CHAPTER-2
CATCHMENT AREA TREATMENT

2.1 NEED FOR CATCHMENT AREA TREATMENT

It is a well-established fact that reservoirs formed by dams, weirs or barrages on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The study of erosion and sediment yield from catchments is of utmost importance as the deposition of sediment in reservoir reduces its capacity, and thus affecting the water availability for the designated use. The eroded sediment from catchment when deposited on streambeds and banks causes braiding of river reach. The removal of top fertile soil from catchment adversely affects the agricultural production. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above-mentioned adverse process of soil erosion.

Soil erosion may be defined as the detachment and transportation of soil. Water is the major agent responsible for this erosion. In many locations, winds, glaciers, etc. also cause soil erosion. In a hilly catchment area as in the present case erosion due to water is a common phenomenon and the same has been studied as a part of the Catchment Area Treatment (CAT) Plan.

The Catchment Area Treatment (CAT) plan highlights the management techniques to control erosion in the catchment area of a water resource project. The life span of a reservoir is greatly reduced due to erosion in the catchment area. Adequate preventive measures are thus needed for the treatment of catchment for its stabilization against future erosion. The total catchment considered for treatment under the present project i.e. Jakhol Sankari hydroelectric project. The sub-watersheds in the catchment area considered for the present study is given in Figure-2.1.

The catchment area treatment involves

- Understanding of the erosion characteristics of the terrain and,
- Suggesting remedial measures to reduce the erosion rate.

In the present study **`Silt Yield Index' (SYI)**, method has been used. In this method, the terrain is subdivided into various watersheds and the erodibility is determined on relative basis. SYI provides a comparative erodibility criteria of catchment (low, moderate, high, etc.) and do not provide the absolute silt yield. SYI method is widely

used mainly because of the fact that it is easy to use and has lesser data requirement. Moreover, it can be applied to larger areas like sub-watersheds, etc.

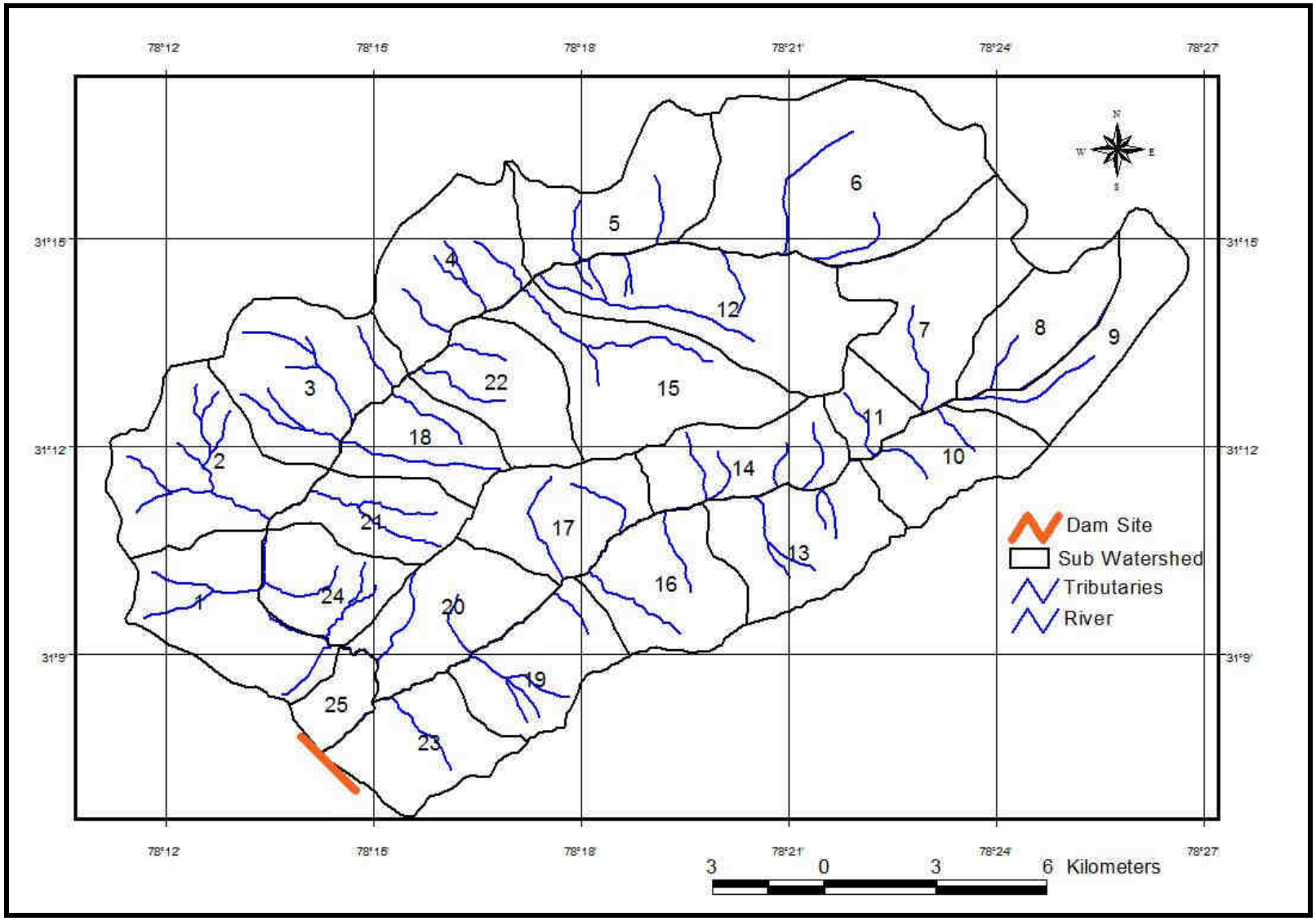

Figure-2.1: Sub-watersheds in the catchment area

2.2 APPROACH FOR THE STUDY

A detailed database on natural resources, terrain conditions, soil type of the catchment area, socio-economic status, etc. is a pre-requisite to prepare treatment plan keeping in view the concept of sustainable development. Various thematic maps have been used in preparation of the CAT plan. Due to the spatial variability of site parameters such as soils, topography, land use and rainfall, not all areas contribute equally to the erosion problem. Several techniques like manual overlay of spatially index-mapped data have been used to estimate soil erosion in complex landscapes.

Geographic Information System (GIS) is a computerized resource data base system, which is referenced to some geographic coordinate system. In the present study, real coordinate system has been used. The GIS is a tool to store, analyze and display various spatial data. In addition, GIS because of its special hardware and software characteristics, has a capacity to perform numerous functions and operations on the various spatial data layers residing in the database. GIS provides the capability to analyze large amounts of data in relation to a set of established criteria.

In order to ensure that latest and accurate data is used for the analysis, satellite data has been used for deriving land use data and ground truth studies too have been conducted.

The various steps covered in the study are as follows:

- Data acquisition
- Data preparation
- Output presentation

The above mentioned steps are briefly described in the following paragraphs.

2.2.1 Data Acquisition

The requirement of the study was first defined and the outputs expected were noted.

The various data layers of the catchment area used for the study are as follows:

- Slope Map
- Soil Map
- Land use Classification Map
- Current Management Practices
- Catchment Area Map.

2.2.2 Data Preparation

The data available from various sources was collected. The ground maps, contour information, etc. were scanned, digitized and registered as per the requirement. Data was prepared depending on the level of accuracy required and any corrections required were made. All the layers were geo-referenced and brought to a common scale (real coordinates), so that overlay could be performed. A computer programme was used to estimate the soil loss. The formats of outputs from each layer were firmed up to match the formats of inputs in the program. The grid size to be used was also decided to match the level of accuracy required, the data availability and the software and time limitations. The format of output was finalized. Ground truthing and data collection was also included in the procedure.

For the present study IRS 1C-LISS III digital satellite data was used for interpretation & classification. The classified land use map of the catchment area considered for the study is shown as Figure-2.2. The landuse pattern of the catchment interrupted at weir site is summarized in Table-2.1.

TABLE-2.1

Landuse pattern of the catchment area

Category	**Area (ha)**	**Percentage of Catchment area (%)**
Dense vegetation	5405	20
Open vegetation	2121	8
Agricultural land	137	1
Alpine pasture	5609	21
Barren land	2941	11
Water body	3311	12
Snow Cover	7273	27
Total	**26800**	**12**

Digitized contours from toposheets were used for preparation of Digital Elevation Model (DEM) of the catchment area and to prepare a slope map. The first step in generation of slope map is to create surface using the elevation values stored in the form of contours or points. After marking the catchment area, all the contours on the toposheet were digitised (100 m interval). The output of the digitisation procedure was the contours as well as points contours in form of x, y & z points. (x, y location and their elevation). All this information was in real world coordinates (latitude, longitude and height in meters above sea level).

A Digital Terrain Model (DTM) of the area was then prepared, which was used to derive a slope map. The slope was divided in classes of slope percentages. The slope map is enclosed as Figure-2.3.

Various layers thus prepared were used for Modeling. Software was prepared to calculate the soil loss using input from all the layers.

2.2.3 Output Presentation

The result of the modeling was interpreted in pictorial form to identify the areas with high soil erosion rates. The primary and secondary data collected as a part of the field studies were used as an input for the model.

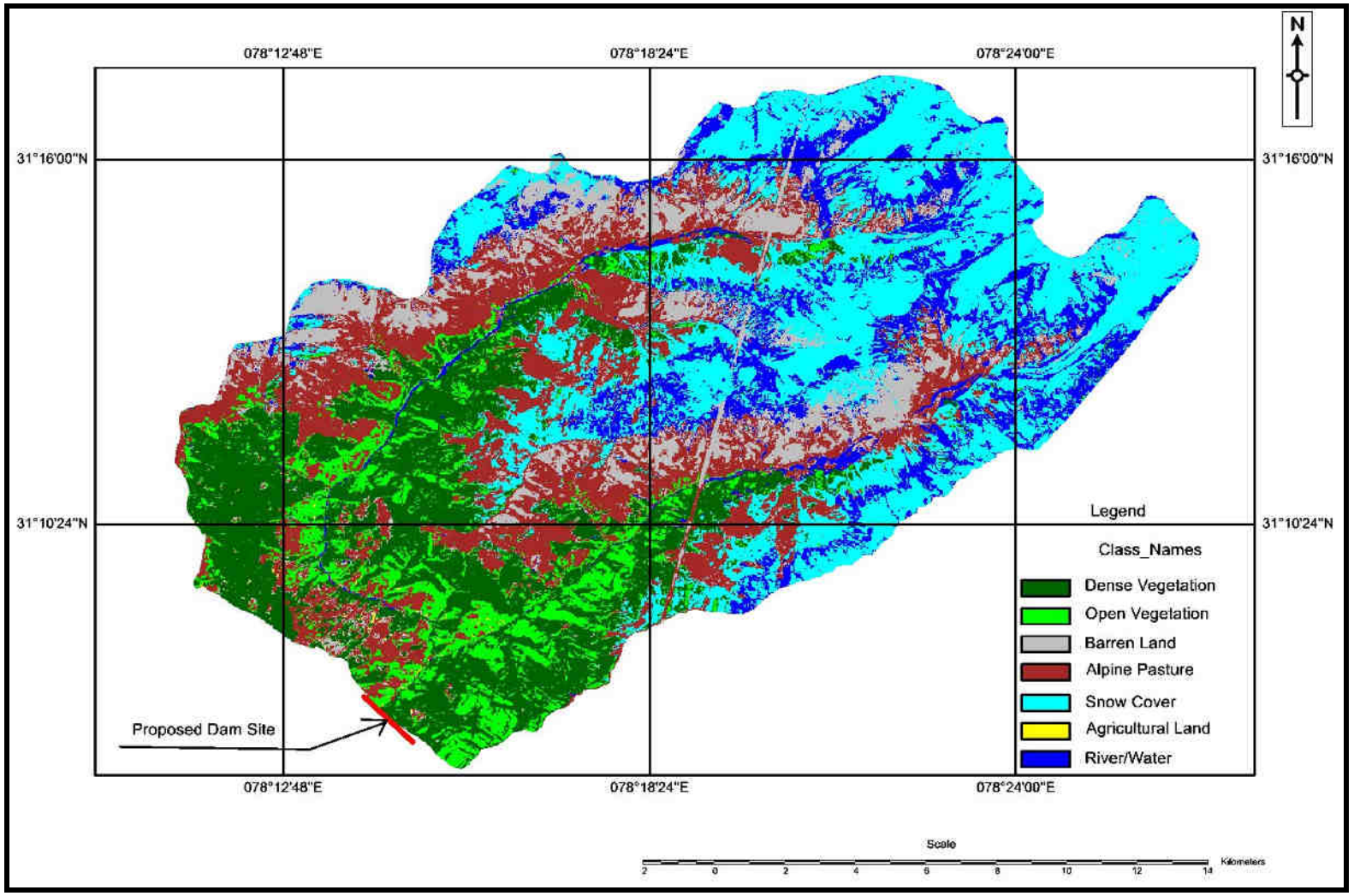

Figure-2.2: Classified imagery of the catchment area

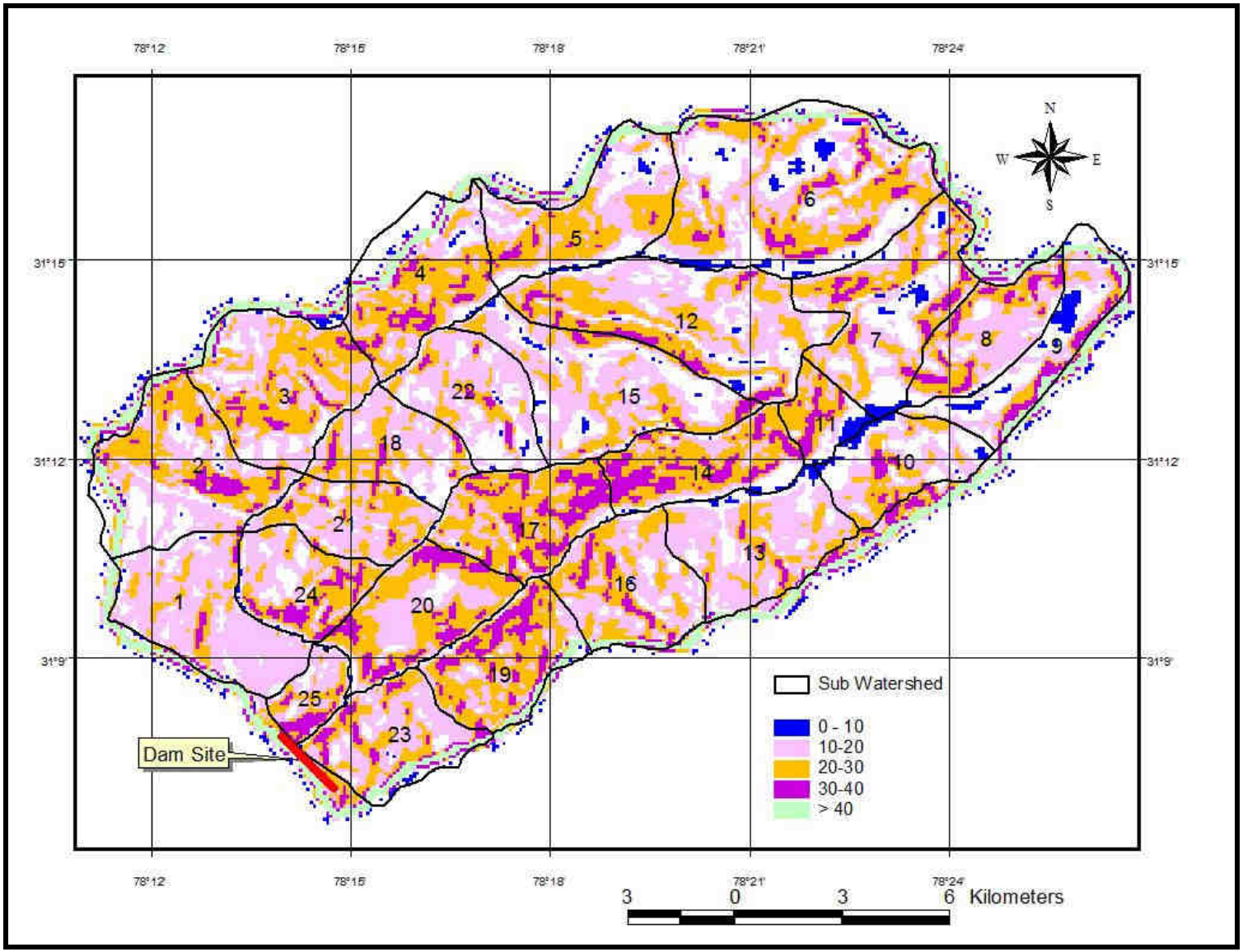

Figure-2.3: Slope Map of the catchment area

2.3 ESTIMATION OF SOIL LOSS USING SILT YIELD INDEX (SYI) METHOD

The Silt Yield Index Model (SYI), considering sedimentation as product of erosivity, erodibility and arial extent was conceptualized in the All India Soil and Land Use Survey (AISLUS) as early as 1969 and has been in operational use since then to meet the requirements of prioritization of smaller hydrologic units.

The erosivity determinants are the climatic factors and soil and land attributes that have direct or reciprocal bearing on the unit of the detached soil material. The relationship can be expressed as:

Soil erosivity = f (Climate, physiography, slope, soil parameters, land use/land cover, soil management)

Silt Yield Index

The Silt Yield Index (SYI) is defined as the Yield per unit area and SYI value for hydrologic unit is obtained by taking the weighted arithmetic mean over the entire area of the hydrologic unit by using suitable empirical equation.

Prioritization of Watersheds/Sub-watersheds

The prioritization of smaller hydrologic units within the vast catchments are based on the Silt Yield Indices (SYI) of the smaller units. The boundary values or range of SYI values for different priority categories are arrived at by studying the frequency distribution of SYI values and locating the suitable breaking points. The watersheds/ sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values.

The application of SYI model for prioritization of subwatersheds in the catchment areas involves the evaluation of:

a) Climatic factors comprising total precipitation, its frequency and intensity,
b) Geomorphic factors comprising land forms, physiography, slope and drainage characteristics,
c) Surface cover factors governing the flow hydraulics and
d) Management factors.

The data on climatic factors can be obtained for different locations in the catchment area from the meteorological stations whereas the field investigations are required for estimating the other attributes. The various steps involved in the application of model are:

- Preparation of a framework of sub-watersheds through systematic delineation

- Rapid reconnaissance surveys on 1:50,000 scale leading to the generation of a map indicating erosion-intensity mapping units.
- Assignment of weightage values to various mapping units based on relative silt-yield potential.
- Computing Silt Yield Index for individual watersheds/subwatersheds.
- Grading of watersheds/subwatersheds into very high, high medium, low and very low priority categories.

The area of each of the mapping units is computed and silt yield indices of individual subwatersheds are calculated using the following equations:

a. Silt Yield Index

$$SYI = \frac{\Sigma (Ai \times Wi) \times 100}{Aw}; \quad \text{where } i = 1 \text{ to } n$$

where

Ai = Area of ith unit (EIMU)
Wi = Weightage value of ith mapping unit
n = No. of mapping units
Aw = Total area of sub-watershed.

The SYI values for classification of various categories of erosion intensity rates are given in Table-2.2.

TABLE-2.2
Criteria for erosion intensity rate

Priority categories	SYI Values
Very high	> 1300
High	1200-1299
Medium	1100-1199
Low	1000-1099
Very Low	<1000

2.4 WATERSHED MANAGEMENT – AVAILABLE TECHNIQUES

Watershed management is the optimal use of soil and water resources within a given geographical area so as to enable sustainable production. It implies changes in land use, vegetative cover, and other structural and non-structural action that are taken in a watershed to achieve specific watershed management objectives. The overall objectives of watershed management programme are to:

- increase infiltration into soil;
- control excessive runoff;
- manage and utilize runoff for useful purpose.

Following Engineering and Biological measures have been suggested for the catchment area treatment.

1. Engineering measures

- Step drain
- Angle iron barbed wire fencing
- Stone masonry
- Check dams

2. Biological measures

- Development of nurseries
- Plantation/afforestation
- Pasture development
- Social forestry

The basis of site selection for different biological and engineering treatment measures under CAT are given in Table-2.3.

TABLE-2.3
Basis for selection of catchment area treatment measures

Treatment measure	Basis for selection
Social forestry, fuel wood and fodder grass development	Near settlements to control tree felling
Contour Bunding	Control of soil erosion from agricultural fields.
Pasture Development	Open canopy, barren land, degraded surface
Afforestation	Open canopy, degraded surface, high soil erosion, gentle to moderate slope
Barbed wire fencing	In the vicinity of afforestation work to protect it from grazing etc.
Step drain	To check soil erosion in small streams, steps with concrete base are prepared in sloppy area where silt erosion in the stream and bank erosion is high due to turbidity of current.
1:4:8 Stone masonry	Steep slopes, sliding surfaces, less vegetative cover and silt erosion is high
Nursery	Centrally located points for better supervision of proposed afforestation, minimize cost of transportation of seedling and ensure better survival.

2.5 CATCHMENT AREA TREATMENT MEASURES

The total catchment area is 26800 ha. The erosion category of various watershed in the catchment area as per a SYI index are given in Tables-2.4 and 2.5. The details are shown in Figure-2.4.

TABLE-2.4
Erosion category of various watersheds

Watershed number	Area (ha)	SYI values	Category
W1	1225	1240	High
W2	1461	1253	High
W3	1341	1125	Medium
W4	1194	1036	Low
W5	1165	1047	Low
W6	2497	1036	Low
W7	738	1137	Medium
W8	709	1170	Medium
W9	771	1153	Medium
W10	932	1153	Medium
W11	1519	1038	Low
W12	1799	1039	Low
W13	563	1058	Low
W14	322	1143	Medium
W15	1027	1236	High
W16	985	1170	Medium
W17	907	1151	Medium
W18	1193	1147	Medium
W19	905	1148	Medium
W20	952	1256	High
W21	1035	1017	Low
W22	1129	1054	Low
W23	775	1027	Low
W24	859	1054	Low
W25	797	1043	Low
Total	**26800**		

TABLE-2.5
Area under various erosion categories

S. No.	Category	Area (ha)
1.	Low	13332 (49.7)
2.	Medium	8803 (32.8)
3.	High	4665 (17.4)
	Total	**26800 (100)**

Note: Figure in brackets indicates percentage.

The objective of the SYI method is to prioritize sub-watershed in a catchment area for treatment. The area under very high and high erosion categories is to be treated at project cost. Hence, CAT plan has been suggested for area under high erosion category, as a part of the present CEIA study, the expenses of which have to be borne by project proponents. No area under very high erosion category is observed in the proposed project. The area under high erosion categories is 4665 ha.

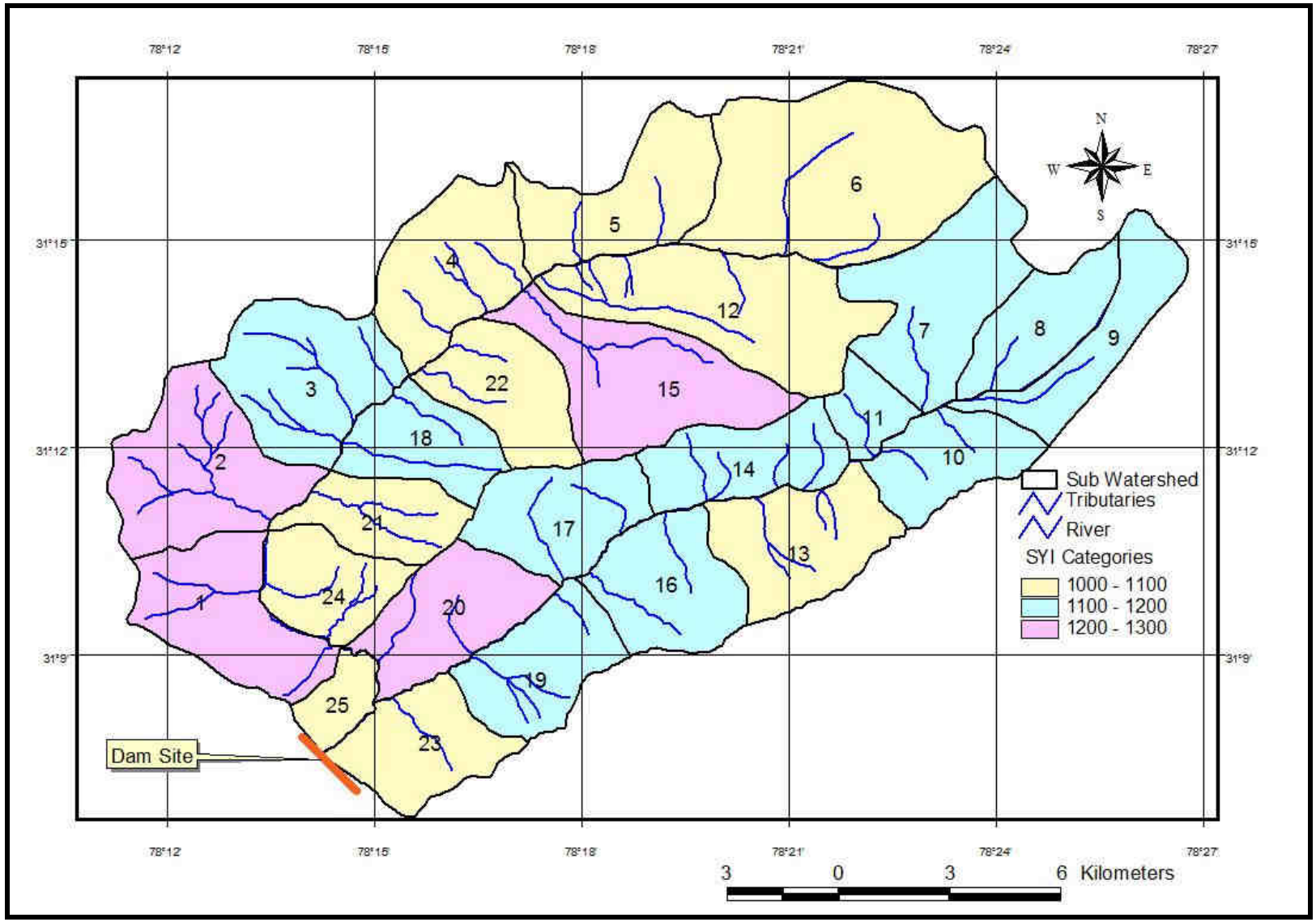

Figure-2.4: Prioritization Map of the catchment area

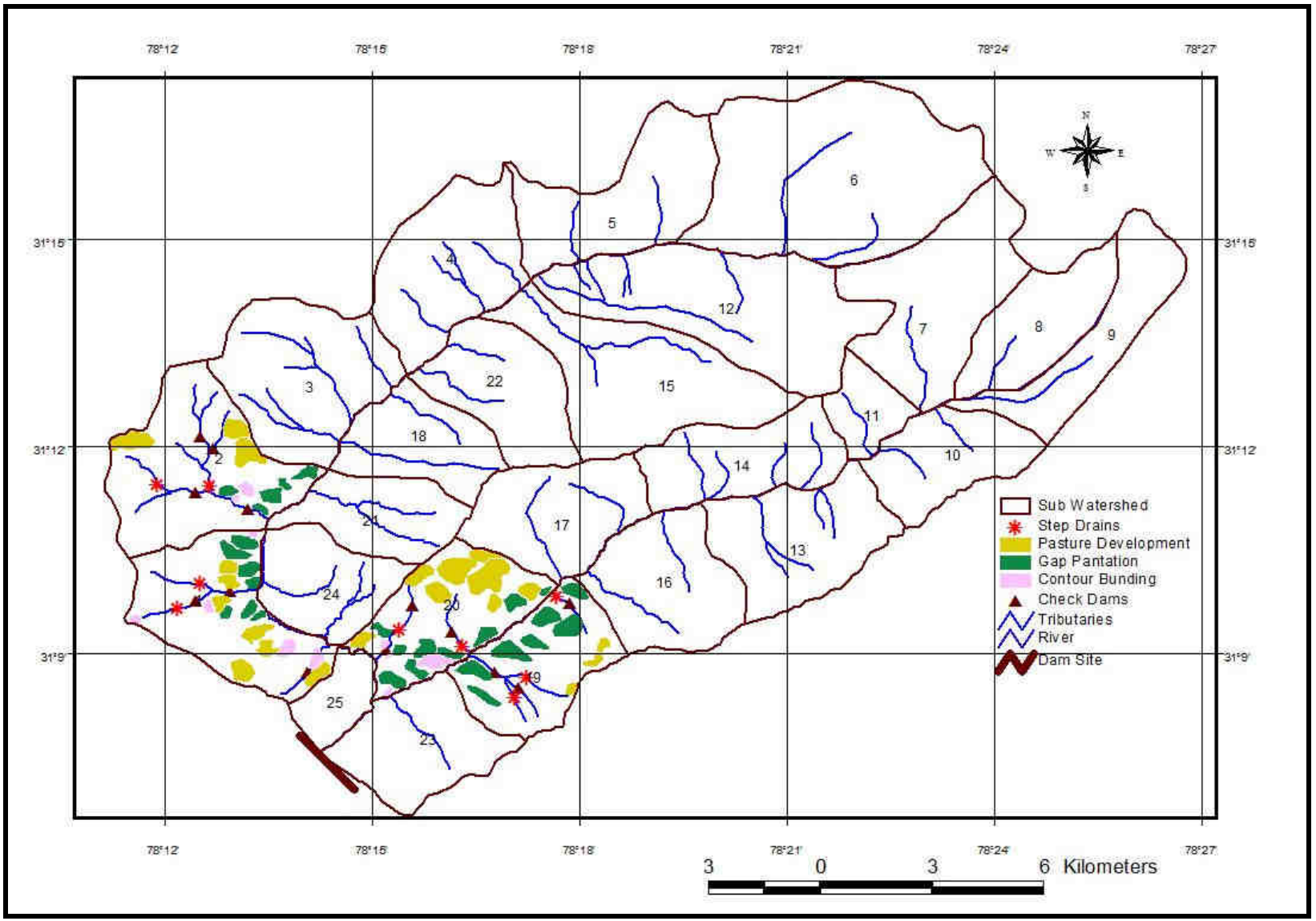

Figure-2.5 : Catchment Area Treatment Measures recommended for Jakhol Catchment

2.5.1 Biological Treatment Measures

An amount of Rs. 361.2 lakh has been earmarked for various afforestation measures. The details are given in Table-2.6.

TABLE-2.6
Cost estimate for implementation of Afforestation measures as a part of CAT Plan

S. No.	Item	Unit Rate (Rs.)	Unit	Target	
				Physical	Financial (Rs. lakh)
1.	Enrichment Plantation	30,000/ha	ha	428	128.4
2.	Pasture development	10,000/ha	ha	444 ha	44.4
3.	Nursery development	5,00,000/ no.	no.	5	25.0
4.	Barbed wire fencing	1,00,000/km	km	5	5.0
5.	Watch and ward for 5 years for 8 persons	8000/-	Man-months	480	38.4
6.	Rim Plantation	Lumpsum			70.0
7.	Social Forestry	Lumpsum			50.0
	Total				**361.2**

2.5.2 Soil & Water Conservation Works

An amount of Rs. 126.3 lakh has been earmarked for various Soil & Water Conservation measures. The details are given in Table-2.7.

TABLE-2.7
Cost estimate for implementation of Soil & Water Conservation measures as a part of CAT Plan

S. No.	Item	Unit Rate (Rs.)	Unit	Target	
				Physical	Financial (Rs. lakh)
1.	Contour Bunding	25,000/ha	ha	85	21.3
2.	Step drains	1,00,000	Nos.	9	9.0
3.	Check Dams	2,00,000	Nos.	13	26.0
4.	Landslide Control Measures				70.0
	Total				**126.3**

2.5.3 Research Training and Capacity Building

An amount of Rs. 60 lakh has been earmarked for Training & Capacity building of forest staff as well as local community through State Forest Training Institutes and reputed non-governmental organizations.

2.5.4 Forest Protection

An amount of Rs. 52.5 lakh has been earmarked for implementation of various Forest Protection measures. The details are given in Table-2.8.

TABLE-2.8
Cost summary for Forest Protection measures

S. No.	Component/Item	No.	Unit Rate (Rs. lakh)	Total Cost (Rs. lakh)
1	Fire protection measures			27.5
2	Distribution of Non-conventional Energy and Fuel Saving Devices in catchment area on a cost-sharing basis, such as, LPG, Tandoors, Pressure cookers and Solar devices	-	Lumpsum	25.0
	Total			**52.5**

2.5.5 Wildlife Management

It is recommended to fund various components of wildlife management plan through CAT Plans that have a direct bearing on the reduction of silt load. The activities proposed for wildlife related

interventions will be restricted to the project catchment area only. An amount of **Rs. 80.0 lakh** has been earmarked for implementation of various wildlife management measures.

2.6 COST ESTIMATE

The cost required for implementation of various measures is Rs. 680.0 lakh. The details are given in Table 2.9.

TABLE-2.9
Cost earmarked for implementation of CAT plan

S.No.	Activity	Amount (Rs. lakh)
1	Biological Treatment Measures	361.2
2	Soil & Water Conservation Works	126.3
3	Research Training and Capacity Building	60.0
4	Forest Protection	52.5
5	Wildlife Management	80.0
	Total	**680.0**

2.7 SCHEDULE FOR IMPLEMENTATION OF CAT PLAN

It is proposed to implement the CAT Plan in 5 years. The year wise implementation of physical and financial targets is given in Table-2.10.

TABLE-2.10
Yearwise implementation schedule for CAT Plan

S. No.	Activity	Year											
		Year I		Year II		Year III		Year IV		Year V		Total	
		Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)
A.	**Biological Treatment Measures**												
iii)	Enrichment Plantation	150 ha	45.0	100 ha	30.0	100 ha	30.0	78.0 ha	23.4	-	-	428 ha	128.4
iv)	Pasture Development	200 ha	20.0	150 ha.	15.0	94 ha	9.4	-	-	-	-	444 ha	44.4
v)	Nursery Development	3 No.	15.0	2 No.	10.0	-	-	-	-	-	-	5 No.	25.00
vi)	Barbed wire fencing	3 km	3.0	2 km	2.0	-	-	-	-	-	-	5 km	5.0
vii)	Watch and ward	96 man-months	7.68	96 man-months	7.68	96 man-months	7.68	96 man-months	7.68	96 man-months	7.68	480 man-months	38.4
viii)	Rim Plantation	-	40.0	-	30.0	-		-	-	-	-	-	70.00
ix)	Social Forestry	-	30.0	-	20.0	-	-	-	-	-	-	-	50.00
	Sub-Total (A)		**160.68**		**114.68**		**47.08**		**31.08**		**7.68**		**361.2**
B.	**Soil & Water Conservation Works**												
i)	Contour Bunding	50 ha	12.5	35 ha	8.75	-	-	-	-	-	-	85 ha	21.3
ii)	Step Drains	6	6.0	3	3.0	-	-	-	-	-	-		9.0

S. No.	Activity	Year											
		Year I		Year II		Year III		Year IV		Year V		Total	
		Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)	Phy.	Fin. (Rs. lakh)
iii)	Check Dams	7	14.0	6	12.0	-	-	-	-	-	-		26.0
iv)	Landslide Control Measures	-	50.0	-	20.0	-	-	-	-	-	-	-	70.0
	Sub-Total (B)		**82.5**		**43.75**	**-**	-	-	-	-	-	**-**	**126.3**
C.	Research, Training & Capacity Building	-	12.0	-	12.0	-	12.0	-	12.0	-	12.0	-	60.0
	Sub-Total (C)	**-**	**12.0**	**-**	**12.0**	**-**	**12.0**	**-**	**12.0**	**-**	**12.0**	**-**	**60.0**
D	**Forest Protection Measures**												
i)	Fire Protection Measures	-	20.0	-	7.5	-	-	-	-	-	-	-	27.5
ii)	Distribution of Non-conventional Energy and Fund Saving Devices	-	15.0	-	10.0	-	-	-	-	-	-	-	25.0
	Sub-Total (D)		**35.0**	**-**	**17.0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**52.5**
E	Wildlife Management	-	40.0	-	40.0	-	-	-	-	-	-	-	80.00
	Sub-Total (E)	**-**	**40.0**	**-**	**40.0**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**80.00**
	Grand Total	**-**	**330.18**		**227.93**		**59.08**		**43.08**		**19.68**		**680**