REGO HYDRO ELECTRIC PROJECT

(Tailrace scheme of Kangtangshiri H.E.P)

CATCHMENT AREA TREATMENT PLAN

FOR KANGTANGSHIRI HYDRO ELECTRIC PROJECT ARUNACHAL PRADESH

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Background of the Project:

A Memorandum of Agreement was executed between Government of Arunachal Pradesh and M/s Greenko Energies Pvt. Ltd. on 25-09-2012 for developing Rego Hydro Electric Project over Yargyap Chu River in West Siang District of Arunachal Pradesh with FRL and TWL of El. 1770.00m and El. 1685.00m respectively. Subsequently an SPV was incorporated by name of Greenko Rego Hydro Projects Pvt. Ltd on 24-03-2014 for implementing the project.

The distance available between FRL of El. 1770.0 m and TWL of El. 1685.0 m of Rego project is about 900 m only. Construction of diversion structure either with barrage or Dam will involve submergence of land. Also, construction of diversion tunnel for diverting flood discharge during construction and muck generation quantity from excavation of diversion tunnel and diversion structure will require more area of land for muck dumping which are not environmentally advantageous to the project.

Considering the above, instead of going in for an independent project, Rego project was envisaged as a tail race extension of upstream Kangtangshiri project and hence FRL of Rego HEP has been kept at El.1805.00m (i.e. TWL of Kangtangshiri HEP). Based on the above details, approval has been obtained for the revised FRL of EL 1805.00m from Department of Power, GoAP vide letter no. PWRS/E-1681/2008/Vol-III/4217-18 dated 02-08-13.

Rego project was envisaged as tail race development of Kangtangshiri project (utilizing the discharge from tail race of Kangtangshiri only) with an installed capacity of 82.8 MW. It envisages construction of an intake and an underground powerhouse on the left bank of Yargyap Chu nearby Rego village. The project area is bounded by latitudes $28^{o}34'$ N to $28^{o}34'8"$ N and longitudes 94^{o} 11'39"E to 94^{o} 12'31"E. The intake structure followed by HRT and pressure shaft all along the left bank will feed water to Francis turbines housed in underground powerhouse. The design discharge of the proposed scheme is 78.42 m^3/s with the rated head of 116.33 m. The project consists of bypass arrangement, intake chamber, 5.7 m dia. 1131.4 m long headrace tunnel, a 5.0 m dia. 124.8 m long pressure shaft, 3.5 m dia. branch pressure shafts, an underground powerhouse and tailrace Tunnel.

To facilitate the excavation of underground structures, adits have been provided. The powerhouse have two units of vertical axis Francis turbines and its accessories.

The project sites are accessible to motor vehicles from Passighat via Along. All the project components are well connected with the National Highway 52 up to the district headquarters Along of West Siang and then all-weather road from Along to Mechuka, which is maintained by Border Road Organization (BRO).

Project is also accessible from Dibrugarh which is on the left bank of Brahmaputra River. Regular ferry services are available to cross Brahmaputra River. Ferry has to be taken at Dibrugarh to cross the wide Brahmaputra River. After crossing Brahmaputra River at Majobari ghat on the right bank, one can reach Along either via Silapather or via Passighat (an important town of Arunachal Pradesh and headquarter of East Siang district). Along is

180 km from Majobari ghat via Silapathar whereas the other route via Passighat town is about 200 km up to Along.

The annual energy generation for 90% dependable year (1978-79) has been worked out. The unrestricted annual energy, energy generation restricted to 82.8 MW and annual energy generation (with 95% machine availability) works out to 391.46 GWh, 369.62 GWh and 361.62 GWh respectively. The annual load factor of the 82.8 MW plant at 100% machine availability and 95% machine availability is 50.97 % and 49.87 % respectively.

The Rego HEP, with an estimated cost of Rs. 363.60 crores and design energy of 361.62 GWh in a 90% dependable year with 95% machine availability is proposed to be completed in a period of 3 years. The tariff for first year and levelized tariff (at power house bus bar) have been worked out as Rs. 2.48 /kWh & Rs. 2.07 /kWh respectively.

CATCHMENT AREA TREATMENT PLAN

2.1 NEED FOR CATCHMENT AREA TREATMENT

It is a well-established fact that reservoirs formed by dams and 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

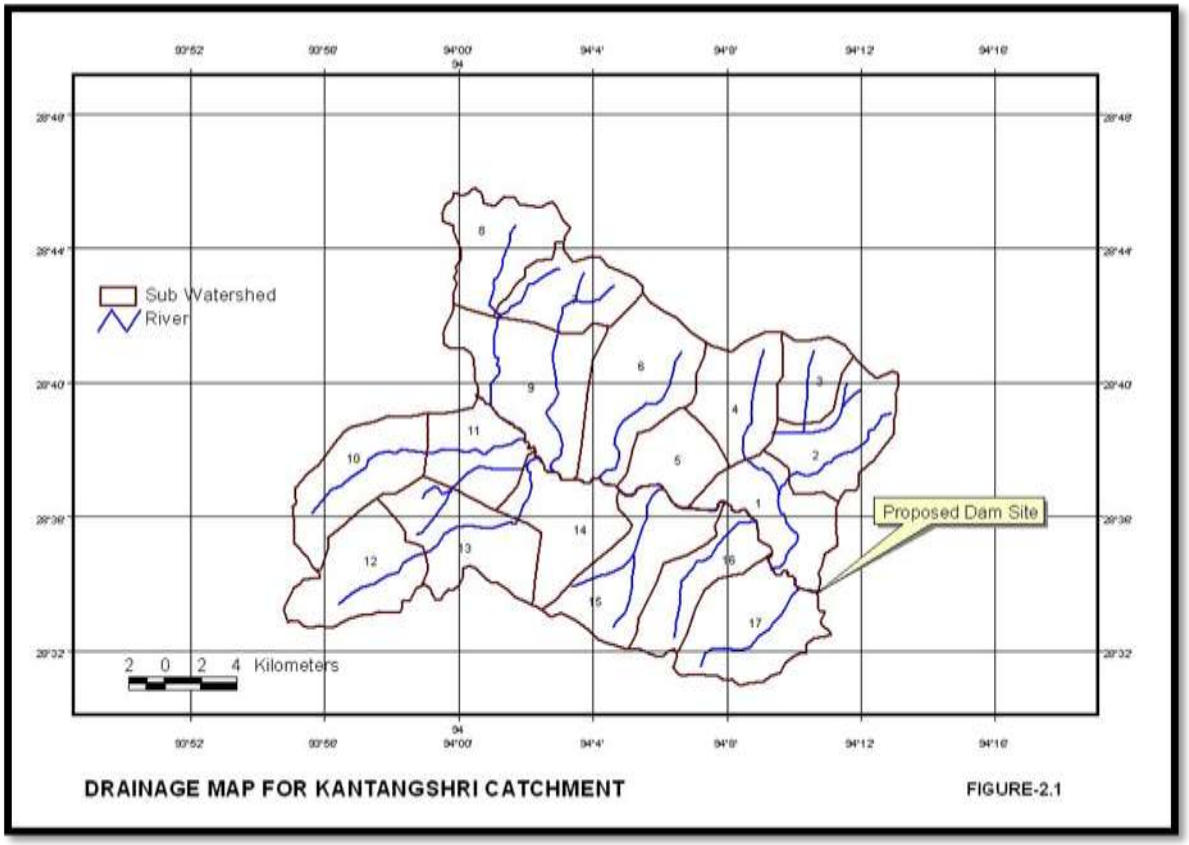
Soil erosion may be defined as the detachment and transportation of soil. Water is the major agent responsible for this erosion. In many locations, winds, glaciers, etc. also cause soil erosion. In a hilly catchment area, as in the present case erosion due to water is a common phenomenon and the same 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. Life span of a reservoir in case of a seasonal storage dams and barrages is greatly reduced due to erosion in the catchment area. The catchment area intercepted at the diversion structure of Kangtangshiri barrage site is 810 km^2. The catchment area intercepted at the diversion structure of Pemashelphu barrage site is 368 km^2. The catchment area considered for treatment is about (810-368=442 km^2) 44200 ha. The sub-watersheds in the catchment area considered for the present study are 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.



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.

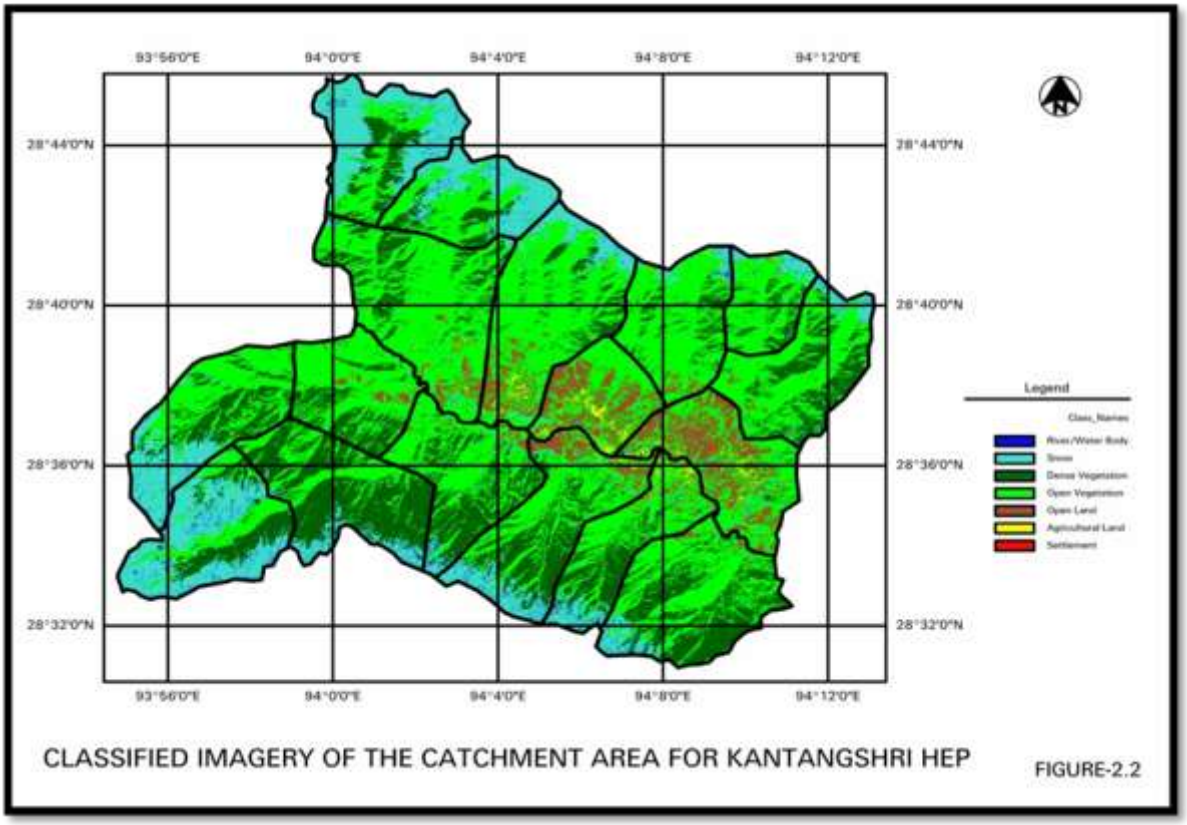
2.2.2 Data Preparation

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 Resourcesat-2 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 land use pattern of the catchment is summarized in Table-2.1.

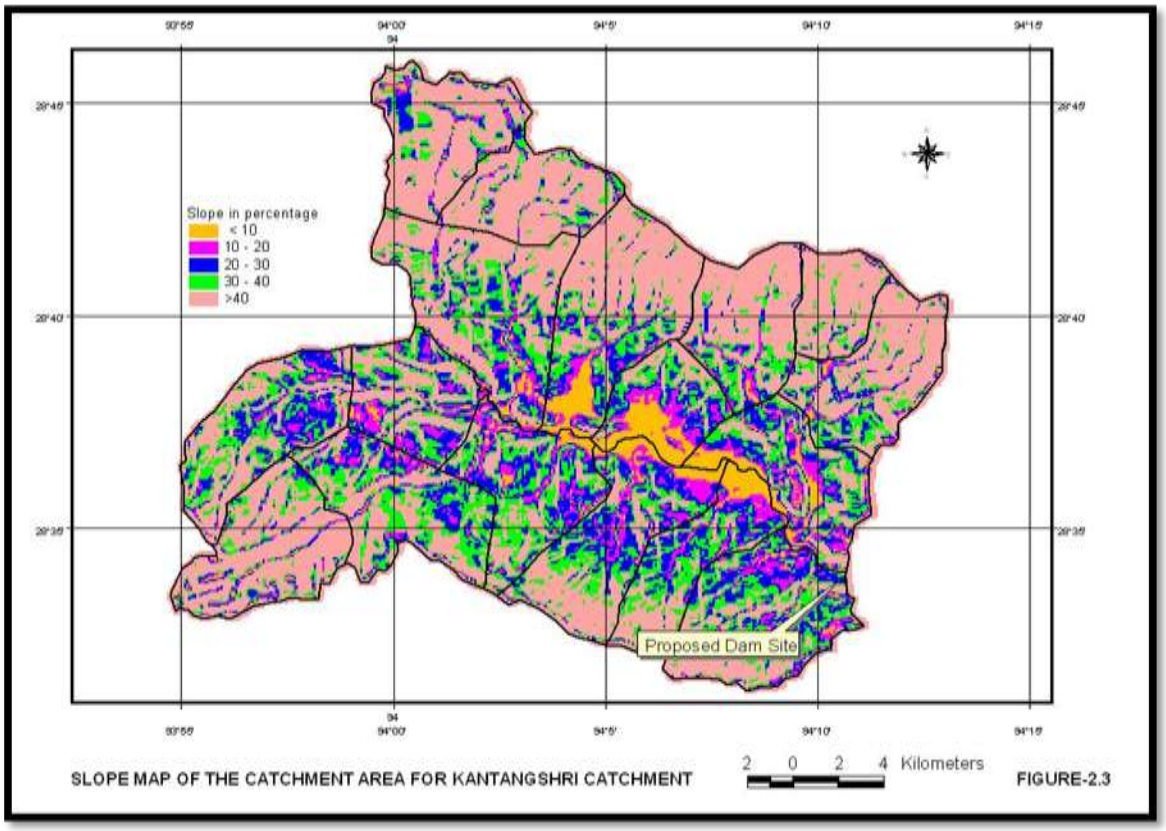
Table-2.1: Landuse pattern of the catchment area

Category	**Area (ha)**	**Percentage**
Dense Vegetation	10996	24.88
Open Vegetation	22340	50.54
Barren/Open Land	2726	6.17
Snow	7413	16.77
Agricultural Land	271	0.61
River/ Water body	439	0.99
Settlements	15	0.04
Total	**44200**	**100.00**



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 digitized (100 m interval). The output of the digitization 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.

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/Subwatersheds:

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 sub watersheds 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/sub watersheds.
- Grading of watersheds/sub watersheds 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 sub watersheds 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 & 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.
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

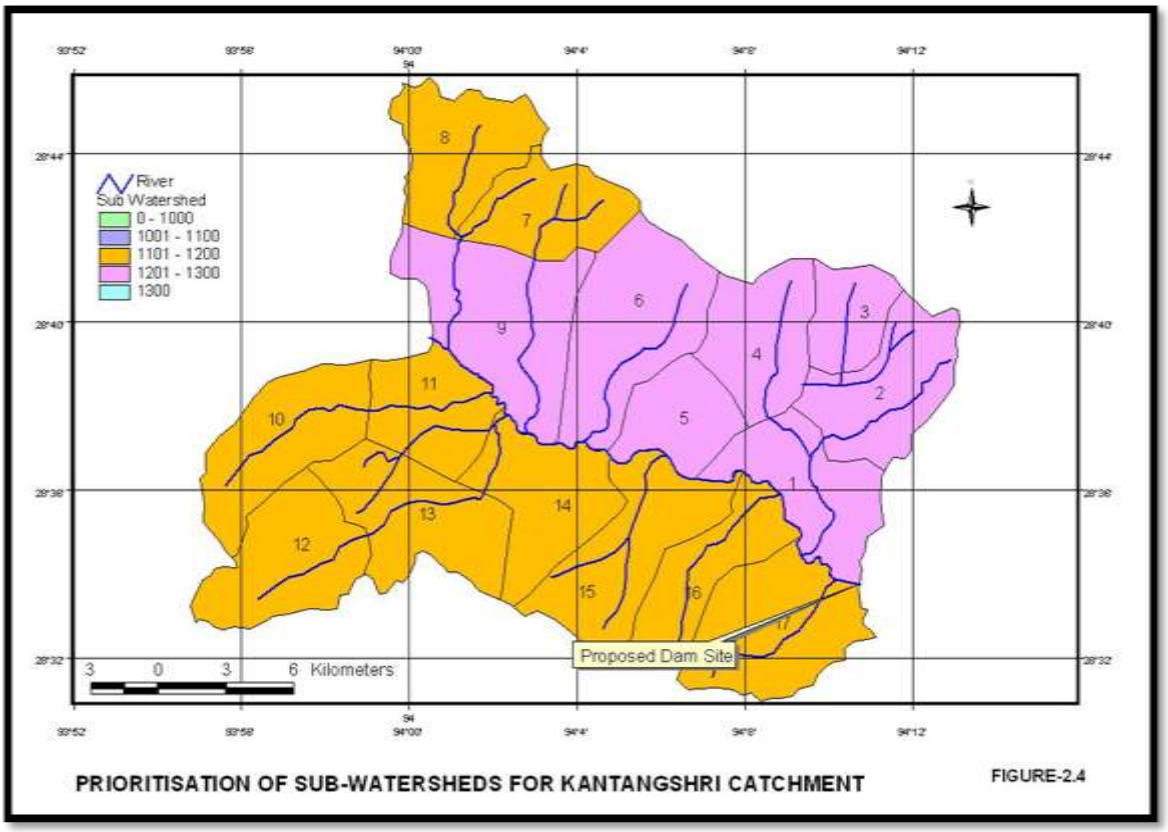
The total catchment area is 44200 ha. The erosion category of various watersheds in the catchment area as per a SYI index is given in Table-2.4. The details are shown in Figure-2.4. The area under different erosion categories is given in Table-2.5.

Table-2.4: Erosion intensity categorization as per SYI classification

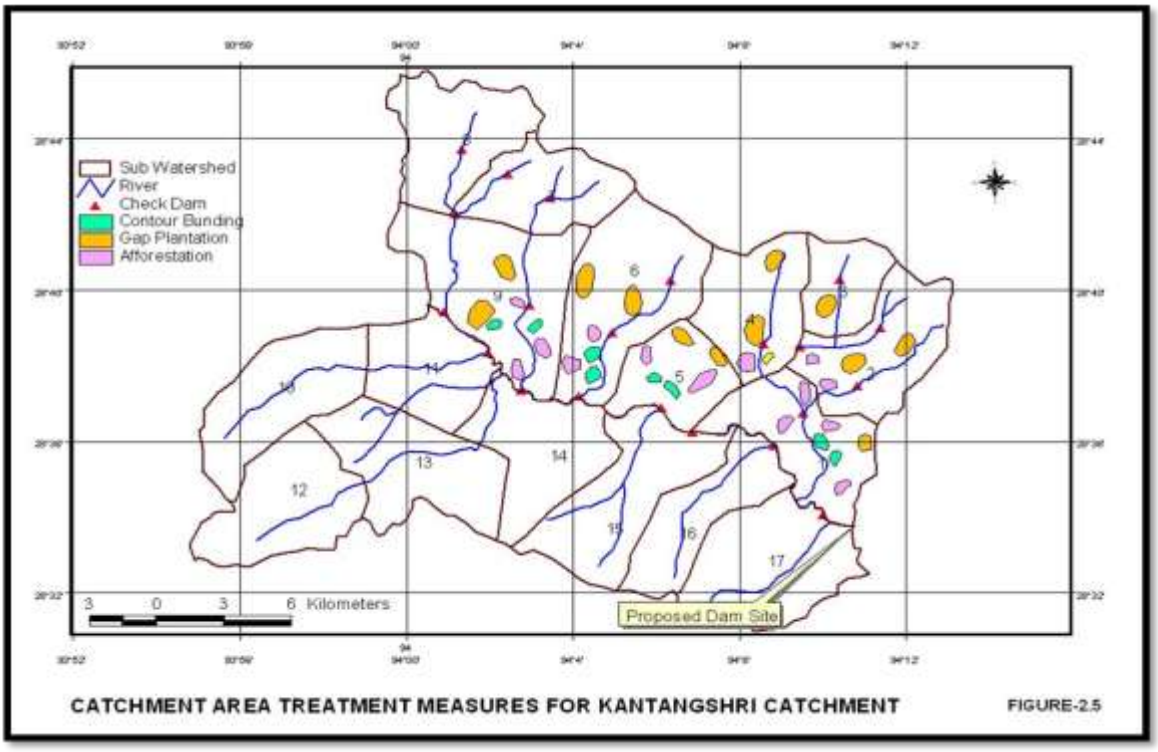
Watershed number	Area	SYI values	Category
W1	2490	1210	High
W2	2634	1220	High
W3	1295	1210	High
W4	2304	1230	High
W5	1670	1210	High
W6	3676	1230	High
W7	2065	1150	Medium
W8	2490	1150	Medium
W9	3906	1210	High
W10	2812	1130	Medium
W11	2080	1150	Medium
W12	2777	1140	Medium
W13	2955	1120	Medium
W14	2599	1140	Medium
W15	3104	1160	Medium
W16	2098	1180	Medium
W17	3245	1180	Medium
Total	**44200**		

Table-2.5: Area under different erosion categories

Category	Area (ha)	Percentage
Very low	-	-
Low	-	-
Medium	26225	59.33
High	17975	40.67
Very High	-	-
Total	**44200**	**100.00**



The objective of the SYI method is to prioritize sub-watershed in a catchment area for treatment. The total area under high erosion category is 17976 ha. The various measures suggested for catchment area treatment are mentioned in Figure-2.5, expenses of which have to be borne by the project proponents.



2.6 COST ESTIMATE

The cost required for Catchment Area Treatment is Rs. 690.5 lakh. The details are given in Table -2.6.

Table-2.6: Yearwise Cost Break up for CAT Measures for Kantangshri HEP

Measure	Year-I		Year-II		Year-III		Total	
	Physical	Financial (Rs. lakh)	Physical	Financial (Rs. lakh)	Physical	Financial (Rs. lakh)	Physical	Financial (Rs. lakh)
Gap Plantation	200 ha	100	200 ha	100	100 ha	50	500 ha	250
Afforestation	125 ha	125	100 ha	100	100 ha	100	325 ha	325
Nursery development	2 No.	8.0	-	-	-	-	2 No.	8.0
Maintenance of nursery	-	-	-	3.6	-	3.6	-	7.2
Barbed wire fencing	1 km	1.0	1 km	1.0	1 km	1.0	3 km	3.0
Watch and ward for 3 years for 5 persons	60 man-month	3.6	60 man-month	3.6	60 man-month	3.6	180 man-month	10.8
Contour bunding	40 No.	14	40 No.	14	30 No.	10.5	110 No.	38.5
Check dam	12 No.	24	12 No.	24	-	-	24 No.	48.0
Total		**275.6**		**246.2**		**168.7**		**690.5**
Say								**700.00**