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No. APGCL/CGM/(H)/W/2012-13/410/Pt-I/42 Dated:11/06/2017

To,

The Nodal Officer
Additional PCCF,
Dept. of Environment & Forest, Govt. of Assam
Aranya Bhawan, Panjabari, Guwahati-781037

Sub: Catchment Area Treatment (CAT) Plan for Lower Kopili H.E. Project (LKHEP), Assam

Sir,

In inviting a reference to the subject matter cited above, enclosed please find herewith the draft Catchment Area Treatment (CAT) Plan for Lower Kopili H.E. Project, Assam. You are requested to examine the draft CAT Plan prepared by APGCL and give your necessary comments/approval so that the approved CAT Plan can be uploaded along with the Forest Clearance application for LKHEP.

Yours Sincerely

Enclo: as above

11/06/17
(Antara Baruah)
Chief General Manager (Hydro & Civil)
APGCL

Copy to:

1. Relevant file

CATCHMENT AREA TREATMENT PLAN

NEED FOR CATCHMENT AREA TREATMENT

Accelerated soil erosion in the catchment area of the reservoirs and transport of detached material through the drainage network gives rise to a series of problems, notably depletion of flow capacity, steady loss of storage capacity, consistent drop in hydro-electric power generation and frequent floods. The loss of dead and live storage leads to heavy economic losses due to reduced life span of reservoirs. Therefore, extensive soil conservation and watershed management programmes are needed to minimize the damage to the catchment and mitigation of soil erosion problems. As a part of the CEIA study, a Catchment Area Treatment Plan has been prepared. Silt Yield Index (SYI) method has been used to prioritize sub-watershed into various erosion categories.

The CAT Plan has been formulated for intervening draining catchment i.e. up to the proposed diversion structure of Lower Kopili H. E. Project on Kopili river. The total catchment area at proposed Lower Kopili HEP site is 2076.62 sq km while at proposed Kopili Dam HEP is 1256 sq km. Thus, the free draining catchment area proposed to be treated in the present study is 820.62 sq.km (82062 ha). The sub-watersheds in the catchment area considered for the present study are given in Figure-1.

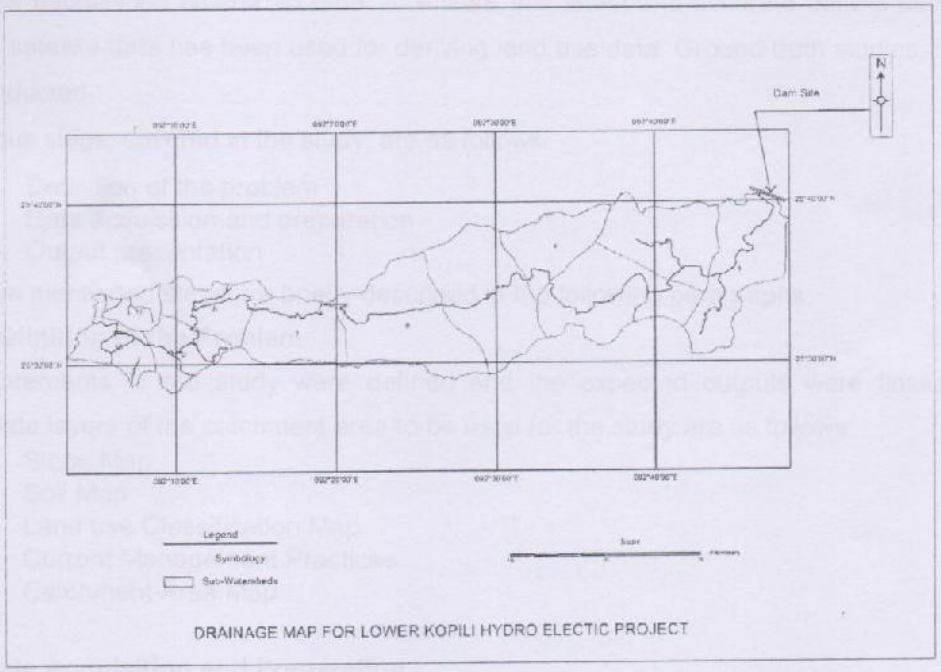

Figure 1: Drainage map for Lower Kopili Catchment

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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.

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. Geographic Information System (**GIS**) is a computerized resource data base system, which is referenced to a 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. Ground truth studies, too, have been conducted.

The various steps, covered in the study, are as follows:

- Definition of the problem
- Data acquisition and preparation
- Output presentation

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

Definition of the Problem

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:

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

Data Acquisition and Preparation

The data available from various sources has been 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 co-ordinates), so that

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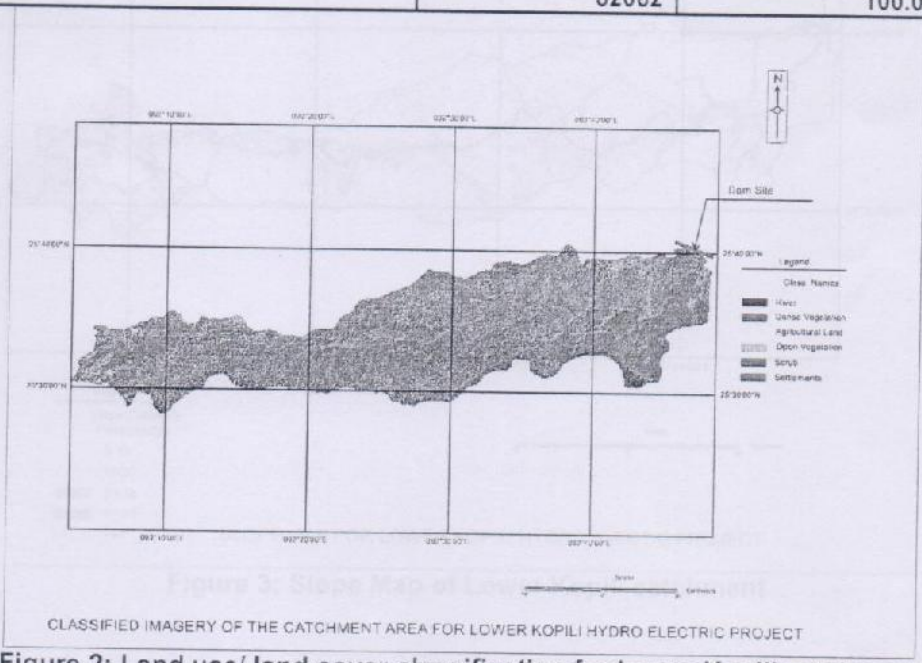
overlay could be performed. A computer program using standard modeling techniques was used to estimate the soil loss. The formats of outputs from each layer were firmed up to match the formats of inputs in the program. The grid size to be used was also decided to match the level of accuracy required, the data availability and the software and time limitations. Ground truthing and data collection was also included in the procedure.

For the present study, Resourcesat-2, LISS-IV digital satellite data was used for interpretation & classification. The data has been procured in raw digital format and has been geo-referenced using Survey of India topographical sheets with the help of standard data preparation techniques in standard image processing software. The interpretation of geo-referenced satellite data has been done using standard enhancement techniques, ground checks and experiences of qualified professionals. A detailed ground truth verification exercise has been undertaken as a part of field survey to enrich the image interpretation process. The classified land use map of the free draining catchment area, considered for the study, is shown as Figure 2. The land use pattern of the catchment area is summarized in Table 1.

Table - 1:Land use classification for free draining catchment at diversion site

Land use/Land cover	Area (ha)	Distribution (%)
River	1517	1.85
Dense Vegetation	52058	63.44
Open Vegetation	9392	11.45
Agricultural Land	4412	5.38
Scrubs	14605	17.80
Settlements	77	0.09
Total	**82062**	**100.00**



CLASSIFIED IMAGERY OF THE CATCHMENT AREA FOR LOWER KOPILI HYDRO ELECTRIC PROJECT

Figure 2: Land use/ land cover classification for Lower Kopili catchment

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Derived contours from topographical maps were used for preparation of Digital Elevation Model (DEM) of the free draining 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 topographical maps were derived. 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 z - their elevation). All this information was in real world co-ordinates (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-3. The Area under different slope categories are given in Table-2

Table-2:Area under various slope category

Slope categories (%)	Area (ha)	Area(%)
0-10	41555	50.64
10-20	30098	36.68
20-30	8458	10.31
30-40	1724	2.10
>40	227	0.28
Total	**82062**	**100.00**

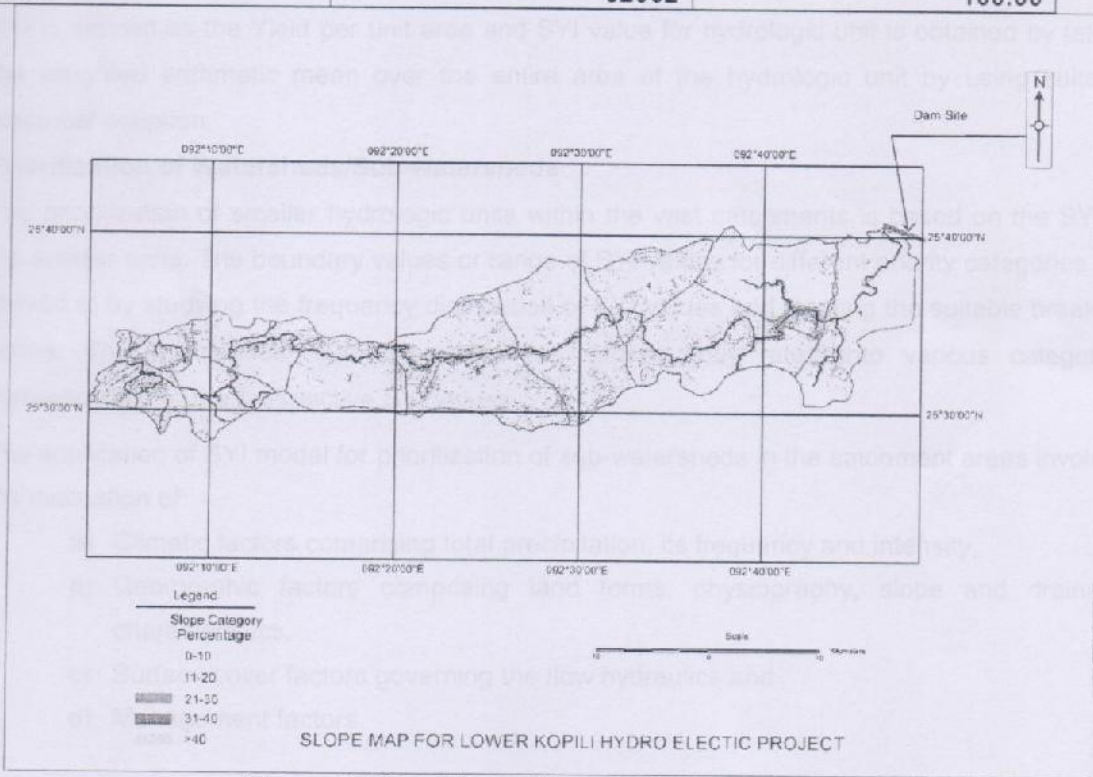

Figure 3: Slope Map of Lower Kopili catchment

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

In '**Silt Yield Index' (SYI)**, 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.

The SYI model, 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 within river valley project catchment areas.

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

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 is based on the 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.

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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:

Silt Yield Index

To calculate SYI, the methodology developed by All India Soil & Land Use Survey (Department of Agriculture, Govt. of India) has been followed, where each erosion intensity unit is assigned a weightage value. When considered collectively, the weightage value represents approximately the relative 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.

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. Area of each composite unit in each sub-watershed was then estimated.

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 i^{th} unit (EIMU)
Wi	=	Weightage value of i^{th} mapping unit
n	=	No. of mapping units
Aw	=	Total area of sub-watershed.
Di	=	Delivery ratio

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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

The SYI values for classification of various categories of erosion intensity rates for the catchment area under study are given in Table 3.

Table-3:Criteria for erosion intensity rate

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

The erosion category of various watersheds in the catchment area as per a SYI index has been estimated. 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 the project proponent's cost. Hence, CAT plan has been suggested for very high and high erosion categories, as a part of the EIA study, the expenses of which have to be borne by project proponents.

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 shall be suggested for the catchment area treatment depending upon the requirement and suitability:

a. Engineering measures

- Brushwood Check Dam
- Stone masonry
- Check dams

b. Biological measures

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- Development of nurseries
- Plantation/afforestation
- Pasture development
- Gap Plantation

The basis of site selection for different biological and engineering treatment measures under CAT are given in Table 4.

Table-4: 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
Brushwood checkdams	Over small gullys or at the starting stretch of gullies
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.

CATCHMENT AREA TREATMENT (CAT) PLAN

In the present report, CAT Plan as per the slope, land use pattern, soil characteristics has been suggested based on the prioritization of sub watersheds using SYI method. The CAT plan has been suggested for Sub-watersheds with high and vey high erosion categories. The objective of the SYI method is to prioritize sub-watershed in a catchment area for treatment. The erosion category of various watersheds in the catchment area as per SYI Method is given in Tables-5 and 6. The details are shown in Figure-4. The area under different erosion categories is given in Table-7.

Table-5: Erosion intensity categorization as per SYI classification

Watershed number	Area (ha)	SYI values	Category
W1	9913	1080	Low
W2	8674	1230	High
W3	11070	1070	Low
W4	5797	1160	Medium
W5	11953	1170	Medium
W6	12541	1210	High
W7	6680	1220	High
W8	5289	1180	Medium
W9	4204	1160	Medium
W10	3934	1220	High
W11	2006	1210	High
Total	**82062**		

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Table-6: Prioritised SYI value of erosion intensity rates with sub-watershed code

Priority categories	SYI Values	Sub Watershed codes
High	1200-1299	W2,W6,W7,W10,W11
Medium	1100-1199	W4,W5,W7,W8
Low	1000-1099	W1,W3

Table-7 : Area under different erosion categories

Category	Area (ha)	Area (Percentage)
Low	20984	25.57
Medium	27243	33.20
High	33836	41.23
Total	**82062**	**100.00**

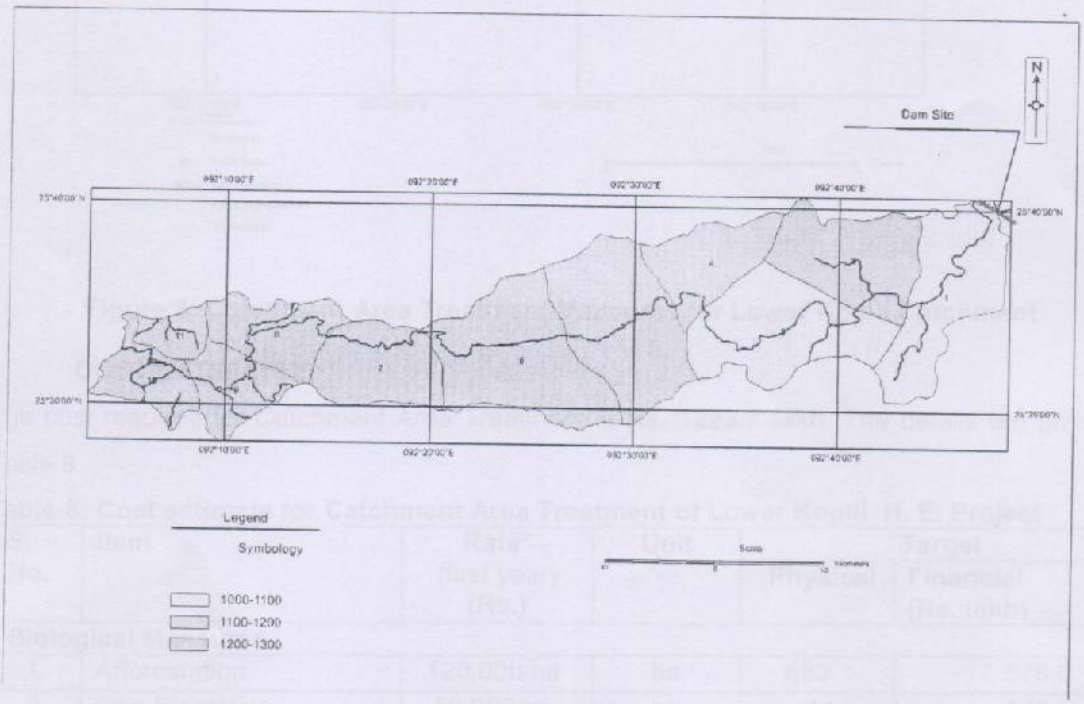

Figure 4: Prioritisation of sub-watersheds for Lower Kopili HEP

The area under high erosion category has to be treated by the project proponents, which accounts for about 48.84% of the total free draining catchment area. Sub-watershed wise proposed treatment measures in these sub watersheds superimposed over SOI toposheets are given in Table-6 and have been shown in Figure 5. It is proposed that treatment measures shall be implemented over five years and shall be co-terminus with the construction of dam.

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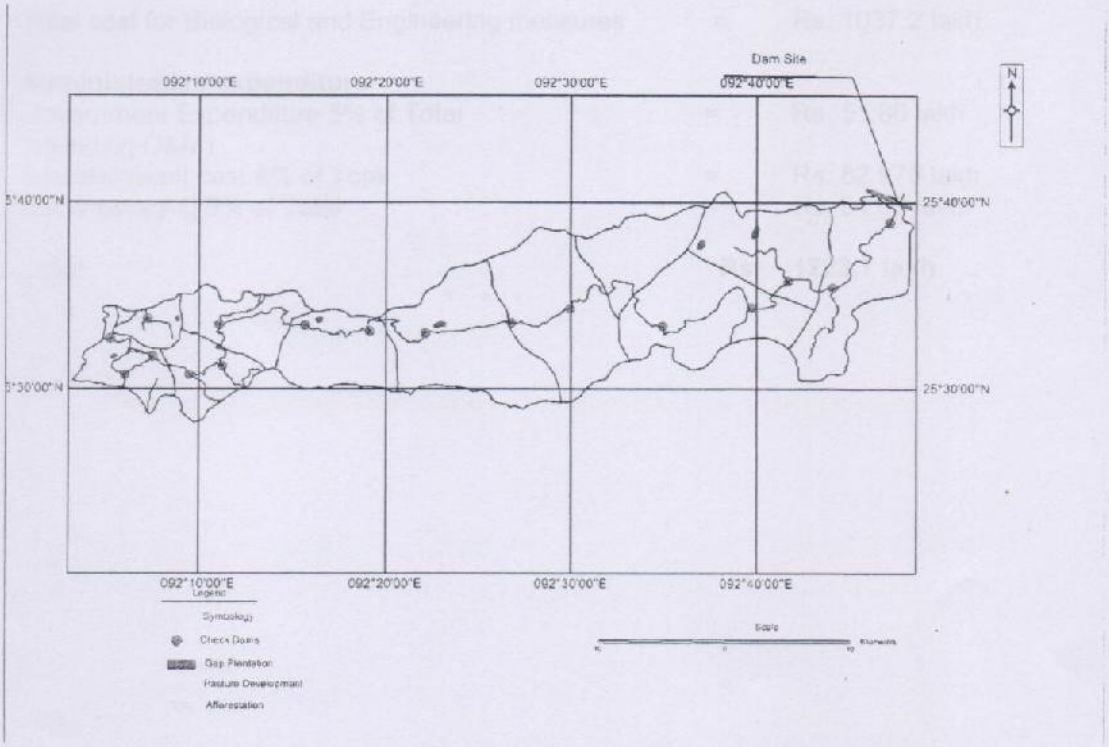

Figure 5: Catchment Area Treatment Measures for Lower Kopili Catchment

COST ESTIMATES

The cost required for Catchment Area Treatment is **Rs. 1223.7 lakh**. The details are given in Table 8.

Table-8: Cost estimate for Catchment Area Treatment of Lower Kopili H. E. Project

S. No.	Item	Rate* (first year) (Rs.)	Unit	Target	
				Physical	Financial (Rs. lakh)
Biological Measures					
1.	Afforestation	120,000/ha	ha	683	576.0
3.	Gap Plantation	50,000/ha	ha	281	140.5
4.	Pasture development	30,000/ha	ha	574	172.2
5.	Nursery development	2,80,000/no.	no.	5	14.0
6.	Maintenance of nursery	1,40,000/no.	no.	5	7.0
7.	Vegetative fencing	65,000/km	km	20	13.0
8.	Watch and ward for 5 years @ 10 persons	12,000/man-month	Man-months	600	72.0
Engineering Measures					
9.	Check Dams	2,50,000	Nos.	17	42.5
	Total				**1037.2**

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Total cost for Biological and Engineering measures	=	Rs. 1037.2 lakh
Administrative expenditure		
Government Expenditure 5% of Total (including O&M)	=	Rs. 51.86 lakh
Establishment cost 8% of Total	=	Rs. 82.976 lakh
Contingency @5% of Total	=	Rs. 51.86 lakh
Total	**Rs.**	**1223.7 lakh**

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