PAPUM HYDRO ELECTRIC POWER PROJECT
(2 x 5 MW)

CATCHMENT AREA TREATMENT PLAN

Submitted By:

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1.1 BACKGROUND OF THE PROJECT

The Government of Arunachal Pradesh (GoAP) has been encouraging private entrepreneurs in development of small and mini hydro power schemes. M/s. Sonam Hydro Power Private Limited (SHPPL) has been incorporated under the companies Act, 1956 with an objective of developing power using renewable sources.

M/s. Sonam Hydro Power Private Limited, New Delhi has been allotted 10 MW installed capacity Papum Hydro Electric Project, a small hydro project on river Papum near Longdong village in district Papum Pare of Arunachal Pradesh State, by Government of Arunachal Pradesh. The project site is about 35 km from Itanagar, the State Capital.

Concept Green Energy Pvt, Ltd., New Delhi has been preparing the Detailed Project Report (DPR) & evaluated the technical and financial viability of this scheme.

M/s. Sonam Hydro Power Private Limited envisages to develop the Papum HEP on the left bank of Papum river.

1.2 PROPOSED PROJECT

The project being developed as a run-of the river scheme envisages utilization of the water of Papum river for generation of 10 MW Hydel power by utilizing design discharge of 13.79 cumecs and gross head of 90 m available over a stretch of about 2.5 kms. The project, as conceived, comprises the following principal components:

- 25 m long raised crest type diversion weir across river Papum with intake on left bank
- Intake Structure on left bank comprising with Trashrack, Stoplogs, Gates etc.
- 15 m long RCC Intake channel to convey design discharge from Intake to Desilting chamber
- 80 m long dual tank desilting basin
- A water conductor system comprising of 1934 m long underground Head Race Tunnel (HRT), 115 m long dual pipeline over aquaduct and 155 m long RCC Power Channel
- 38 m long x 24 m wide forebay tank

- 412 m long steel liner surface penstock of dia. 2 m bifurcation into two nos. unit penstocks of dia. 1.45 m each to convey water from forebay tank to Power House
- A surface powerhouse with two units each of 5000 KW capacity located on left bank of Papum river.
- 30 m long open tail race channel.

The location of Project area is shown in Figure-1.1 below:

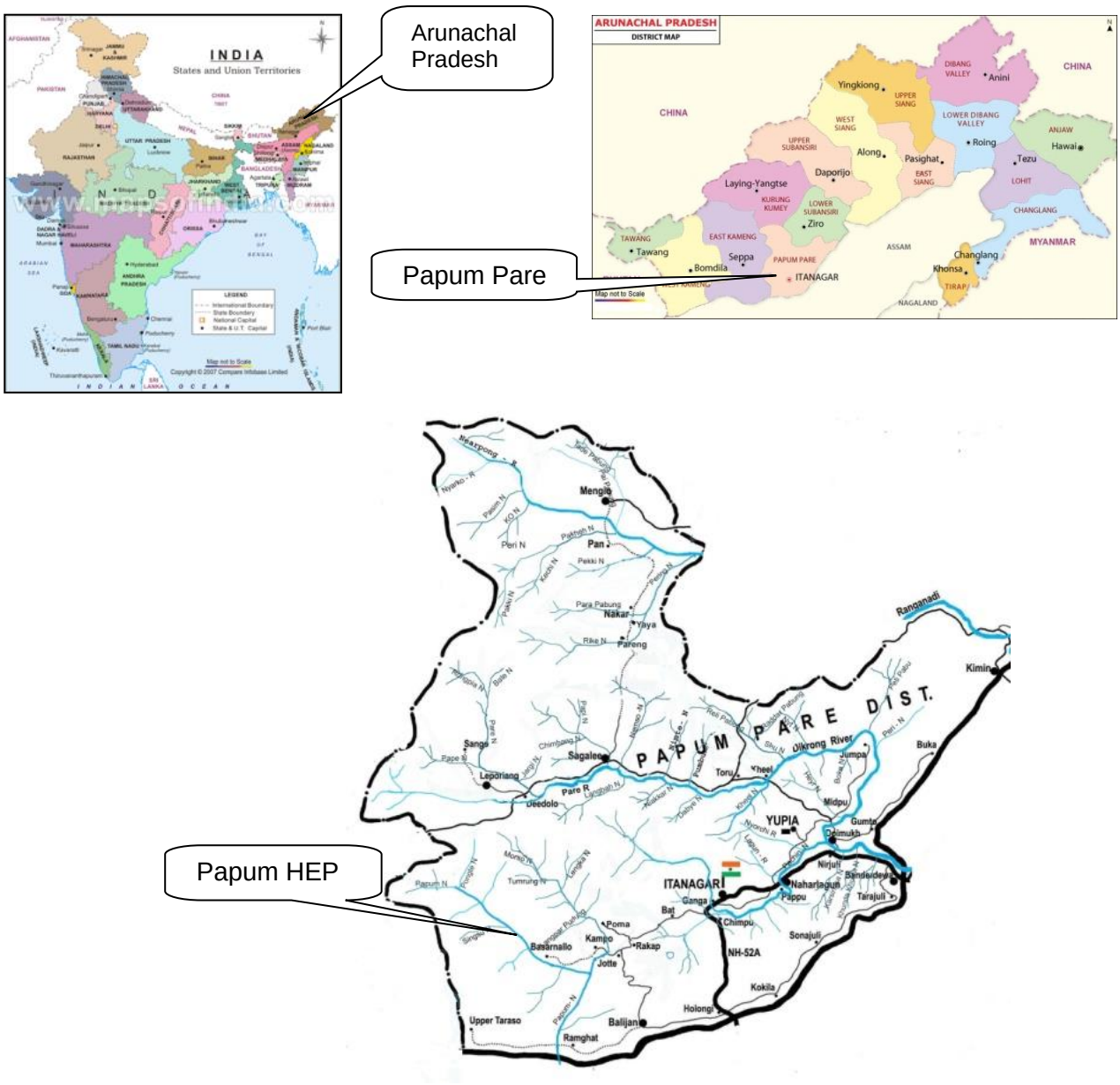

Figure-1.1: Location of the project

The power generated at this project is proposed to be transmitted to the nearest substation of the GoAP. The generated power will be evacuated through 33/11 kV transmission line to the existing substation.

The general layout has been formulated with a view to ensure least submergence behind the diversion structure and to avoid changes in the upstream regime of the river. The crest level of the Diversion weir has been kept as EL 310 m. The diversion structure has a height of only 5 m above the average riverbed level ensuring minimum submergence behind the structure. The powerhouse and the water conductor system are located on the left bank of the river. Presently a foot track is available on left bank of the river only. Therefore, a trace-cut approach road needs to be developed during construction of the project.

On the basis of techno-economic studies, it is recommended that 2 nos. TG units with a capacity of 5 MW each are to be installed with Horizontal shaft Francis turbines for this project.

Power potential studies indicate that the average annual energy generation for 10 MW installations would be 41.36 Million Units at 95% plant availability in 75% dependable year.

The total capital cost of the project is estimated as Rs. 88.15 crores. M/s. Sonam Hydro Power Private Limited propose to invest 30% of the project cost as equity and the balance amount will be raised by availing loan from Indian Financial Institutions. The cost of generation is about Rs 4.16 per Kwh.

The construction period of the project will be 30 months. M/s Sonam Hydro Power Private Limited will enter into Power Purchase Agreement (PPA) with Arunachal Pradesh Power Transmission Corporation Limited on terms and conditions similar to other small hydro-electric projects. The financial analysis indicates that the entire loan can be paid back within a period of 13 years from the date of commissioning of the project.

1.3 ADVANTAGES OF HYDROPOWER

- A renewable source of energy – saves scarce fuel reserves.
- Non-polluting and hence environment-friendly.

- Long life – The first hydro project completed in 1897 is still in operation at Darjeeling is still in operation.
- Cost of generation, operation and maintenance is lower than the other sources of energy.
- Ability to start and stop quickly and instantaneous load acceptance/ rejection makes it suitable to meet peak demand and for enhancing system reliability and stability.
- Has higher efficiency (over 90%) compared to thermal (35%) and gas (around 50%).
- Cost of generation is free from inflationary effects after the initial installation.
- Can provide attendant benefits of irrigation, flood control, drinking water supply, recreation, tourism, etc.
- Being located in remote regions leads to development of interior backward areas (education, medical, road communication, telecommunication, etc.)

1.4 PROPOSED SITE LOCATION

The proposed Papum HEP is situated on Papum river in Papum Pare district of Arunachal Pradesh. The project site is about 35 km from Itanagar.

The nearest railway station to the project site are at Naharlagun which are about a distance of 50 Km from the project site. The Nearest Airports are at Guwahati, at a distance of 360 km and Dibrugarh, at a distance of about 250 kms respectively from the project site.

The geographical co-ordinates of the project site are as follows;

a. Power House: Latitude $27^0$02’37” N and Longitude $93^0$22’45” E,
b. Weir: Latitude $27^0$03’37” N and Longitude $93^0$21’41” E.

The project area is marked on satellite image in Figure-1.2 below:

Figure-1.2: Location of the project on Satellite image

The project area is marked Toposheet in Figure-1.3 below:

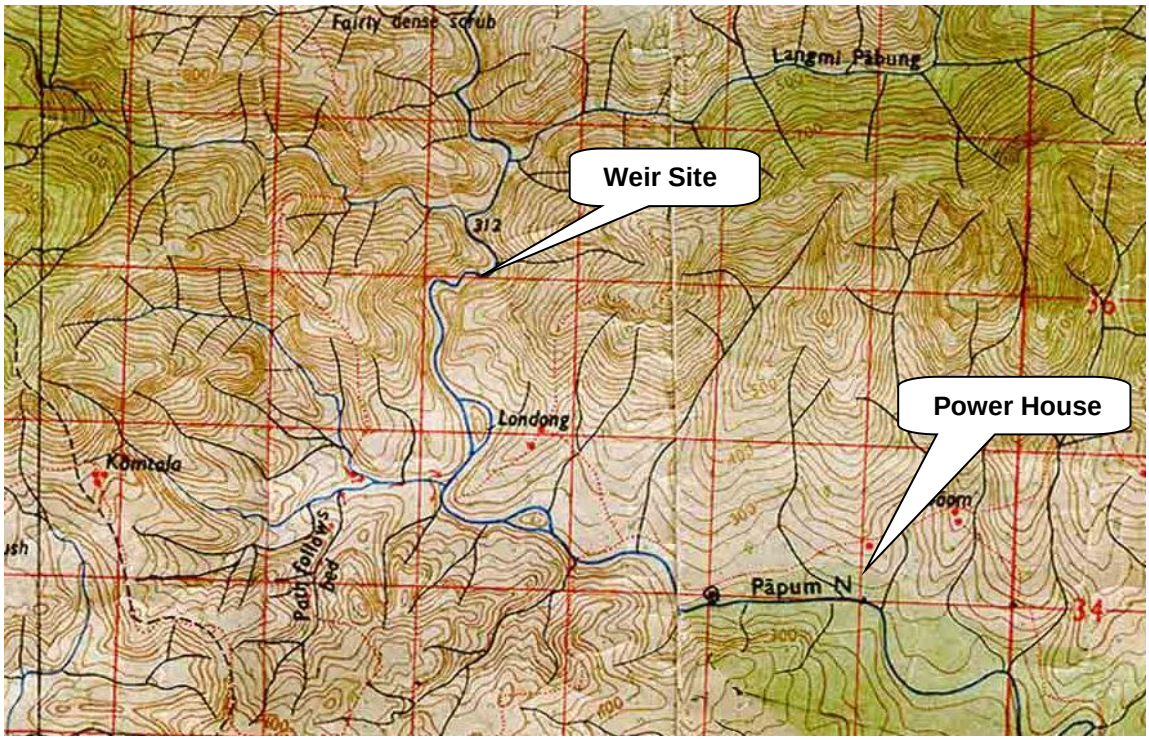

Figure-1.3: Location of the project on Toposheet

1.5 JUSTIFICATION OF THE PROJECT SITE

Any hydel project is a site-specific project for the following reasons:

- There should be sufficient flow of water in the stream to generate power.
- There should be sufficient head difference available for running the turbines.
- The site should be easily accessible.
- Power evacuated facilities should be available within a short distance.

The basic advantages of the proposed Papum HEP are as following:

a. Less Human Habitation In The Vicinity – The powerhouse is proposed to be set up at a distance of around 1 km from the village. Within a km area radius from the proposed project there are very less houses. Thus, the population likely to be affected by the project is negligible.

b. No/ Minimal Impact On Fauna – The project site is proposed to be located across River Papum. The total project activities lie all along the river without disturbing the river and other areas. Hence will not have any impact on the fauna located in the study area.

c. No/ Less Waste Generation – It is proposed to utilize most of the excavated material for the construction of the components of the project. In view of the above, the proposed project site is considered appropriate for construction of the small hydro project.

1.6 INFRASTRUCTURE REQUIREMENTS

The proposed Papum HEP will require the following infrastructure for construction and operation and maintenance of the hydropower station.

a. Land: Total land requirement estimated for the proposed project is 6.95 Ha.

b. Water: Water will be used at the facility for construction, power generation and domestic purpose.

However, the power generation does not consume any water. Water requirement during construction has been estimated at about 100 KLD for construction and domestic purposes. Water for construction purpose will be drawn from the river course using portable pumps.

Potable water for the staff will be obtained from the bore well & packaged drinking cans during the operation phase.

c. **Power:** It is proposed to derive the construction power supply and temporary lighting arrangements from 250 kVA emergency DG set proposed for the plant. This DG set will later be used as plant emergency DG set. In addition, temporary lighting arrangement will be derived from state transmission line, which is normally available near the proposed plant during the period of construction.

d. **Access and service roads:** Construction of new approach roads to the project sites are required upto intake, water conductor, forebay and Power House.

e. **Manpower:** Manpower requirement for the proposed project during its construction stage will be approximately 100 persons (depends on the contractor). Whereas about 10 persons will be employed during the operation phase of the project. The plant will operate in three shifts.

f. **Site office and quarters:** Permanent housing: For routine supervision and erection of equipment, permanent accommodation consisting of 2 quarters shall be constructed in the beginning. These quarters shall be used for supervision of operation & maintenance of the plant in the O&M phase of the project.

   After the construction of the scheme, the accommodation required for the skeleton O & M staff shall be constructed near the powerhouse location. A field hostel of 5 quarters shall also be constructed for construction team.

   Temporary housing: All sites can be reached within half an hour from the road head. Houses will be rented at nearby villages for use by the construction team. However,

some additional temporary houses will be constructed nearby the project site.

Construction camps: The following minimum number of temporary stores and workshops need to be constructed at the site as listed below:

Diversion weir & Power house Complex: 2 stores, 2 workshop, 2 contractor's offices and Resident Engineer's (RE's) office Actual allocation of space for site offices and staff residential quarters would be finalized after the process of land acquisition is complete.

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 Papum HEP Weir site is 157.7 km^2.
The catchment area considered for treatment is about 0.90 Ha. 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 sub divided 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 catchment area plot is shown in Figure-2.1 below:

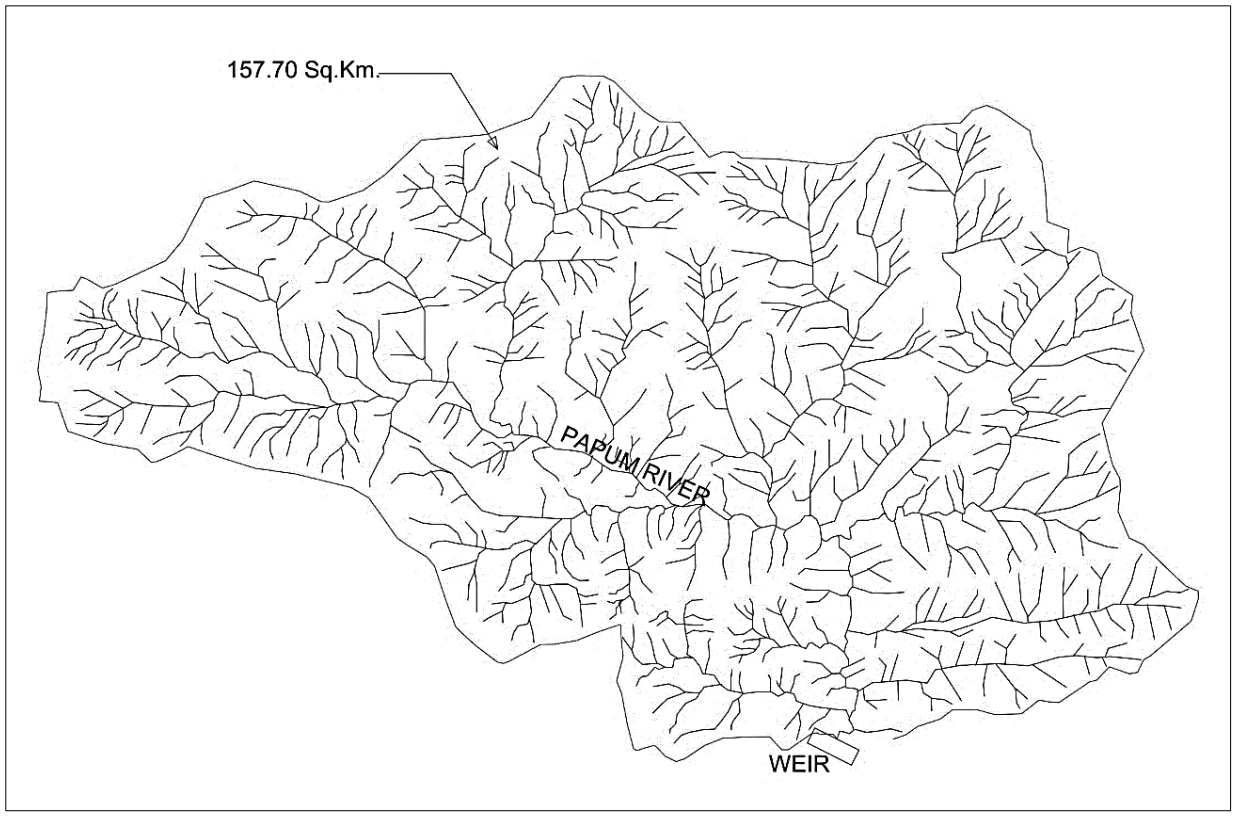

Figure-2.1: Catchment area of Papum HEP

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

Table- 2.1: Tabulated percentage of land use

Barren Rocky Area	22.43%
Crop Land	0.43%
Deciduous	33.88%
Fallow Land	10.65%
Plantation	0.32%
Reservoirs/Lakes and pond	0.45%
Rivers/Streams/Canals	3.06%
Rural	0.64%
Sandy area	0.37%
Scrub Forest	33.88%
Scrub Land	12.53%

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).

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

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

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

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

Silt Yield Index

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

Prioritization of Watersheds/Sub-watersheds:

The prioritizations 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 = Σ (Ai x Wi) x 100 ; where i = 1 to n Aw 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 AREA	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 SUBMERGENCE AREA TREATMENT MEASURES

The submergence area is 0.90 ha. The erosion category of various watersheds in the catchment area as per a SYI index is given in Table-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 in Ha.	SYI values	Category
W1	0.39	1120	Medium
W2	0.51	1120	Medium
Total 0.90 Ha.			

Table-2.5: Area under different erosion categories

Category	Area (ha)	Percentage
Very low	- -	- -
Low	--	--
Medium	0.90	100
High	- -	- -
Very High	- -	- -
Total	**0.90 Hectares**	

The objective of the SYI method is to prioritize sub-watershed in a catchment area for treatment. The total area under medium erosion category is 0.90 ha. The various measures suggested for catchment area treatment are mentioned in Table -2.6, expenses of which have to be borne by the project proponents.

2.6 COST ESTIMATE

The cost required for Catchment Area Treatment is Rs. 34.70 lakh. The details are given in Table 2.6.

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

Measure	Year-I		Year-II		Total	
	Physical	Financial	Physical	Financial	Physical	Financial
Gap Plantation	0.5 Ha	0.5 Lakhs	0.4 Ha	0.5 Lakhs	0.9 Ha	1.0 Lakhs
Afforestation	0.5 Ha	1.0 Lakhs	0.4 Ha	1.0 Lakhs	0.9 Ha	2.0 Lakhs
Contour bunding	0.5 Ha	1.0 Lakhs	0.4 Ha	1.0 Lakhs	0.9 Ha	2.0 Lakhs
Nursery development	0.5 Ha	0.5 Lakhs	0.4 Ha	0.5 Lakhs	0.9 Ha	1.0 Lakhs
Nursery maintenance	0.5 Ha	0.5 Lakhs	0.4 Ha	0.5 Lakhs	0.9 Ha	1.0 Lakhs
Barbed wire fence	0.5 Ha	0.5 Lakhs	0.4 Ha	0.5 Lakhs	0.9 Ha	1.0 Lakhs
Watch and Ward for 2 years for 2 persons	0.5 Ha	1.5 Lakhs	0.4 Ha	1.5 Lakhs	0.9 Ha	3.0 Lakhs
Check dam	0.5 Ha	2.0 Lakh	0.4 Ha	1.5 Lakhs	0.9 Ha	3.5 Lakhs
Total	**0.5 Ha**	**7.5 Lakhs**	**0.4 Ha**	**7.0 Lakhs**	**0.9 Ha**	**14.5 Lakhs**