DRAFT CATCHMENT AREA TREATMENT PLAN

OF

RHO HYDRO ELECTRIC PROJECT

October, 2015

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1 INTRODUCTION

The proposed Rho Hydro Electric Project (HEP), a run-of-river scheme is proposed to be developed on Tawang Chu, near Rho village in Tawang district in the state of Arunachal Pradesh. SEW Rho Power Corporation Pvt. Ltd. is the proposed SPV to implement Rho HEP. The project location map is enclosed as **Figure 1**.

The diversion structure of 93 MW Rho HEP is envisaged as a barrage on Tawang Chu and an underground power house at the right bank of Tawang Chu. The project also involves the construction of the head race tunnel, surge shaft, pressure shaft and a powerhouse-tailrace channel, and proposed to have three units, each having capacity of 31 MW.

Scope of the present study is to prepare Catchment Area Treatment (CAT) Plan for the free draining catchment area of Rho HEP. Hence, the free draining catchment has been delineated as intercepting catchment area falling between diversion sites of upstream Mago Chu HEP on Mago Chu and Nyukcharong Chu HEP on Nyukcharong Chu and till diversion site of proposed Rho HEP on Tawang Chu.

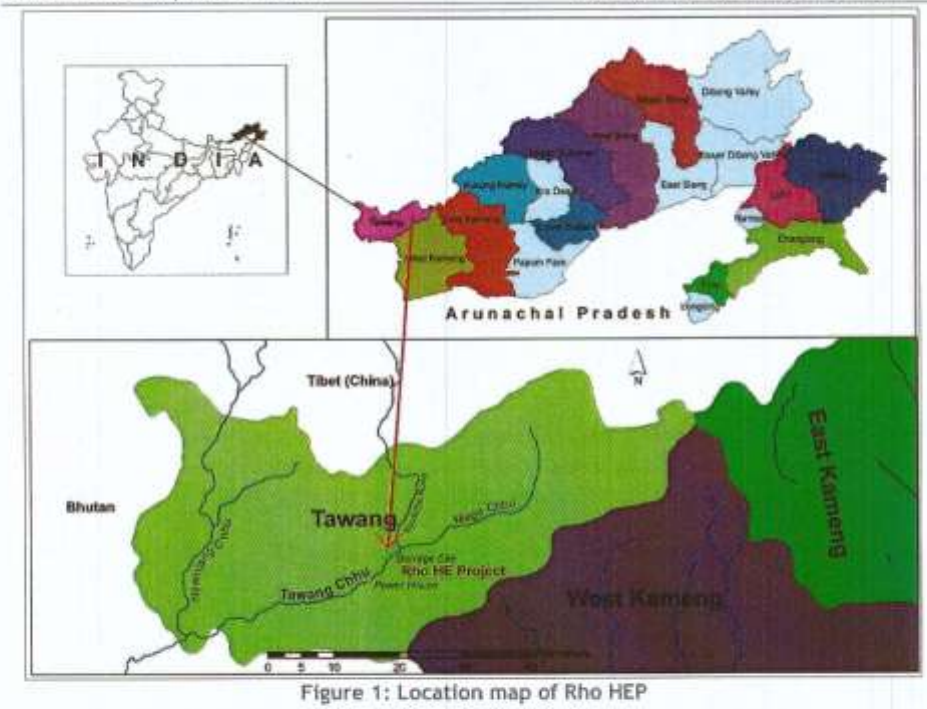

Figure 1: Location map of Rho HEP

1.1 Salient Features

The salient features of the proposed Rho HEP are given in **Table 1**. A general layout plan of the project is given at **Figure 2**.

Table 1: Salient Features of Rho HEP

GENERAL	
State	Arunachal Pradesh
District	Tawang
River	Tawang Chu
Nearest Rail Head (Broad Gauge)	Guwahati, Assam
Nearest Rail Head (Meter Gauge)	Bhalukpong (Arunachal Pradesh)
Nearest Airport	Guwahati, Assam
Coordinates at Barrage	Lat. 27° 36' 51.34" N Long. 92° 00' 8.78" E
PROJECT HYDROLOGY	
Catchment area	2893 km^2
Standard Project Flood (SPF)	3904 m^3/sec
GLOF	1406 m^3/sec
Diversion flood	415 m^3/sec
CIVIL WORKS	
Reservoir	
Full reservoir level (F.R.L.)	El. 2240.0m
Minimum Draw -down Level (M.D.D.L.)	El. 2232.0m
Live Storage	0.251 MCM
Submergence Area (Up to F.R.L.)	4.74 ha.
Barrage-Spillway	
Top of Barrage	El. 2242.0m
Barrage Height above River Bed	26.0m
Barrage Length	155.0m
Length of Spillway	54.5m
Desanding Chambers	
Type	Underground, Du four type
Number	2 Nos.
Shape & Size (W x H x L))	14.0m x 18.8m x 176.0m

Head Race Tunnel			
Shape & Size	Modified horse shoe, 6.0m diameter		
Lining type & lining thickness	Concrete lined, 350mm thick		
Length of head race tunnel	1552.06m		
Design discharge	105.83 m^3/sec		
Flow through velocity	3.61 m/sec		
Surge Shaft			
Type	Underground, Restricted orifice type		
Diameter of surge shaft	16.0m		
Dia. of orifice	2.7m		
Surge Shaft top elevation	El. 2266.39m		
Pressure Shaft	Main	Intermediate	Unit
Type	Steel lined	Steel Lined	Steel lined
Number	1	1	3
Diameter (m)	5.1	4.1	2.9
Maximum discharge (m^3/sec)	105.83	70.55	35.28
Length	135.41m	2408m	245.02m
Steel liner grade	ASTM-537 Grade-II		
Power House			
Type	Underground		
Size (W x H x L)	21.0m x 95.0m x 38.15m		
Number of units	3 units		
Rated capacity of each unit	31.0 MW		
Total installed capacity	93 MW		
Type of turbine	Vertical axis Francis		
Rated discharge for each unit	35.276 m^3/sec		
Net Head/ Design head	96.33m		
Erection bay elevation	El. 2134.90m		

Transformer Hall / GIS Cavern	
Type	Underground
Size (W x H x L)	12.0m x 22.0m x 64.9m
Number of transformers	3 unit transformes & 1 spare transformer
Tail Race tunnel	
Shape & Size	Modified Horse Shoe, 6.0m diameter
Length	248.74m
Outlet invert elevation	El. 2128.65m
Pot Head Yard	
Type	Outdoor
Size (W x L)	28.0m x 56.0m
POWER GENERATION	
Generation in 90% dependable year	493.97 GWh
Free Power to home State	13%
COST ESTIMATION	
Civil Cost	611.69 Cr
E&M Works	171.72 Cr
Total Basic cost	783.41 Cr
Escalation	203.03 Cr
IDC and Financing charges	174.31 Cr
Total Cost	1160.75 Cr
Construction Period	18 Months for pre- construction activities and 45 months for main construction
Levelised Tariff	5.19 Rs / KWh

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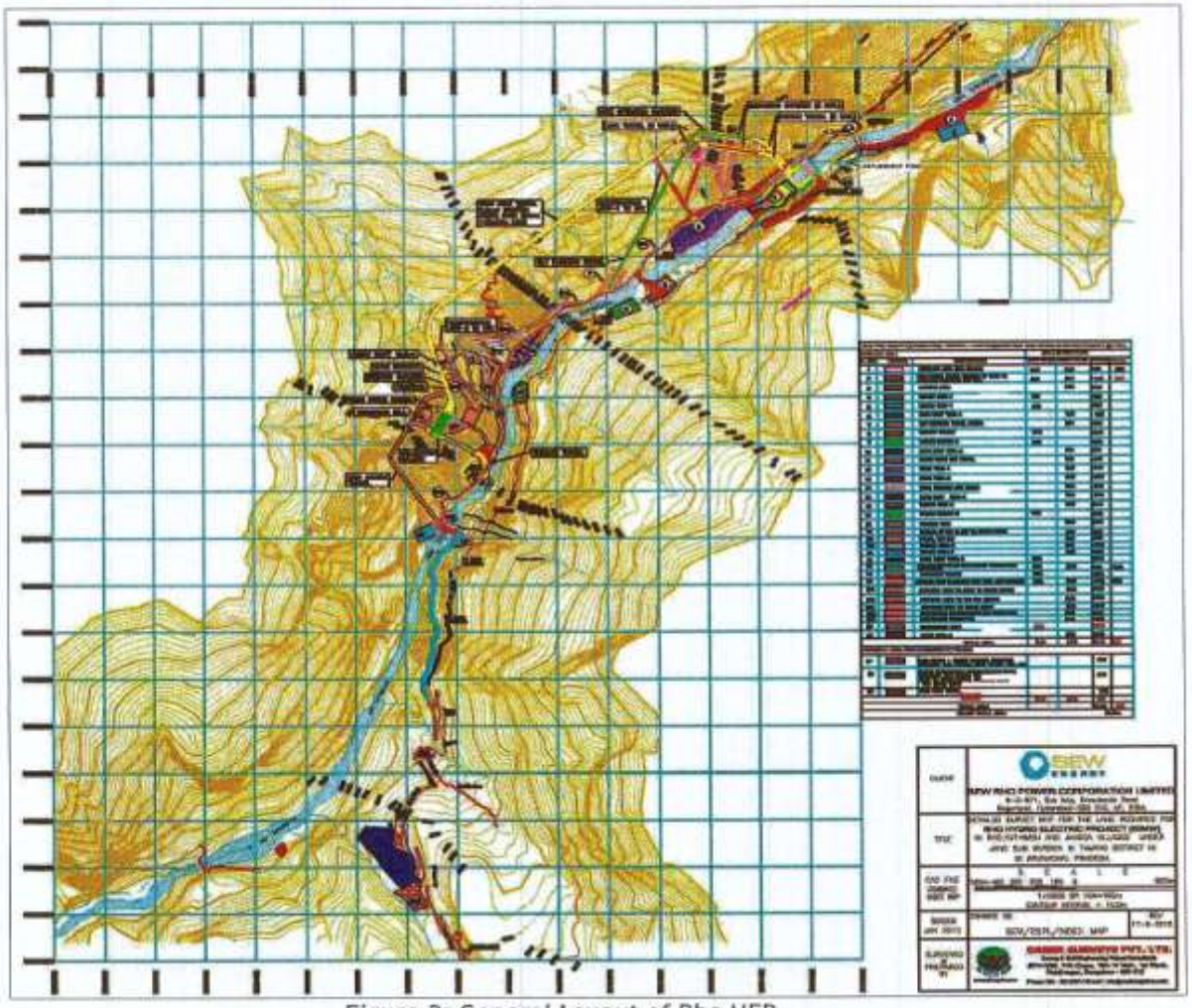

Figure 2: General Layout of Rho HEP

2 NEED FOR CATCHMENT AREA TREATMENT

Increasing competition for land to meet the requirement of rapidly increasing population has resulted in over exploitation of natural resources leading to widespread damage to soil environment. A large number of hydropower projects are coming up in Brahmaputra Basin to meet the peak power demand of the country, which consists of construction of diversion structures on various rivers. The development of these hydropower projects aggravates the problem of soil erosion.

Soil erosion can be defined as detachment, transportation and deposition of soil particles from one place to other by means of transporting agent like air, water or animals. Soil erosion is mainly affected by rainfall intensity and runoff, slope gradient and length, soil erodibility and vegetation cover (landuse pattern). In a hilly catchment area, as in the present case, erosion due to water is a common phenomenon. Therefore study of erosion and sediment yield from catchments are of great importance. Soil erosion leads to:

- loss in production potential
- reduction in infiltration rates
- reduction in water-holding capacity
- loss of nutrients
- increase in tillage operation costs
- reduction in water supply

To control the rate of soil erosion in the catchment, Catchment Area Treatment (CAT) is an ineluctable part of any hydropower project. The CAT plan pertains to preparation of a management plan for treatment of erosion prone areas through adequate preventive measures. An effective CAT plan of a hydropower project is a key factor to make the project eco-friendly and sustainable. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above mentioned adverse process of soil erosion. CAT plan essentially consist of following steps.

1. Identification of highly erodible areas within the catchment by calculation of Silt Yield Index (SYI) and sediment load for sub watersheds using Geographical Information System (GIS).
2. Prioritizing the areas for treatment.
3. Planning of suitable erosion control measures.
4. Cost estimation for CAT plan.

3 RIVER BASIN

Tawang Chu and Nyamjang Chu are the two main rivers in Tawang Basin. Tawang Chu is the result of the confluence of Mago Chu and Nyukcharong Chu rivers at an elevation of around 2,270 m. Nyukcharong Chu originates from Tibet in the Eastern Himalayan ranges and flow towards southern direction and joins Seti Chu after traversing about 52 km in Tibet. It further flows southward direction and enters India after Shoe/ Tsona Chu joins it at its left bank at an elevation of around 3,060 m near Shyamdling. Mago Chu originates in India at an elevation of around 6,500 m. It traverses south-west and joins Nykcharong Chu near Kyelatongbo. The

river after confluence is known as Tawang Chu. Tawang Chu flows towards Bhutan through a narrow valley in most part of its length and crosses international boundaries after cruising in India for a distance of 45 km.

3.1 Free Draining Catchment

Free draining catchment has been delineated as intercepting catchment area falling between diversion sites of upstream Mago Chu HEP on Mago Chu and Nyukcharong Chu HEP on Nyukcharong Chu and till diversion site of proposed Rho HEP on Tawang Chu. Nyukcharong Chu and Mago Chu meets near Kyelatongbo to form Tawang Chu. In the free draining catchment area several tributaries and streams joins Tawang Chu on either banks. The drainage system of free draining catchment of Rho HEP is given in **Figure 3**.

4 METHODOLOGY ADOPTED FOR THE STUDY

In the present study 'Silt Yield Index' (SYI), method has been used. In this method, the terrain is subdivided into various sub-watersheds and the erodibility is determined on relative basis. SYI provides a comparative erodibility criteria of catchment (low, moderate, high, etc.) and does 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. The application of SYI model for prioritization of sub-watersheds in the catchment areas involves the evaluation of:

- Climatic factors comprising total precipitation, its frequency and intensity,
- Geo-morphic factors comprising land forms, physiography, slope and drainage characteristics,
- Surface cover factors governing the flow hydraulics and
- Management factors.

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 sub-watersheds.
- Grading of sub-watersheds into very high, high, medium, low and very low priority categories.

A detailed database on natural resources, terrain conditions, soil type of the catchment area, 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. All the thematic maps thus prepared were processed in Geographic Information System (GIS) domain. The GIS has a capacity to perform numerous functions and operations on the various spatial data because of its special hardware and software characteristics. In order to ensure that latest and accurate data is used for the analysis, Survey of India (SoI) topographical sheets on

1:50,000 scale, satellite data (LANDSAT) and digital elevation model derived from ASTER GDEM data have been used for deriving data for drainage, land use, slope, and elevation. Various steps, covered in the study, are as follows:

- Defining data requirement
- Data acquisition and preparation
- Modelling
- Output presentation

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

4.1 Defining Data Requirement

The requirements of the study were defined and the expected outputs were finalized. The various data layers of the catchment area to be used for the study are as follows:

- Catchment Area/ Sub-Watershed Map
- Slope Map
- Soil Map
- Land use Classification Map
- Rainfall Intensity

4.2 Data Acquisition and Preparation

The data available from various sources were collected. The ground maps, topographical maps etc. were scanned, geo-referenced and digitized 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 co-ordinates), so that overlay could be performed. A computer program using standard modeling techniques was used to estimate the soil loss. The formats of outputs from each layer were formed to match the formats of inputs in the program.

4.2.1 Delineation of Sub-Watershed

Soil and Land Use Survey of India (SLUSI) has Watershed Atlas of India under digital environment using GIS and produced a Digital Watershed Atlas (DWA) where the delineation and codification of watersheds in the country has been undertaken in GIS environment. The delineation for DWS has been done in seven stages starting with Water Resource Regions and their subsequent division and subdivisions into Basins, Catchments, Sub-catchments, Watershed, Sub watershed and Micro-watersheds in decreasing size of the delineated hydrologic unit.

As per Watershed Atlas of India, the catchment area of Rho HEP falls in Tabina Watershed (3A2B3), which can be interpreted as Brahmaputra Region (3), Right bank of Brahmaputra upto Lohit confluence Basin (3A), Manas to Kameng confluence (Tezpur) Catchment (3A2), Manas Sub-Catchment (3A2B) and Tabina Watershed (3A2B3). So far, SLUSI has delineated the catchment up to Watershed level only. In order to plan watershed management and to formulate action plans it requires sub-watershed delineation. Therefore, the Watershed 3A2B3 is further divided into three sub-watersheds on 1:50,000 scale (Sol topographical maps)

in which main tributaries and streams are taken up for delineation of sub-watersheds. The detail of Watersheds delineated by SLUSI and further sub-watersheds delineated is given below (Table 2 and Figure 3).

Table 2: Names and codes of Sub-watersheds delineated in the Catchment of Rho HEP

S. No	Water Resource Region	Basin	Catchment	Sub-Catchment	Watershed	Sub-Watershed Code	Sub-Watershed Area (Sq km)
1.	Brahmaputra (3)	Right bank of Brahmaputra up to Lohit Confluence (3A)	Manas to Kameng confluence (Tezpur) (3A2)	Manas (3A2B)	Tabina (3A2B3)	3A2B3a	12.04
2.						3A2B3b	3.38
3.						3A2B3c	9.16
TOTAL							24.58

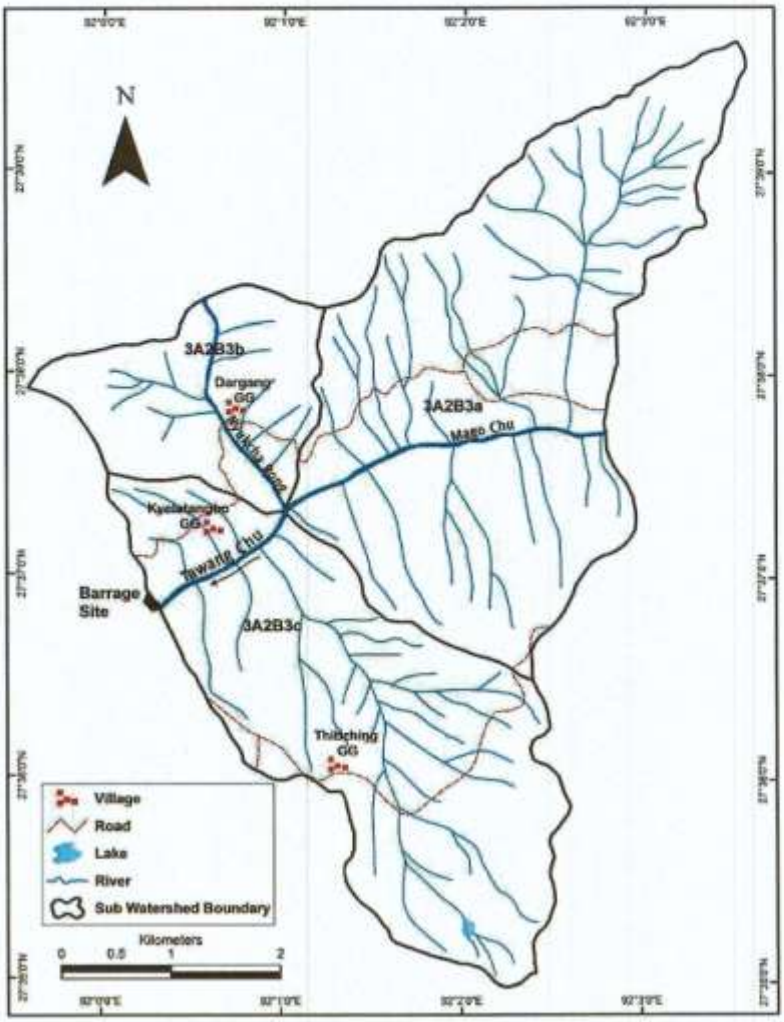

Figure 3: Drainage Map of Rho HEP Free Draining Catchment Area showing Sub-Watersheds

4.2.2 *Slope Map*

ASTER Global Digital Elevation Data (GDEM) was used for preparation of slope map. The data was downloaded in Georeferenced Tagged Image File Format (GeoTIFF) format and using ArcGIS software a slope (in degrees) map was prepared. The degree slope was divided into different slope classes as per SLUSI. The areas falling under various standard slope categories in the Rho HEP catchment as well as Sub-Watersheds have been tabulated below in **Table 3**. The slope map is enclosed as **Figure 4**. As seen from the table (**highlighted cells**) and map, maximum area of free draining catchment area as well as of sub-watersheds falls under Steep sloping category. In free draining catchment area around 47% of the area falls in steep sloping category, while in sub-watersheds it is between 40% to 50%.

Table 3: Areas falling under different slope categories

Slope Category (Degree)	Sub-Watersheds (Area in sq km)						Total (Area in sq km)	
	3A2B3a		3A2B3b		3A2B3c			
	Area	Area %	Area	Area %	Area	Area %	Area	Area %
Gently Sloping (Upto 2)	0.01	0.05	0.00	0.10	0.01	0.11	0.02	0.08
Moderately Sloping (2-8)	0.12	0.97	0.02	0.65	0.19	2.06	0.33	1.33
Strongly Sloping (8-15)	0.38	3.14	0.08	2.33	0.59	6.42	1.04	4.25
Moderately Steep (15-30)	2.82	23.41	0.60	17.74	3.31	36.13	6.73	27.37
Steep (30-45)	5.94	49.34	1.71	50.67	4.01	43.80	11.66	47.46
Very Steep (45-60)	2.64	21.92	0.91	26.92	1.01	11.02	4.56	18.55
Extremely Steep (60 - 70)	0.14	1.17	0.05	1.58	0.04	0.44	0.24	0.96
Total	12.04	100	3.38	100	9.16	100	24.58	100

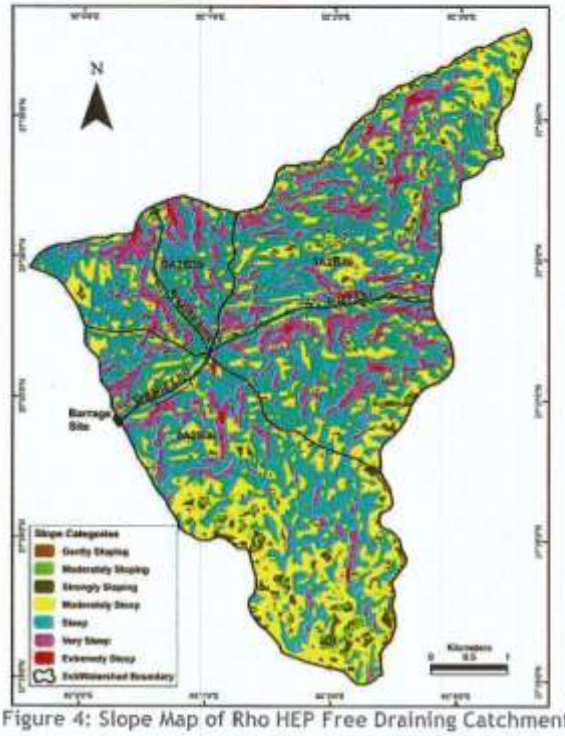

Figure 4: Slope Map of Rho HEP Free Draining Catchment Area

4.2.3 Soil Map

Soil map has been digitized and produced using soils map of Arunachal Pradesh, prepared and published by National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), Nagpur in co-operation with Department of Agriculture, Govt. of Arunachal Pradesh. The above said map has been collected from the Regional Centre of National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), New Delhi.

Soil map has been shown in Figure 5. The legend for soil classes has been given in Table 4. There are only 2 types of soil found in the free draining catchment area and both the soil types are of Eastern Himalayas. Almost entire area i.e. around 98% is covered by soil unit no. 02. Therefore, soil in the free draining catchment area is Deep, somewhat excessively drained having loamy surface with severe erosion hazard. The areas falling under different soil units in the Rho HEP catchment as well as Sub-Watersheds have been tabulated below in Table 5.

Table 4: Description of Soil Units of Catchment Area of the proposed Rho HEP

Soil Unit	Soil Types	Area (sq km)	Area (%)
1	**Loamy-skeletal, Lithic Udorthents** Shallow, excessively drained, loamy-skeletal soils on very steeply sloping hill summit having loamy surface with very severe erosion hazard and moderate stoniness: *associated with;* **Loamy-skeletal, Typic Udorthents** Moderately deep, somewhat excessively drained, loamy-skeletal soils on moderately steeply sloping side slopes with severe erosion hazard and moderate stoniness.	0.51	2.08
2	**Loamy-skeletal, Entic Haplumbrepts** Deep, somewhat excessively drained, loamy-skeletal soils on moderately steeply sloping summits having loamy surface with severe erosion hazard and moderate stoniness: *associated with;* **Sandy-skeletal, Typic Udorthents** Moderately shallow, excessively drained, sandy-skeletal soils on steeply sloping summits with very severe erosion hazard and slight stoniness.	24.07	97.92
Total		24.58	100

Table 5: Sub-Watershed wise areas falling under different soil units

Soil Units	Sub-Watersheds (Area in sq km)						Total (Area in sq km)	
	3A2B3a		3A2B3b		3A2B3c			
	Area	Area %	Area	Area %	Area	Area %	Area	Area %
1	0.00	0.005	0.51	15.09	0.00	0.00	0.51	2.08
2	12.04	100.00	2.87	84.91	9.16	100.00	24.07	97.92
Total	12.04	100	3.38	100	9.16	100	24.58	100

4.2.4 Land Use/ Land Cover Map

For the present study, IRS-1D LISS-III digital satellite data of Path 111 and Row 52 was used for interpretation & classification (Figure 6). The data has been procured in GeoTIFF format. The interpretation of geo-referenced satellite data has been done using standard enhancement techniques and experiences of qualified professionals. For the assessment of accuracy, landuse/landcover maps prepared by National Remote Sensing Centre (NRSC), Indian Space Research Organisation (ISRO) of Dept. of Space with State Remote Sensing Applications Centre, Arunachal Pradesh Council for Science & Technology as partner under

Natural Resource Census (NRC) project of National Natural Resource Repository (NRR) programme; Google Earth were also referred.

Figure 5: Soil Map of Rho HEP (For details of Soil Unit legend refer Table 4)

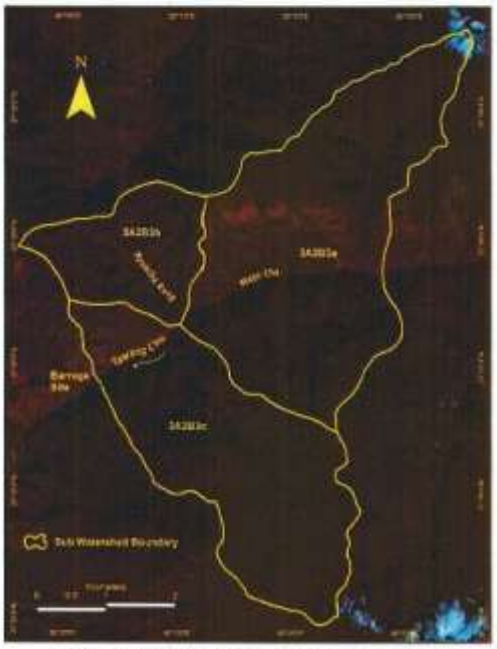

Figure 6: Satellite Imagery of Rho HEP

The classified land use/ land cover map of the catchment area is shown as **Figure 7**. The land use/ land cover pattern of the proposed Rho HEP free draining catchment area as well as of Sub-Watershed has been given in **Table 6**. As can be seen from the map and table (highlighted cells) the land use/ land cover pattern can be classified into five classes, out of these five classes, dense forest covers the maximum area i.e. around 58%. In case of sub-watersheds also it can be seen that dense forest covers the maximum area except in sub-watershed 3A2B3a where scrub covers the maximum area i.e. around 51%.

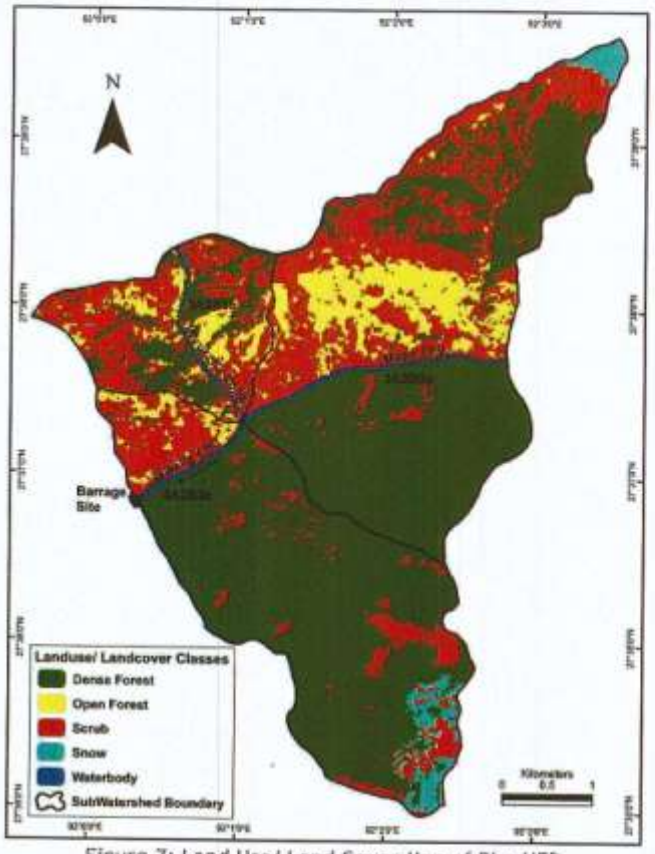

Figure 7: Land Use/ Land Cover Map of Rho HEP

Table 6: Sub-Watershed wise area falling under different land use/ land cover categories

Land use/ Land cover Categories	Sub-Watersheds (Area in sq km)						Total (Area in sq km)	
	3A2B3a		3A2B3b		3A2B3c			
	Area	Area %	Area	Area %	Area	Area %	Area	Area %
Dense Forest	4.41	37.25	0.99	29.16	6.81	74.31	14.20	57.75
Open Forest	1.63	13.58	0.60	17.82	0.25	2.77	2.49	10.13
Scrub	3.72	30.92	1.75	51.04	1.63	17.80	7.08	28.80
Snow	0.17	1.40	0.00	0.00	0.42	4.54	0.58	2.38
Waterbody	0.10	0.85	0.07	1.98	0.05	0.57	0.22	0.90
Total	12.04	100	3.38	100	9.16	100	24.58	100

4.3 Modeling

Soil loss has been calculated through RUSLE (Revised Universal Soil Loss Equation) model which is computed by the following equation:

Soil Loss (A) = R*K*LS*C*P

Wherein;

A = Soil loss (Tons/ha/year)

R is Rainfall & Runoff Erosivity Factor (MJ/ha/mm/year), which depends upon the annual average rainfall in mm.

K is Erodibility Factor (Tons/MJ/mm), which depends on the organic matter, texture permeability and profile structure of the soil. Also, it is a constant value for each soil type. LS is Topographic Factor (dimensionless), which depends upon flow accumulation and steepness and length of slope in the area.

C is Vegetation Cover and Crop Management Factor (dimensionless), which is the ratio of bare soil to vegetation and non-photosynthetic material. It is a constant value for each land use category.

P is Support Practice Factor (dimensionless), which takes into account specific erosion control practices like contour bunding, bench terracing etc. This factor is taken as 1 for bare soil where no erosion control practice is taking place.

4.4 Output Presentation

A thematic map for soil loss of the catchment area has been prepared using RUSLE model mentioned in the above section. The catchment area was then demarcated into different soil erosion intensity classes based upon the extent of soil loss (see Table 7 & Figure 8).

Table 7: Soil loss ranges for Catchment area of the proposed Rho HEP

S. No.	Soil loss in tons/hectare/annum	Area (ha)	Area (%)	Soil Erosion Intensity
1	<1	1355.30	55.15	Negligible
2	1-5	433.74	17.65	Slight
3	5-10	196.63	8.00	Very Low
4	10-20	233.93	9.52	Low
5	20-40	158.73	6.46	Moderate
6	40-80	64.57	2.63	Severe
7	>80	14.75	0.60	Very Severe
	Total	2457.65	100	

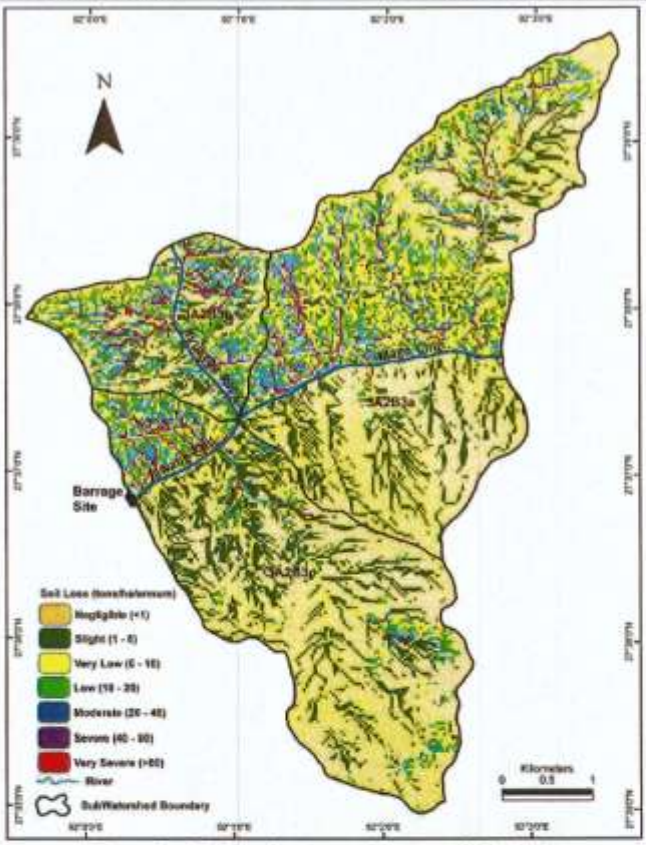

Figure 8: Soil Erosion Intensity Map of Rho HEP

5 PRIORTIZATION USING SILT YIELD INDEX (SYI) METHOD

'Silt Yield Index' (SYI), method has been used for prioritization of sub-watersheds in the catchment for treatment. 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. The Silt Yield Index Model (SYI) considers sedimentation as product of erosivity, morphometry and delivery ratio of a particular sub-watershed and was conceptualized by Soil and Land Use Survey of India (SLUSI) as early as 1969 and has been operational since then to meet the requirements of prioritization of smaller hydrologic units within river valley project catchment areas. Silt yield index (SYI) was calculated using following empirical formula:

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

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.

Di = Delivery ratio

5.1 Erosion Intensity Mapping Unit

Erosion Intensity Mapping Units (EIMU) are demarcated and defined as per the soil erosion intensity map prepared above. Various EIMU categories, such as Very Severe, Severe, Moderate, Low, Very Low, and Negligible & Slight (clubbed together), were then used to calculate sub-watershed-wise SYI. Erosion Intensity Mapping Units (EIMU) is a composite expression of physiography, land use, and conservation practices adopted. While computing soil erosion intensity in a catchment all the factors (physiography, land use, and conservation practices) are already taken into consideration. Therefore, EIMUs are assumed as per the soil erosion intensity in the sub-watershed. The sub-watershed wise area under each EIMU class is given in **Table 8**.

Table 8: Sub-watershed wise area under each EIMU class

EIMU Class	Sub-Watershed Area (ha)			Total Area (ha)
	3A2B3a	3A2B3b	3A2B3c	
Very Severe	7.32	3.50	3.93	14.75
Severe	27.79	22.08	14.71	64.57
Moderate	78.71	47.17	32.85	158.73
Low	119.70	63.00	51.23	233.93
Very Low	123.73	31.49	41.40	196.63
Negligible/ Slight	846.25	170.91	771.87	1789.04
Total	1203.50	338.15	915.99	2457.65

5.2 Weightage Value

Each erosion intensity unit is assigned a weightage value. When considered collectively, the weightage value represents approximately the comparative erosion intensity. A basic factor of K = 10 was used in determining the weightage values. The value of 10 indicates a static condition of equilibrium between erosion and deposition. Any addition to the factor K (10+X) is suggestive of erosion in ascending order whereas subtraction, i.e. (10-X) is indicative of deposition possibilities. The weightage value assigned to erosion mapping unit in a sub-watershed ranges from 11-20.

5.3 Delivery Ratio

Delivery ratios were adjusted for each of the erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into reservoir or river/ stream. Delivery ratios are assigned to all erosion intensity units depending upon their distance from the nearest stream. The criteria adopted for assigning the delivery ratio are as follows:

Nearest Stream	Delivery ratio
0 - 0.9 km	1.00
1.0 - 2.0 km	0.95
2.1 - 5.0 km	0.90
5.1 - 15.0 km	0.80
15.1 - 30.0 km	0.70

5.4 Silt Yield Index

The area of each of the mapping units is computed and silt yield indices of individual sub-watersheds are calculated using the equations mentioned above. The SYI values for classification of various categories of erosion intensity rates are given in Table 9.

Table 9: SYI Classification of Sub-Watersheds

Sub-Watershed	EIMU	EIMU Area (EA) in ha.	Weightage Factor (WF)	Silt Yield (SY) = EA * WF	Delivery Ratio (DR)	SYI = (SY*DR*100)/SA
3A2B3a	1	7.32	20	146	0.9	1191
	2	27.79	20	556		
	3	78.71	18	1417		
	4	119.70	16	1915		
	5	123.73	14	1732		
	6	846.25	12	10155		
Total		1204		15921		1191
3A2B3b	1	3.50	20	70	0.9	1294
	2	22.08	20	442		
	3	47.17	18	849		
	4	63.00	16	1008		
	5	31.49	14	441		
	6	170.91	12	2051		
Total		338		4861		1294
3A2B3c	1	3.93	20	79	0.9	1142
	2	14.71	20	294		
	3	32.85	18	591		
	4	51.23	16	820		
	5	41.40	14	580		
	6	771.87	12	9262		
Total		916		11626		1142

5.5 Prioritization of Sub-Watersheds

The sub-watersheds are subsequently rated into various categories corresponding to their respective SYI values. The criteria followed for priority categorization of sub-watersheds depending upon their SYI values is given in Table 10 and the priority classification of individual sub-watershed is given in Table 11 and Figure 9.

Table 10: Criteria for Priority

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

Table 11: Priority Number as per SYI Classification

Sub-watershed	SYI	Priority	Priority Number
3A2B3b	1191	Medium	1
3A2B3a	1294	High	2
3A2B3c	1142	Medium	3

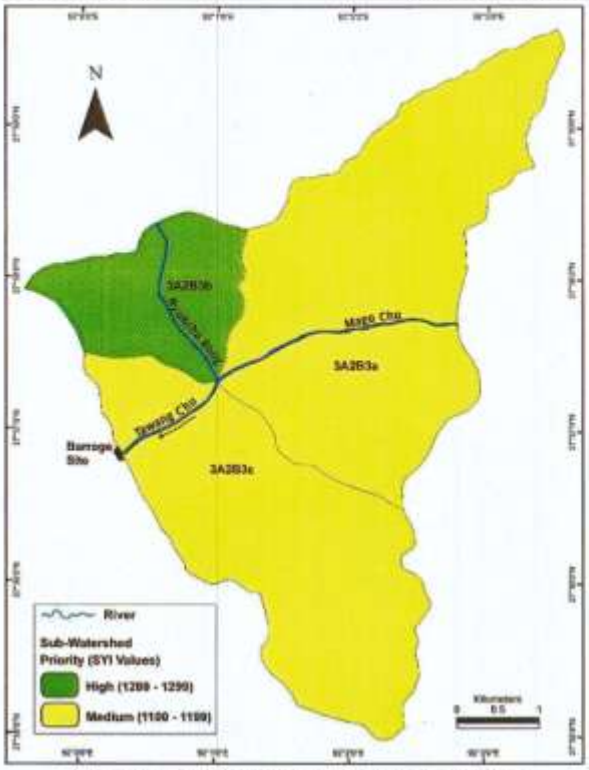

Figure 9: Priority Classification Map of Rho HEP

6 TREATMENT PLAN

6.1 Area to be taken up for treatment

The elevation of catchment area of Tawang Chu river up to proposed barrage site in the free draining catchment area of proposed Rho HEP ranges from El. 2216 m to around EL. 4500 m and majority of the free draining catchment is free from human interference. About 60% of the free draining catchment area is having elevation of more than EL. 3000 m. Around 48% of the free draining catchment area is under steep (30° - 45°) sloping category and around 20% is under very steep (45° - 60°) sloping category.

In view of above, areas which were found inaccessible i.e. areas with more than 60° slope and areas above tree line (>3,000 m) with natural ecosystems with little human interference were excluded to arrive at those areas where appropriate treatment measures can be undertaken. Such area was extracted for each individual sub- watershed and in all total area of **58.12 ha** was extracted with **11.55 ha** under very severe category and **46.56 ha** under severe erosion intensity category (Table 12). Thus, total area to be taken up for the treatment measures is **58.12 ha**. The period for implementing CAT plan interventions including maintenance has been taken as 8 years with the sub-watershed falling in high priority to be treated in second

year and the sub-watersheds falling in medium priority to be treated in third year. First year has been kept for nursery development and other entry point activities.

Table 12: Sub-watershed wise area under severe and very severe categories

Sub-watershed	Area under severe and very severe category in free draining catchment (ha)			Area under severe and very severe category with slope less than 60° and elevation below 3000 m (ha)		
	Very Severe	Severe	Total	Very Severe	Severe	Total
3A2B3a	7.32	27.79	35.11	4.22	14.40	18.61
3A2B3b	3.50	22.08	25.58	3.50	19.41	22.91
3A2B3c	3.93	14.71	18.63	3.84	12.76	16.60
Total	14.75	64.57	79.32	11.55	46.56	58.12

6.2 Treatment Measures

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.

The basis of site selection for different engineering treatment measures under CAT are given in Table 13.

Table 13: Basis for selection of catchment area treatment measures

Treatment measure	*Basis for selection*
Afforestation	Open canopy, degraded surface, high soil erosion, gentle to moderate slope
Non Timber Forest Produce	Existing forests, near habitation
Pasture Development	Degraded surface, upper reaches, high soil erosion, gentle to moderate slope
Assisted Natural Regeneration	Existing forests
Brushwood check dams	Gullies formed around the streams
Dry Stone Masonry Check dams	In the streams of 3rd and 4th order
Contour Bunding	Control of soil erosion from jhummed areas on moderate to steep slopes
Bench Terracing	Control of soil erosion from jhummed areas and in agricultural fields on moderate to steep slopes

6.2.1 Biological Measures

The biological measures would comprise of:

- Afforestation
- Non Timber Forest Produce
- Pasture Development
- Assisted Natural Regeneration

6.2.1.1 *Afforestation*

A well-stocked forest plays a very important in control of soil erosion. Thus, it is proposed to increase the vegetal cover in the area. As most of areas in Arunachal Pradesh have sufficient rainfall and light, the growth of plants is very fast. The areas which are abandoned after jhumming are rapidly colonized by a variety of shrubs and followed by growth of bamboos in quick succession. It is suggested to undertake plantation of shrubs as well as trees, wherever the slopes have been abandoned after jhum cultivation and other erosion prone areas in various sub-watersheds. The preference would be given to planting of only local shrubs and trees with a judicious mixture of rapid colonizers as well as fruit trees. The area to be brought under afforestation programme and its unit cost is given at **Table 14**.

6.2.1.2 *Non Timber Forest Produce*

Considering the local topography, soil conditions and climatic condition, at few places non timber forest produce in form of medicinal plants, shrubs and herbs would be the appropriate measures instead of traditional pasture development. Propagation of medicinal plants, shrubs and herbs is not only an innovative land use strategy it also helps in un-situ conservation of plants. The area to be brought under non timber forest produce programme and its unit cost is given at **Table 14**.

6.2.1.3 *Pasture Development*

As there are degraded patches in the area, this measure will be adopted to encourage development of new and healthy pastures for use of cattle of the area. Scrub land with greater slopes has been recommended to be treated by developing pastures over them. Under this treatment, suitable species of grasses and leguminous plant species be planted in the land area earmarked for the purpose. The area to be brought under pasture development programme and its unit cost is given at **Table 14**.

6.2.1.4 *Assisted Natural Regeneration*

It is important to enhancing the establishment of secondary forest from degraded grassland and shrub vegetation by protecting and nurturing the mother trees and their wildlings inherently present in the area. Assisted natural regeneration is proposed to accelerate, rather than replace, natural successional processes by removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species, and recurring disturbances (e.g., fire, grazing, and wood harvesting). The area to be brought under pasture development programme and its unit cost is given at **Table 14**.

6.2.2 *Engineering Measures*

The engineering treatment measures require less time to be put in place and can provide quick solutions. These would comprise mainly of Brushwood check dams, Dry stone masonry check dams, Contour bunding and Bench terracing.

6.2.2.1 *Brushwood Check Dams*

Brushwood check dams are very feasible where vegetative material for construction is abundant. Brushwood check dams can only be constructed in small gullies not deeper than 1m depth. As material required for construction of these types of dam is available locally these can be constructed faster and in very short span of time thereby effectively reducing the erosion in early phase of Project. The numbers of check dams are estimated using number of first order streams in an area under severe and very severe erosion intensity, and constructed at an interval of 100 m. The number of brushwood check dams suggested and its unit cost is given at **Table 14.**

6.2.2.2 *Dry Stone Masonry Check Dams*

Dry stone masonry check dams/ walls can be made of boulder piled up across the gulley and along the banks if they are locally available. Such structures for damming a gulley or a stream to refine the flow velocity and to control bank erosion are called dry stone masonry/ loose bolder check dams/ walls. The number of dry stone masonry check dams suggested and its unit cost is given at **Table 14.**

6.2.2.3 *Contour Bunding*

Contour Bunding is used for retaining the water by creating obstruction to control erosion. It consists of constructing narrow based trapezoidal bunds on contours to improve runoff rainwater in such a manner that it percolates and recharges the root profile on either side of the bunds. Bunds are simply embankments like structures, constructed across the land slope. The area to be treated under Contour Bunding scheme and its unit cost is given at **Table 14.**

6.2.2.4 *Bench Terracing*

Bench terracing is one of the most popular mechanical soil conservation practices adopted by farmers of India and other countries for ages. On sloping and undulating lands, intensive farming can be only adopted with bench terracing. It consists of construction of step like fields along contours by half cutting and half filling. Original slope is converted into level fields and thus all hazards of erosion are eliminated. The area to be treated under Contour Bunding scheme and its unit cost is given at **Table 14.**

Table 14: Summary of treatment measures and their cost for CAT Plan

Treatment Measures	Quantity	Unit Cost (Rs)*	Total Cost (Rs.)
Afforestation (Ha)	10.50	61,140	6,41,970.00
Non Timber Forest Produce (Ha)	6.30	58,200	3,66,660.00
Pasture Development (Ha)	5.11	31,140	1,59,125.40
Assisted Natural Regeneration (Ha)	9	23,010	2,07,090.00
Brushwood Check Dams (Nos)	16	26,000	4,16,000.00
Dry Stone Masonry Check Dams (Nos)	14	33,280	4,65,920.00
Contour Bunding (Ha)	10.20	25,000	2,55,000.00
Bench Terracing (Ha)	11.60	7,500	87,000.00
TOTAL			25,98,765.40

Note*: Unit Cost has been taken as per the cost norms given in Annexure I

6.2.3 *Development of Nurseries*

Nursery is defined as an area where plants are raised for eventual planting out in the forest area or elsewhere selected for afforestation in field. In hills the nurseries are better on Northern aspect than on south aspect. Nursery should preferably be rectangular or square in shape with well laid out beds, separated by main paths, around the fence and within the Nursery for the movement of small machinery, wheel barrows, etc. Nursery should be properly fenced; 5 to 7 strands barbed wire (with criss-cross barbed wire), with distance of strands closer below the ground and gradually increasing upwards. It should have gate for day to day labour movements. Nursery should have Mali's quarter, tool shade, store, and labour shed, with in nursery or just adjoining it for constant supervision and better success of the nursery. Water supply should have assured from perennial water sources/ springs/ streams throughout the year.

Some of the important points for nursery raising are:-

Nature of Nursery (Permanent or Temporary), Choice of site (Preferably Northern Aspect), Lay-out of nursery (Flat or Terraced), Dimensions of beds, Soil Preparations, Level & Edging, Inoculation with mycorrhiza (if required), Inputs in the soil (Forest Manure/ Farm Yard Manure), Pre-germination (Treatment), Method of Sowing (Line/ Broadcasting), Quality of Seed, Time of Sowing (Pre Monsoon/ Post Monsoon), Protection/ Covering the seed against birds & Rodents, Shading, Protection from Frost, Protection from rain & hail, Types of shade (Polythene/ Brush wood/ Grass), Hardening off (Permeability/ Texture of soil), Watering and damping off (Drainage/ Aeration), Weeding & soil working, Herbicides for the nursery Hoeing/ weeding etc.

7 OTHER COMPONENTS OF CAT PLAN

Apart from the biological and engineering treatment measures in the catchment area there are other aspects of the CAT Plan to be addressed and their cost included in the overall cost estimate of the plan. The charges for operational support, forest protection, social mobilization, documentation and publication, monitoring and evaluation and providing environmental services are some of the integral ingredients which have to be considered and included while formulating the CAT plans.

7.1 Provision for Micro Planning

The year-wise areas requiring treatment measures have been suggested but have not been marked. The spatial location of specific treatment to be carried out in the catchment area would require extensive detailing during the implementation of CAT and a provision for micro-planning has been made in the total CAT financial allocation. For this purpose a provision of Rs 2.50 lakh is being made.

7.2 Establishment Support

For an efficient management of forest resources, it is essential that operational support to the Forest Department is adequately developed. Similarly, in remote localities there are no

places for shelter for the staff, people and trekkers. Therefore, a budgetary provision of Rs 3.50 lakh has been kept for this component.

7.3 Forest Infrastructure Development

In order to develop new infrastructure and strengthen the existing infrastructure of forest department especially at the site of treatment interventions a budgetary provision of Rs 25.50 lakh has been kept.

7.4 Monitoring & Evaluation

Monitoring and evaluation will be undertaken as a part of project management. A process of self-evaluation at specified intervals of time will ensure the field level verification of suggested treatment measures and efficacy of the CAT plan.

The year-wise areas requiring treatment measures have been suggested but have not been marked. The spatial location of specific treatment to be carried out in the catchment area would require extensive detailing during the implementation of CAT and a provision for micro-planning has been made in the total CAT financial allocation. Thereafter, annual work plan would be prepared well in advance after undertaking initial ground surveys during micro-planning, specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work schedule of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Range Officers to Divisional Forest Officer. The monitoring committee shall be constituted at the project level for this purpose which too would monitor on a regular basis the quality and quantity of works being carried out under the CAT plan area.

A provision of Rs 41.00 lakh has been made for this component.

7.5 Contingencies

A provision of Rs 2.50 lakh has been kept under this component for some leeway to adjust any unforeseen expenditure.

8 COST ESTIMATE

The estimated cost of implementation of CAT plan including monitoring and evaluation is Rs. 125.00 lakh and is given at Table 15. The phasing of physical and financial targets is given in Table 6. Sub-Watershed wise phasing of physical and financial targets are given in Table 17 to Table 19.

Table 15: Estimated cost of CAT Plan Implementation

S. No.	Item	Rate (Rs)	Unit	Target	
				Physical	Financial (Rs in lac)
I	**Biological Measures**				
1	Afforestation				
	i) Creation	39,000	Ha	10.50	4.10
	ii) Maintenance for 5 years	22,140	Ha	10.50	2.32
2	Non Timber Forest Produce				
	i) Creation	36,600	Ha	6.30	2.31
	ii) Maintenance for 5 years	21,600	Ha	6.30	1.36
3	Pasture Development				
	i) Creation	20,000	Ha	5.11	1.02
	ii) Maintenance for 5 years	11,140	Ha	5.11	0.57
4	Assisted Natural Regeneration				
	i) Creation	11,760	Ha	9.00	1.06
	ii) Maintenance for 5 years	11,250	Ha	9.00	1.01
5	Nursery Development				
	i) Creation	LS			21.43
	ii) Maintenance for 5 years	LS			1.92
	SubTotal I (1+2+3+4+5)				**37.10**
II	**Engineering Measures**				
6	Brushwood Check Dams	26,000	No	16	4.16
	Maintenance Cost @ 5% of the cost				0.21
7	Check Dams (DRSM)	33,280	No	14	4.66
	Maintenance Cost @ 5% of the cost				0.23
8	Contour Bunding	25,000	Ha	10.20	2.55
	Maintenance Cost @ 5% of the cost				0.13
9	Bench Terracing	7,500	Ha	11.60	0.87
	Maintenance Cost @ 5% of the cost				0.04
	Sub Total II (6+7+8+9)				**12.85**
A	**Treatment Cost (Sub Total I + II)**				**49.95**
III	**Administrative Measures**				
10	Micro planning @5% of Treatment Cost				2.50
11	Establishment Cost @7% of Treatment Cost				3.50
12	Forest Infrastructure Development				25.50
13	Contingencies @5% of Treatment Cost				2.50
14	Monitoring & Evaluation of 5 Years				41.00
B	Sub Total III				74.99
	Total CAT Plan Cost (A + B)				124.94
	OR SAY				125.00

Table 16: Year wise physical & financial targets of treatment measures for CAT Plan

S. No.	Treatment Measures	Year I		Year II		Year III		Year IV		Year V		Year VI		Year VII		Year VIII		Year IX		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
I	BIOLOGICAL MEASURES																				
1	Afforestation (Ha)			5.50	2,14,500	5.00	1,95,000													10.50	4,09,500
	1st Year maintenance					5.50	60,885	5.00	55,350											10.50	1,16,235
	2nd Year maintenance							5.50	30,415	5.00	27,650									10.50	58,065
	3rd Year maintenance									5.50	18,260	5.00	16,600							10.50	34,860
	4th Year maintenance											5.50	6,105	5.00	5,550					10.50	11,655
	5th Year maintenance													5.50	6,105	5.00	5,550			10.50	11,655
2	Non Timber Forest Produce (Ha)			3.30	1,20,780	3.00	1,09,800													6.30	2,30,580
	1st Year maintenance					3.30	35,640	3.00	32,400											6.30	68,040
	2nd Year maintenance							3.30	17,820	3.00	16,200									6.30	34,020
	3rd Year maintenance									3.30	10,692	3.00	9,720							6.30	20,412
	4th Year maintenance											3.30	3,564	3.00	3,240					6.30	6,804
	5th Year maintenance													3.30	3,564	3.00	3,240			6.30	6,804
3	Pasture Development (Ha)			3.00	60,000	2.11	42,200													5.11	1,02,200
	1st Year maintenance					3.00	16,710	2.11	11,753											5.11	28,463
	2nd Year maintenance							3.00	8,340	2.11	5,866									5.11	14,206
	3rd Year maintenance									3.00	5,010	2.11	3,524							5.11	8,534
	4th Year maintenance											3.00	1,680	2.11	1,182					5.11	2,862
	5th Year maintenance													3.00	1,680	2.11	1,182			5.11	2,862
4	Assisted Natural Regeneration (Ha)			5.00	58,800	4.00	47,040													9.00	1,05,840
	1st Year maintenance					5.00	11,250	4.00	9,000											9.00	20,250
	2nd Year maintenance							5.00	11,250	4.00	9,000									9.00	20,250
	3rd Year maintenance									5.00	11,250	4.00	9,000							9.00	20,250
	4th Year maintenance											5.00	11,250	4.00	9,000					9.00	20,250
	5th Year maintenance													5.00	11,250	4.00	9,000			9.00	20,250
5	Nursery Development		21,43,000																		21,43,000
	Maintenance of Nursery				38,400		38,400		38,400		38,400		38,400								1,92,000
	Sub Total I		21,43,000		4,92,480		5,56,925		2,14,728		1,42,328		99,843		41,571		18,972				37,09,845
II	ENGINEERING MEASURES																				
6	Brushwood Check Dams (Nos)			7	1,82,000	9	2,34,000													16	4,16,000
	Maintenance Cost @ 5%						9,100		11,700												20,800
7	Dry Stone Masonry Check Dams (Nos)			6	1,99,680	8	2,66,240													14	4,65,920
	Maintenance Cost @ 5%						9,984		13,312												23,296
8	Contour Bunding (Ha)			5.00	1,25,000	5.20	1,30,000													10.20	2,55,000
	Maintenance Cost @ 5%						6,250		6,500												12,750
9	Bench Terracing (Ha)			6.00	45,000	5.60	42,000													11.60	87,000
	Maintenance Cost @ 5%						2,250		2,100												4,350
	Sub Total II				5,51,680		6,99,824		33,612												12,85,116
A	Treatment Cost (Sub Total I + II)		21,43,000		10,44,160		12,56,749		2,48,340		1,42,328		99,843		41,571		18,972				49,94,961
III	ADMINISTRATIVE MEASURES																				
1	Micro planning @5% of Treatment Cost		1,24,874		1,24,874																2,49,748
2	Establishment Cost @7% of Treatment Cost		1,74,824		1,74,824																3,49,647
3	Forest Infrastructure Development		5,10,000		5,10,000		5,10,000		5,10,000		5,10,000										25,50,000
4	Contingencies @5% of Treatment Cost		1,07,150		52,208		62,837		12,417		7,116		4,992		2,079		949				2,49,748
5	Monitoring & Evaluation of 5 Years				8,20,000		8,20,000		8,20,000				8,20,000						8,20,000		41,00,000
B	Sub Total III		9,16,848		16,81,906		13,92,837		13,42,417		5,17,116		8,24,992		2,079		949		8,20,000		74,99,143
	Total CAT Plan Cost (A + B)		30,59,848		27,26,066		26,49,586		15,90,757		6,59,444		9,24,835		43,649		19,920		8,20,000		1,24,94,105

Table 17: Year wise physical & financial targets of treatment measures for Sub-Watershed 3A2B3a

S. No.	Treatment Measures	Year III		Year IV		Year V		Year VI		Year VII		Year VIII		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
I	BIOLOGICAL MEASURES														
1	Afforestation (Ha)	3.00	1,17,000											3.00	1,17,000
	1st Year maintenance			3.00	33,210									3.00	33,210
	2nd Year maintenance					3.00	16,590							3.00	16,590
	3rd Year maintenance							3.00	9,960					3.00	9,960
	4th Year maintenance									3.00	3,330			3.00	3,330
	5th Year maintenance											3.00	3,330	3.00	3,330
2	Non Timber Forest Produce (Ha)	2.00	73,200											2.00	73,200
	1st Year maintenance			2.00	21,600									2.00	21,600
	2nd Year maintenance					2.00	10,800							2.00	10,800
	3rd Year maintenance							2.00	6,480					2.00	6,480
	4th Year maintenance									2.00	2,160			2.00	2,160
	5th Year maintenance											2.00	2,160	2.00	2,160
3	Pasture Development (Ha)	1.11	22,200											1.11	22,200
	1st Year maintenance			1.11	6,183									1.11	6,183
	2nd Year maintenance					1.11	3,086							1.11	3,086
	3rd Year maintenance							1.11	1,854					1.11	1,854
	4th Year maintenance									1.11	622			1.11	622
	5th Year maintenance											1.11	622	1.11	622
4	Assisted Natural Regeneration (Ha)	2.50	29,400											2.50	29,400
	1st Year maintenance			2.50	5,625									2.50	5,625
	2nd Year maintenance					2.50	5,625							2.50	5,625
	3rd Year maintenance							2.50	5,625					2.50	5,625
	4th Year maintenance									2.50	5,625			2.50	5,625
	5th Year maintenance											2.50	5,625	2.50	5,625
	Sub Total I		2,41,800		66,618		36,101		23,919		11,737		11,737		3,91,910
II	ENGINEERING MEASURES														
5	Brushwood Check Dams (Nos)	5	1,30,000											5	1,30,000
	Maintenance Cost @ 5%				6,500										6,500
6	Dry Stone Maonry Check Dams (Nos)	5	1,66,400											5	1,66,400
	Maintenance Cost @ 5%				8,320										8,320
7	Contour Bunding (Ha)	3.20	80,000											3.20	80,000
	Maintenance Cost @ 5%				4,000										4,000
8	Bench Terracing (Ha)	3.40	25,500											3.40	25,500

S. No.	Treatment Measures	Year III		Year IV		Year V		Year VI		Year VII		Year VIII		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
	Maintenance Cost @ 5%				1,275										1,275
	Sub Total II		4,01,900		20,095										4,21,995
	Treatment Cost (Sub Total I + II)		6,43,700		86,713		36,101		23,919		11,737		11,737		8,13,905

Table 18: Year wise physical & financial targets of treatment measures for Sub-Watershed 3A2B3b

S. No.	Treatment Measures	Year II		Year III		Year IV		Year V		Year VI		Year VII		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
I	BIOLOGICAL MEASURES														
1	Afforestation (Ha)	5.50	2,14,500											5.50	2,14,500
	1st Year maintenance			5.50	60,885									5.50	60,885
	2nd Year maintenance					5.50	30,415							5.50	30,415
	3rd Year maintenance							5.50	18,260					5.50	18,260
	4th Year maintenance									5.50	6,105			5.50	6,105
	5th Year maintenance											5.50	6,105	5.50	6,105
2	Non Timber Forest Produce (Ha)	3.30	1,20,780											3.30	1,20,780
	1st Year maintenance			3.30	35,640									3.30	35,640
	2nd Year maintenance					3.30	17,820							3.30	17,820
	3rd Year maintenance							3.30	10,692					3.30	10,692
	4th Year maintenance									3.30	3,564			3.30	3,564
	5th Year maintenance											3.30	3,564	3.30	3,564
3	Pasture Development (Ha)	3.00	60,000											3.00	60,000
	1st Year maintenance			3.00	16,710									3.00	16,710
	2nd Year maintenance					3.00	8,340							3.00	8,340
	3rd Year maintenance							3.00	5,010					3.00	5,010
	4th Year maintenance									3.00	1,680			3.00	1,680
	5th Year maintenance											3.00	1,680	3.00	1,680
4	Assisted Natural Regeneration (Ha)	5.00	58,800											5.00	58,800
	1st Year maintenance			5.00	11,250									5.00	11,250
	2nd Year maintenance					5.00	11,250							5.00	11,250
	3rd Year maintenance							5.00	11,250					5.00	11,250
	4th Year maintenance									5.00	11,250			5.00	11,250

S. No.	Treatment Measures	Year II		Year III		Year IV		Year V		Year VI		Year VII		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
	5th Year maintenance											5.00	11,250	5.00	11,250
	Sub Total I		4,54,080		1,24,485		67,825		45,212		22,599		22,599		7,36,800
II	ENGINEERING MEASURES														
5	Brushwood Check Dams (Nos)	7	1,82,000											7	1,82,000
	Maintenance Cost @ 5%				9,100										9,100
6	Dry Stone Maonry Check Dams (Nos)	6	1,99,680											6	1,99,680
	Maintenance Cost @ 5%				9,984										9,984
7	Contour Bunding (Ha)	5.00	1,25,000											5.00	1,25,000
	Maintenance Cost @ 5%				6,250										6,250
8	Bench Terracing (Ha)	6.00	45,000											6.00	45,000
	Maintenance Cost @ 5%				2,250										2,250
	Sub Total II		5,51,680		27,584										5,79,264
A	Treatment Cost (Sub Total I + II)		10,05,760		1,52,069		67,825		45,212		22,599		22,599		13,16,064

Table 19: Year wise physical & financial targets of treatment measures for Sub-Watershed 3A2B3c

S. No.	Treatment Measures	Year III		Year IV		Year V		Year VI		Year VII		Year VIII		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
I	BIOLOGICAL MEASURES														
1	Afforestation (Ha)	2.00	78,000											2.00	78,000
	1st Year maintenance			2.00	22,140									2.00	22,140
	2nd Year maintenance					2.00	11,060							2.00	11,060
	3rd Year maintenance							2.00	6,640					2.00	6,640
	4th Year maintenance									2.00	2,220			2.00	2,220
	5th Year maintenance											2.00	2,220	2.00	2,220
2	Non Timber Forest Produce (Ha)	1.00	36,600											1.00	36,600
	1st Year maintenance			1.00	10,800									1.00	10,800
	2nd Year maintenance					1.00	5,400							1.00	5,400
	3rd Year maintenance							1.00	3,240					1.00	3,240
	4th Year maintenance									1.00	1,080			1.00	1,080
	5th Year maintenance											1.00	1,080	1.00	1,080

S. No.	Treatment Measures	Year III		Year IV		Year V		Year VI		Year VII		Year VIII		Total	
		Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.	Phy.	Fin.
3	Pasture Development (Ha)	1.00	20,000											1.00	20,000
	1st Year maintenance			1.00	5,570									1.00	5,570
	2nd Year maintenance					1.00	2,780							1.00	2,780
	3rd Year maintenance							1.00	1,670					1.00	1,670
	4th Year maintenance									1.00	560			1.00	560
	5th Year maintenance											1.00	560	1.00	560
4	Assisted Natural Regeneration (Ha)	1.50	17,640											1.50	17,640
	1st Year maintenance			1.50	3,375									1.50	3,375
	2nd Year maintenance					1.50	3,375							1.50	3,375
	3rd Year maintenance							1.50	3,375					1.50	3,375
	4th Year maintenance									1.50	3,375			1.50	3,375
	5th Year maintenance											1.50	3,375	1.50	3,375
	Sub Total I		1,52,240		41,885		22,615		14,925		7,235		7,235		2,46,135
II	ENGINEERING MEASURES														
5	Brushwood Check Dams (Nos)	4	1,04,000											4	1,04,000
	Maintenance Cost @ 5%				5,200										5,200
6	Dry Stone Maonry Check Dams (Nos)	3	99,840											3	99,840
	Maintenance Cost @ 5%				4,992										4,992
7	Contour Bunding (Ha)	2.00	50,000											2.00	50,000
	Maintenance Cost @ 5%				2,500										2,500
8	Bench Terracing (Ha)	2.20	16,500											2.20	16,500
	Maintenance Cost @ 5%				825										825
	Sub Total II		2,70,340		13,517										2,83,857
A	Treatment Cost (Sub Total I + II)		4,22,580		55,402		22,615		14,925		7,235		7,235		5,29,992

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