the summer months and scattered population in these areas. The main concern would be grazing, browsing by cattle and deliberate forest fire by the vested interests of the local people. The preventive measures to be adopted for mitigations of these adverse processes are given as follow:

Fire Protection

Forest fires are common in these forests especially the chir belt which is under resin tapping. People deliberately put these forests on fire particularly in the vicinity of the settlements for Jhumming cultivation. In the scrub forests, fires incidents take place during the autumn months when the grasses dry. In order to protect forest fire precautionary measures need to be taken up. Local people should be encouraged to

cut grass after the felling of seeds. The forest staff should supervise the grass cutting in order to avoid the damage to the young plants. Appropriate fire control measures should be taken up in the event of forest fires.

Forest Protection

For achieving the target of rehabilitation in the catchment area, forest protection has been to be ensured. The most important among the forest protection is to educate the local inhabitants and to involve them in the process. In this respect the students can be of tremendous help in dissemination of the need for forest protection. For this purpose the students' participation in forest protection can be achieved through their participation in seminars, symposia, competition, etc. in the schools and colleges. Besides, village forest protection committees should be constituted to seek co-operation from the local inhabitants. At the Departmental level for the protection of plantation particularly in the juvenile stage engagement of watchmen from the near by villages for the job is recommended.

Illicit Damage and Encroachments

The rapid population explosion, urbanization and changing socio-economic status of the society have led to the multifold demand in timber requirement by the people. This has exerted tremendous pressure on the forests and led to legal and illegal felling of trees to the level of total destruction of certain areas. Furthermore, the need for more food grains by the local people has also adversely affected the forest felling for clearing of the areas for agricultural practices. Thus the forest encroachment problem has become socio-economic and socio-politic. The forest encroachment and illicit feeling of trees is to be discouraged and prevented by all legal means and practices.

Pasture Development

The rural population in general and the inhabitants near the forest areas domesticate the cattle and consequently grazing is one of their main occupations. The catchment areas in the lower reaches are degraded and marred by soil erosion and there no marked pastures in these areas. However, in the higher reaches there

are some well-defined pastures. Nomadic people invade these pastures during the summer months. Therefore, there is a need to develop more pastures in the catchment area particularly in the lower reaches where the cattle graze mostly on already degraded village shamlats, community lands, kahcharai, etc. Most of the higher reaches of the catchment area is severely degraded where trees and shrubs are mostly absent. These degraded pastures should be treated for soil conservation followed by plantation. These areas should be closed for grazing on rotational basis. Sowing and plantation of the plausible grasses, shrubs and trees of fodder value should be introduced. Some pressure on pastures can be removed by introducing stall-feeding.

In order to meet the demand for green fodder various plant species should be grown in the blank slopes in the vicinity of the habitation. Mixed pasture development having legumes and grasses forms the most nutritious fodder for the cattle. In the pits, saplings of leguminous fodder tree species; nutritious grasses and legumes raised in the nursery would be planted at the rate of 400 plants per ha.

The following species of grasses and legumes are suggested to be grown in the pastures:

Grasses

1. Cocks foot (Dactylis glomerata)
2 Perennial Rye grass (Lolium perenne)
2. Tall Fescue (Festuca arundinacea)
3. Brome grass (Bromus inermis)
4. Georgia selection
5. Timothy grass (Phleum pratense)
6. Poa grass

Legumes

1. White clover (Trifolium repens)
2. Red clover (Trifolium pratense)
3. Lucerene (Medicago sativa)

4. Vetch (Vicia villosa)
5. Sainfoin (Onobrychis viciaefolia) and
6. Caucasian clover (Trifolum ambiguum)

Fuel wood and Fodder plantation

The ever-increasing demand for fuel wood, fodder and grazing would exert tremendous pressure on the vegetation in the project area during the construction period. In areas with maximum human and livestock population within and in the vicinity of the project, it is envisaged to create more resources for fuel wood and fodder to check further degradation of the area. Such a step is bound to go a long way to provide vegetation cover to barren slopes to check erosion and cater to the increase in demand of fuel wood and fodder. To mitigate the pressures of grazing and for successful establishment of fuel wood and fodder species in the area, it is essential to raise mixed plantation.

The following species has been suggested for plantation in this group:

Fodder species:

Kharik (Celtis australis)
Bhimal (Grewia elastica)
Robinia pseudoacacia
Subabul (Leucaena leucocephela),
Shehtut (Morus serrata),
Ficus species,
Bamboo,
Oak,
Himalayan Poplar(Populus ciliata) and
Siras (Albizza stipulata)

Fuelwood species:

Acacia mollissima,
Jungle Jalebi (Pithecolobium dulce),

Rhus parviflora,

Alder (Alnus nepalensis),

Robinia pseudoacacia,

Silver oak,

Darli (Toona serrata),

Anga (Fraxinus micrantha),

chillu (Prunus armeniaca),

Walnut (Junglans regia),

Khanor (Aesculus indica), and

Willow (Salix spp.)

Plantation of horticulture crops

It is suggested either to level the fields properly or change the land use from agriculture to horticulture plantations in such areas. Under this plan suitable horticultural crop species like apple, plum and prunus shall be planted in selected areas adjacent to the villages. This plantation would become source of good income for the villagers.

3.13: Watershed-wise Treatment Measures

The analysis of the watersheds in the entire catchment area of the project has revealed that these watersheds fall under the different degraded intensity units. The watershed-wise total area in ha and its break-up into different degraded intensity units is given as follows:

Watershed	Area (ha)	N	SM	M	S	VS
S1a	2450	1129	574	572	175	-
S1b	6425	3273	1224	1844	84	-
S1c	2950	1394	1328	228	- -	
S2a	7525	4655	481	1782	83	524
S2b	6200	3210	768	688	1495	39
S2c	10925	5134	3591	259	728	1213
G. Total	**36475**	**18795**	**7966**	**5373**	**2565**	**1776**

For restoration of degraded areas in different watersheds by different bioengineering and biological measures, only 75% of severely degraded and very severely degraded areas have been considered. The selection of areas for mitigation measures has been done on the basis of erosion intensity units and feasibility of applying these measures. The watershed-wise distribution of these degraded areas in ha for different corrective measures is given in the following table and the work plan Yearwise has been deputed in Tab. 3.12.3.

Watershed Code	Total Area in ha	Areas cover under Severe and very Severe category	Area Proposed for treatment
S1a	2450	175	131
S1b	6425	84	63
S1c	2950	--	--
S2a	7525	607	455
S2b	6200	1534	1151
S2c	10925	1941	1456
Total	**36475**	**4341**	**3256**

3.13.1: Watershed S1a

The S1a watershed has a total area of 5700 ha and fall within 600 to 2400 m-attitude zone but only 2450 ha contribute its run-off to the reservoir. The altitudinal distribution of the total area in this watershed is given in Figure 3.6. The predominant landuse in this watershed is dense forest constituting 1129 ha of the area followed by open forest of 574 ha, cultivation and settlements spread over 572 ha and remaining 175 ha is almost totally barren (Fig. 3.7). The area requiring treatment under

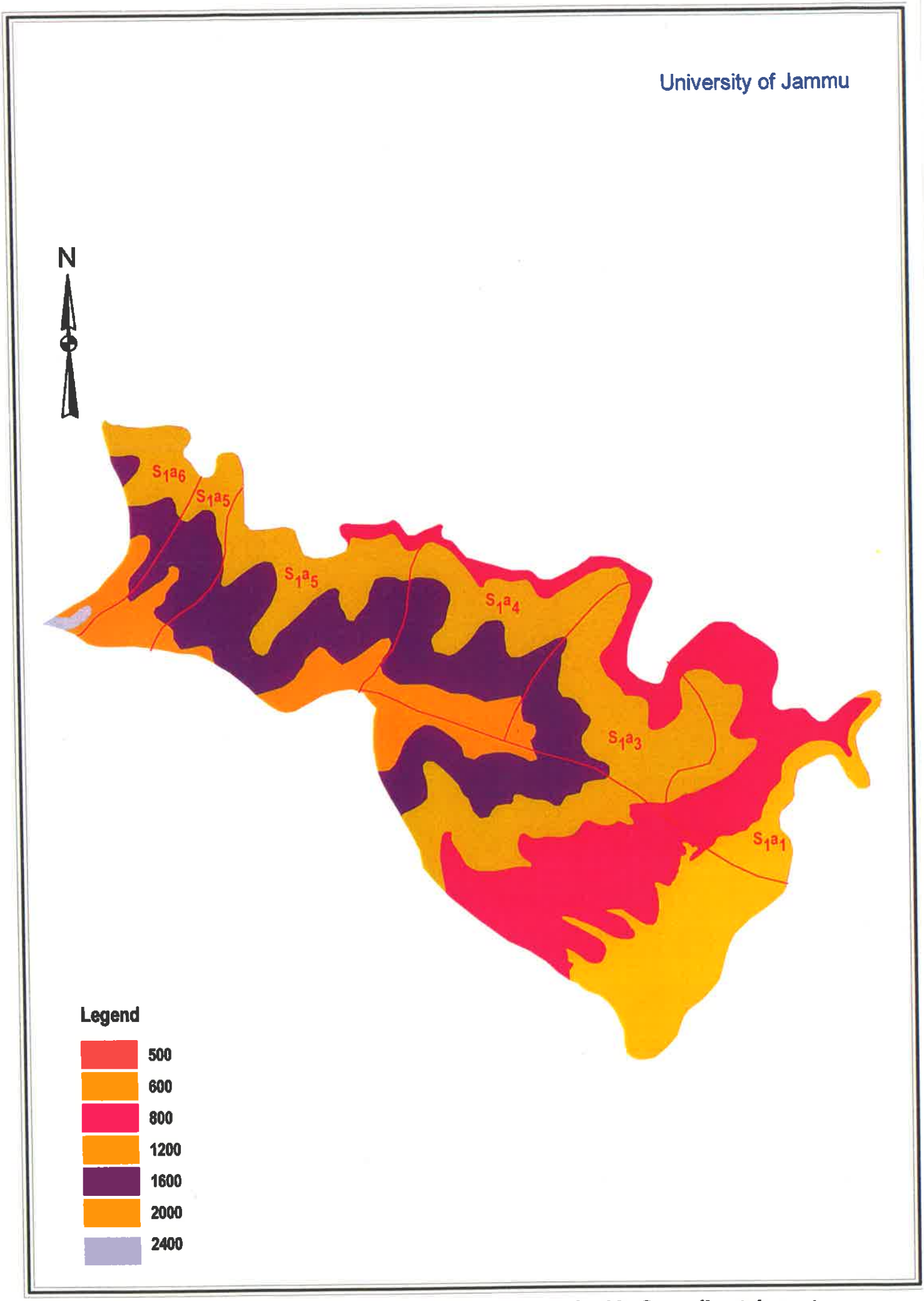
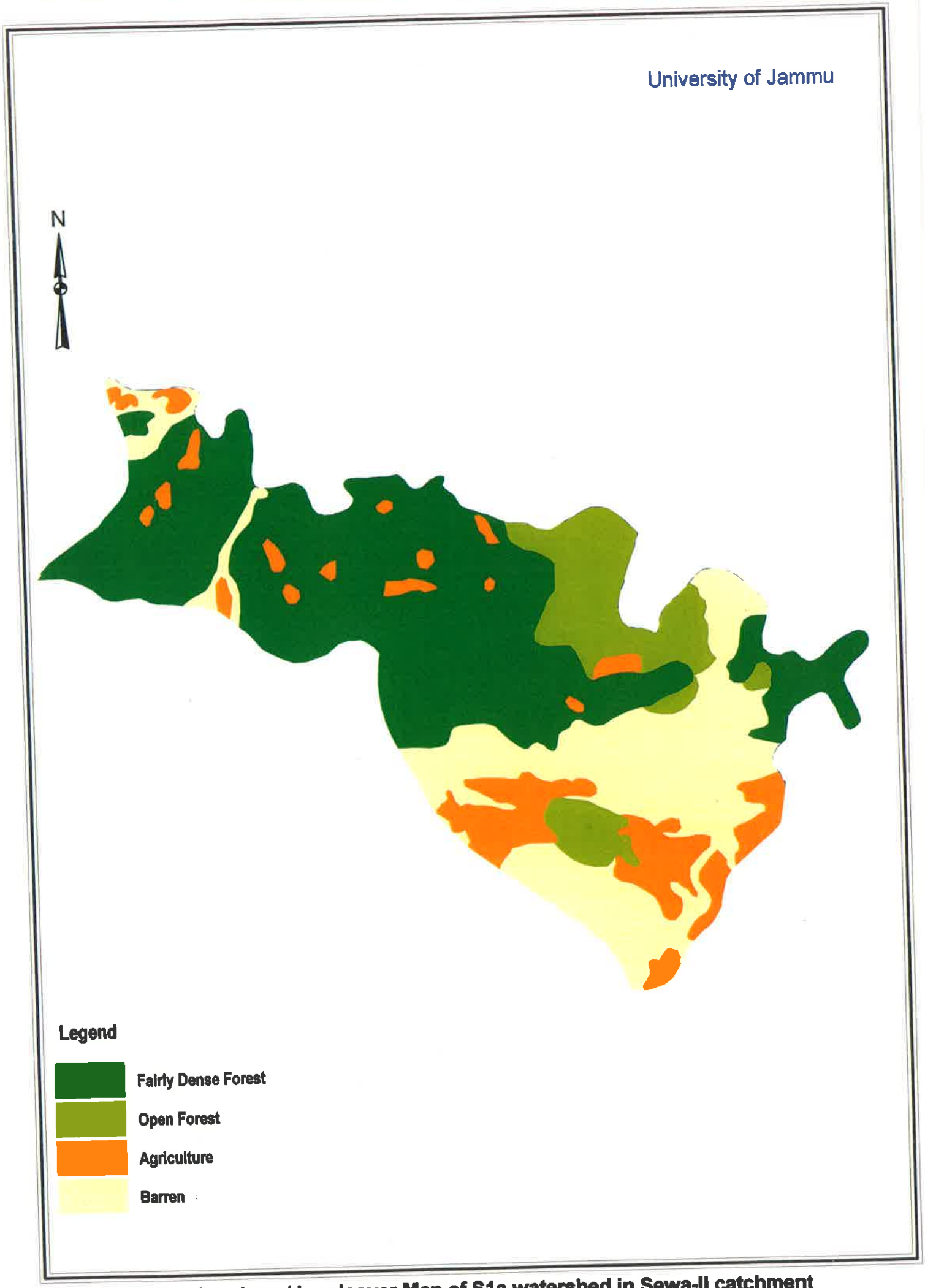


Fig 3.6 - Physiography Map of S1a watershed in Sewa-II catchment



Fg 3.7 - Landuse / Landcover Map of S1a watershed in Sewa-II catchment

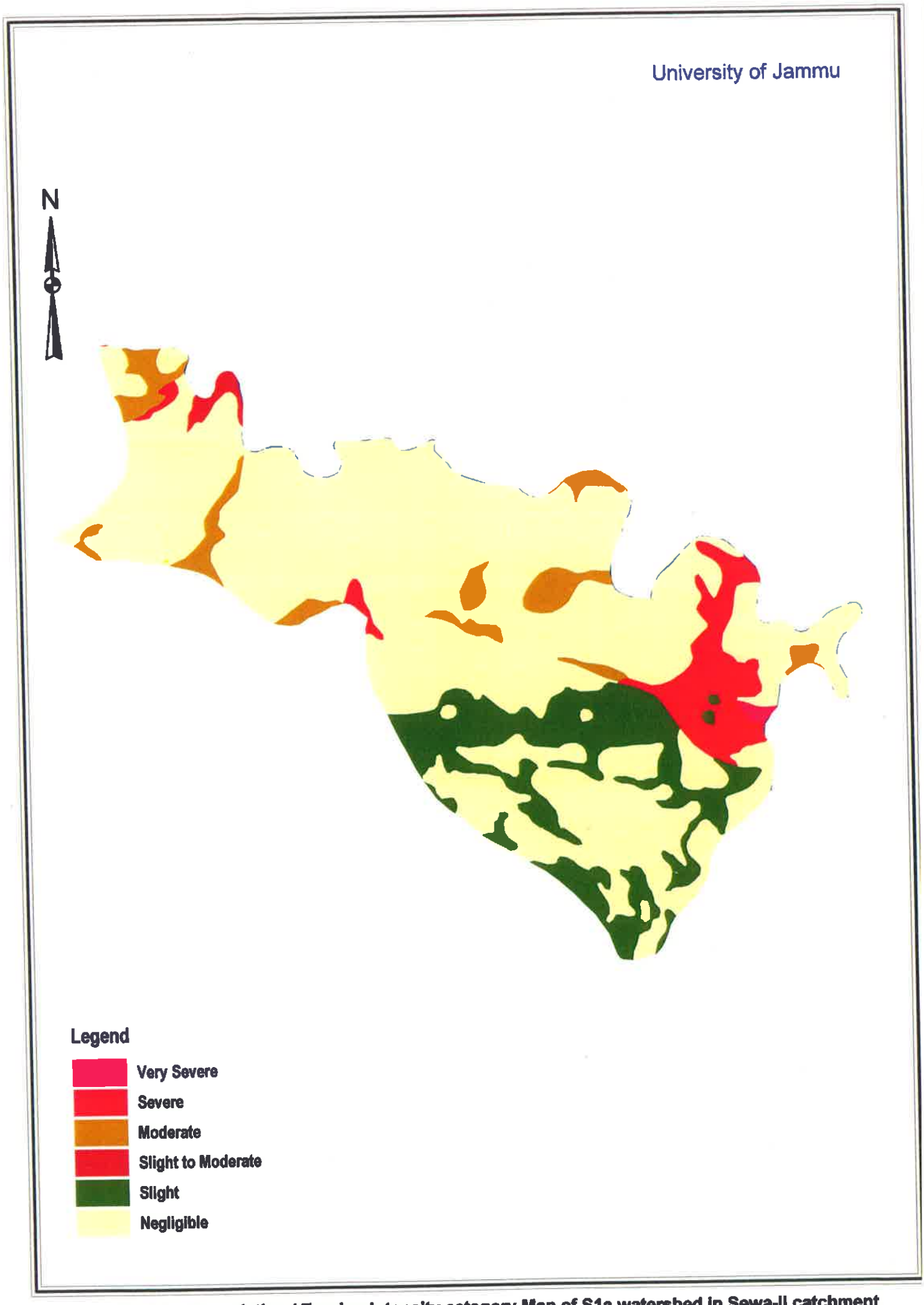


Fig 3.8 - Degradation / Erosion Intensity catagory Map of S1a watershed in Sewa-II catchment

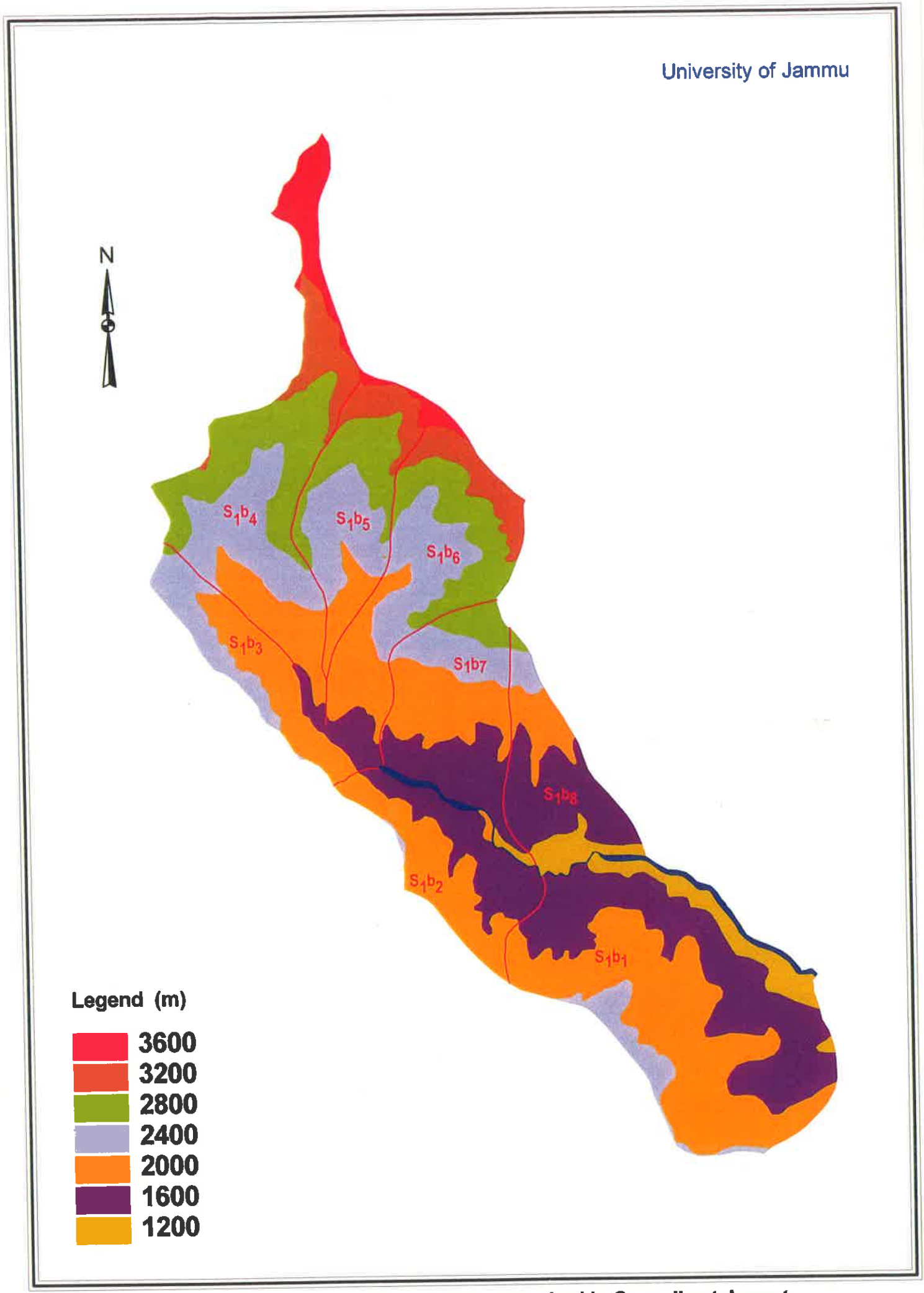


Fig 3.9 - Physiography Map of S1b watershed in Sewa-II catchment

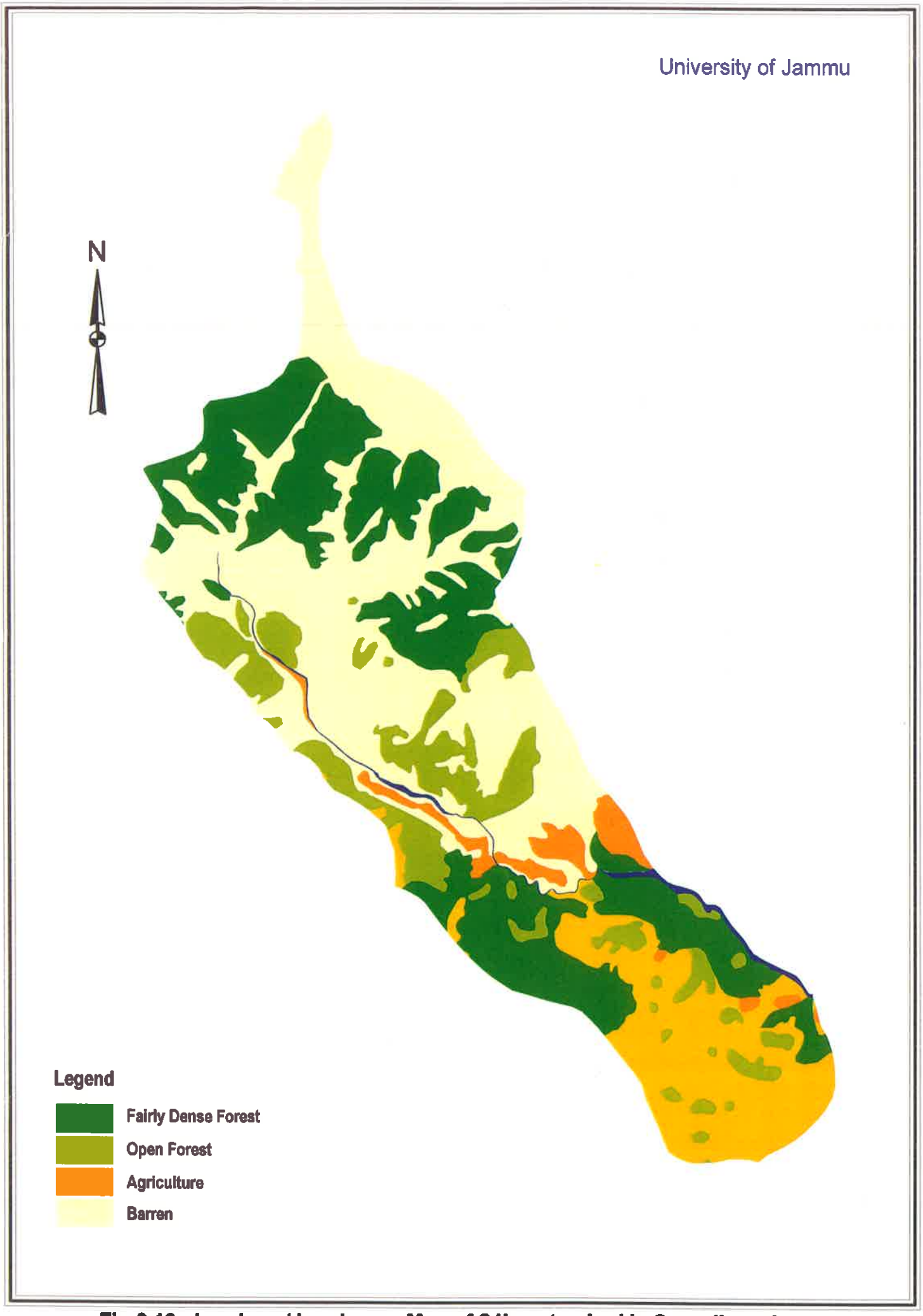


Fig 3.10 - Landuse / Landcover Map of S1b watershed in Sewa-II catchment

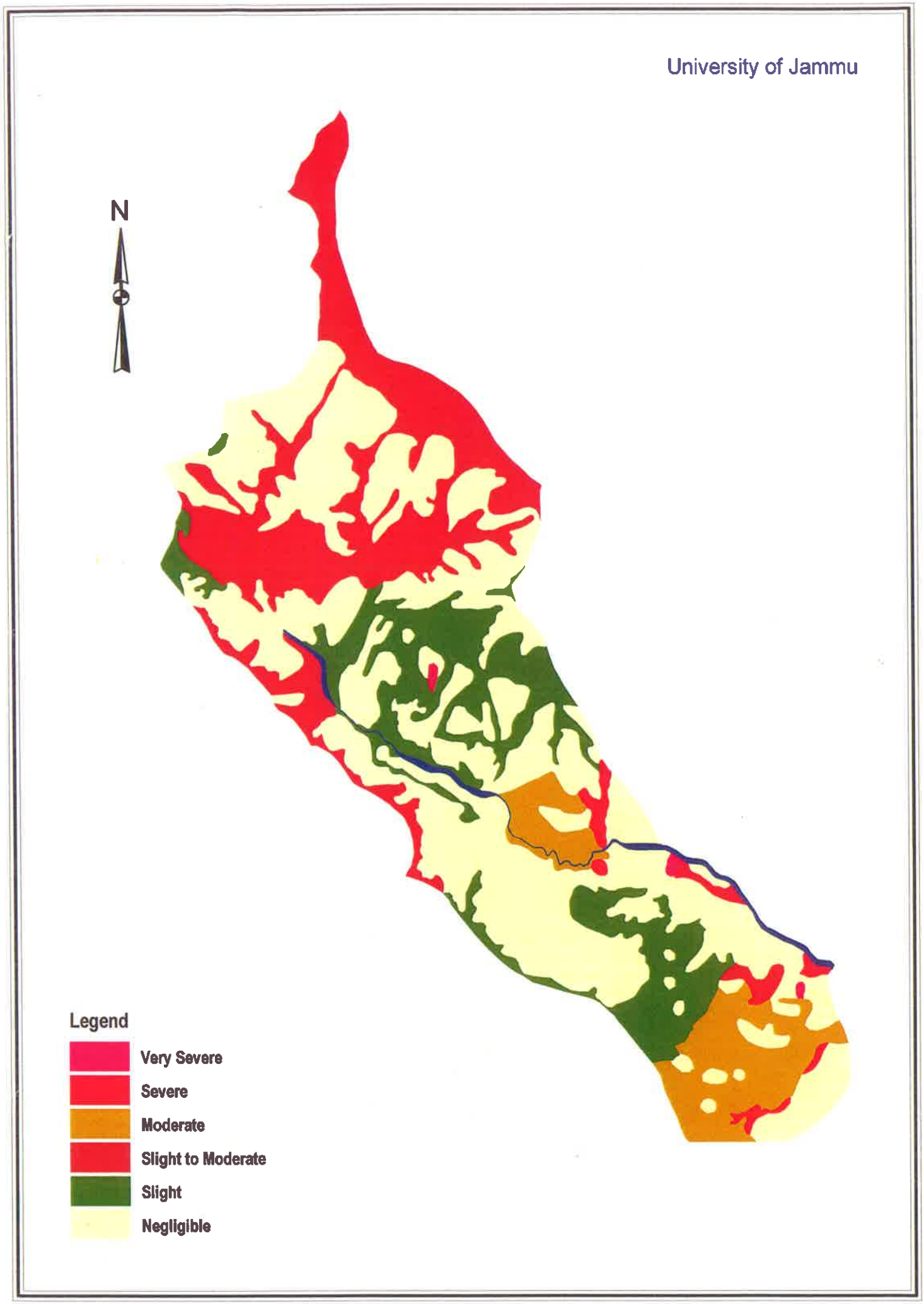


Fig. 3.11- Degradation / Erosion Intensity catagory Map of S1b watershed in Sewa-II catchment

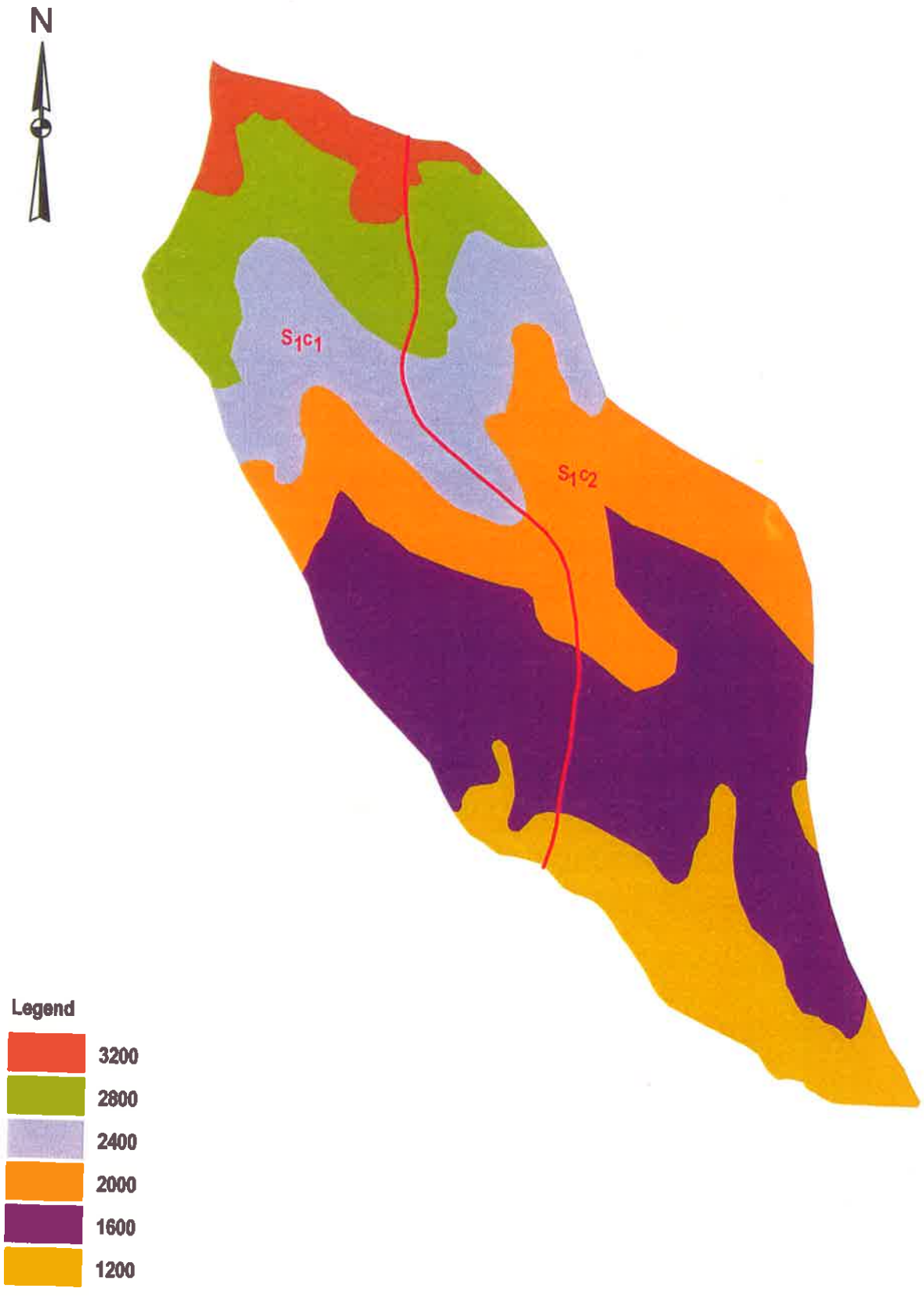


Fig.3.12- Physiography Map of S1c watershed in Sewa-II catchment

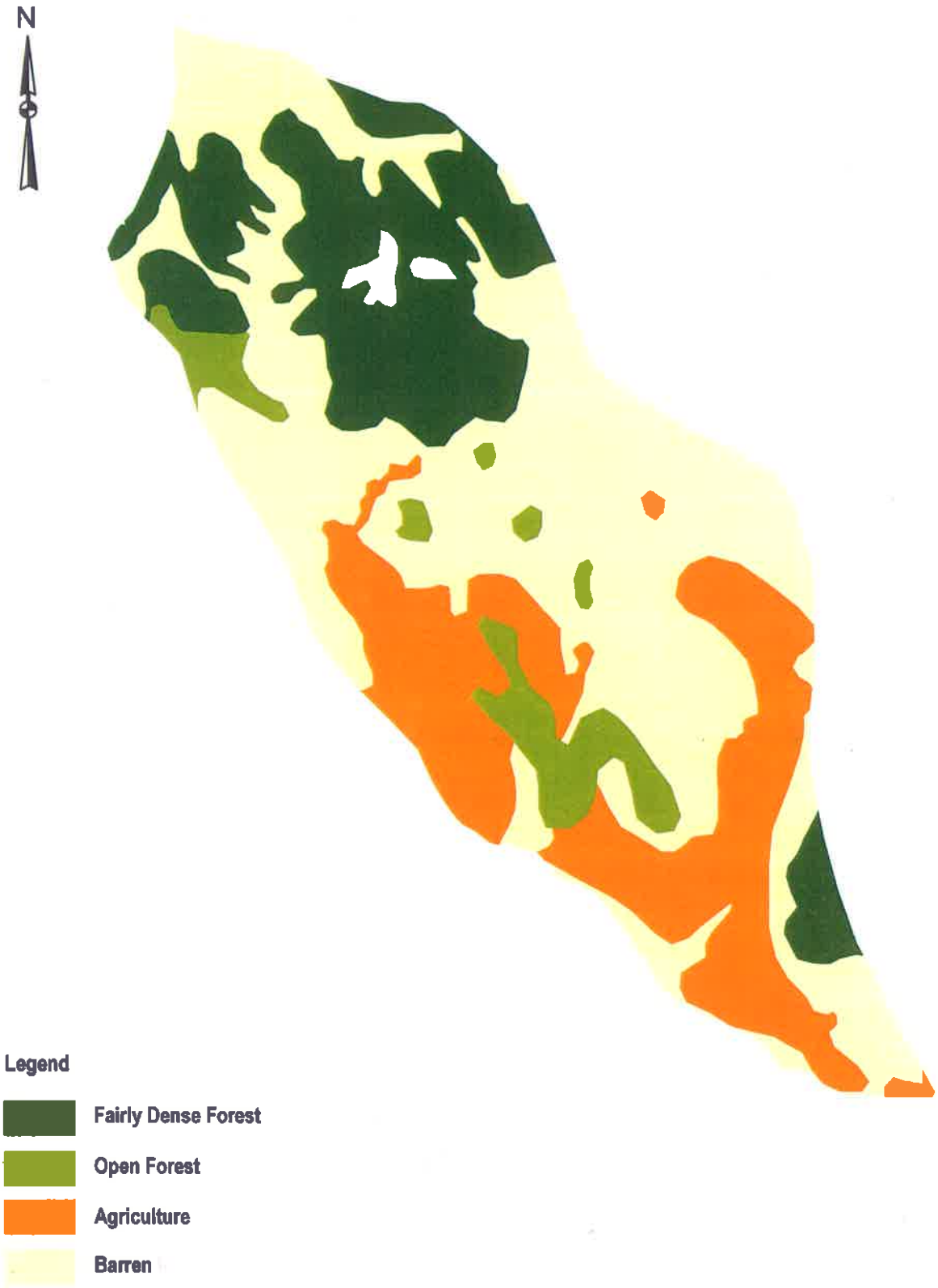


Fig.3.13-Landuse / Landcover Map of S1c watershed in Sewa-II catchment

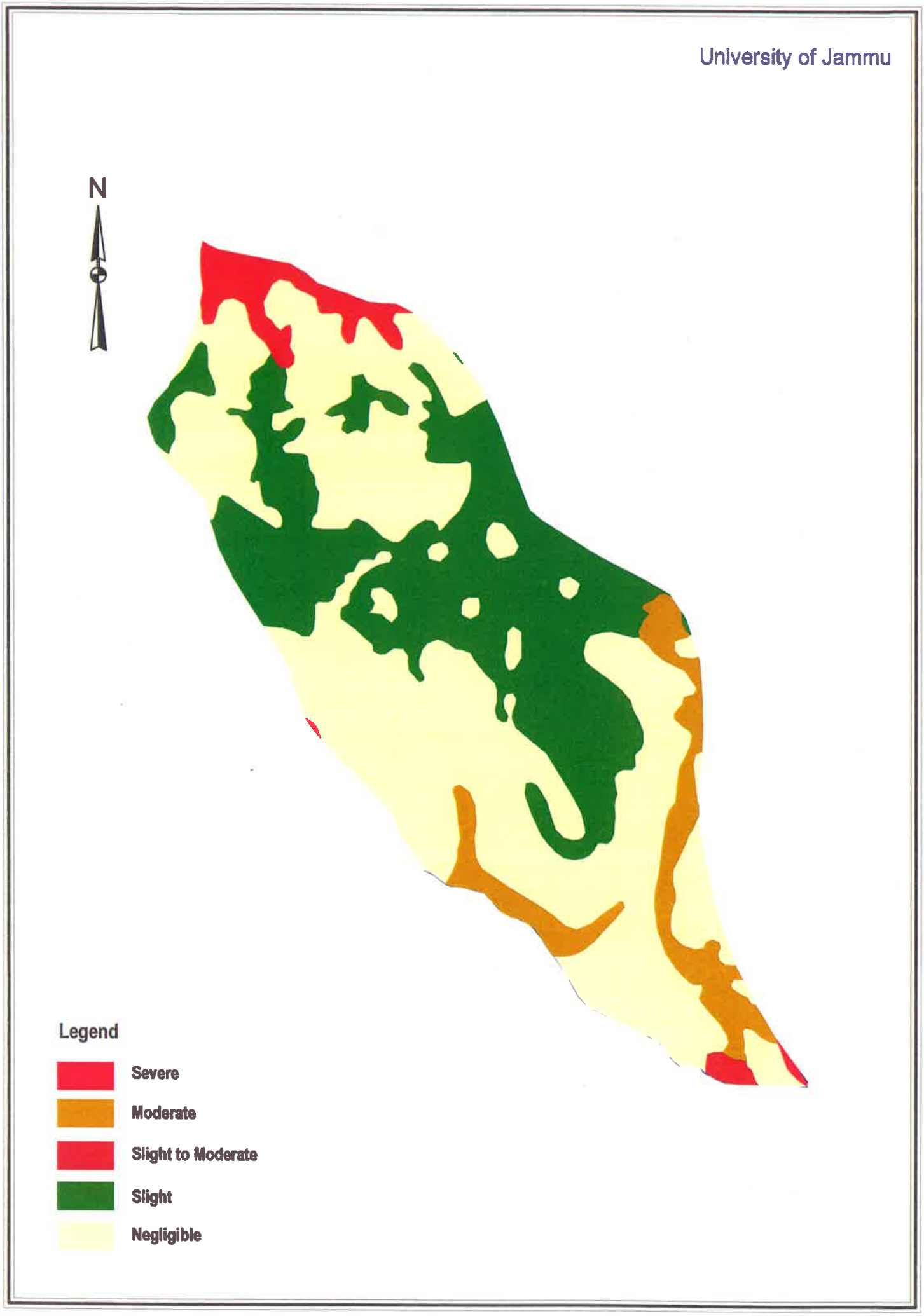


Fig.3.14- Degradation / Erosion Intensity catagory Map of S1c watershed in Sewa-II catchment

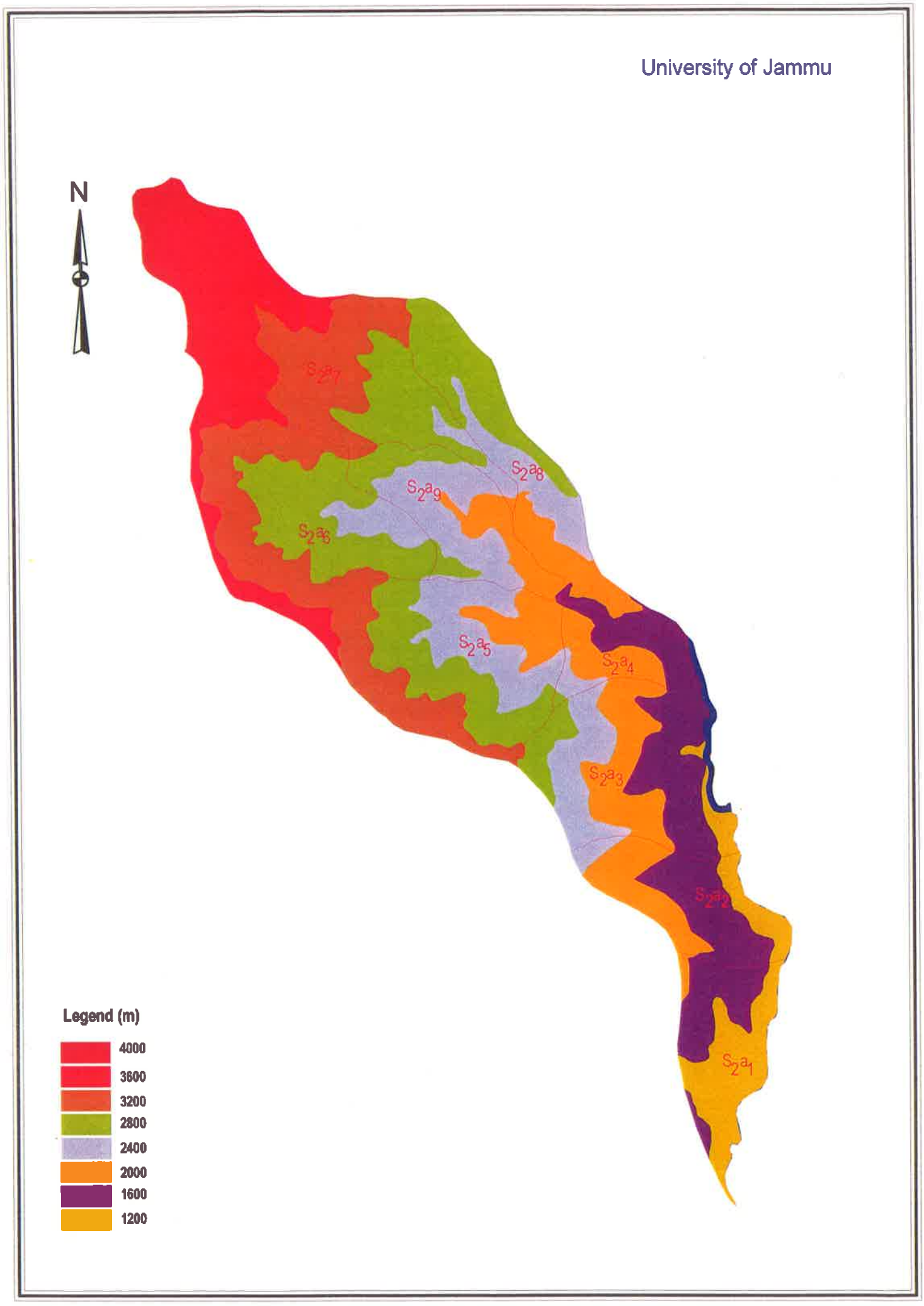


Fig 3.15- Physiography Map of S2a watershed in Sewa-II catchment

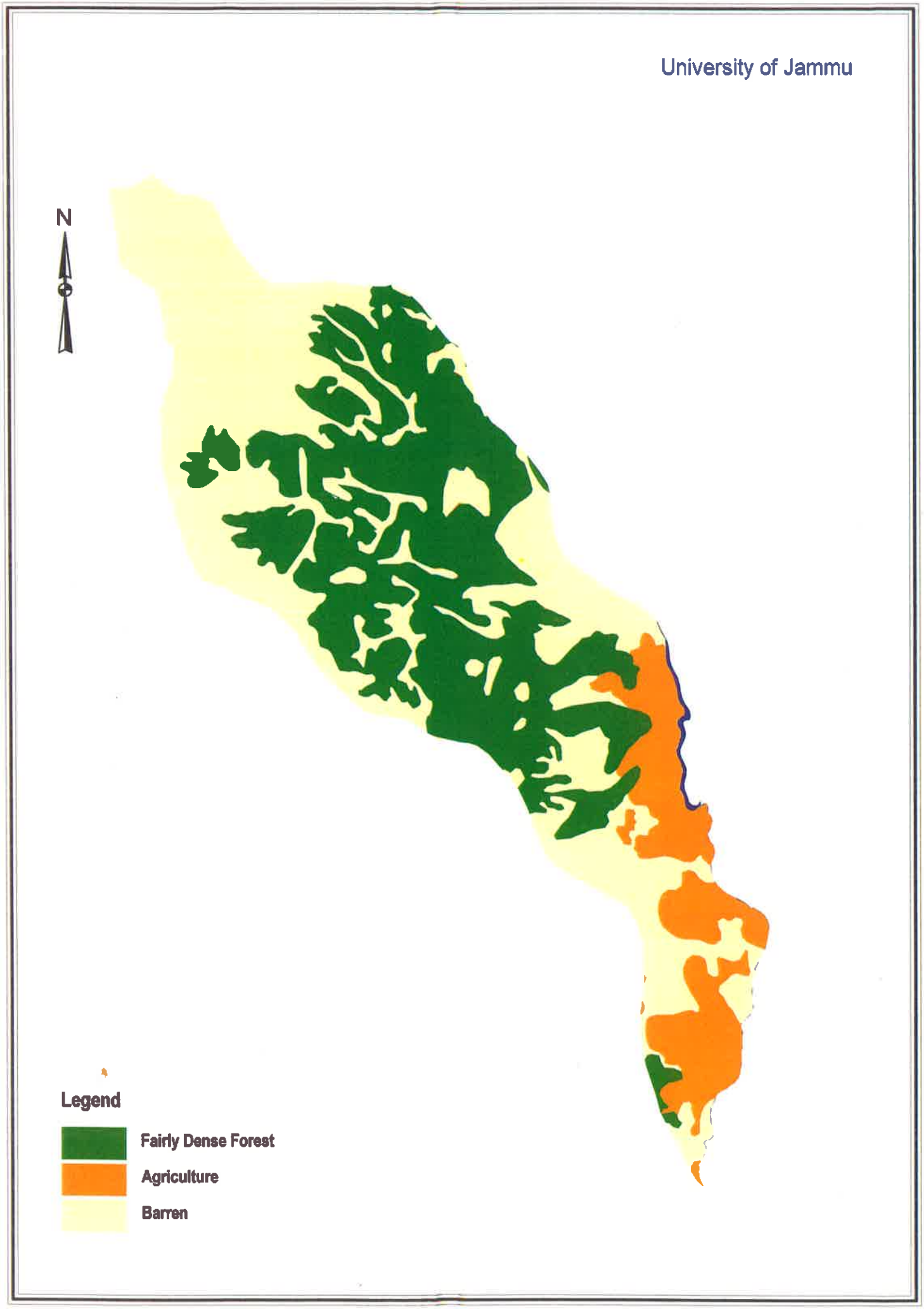


Fig.3.16 - Landuse / Landcover Map of S2a watershed in Sewa-II catchment

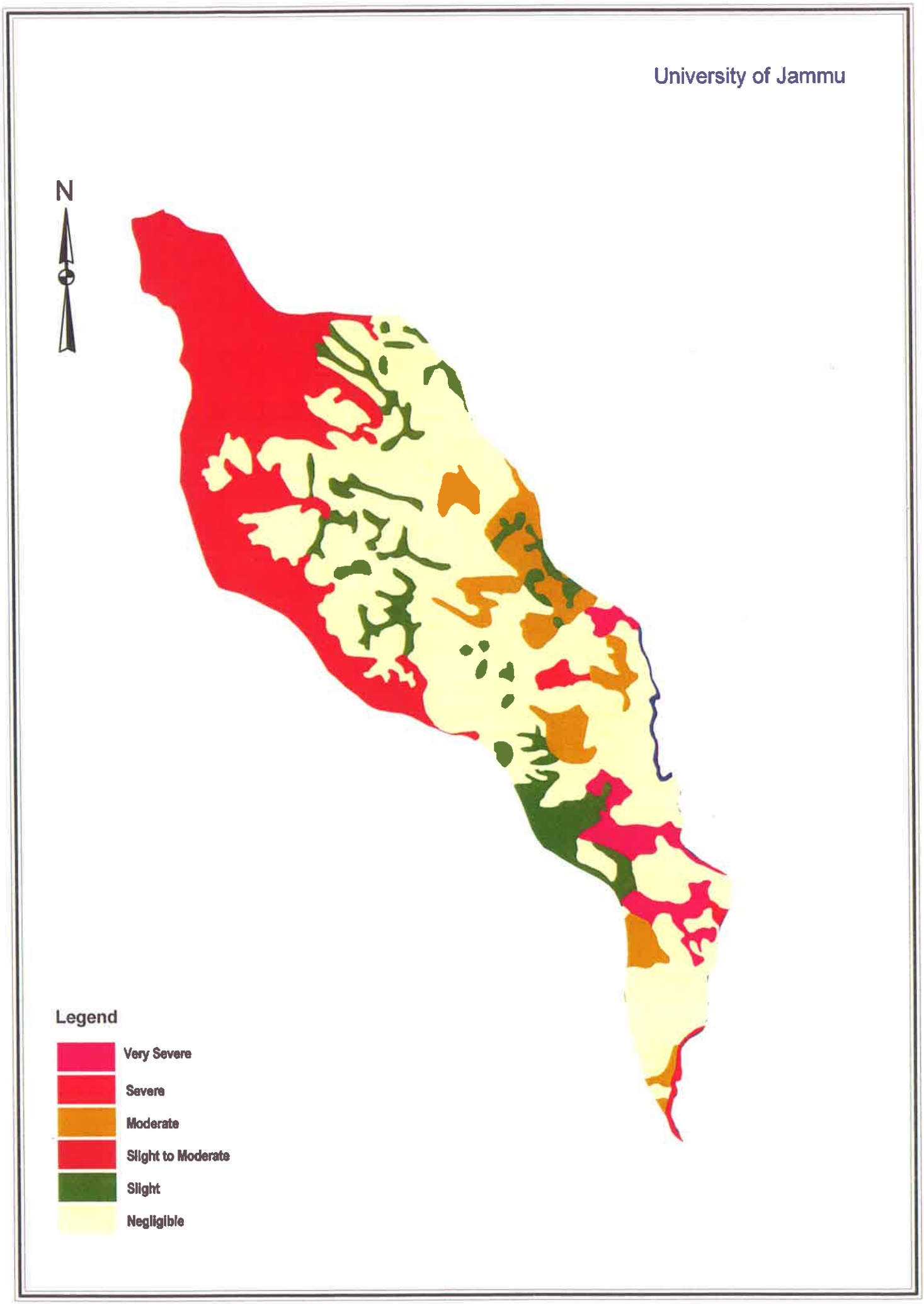


Fig. 3.17 - Degradation / Erosion Intensity catagory Map of S2a watershed in Sewa-II catchment

moderate, a severe and very severe category is 131 ha (Fig. 3.8). The following treatment measures are suggested for this watershed:

S. No.	Treatment Measures	S1a	No. of structures
1.	Afforestation	40	-
2.	Fodder and fuel wood plantation	15	-
3.	Horticulture plantation	10	-
4.	Pasture development	10	-
5.	Contour trenches and plantation pits	20	1896 pits and 7584 trenches
6.	Bench terracing	-	-
7.	Stream bank protection	8	400 m^3
8.	Gully control measures	12	-
9.	Landslide control	4	200 m^3
10.	Contour bunds	4	-
11.	Check dams	8	8 (Av. Dim. 8x1.5x2 m)
12.	Nala training	-	-
13.	Total	131	-

3.13.2: Watershed S1b

The S1b watershed has a total area of 6425 ha and falls within the 1200 to 3600 m altitude zone, and contributes its run-off to the reservoir. The altitudinal distribution of the total area in this watershed is given in Figure 3.9. The predominant landuse in this watershed is dense forest constituting 3273 ha of the area followed by agricultural and settlement area covering 1844 ha, open forest of 1224 ha, and remaining 84 ha is barren (Fig. 3.10). The area requiring treatment under severe and very severe category is 63 ha (Fig. 3.11). The following treatment measures are suggested for this watershed:

S. No.	Treatment Measures	S1b	No. of structures
1.	Afforestation	30	-
2.	Fodder and fuel wood plantation	5	-
3.	Horticulture plantation	5	-
4.	Pasture development	5	-

5.	Contour trenches and plantation pits	10	958 pits and 3792 trenches
6.	Bench terracing	-	-
7.	Stream bank protection	2	100 m^3
8.	Gully control measures	2	-
9.	Landslide control	2	100 m^3
10.	Contour bunds	-	-
11.	Check dams	2	2(Av. Dim. 8x1.5x2 m)
12.	Nala training	-	-
13.	Total	63	-

3.13.3: Watershed S1c

The S1c watershed has a total area of 2950 ha and falls within the altitude zone of 1200 to 3200 m, and contributes its run-off to the reservoir. The altitudinal distribution of the total area in this watershed is given in Figure 3.12. The predominant landuse in this watershed is the forest cover with almost equal distribution of land areas between dense and open forests with 1394 ha and 1328 ha respectively followed by cultivation and settlements spread over 228 ha (Fig. 3.13). The watershed is the least degraded one in the entire catchment of the project. No area falls under severe and very severe category hence no treatment works are proposed in this watershed
(Fig. 3.14).

3.13.4: Watershed S2a

The S2a watershed has a total area of 7525 ha and falls with 1200 to 4000 m altitude zone, and contributes its run-off to the reservoir. The altitudinal distribution of the total area in this watershed is given in Figure 3.15. The predominant landuse in this watershed is the dense forest with 4655 ha followed by cultivation and settlements spread over 1782 ha, and open forest of 481 ha. This watershed has very severely degraded (barren and rocky) areas spread over 524 ha and severely degraded area of 83 ha (Fig. 3.16). The area requiring treatment under the severe and very severe degraded categories is 455 ha (Fig. 3.17). The following treatment measures are suggested for this watershed:

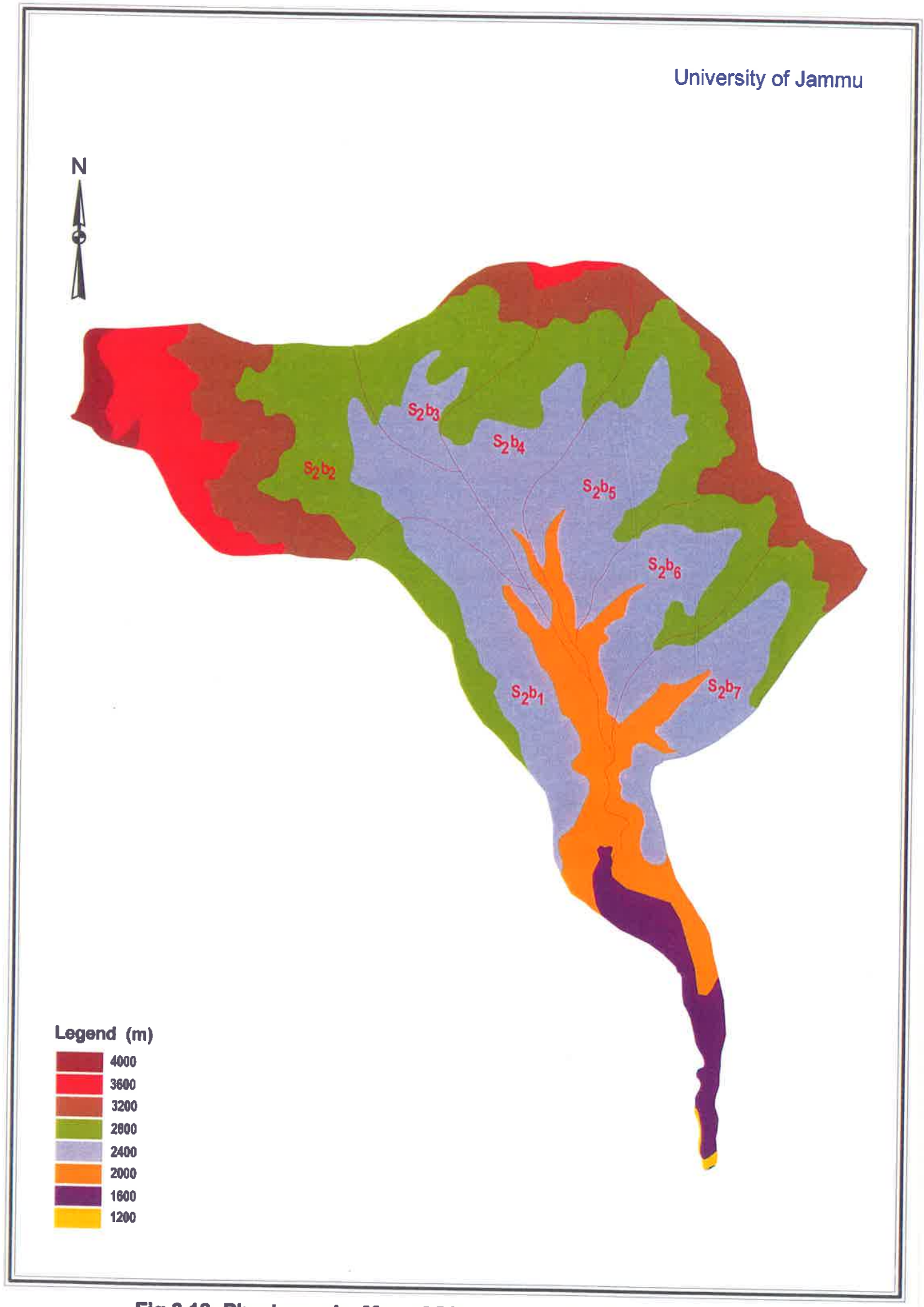


Fig 3.18- Physiography Map of S2b watershed in sewa-II catchment

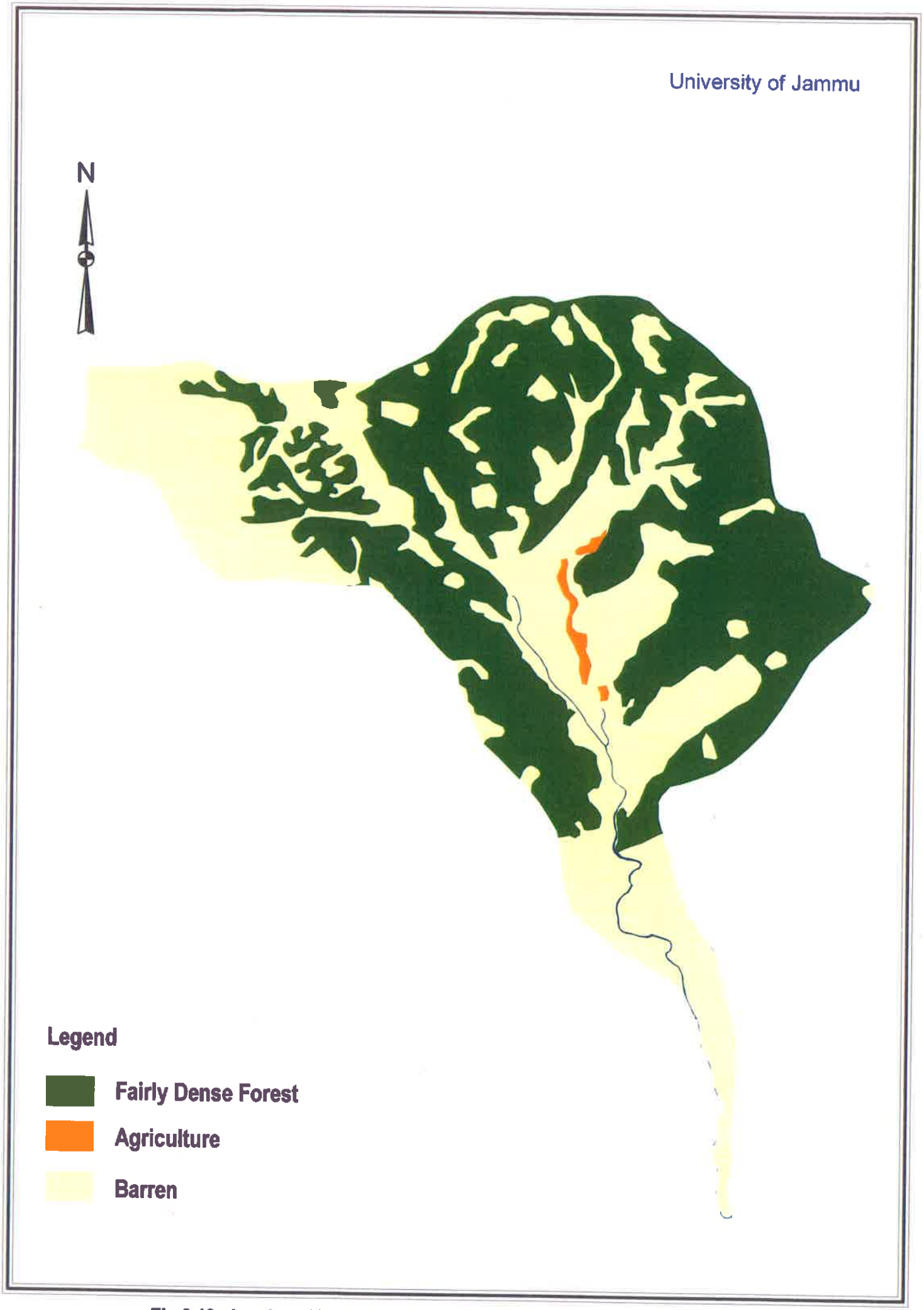


Fig 3.19 - Landuse / Landcover Map of S2b watershed in Sewa-II catchment

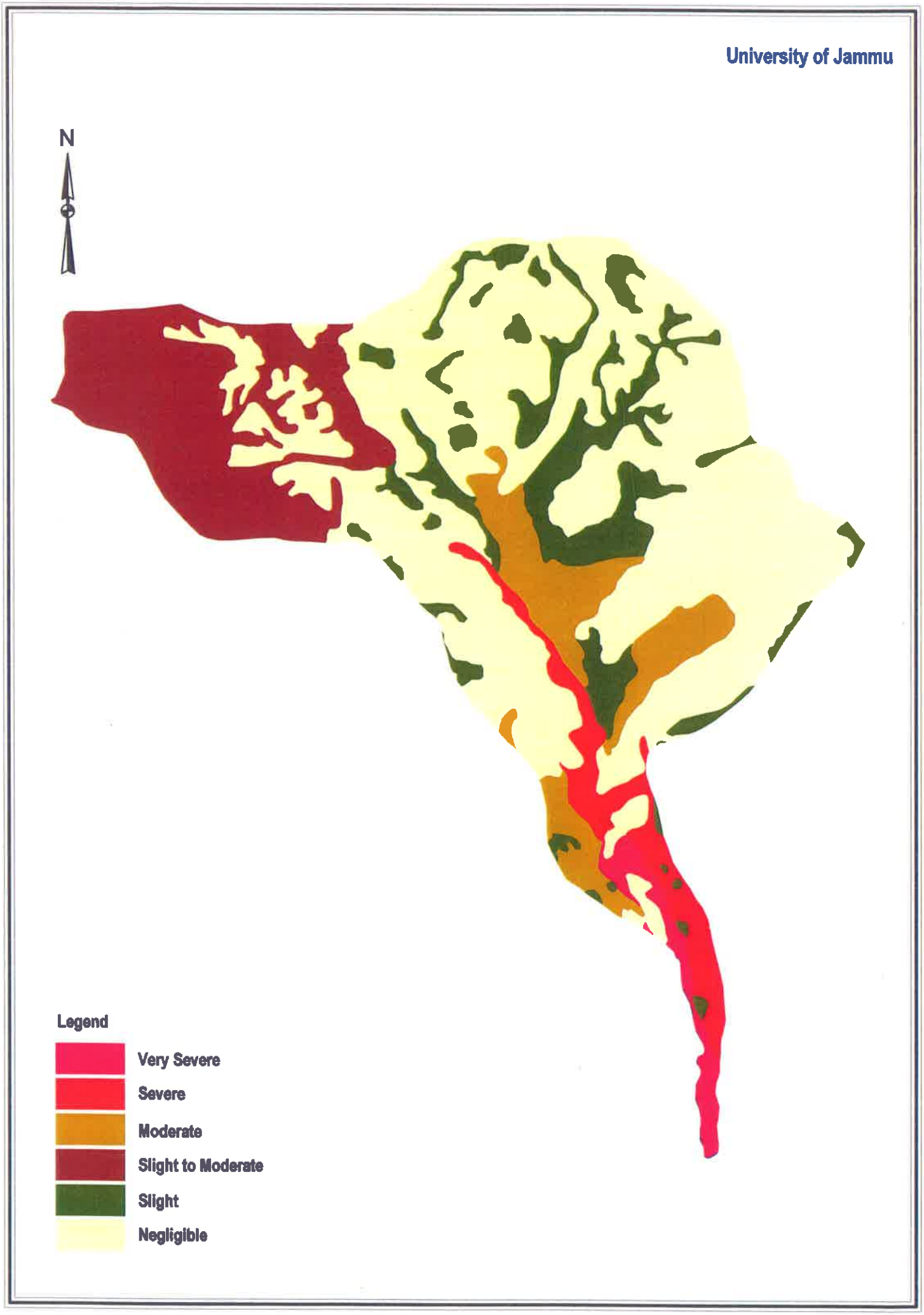


Fig 3.20 - Degradation / Erosion Intensity catagory Map of S2b watershed in Sewa-II catchment

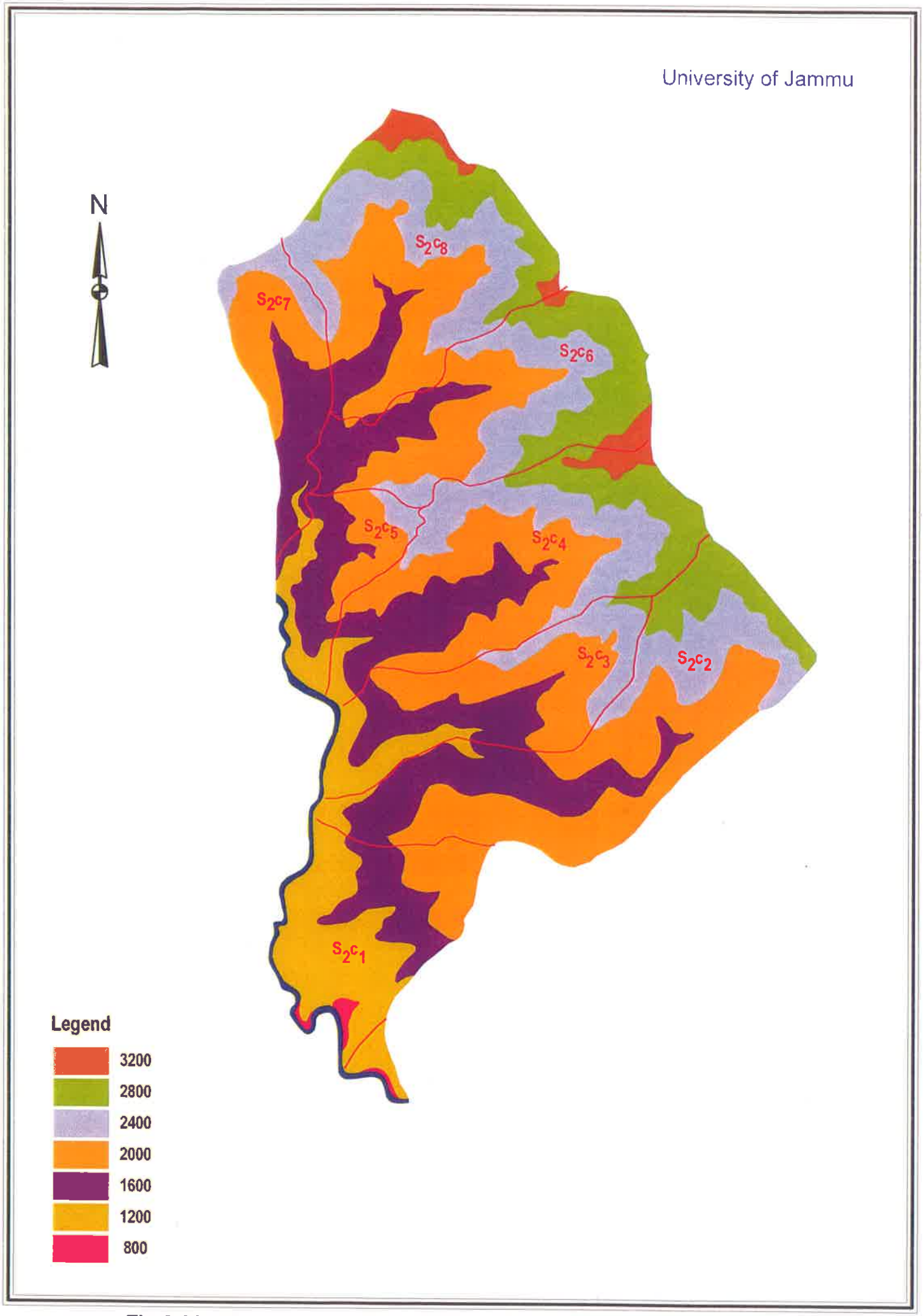


Fig 3.21 - Physiography Map of S2c watershed in Sewa-II catchment

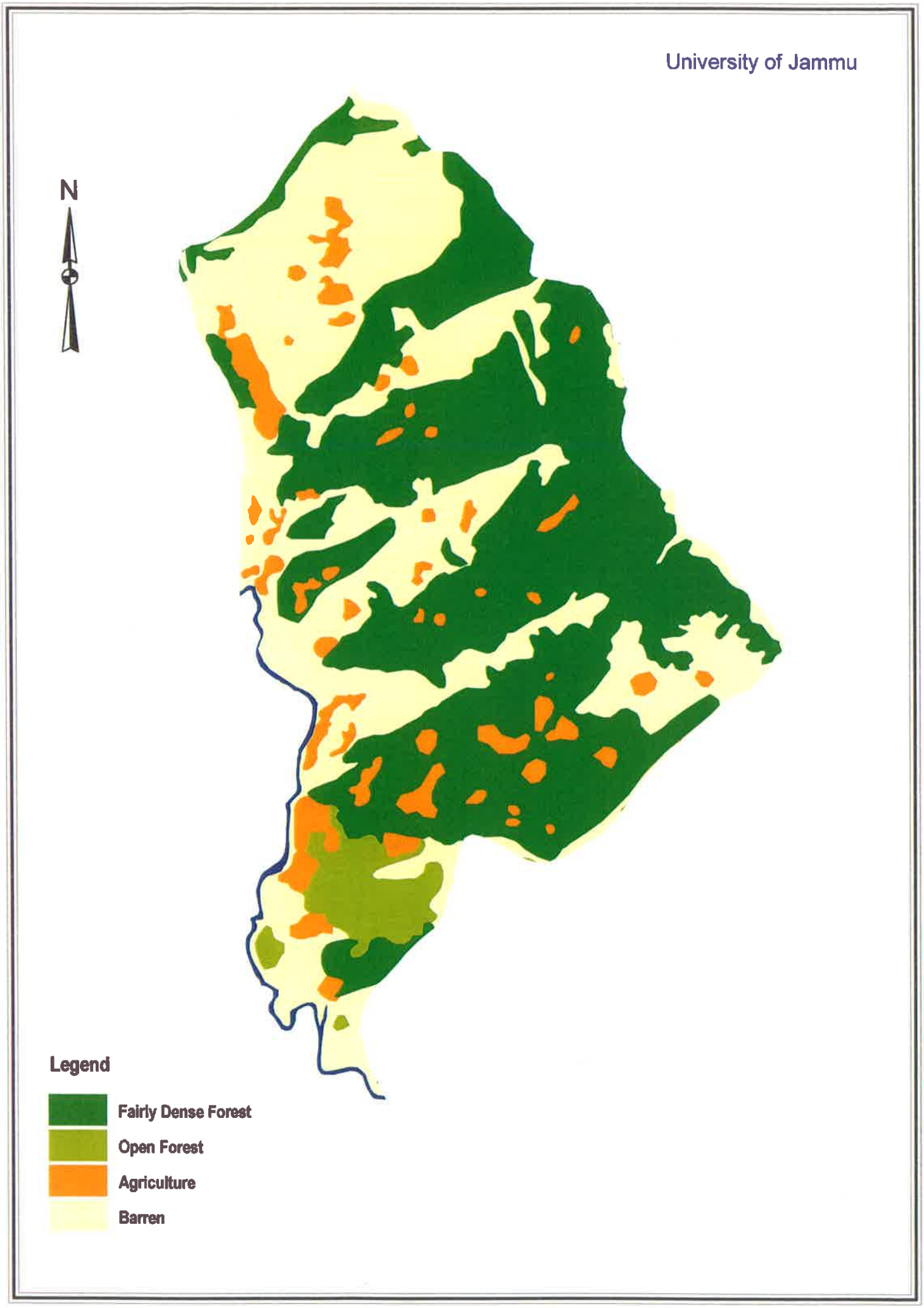


Fig 3.22 - Landuse / Landcover Map of S2c watershed in Sewa-II catchment

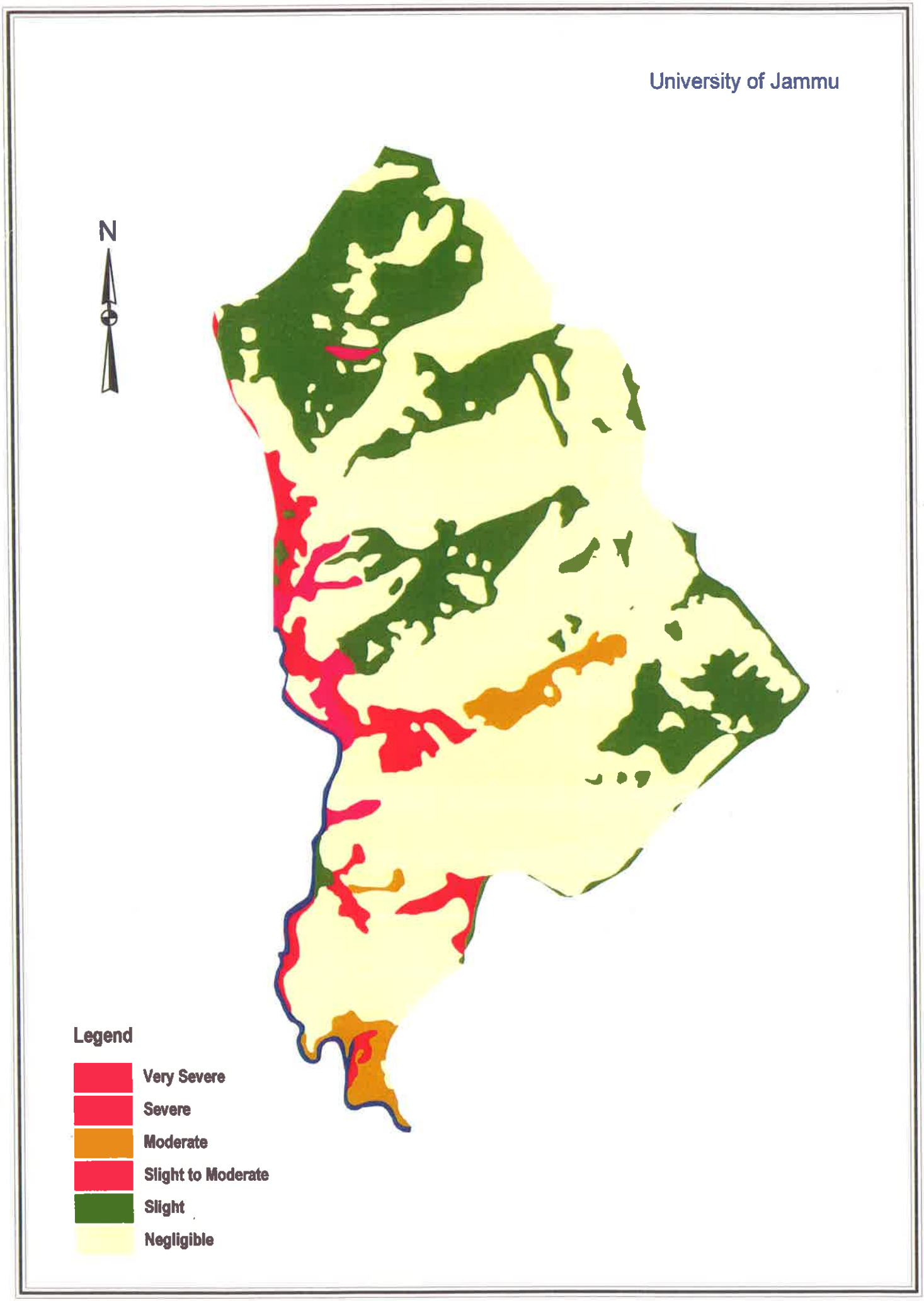


Fig 3.23 - Degradation / Erosion Intensity catagory Map of S2c watershed in Sewa-II catchment

S. No.	Treatment Measures	S2a	No. of structures
1.	Afforestation	280	-
2.	Fodder and fuel wood plantation	55	-
3.	Horticulture plantation	10	-
4.	Pasture development	10	-
5.	Contour trenches and plantation pits	35	3318 pits and 13272 trenches
6.	Bench terracing	12	-
7.	Stream bank protection	5	250 m^3
8.	Gully control measures	5	-
9.	Landslide control	10	500 m^3
10.	Contour bunds	10	-
11.	Check dams	15	15(Av. Dim. 8 x 1.5x2 m)
12.	Nala training	8	-
14.	Total	455	-

3.13.5: Watershed S2b

The S2b watershed has a total area of 6200 ha and falls within 1200 to 4000 altitude zone, and contributes its run-off to the reservoir. The altitudinal distribution of the total area in this watershed is given in Figure 3.18. The predominant landuse in this watershed is the dense forest with 3210 ha followed by severely degraded (barren land) of 1495 ha, open forest of 768 ha, cultivation and settlements spread over 688 ha, and very severely degraded (barren and rocky) of 39 ha (Fig. 3.19). This watershed is the second most degraded one having the largest severely degraded area in the entire catchment. The area requiring treatment in severe and very severe degraded categories is 1151 ha (Fig. 3.20). The following treatment measures are suggested for this watershed:

S. No.	Treatment Measures	S2b	No. of structures
1.	Afforestation	550	-
2.	Fodder and fuel wood plantation	220	-
3.	Horticulture plantation	150	-
4.	Pasture development	80	-

5.	Contour trenches and plantation pits	55	5214 pits and 20856 trenches
6.	Bench terracing	12	-
7.	Stream bank protection	15	750 m^3
8.	Gully control measures	10	-
9.	Landslide control	14	700 m^3
10.	Contour bunds	25	-
11.	Check dams	15	15(Av. Dim. 8 x 1.5x2 m)
12.	Nala training	5	-
13.	Total	1151	-

3.13.6: Watershed S2c

The S2c watershed is the largest one in the entire catchment has a total area of 10925 ha, which contributes its run-off to the reservoir. This watershed falls within the altitude zone of 800 to 3200 m. The altitudinal distribution of the total area in this watershed is given in Figure 3.21. The predominant landuse in this watershed is the dense forest with 5134 ha followed by open forest of 3591 ha, very severely degraded (barren and rocky land) of 1213 ha, and severely degraded (barren land) of 728 ha and cultivation and settlements spread over 259 ha (Fig. 3.22). The area requiring treatment in severe and very severe degraded categories is 1456 ha (Fig. 3.23). The following treatment measures are suggested for this watershed:

S. No.	Treatment Measures	S2c	No. of structures
1.	Afforestation	740	-
2.	Fodder and fuel wood plantation	227	-
3.	Horticulture plantation	75	-
4.	Pasture development	75	-
5.	Contour trenches and plantation pits	40	3792 pits and 15168 trenches
6.	Bench terracing	80	-
7.	Stream bank protection	45	2250 m^3
8.	Gully control measures	30	-
9.	Landslide control	50	2500 m^3
10.	Contour bunds	50	-
	Check dams	15	15(Av. Dim. 8 x 1.5x2 m)
12.	Nala training	29	-
13.	Total	1456	-

3.14: ADMINISTRATIVE SET-UP

The execution of the catchment treatment project is basically a technical plan and therefore, needs the involvement of technical personnel at different stages of its execution. For this purpose constitution of an expert staff from the implementing agency and a monitoring committee of technical officials of Environment, NHPC (under rules) are recommended. The staff to be required must include Forest Officer (1), Ranger Officer/ Dy. Ranger (2), Junior Engineer (1), Forest Guards (5), Assistant (1), Driver (1) and Peon (1).

The NHPC would be responsible to get different catchment treatment measures proposed in CAT Plan implemented through J&K Forest Department. The necessary fund for the administrative staff and equipment has been given in Table 3.2 which shall be provided by the project during the execution period.

3.15: MONITORING AND PERIOD OF IMPLEMENTATION

The CAT Plan joint monitoring Committee comprising of Environment Officers of NHPC and State Forest Officer will review the progress of execution of the CAT plan after every six-month period. The joint monitoring committee will also prepare a report on the progress of the work done during the period of review.

The execution of the CAT Plan of Sewa River catchment would require time involving and extensive efforts for its successful completion. Since the catchment area is topographically and climatically very difficult and remains snow bound during the winter months. Keeping the time-lapse option in implementation due to adverse climatic conditions and other unforeseen events, the implementation time of 4 years and follow up maintenance period of 3 years is recommended. All these works should be simultaneously started with the pre-construction activities especially the studies for micro-level planning for each watershed. The physical and financial time schedule for different bioengineering and biological activities suggested in the CAT Plan along with watershed-wise distribution is given in Table 3.3.

3.16: FINANCIAL REQUIREMENT:

The necessary fund for execution of CAT Plan should be made available by the Project subject to following conditions :

- A joint monitoring monitoring committee should be constituted comparising officers from Project (NHPC) and State Forest Department.

- The above proposed joint monitoring committee will be implemented CAT area once in six months and submit their report to the project.

- Fund will be released half yearly subject to the recommendation of Joint Monitoring Committee.

- The proposed CAT fund should not be enhanced in any circumstances and the completion schedule must be fulfilled by the executing agency i.e. State Forest Department in through spirit.

Tab.: 3.1: WATERSHED-WISE TREATMENT MEASURES PROPOSED IN CATCHMENT AREA

Sl No	Treatment Measures	S1a	S1b	S2a	S2b	S2c	Total
1.	Afforestation	40	30	280	550	740	**1640**
2.	Fodder & Fuel Wood Plantation	15	5	55	220	227	**522**
3.	Horticulture Plantation	10	5	10	150	75	**250**
4.	Pasture Development	10	5	10	80	75	**180**
5.	Contour Trench Plantation	20	10	35	55	40	**160**
6.	Bench Terracing	-	-	12	12	80	**104**
7.	Stream Bank Protection	8	2	5	15	45	**75**
8.	Gully Control Measures	12	2	5	10	30	**59**
9.	Landslides Control	4	2	10	14	50	**80**
10.	Contour Bunds	4	-	10	25	50	**89**
11.	Check Dams	8	2	15	15	15	**55**
12.	Nala Training	--	--	8	5	29	**42**
	Total	**131**	**63**	**455**	**1151**	**1456**	**3256**

Tab. 3.2

COST ESTIMATE FOR ADMINISTRATIVE STAFF AND EQUIPMENT

S.No	Post	Salary	No. of post	Total Annual (Rs in Lakhs)
A.	**Administrative Staff (For First four years)**			
1	Forest Officer	15000	1	1,80,000
2	R.O/Dy.R.O	10000	2	2,40,000
3	Junior Engineer	10000	1	1,20,000
4	Forest Guards.	5000	5	3,00,000
5	Assistant	8000	1	96,000
6	Driver	5000	1	60,000
7	Peon/Khalasi	4000	1	48,000
	Total for Ist Year			10,44,000
	Total for IInd Year			11,48,400
	Total for IIIrd Year			12,63,240
	Total for IVth Year			13,89,564
	Total (A)			**48,45,204**
B.	**Administrative Staff (During Maintenance)**			
1	R.O/Dy.R.O	12,000	1	1,20,000
2	Forest Guards.	6,000	5	3,60,000
3	Assistant	8000	1	96,000
4	Driver	5000	1	60,000
5	Peon/Khalasi	4000	1	48,000
	Total for Vth Year			6,84,000
	Total for Vith Year			7,52,400
	Total for VIIth Year			8,27,740
	Total (B)			**22,64,140**

C. Machinery & Equipment

Item	Qty	Amount(Rs
Gypsy	1	4.00
Computer	1	1.00
Tools	L.S	5.00
Misc./Stationery	L.S	15.00
R&M of vehicle for 4	L.S @	2.50
Total (C)		**27.50**

GRAND TOTAL (A + B+C) = 98,59,344

Say Rupees 100.00 Lacs Only

Tab.-3.3

Sl. No.	Item of Work	Unit	Unit Cost (Rs.)	Yearwise breakup for Treatment Works								Yearwise breakup for Maintenance						Total	
				Ist Year		IInd Year		IIIrd Year		IVth Year		Vth Year		VIth Year		VIIth Year			
				Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
A.	**BIOLOGICAL MEASURES**																		
1	Afforestation	ha	10000	300	3000000	540	5400000	400	4000000	400	4000000							1640	16400000
2	Fodder and fuel wood planttion	ha	10000	72	720000	150	1500000	150	1500000	150	1500000							522	5220000
3	Horticulture plantation	ha	12000	60	720000	60	720000	65	780000	65	780000							250	3000000
4	Pasture Development	ha	6000	50	300000	40	240000	40	240000	50	300000							180	1080000
5	Maintenance of Plantation								0		0								0
a	Ist year maintenance	ha	1500			432	648000	750	1125000	615	922500	615	922500					2412	3618000
b	2nd year maintenance	ha	1000				0	432	432000	750	750000	615	615000	615	615000			2412	2412000
c	3rd year maintenance	ha	1000				0		0	432	432000	750	750000	615	615000	615	615000	2412	2412000
6	Contour trench Plantation	ha	20425	40	817000	50	1021250	50	1021250	50	1021250		0		0		0	160	3268000
	Sub Total A																		3,74,10,000
B.	**ENGINEERING MEASURES**																		
1	Gully Control	ha	8000	15	120000	15	120000	15	120000	14	112000							59	472000
2	Stream Bank Protection	ha	30000	20	600000	20	600000	20	600000	15	450000							75	2250000
3	Bench Terracing	ha	2500	30	50000	30	75000	30	75000	14	35000							104	260000
4	Landslide Control	ha	30000	20	600000	20	600000	20	600000	30	600000							80	2400000
5	Contour bunds	ha	2000	20	40000	22	44000	22	44000	25	50000							89	178000
6	Check dams	ha	4800	15	72000	15	72000	15	72000	10	48000							55	264000
7	Nala training	ha	8000	10	80000	12	96000	10	80000	10	80000							42	336000
	Sub Total B																		6160000
	TOTAL (A+B)																		43570000
C	**Contingencies @ 5% of (A+B)**																		2178500
	GRAND TOTAL																		**45748500**

CHAPTER - 4

BIODIVERSITY CONSERVATION PLAN