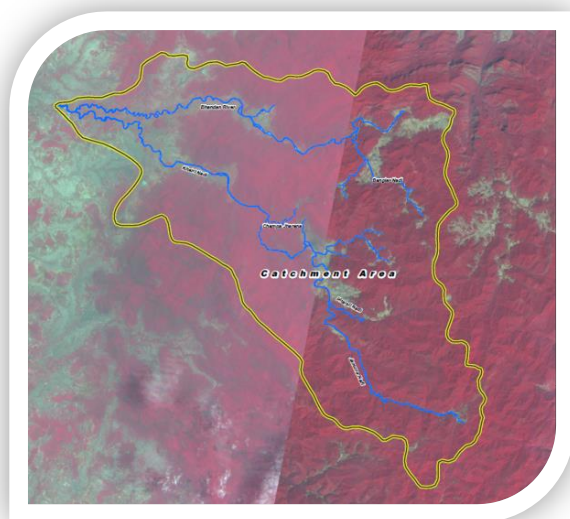




GOVERNMENT OF ODISHA
DEPARTMENT OF WATER RESOURCES

CATCHMENT AREA TREATMENT (CAT)
FOR
KHAIRIBHANDAN BARRAGE PROJECT

DIST: MAYURBHANJ, ODISHA



Udala, Mayurbhanj
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1. Introduction

The Catchment Area Treatment (CAT) targets overall improvement in the environmental conditions of the region. All the activities are aimed at treating the degraded and potential areas of severe soil erosion. The plan provides benefits due to biological and engineering measures.

The CAT Plan would cover the following aspects:

- Identification of free draining catchment
- Assessment of Land Use, Soil, Slope in the catchment based on Remote Sensing (RS) /Geographic Information System (GIS) and Validation through field survey
- Erosion levels the watershed and prioritization of water sheds will be done by appropriate methods.
- As per the requirement of Ministry of Environment & Forests and Climate Change (MoEF & CC), Government of India, the treatment measures will be proposed for the area falling higher priority erosion categories. Both Engineering measures as well as Biological treatment measures will be proposed in the CAT plan.
- The cost of the administrative set up and meditative measures will include recommendation from State Forest Department and other lines department.

2. Need

Pondage formed by barrage on rivers are subject to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entertainment, 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 pondage 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 threading of river reach. The removal of top fertile soil form catchment adversely affects the agricultural production. Thus, a well-designed catchment area treatment plan is essential to ameliorate the above –mentioned adverse process of soil erosion.

The CAT plan highlights the management techniques to control erosion in the catchment area of a water resource project. The life span of a reservoir is greatly reduced due to erosion in the catchment area. Adequate preventive measures are thus needed for the treatment of catchment for its stabilization against future erosion.

Quantifying soil erosion and reservoir sedimentation is necessary for prioritizing catchments for treatment and development of a suitable treatment mix. It is, therefore, also required that the effect of various treatments on controlling soil erosion are quantitatively known. River gauging data are the best information source for undertaking the above activities. As such data are not available for this catchment, so estimation procedure is adopted. At the present level of data availability and also based on the past experience, **Sedimentation (Silt) Yield Index (SYI)** appears to be an acceptable parameter for use in catchment prioritization work.

SYI is calculated using an empirical formula. Based on the numerical value of SYI, catchments are categorized into five priority classes from Very High (SYI>1300) priority to Very Low (SYI<1000) priority. The method was proposed by **All India Soil Survey and Land Use Planning (AISSLUP)** currently known as **Soil and Land Use Survey of India (SLUSI)** based on several studies. The method has been used to prioritize catchments in India totaling in area of millions of hectares. It is reported that, the SYI procedure is fairly reliable for determining priority watersheds. The empiricism in this method is manifest in the selection of unit area (mapping unit) and assigning an appropriate value of delivery ratio to it. SYI method is widely used because of the fact that it is easy to use and lesser data requirement. Moreover, it can applied to larger areas like sub watersheds etc.

3. Methodology adopted

Database on natural resources, terrain conditions and soil type of the catchment area is a pre-requisite to prepare CAT plan. Various thematic maps were prepared and used in preparation of the CAT plan, in Geographic Information System (GIS) platform.

The methodology adopted for development of CAT plan for the project is as under:

- Catchment boundary delineation from Survey of India Topo sheets
- Watershed boundary form watershed Atlas of India of Soil and Land Use Survey of India (SLUSI) and the micro watershed boundary collected from Watershed Mission of Odisha
- Land use/Land cover map preparation from recent 5.8m resolution LISS-IV Multi Spectral Satellite image
- Contour digitization from Survey of India OSM topo sheet and generation of slope map
- Soil map preparation from National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)
- Assigning weightage value of mapping units based on slope, land use and soil texture and Delivery ratio based on distance from nearest stream

- Estimation of Soil Loss using Silt Yield Index
- Watershed Prioritization
- Selection of locations of treatment and Catchment Treatment (CAT) Plan
- Cost Estimate

Thematic data integration and erosion index modeling was done using relevant map layers in GIS.

Silt Yield Index (SYI) of various Sub watersheds within the free catchment was estimated. Watershed management approach were proposed for optimal use of soil and water resources within the catchment with the broad objective of

- increasing infiltration into soil
- control excessive runoff
- manage & utilize runoff for useful purpose

4. Salient feature of Khairibhandan Barrage Catchments

The scheme envisages construction of a barrage at village Anlabani in Jashipur Block of Mayurbhanj District across Khairibhandan River. Khairibhandan River originates from the hill range of Similipal R.F. in Jashipur block of Mayurbhanj District. Khairibhandan river tributary to Baitarani basin. The catchment area of the project at site is 588 Km². The project has planned to irrigate 6950 ha of C.C.A. with 100% intensity during Khariff. The catchment map of Khairibhandan Barrage Project is enclosed at **Plate-1**.

5. Thematic Map Generation

As mentioned in the methodology, various thematic layers like catchment, watershed, drainage, contour, slope, land use, soil were prepared in Geographic Information System (GIS) platform using satellite image, OSM Sol Topo Sheet and other secondary source data. For seamless integration of different thematic layers and interactive spatial analysis, the themes were generated UTM (Universal Transverse Mercator) projection system. This projection system is used in the recent publication Open Series Map (OSM) of Sol and is also suggested in National Map Policy. Datum used for the projection is WGS 1984 and Zone is UTM 45 North.

5.1. Catchment and Watershed map

The catchment boundary of Khairibhandan Barrage was delineated from Sol topo sheets F45-I4, F45-O1, F45-O2, F45-O5 and F45-O6 looking at the contours and drainage. The contour and drainage map of the project is enclosed at **Plate-2**. The entire catchment is a part of the Watershed 4H2B2 as per the Watershed Atlas of India published by SLUSI. Since the catchment is very small (588 km²), it was decided to prepare the CAT plan at Sub Watershed level instead of Watershed level. The sub watersheds are prepared using the information available in Watershed Atlas of India published by Soil and Land Use Survey of India (SLUSI) and the micro watershed boundary collected from Watershed Mission of Odisha. The sub watershed map is enclosed at **Plate-3**.

Table-1: Area falling under different slope category

SL	Sub-watershed Code	Area (Km ²)
1	040802020210	28.92
2	040802020215	28.02
3	040802020221	31.47
4	040802020225	29.58
5	040802020218	44.46
6	040802020224	38.62
7	040802020217	50.30
8	040802020220	46.18
9	040802020213	42.07
10	040802020211	29.55
11	040802020212	18.66
12	040802020222	34.41
13	040802020216	44.78
14	040802020219	56.52
15	040802020207	25.84
16	040802020223	25.54
17	040802020214	13.08
	Total	588.00

5.2. Slope Map

The Slope map was derived from contours shown on Sol Topo sheet. After marking the catchment area, all the contours and spot heights shown on the topographical maps were mapped with 'Z' value (height above MSL in m). Since the area is mostly flat and contours are wide spaced, the spot heights collected in DGPS (differential GPS) during ground truthing of land use were also used as input.

A surface was created using the elevation values stored in the form of contours or points. 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 areas falling under various standard slope categories have been tabulated in **Table-1** and the slope map is enclosed at **Plate-4**.

Table-1: Area falling under different slope category

Slope Category	Slope (%)	Area in %	Area in Km ²
Gently Slopping	0-15	14.39	84.60
Moderately sloping	15-30	3.78	22.22
Strongly sloping	30-45	31.72	186.51
Steeply sloping	45-60	49.62	291.77
Very steeply sloping	60-75	0.49	2.90
Extremely sloping	>75		
Total		100.00	588

5.3. Land Use/ Land Cover Map

Land Use map was prepared from recent 5.8m resolution LISS-IV Multi Spectral Satellite Image collected from National Data Centre of National Remote Sensing Centre (NRSC), Hyderabad. Details of Satellite Image are given bellow.

Satellite: IRS-P6
 Sensor: LISS-IV MX (Multi Spectral)
 Date of Pass: 27th February 2015
 Path: 106
 Row: 057

The image was geo-referenced using the common Ground Control Points (GCP) of Survey of India topographical sheets and satellite image with the help of feature registration techniques in standard image processing software. The satellite image map is enclosed at **Plate-5**. As the catchment area is very small, visual interpretation of the geo-referenced satellite data was done by qualified professionals using standard enhancement techniques followed by detail ground truthing to enhance the quality of image interpretation. The classified land use map of the catchment area is depicted in **Table-2** and the map is enclosed at **Plate-6**.

Table-2: Area falling under different Land Use

Description	Area in Km ²	Area in %
Dense Forest/Plantation	27.52	4.68
Moderate Forest	441.41	75.07
Open Forest	10.58	1.8
Scrub	17.4	2.96
Cultivation	80.5	13.69
Waste Land	0.06	0.01
River/Water body	5.06	0.86
Settlement	5.47	0.93
Total	588	100.00

5.4. Soil Map

Soil map was prepared by digitizing the soil map collected from National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) for Odisha. The soil map is depicted at **Plate-7** and catchment area coming under different soil category is depicted in **Table-3**.

Table-3: Area falling under different soil category

Code	Description	Texture	Area in km ²	Area in %
1	Moderately deep, well drained fine-loamy soils with loamy surface and moderate erosion	Fine-loamy	17.64	2.52
2	Shallow, excessively drained, coarse loamy soils with loamy surface very severe erosion and strong st	Loamy	5.88	0.6
3	Deep poorly drained fine soils with clayey surface and slight erosion	Clayey	11.76	1.85
4	Shallow, somewhat excessively drained, loamy soils with loamy surface very severe erosion and strong	Loamy	540.96	92.88
5	Moderately shallow, moderately well drained, fine loamy soils with clayey surface, moderate erosion	Fine-loamy	11.76	2.15
	Total		588	100.00

6. Estimate of Soil Loss intensity using Silt Yield Index (SYI) method

The Sedimentation (Silt) Yield Index Model (SYI), considering sedimentation as product of erosivity, erodibility and arial extent was conceptualized in the 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 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.

In SYI methodology, each Erosion Intensity Unit (EIU) is assigned a weightage value. When considered collectively, the weightage value represents approximately the relative comparative erosion intensity. The slope, soil and land use theme of the catchment were combined using union tool in GIS and EIU were formed using different combination of soil, slope and land use categories.

SYI was calculated using following empirical formula:

$$SYI = \frac{\sum (A_i \times W_i) \times D_i \times 100}{A_w} \quad [\text{where } i = 1 \text{ to } n \text{ (n is the No. of EIU)}]$$

A_i = Area of i^{th} unit (EIU)

Wi = Weightage value of the ith unit EIU

D_i = Delivery Ratio of the i^{th} unit EIU

A_w = Total area of Sub-watershed

Weightage Value (W)

Weightage Value is a combination of two factors K and X. 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 Ratio (D)

Delivery ratios were assigned for each of the erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into reservoir. Area of each EIU in each Sub watershed was then estimated.

Delivery ratios were 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 - 0.99 km	1.00
1.01 - 2.0 km	0.95
2.01 - 5.0 km	0.90
5.01 - 15.0 km	0.80
15.01 - 30.0 km	0.70

1.0 km, 2.0 km, 5.0 km, 15.0 km and 30.0 km buffers were created around the main stream and reservoir using GIS. EIUs falling in different buffer zone were assigned the Delivery ratio of the respective buffer zone.

7. Prioritization of Sub Watershed based on SYI findings

The objective of the SYI method is to prioritize sub watershed in a catchment area for treatment. For prioritizing the sub watersheds, these are to be divided in to different categories based on their SYI. The SYI values for classification of various categories of erosion intensity rates are depicted below

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

The sub watershed wise SYI and category of erosion is depicted in **Table-4** and **Plate-8**

Table-4: Soil Erosion Priority Category of Sub Watersheds

SL	SWS Code	SYI	Priority
1	040802020207	1246.978058	High
2	040802020221	1239.986743	High
3	040802020211	1237.953032	High
4	040802020223	1232.365519	High
5	040802020222	1219.025123	High
6	040802020212	1217.208447	High
7	040802020216	1202.162299	High
8	040802020219	1179.514505	Medium
9	040802020213	1175.491222	Medium
10	040802020210	1173.524243	Medium
11	040802020225	1171.137487	Medium
12	040802020224	1170.873181	Medium
13	040802020214	1170.83607	Medium
14	040802020220	1170.793044	Medium
15	040802020218	1167.785534	Medium
16	040802020215	1139.516026	Medium
17	040802020217	1132.659021	Medium

As referred from the above table, there isn't any watershed of very high category; therefore the area under high erosion categories is proposed to be treated at the project. A base map showing land use, Reserve Forest boundary, slope, major drains and priority watershed is enclosed at **Plate-9** for micro planning of the catchment area treatment plan. As the steep areas are more prone to soil erosion, looking at the land use and topography **040802020207** and **040802020223** sub-watershed (Area 51.38 km²a) were finally selected for catchment area treatment plan which is directly draining to the rivers. The topographic map, drainage and contour map and land use and slope map of the sub watershed is enclosed at **Plate10.a, 10.b and 10.c** respectively.

7.1. Demography of the watershed

The village map of the sub watershed is enclosed at **Plate-12**. The demography of the villages as per Census 2011 is depicted below.

Sl	Name	Population	Male	Female	SC	ST
1	Madanmohanpur	231	104	127	0	228
2	Jashipur	4516	2270	2246	899	1797
3	Dhalabani	981	478	503	0	968
4	Suanpal	1233	601	632	0	1208
5	Chadripahadi	456	234	222	0	456
6	Podagarh	578	292	286	2	561
7	Tingiriani	214	102	112	0	214
8	Badsole	366	195	171	0	324
9	Chakundakacha	29	12	17	0	29
10	Barsia	403	200	203	0	399
11	Kolajhari	78	40	38	0	78
12	Bareipani	473	227	246	0	445
13	Asanabani	150	81	69	0	150
14	Haladia	132	62	70	0	132
15	Nuniagoda	182	100	82	0	182

8. Catchment Area Treatment (CAT) Plan

Following Engineering and Biological measures are planned for the catchment area treatment depending upon the requirement and suitability:

- a. Biological measures
 - Assisted Natural Regeneration
 - Block Plantation/Afforestation

- Fodder land development
- b. Engineering measures
 - Loose boulder wall-gully plugging in small hilly streams
 - Stone masonry check dams – in major drains

As the majority of the area is agricultural land, awareness campaign will be done for farm management (negatives of burning farm residuals, adoption of proper cropping pattern etc.), digging of farm pond, controlled grazing in graze land, etc.

8.1. Assisted Natural Regeneration

Assisted Natural regeneration is suggested in the **100ha** of open forest available within the Siminai and Similipal Reserve Forests. The sites to be treated are depicted in **Plate-13**. The detail estimate is depicted at **Annexure-1**.

8.2. Block Plantation/Afforestation

The village wise revenue forest and govt. land is depicted in the table below.

All areas are in ha.

Sl.	Village	Govt	Forest	Total
1	Madanmohanpur	60.00	13.62	73.62
2	Jashipur	269.26	947.56	1216.82
3	Dhalabani	184.696	103.07	287.766
4	Suanpal	235.88	263.45	499.33
5	Chadripahadi	118.68	74.08	192.76
6	Podagarh	102.29	74.3	176.59
7	Tingiriani	30.01	41.89	71.9
8	Badsole	251.76	22.29	274.05
9	Chakundakacha	16.15	25.41	41.56
10	Barsia	142.91	422.89	565.8
11	Kolajhari	21.92	7.54	29.46
12	Bareipani	73.26	163.04	236.3
13	Asanabani	33.72	57.95	91.67
14	Haladia	73.51	86.85	160.36
15	Nuniagoda	84.86	20.00	104.86

As 947.56, 263.45 and 422.89 ha. of forest land is available in Jashipur, Suanpal and Barsia village but there is no forest growth, it is proposed to block plantation of **100 ha** in this village. The detailed estimate is enclosed at **Annexure-2**

8.3. Fodder land development

To minimize the pressure on forest for grazing, it is suggested to develop fodder land in the watershed.

All areas are in Ha.

Sl.	Village	Gochhar	Population
1	Madanmohanpur	12.6	231
2	Jashipur	32.89	4516
3	Dhalabani	36.39	981
4	Suanpal	56.83	1233
5	Chadripahadi	19.83	456
6	Podagarh	29.35	578
7	Tingiriani	10.74	214
8	Badsole	25.11	366
9	Chakundakacha	0	29
10	Barsia	36.38	403
11	Kolajhari	49.2	78
12	Bareipani	27.44	473
13	Asanabani	5.66	150
14	Haladia	12.34	132
15	Nuniagoda	12.56	182

Looking at the availability of Gochhar land and population it is proposed to develop 5 blocks (of 10 ha each) of fodder land development in Jashipur, Dhalabani, Suanpal, Podagarh and Kolajhari. The detail estimate is given at **Annexure-3**.

8.4. Loose boulder wall-gully plugging in small hilly streams

Gully erosion, including ephemeral gully erosion, refers to the cutting of narrow channels resulting from concentration of sheet and rill flow of runoff water. Ephemeral gullies are small channels of approximately 3 to 12 inches deep. Gullies may be one to several feet deep. Gully erosion occurs when rill erosion is neglected. The tiny grooves develop into wider and deeper channels, which may assume a huge size. This state is called “gully” erosion. Gullies are the most spectacular evidence of the destruction of soil. The gullies usually deepen and widen with every heavy rainfall. They cut up large fields into small fragments and, in course of time, make them out of shape for cultivation.

Gully plugging work is required for reduction of runoff velocities within permissible limits and for controlling gully erosion of micro-watersheds. Appropriate gully plugging works would be selected from brush wood check dams, pallasiding works, gabion structures, sunken pits, etc. A

provision is kept for 30 gully plugging in the hilly streams. The typical Estimate of Gully Plugging is depicted at **Annexure-4.**

8.5. Stone masonry check dams – in major drains

Check dams range in size, shape and cost. It is possible to build them out of easily available materials and even at a very little cost. Decision of building such a dam depends on its location. Essentially a check dam has an earthen dam and masonry spillway.

It cuts the velocity and reduces erosive activity The stored water improves soil moisture of the adjoining area and allows percolation to recharge the aquifers Spacing between the check dams should be such that water spread of one should be beyond the water spread of the other Height depends on the bank height, varies from 1 metre to 3 metre and length varies from less than 3m to 10m.

The typical Estimate of earthen check dam with concrete core is depicted at **Annexure-5**

The locations of proposals for all treatments other than ANR activities are depicted in **Plate-14.**

The detail year wise cash flow estimate is depicted at **Annexure-6.**

9. Cost Estimate

SL	Item	Rate in Rs.	Unit	Physical	Financial (Rs, in Lakh)
Biological Measure					
1	Afforestation including maintenance (Block Plantation @1600 Seedlings per hectare)	98,075	Ha	100	98.07
2	Enrichment of Plantation/Re-densification (ANR Plantation @200 Seedlings per hectare)	32,881	Ha	100	32.88
3	Fodder land development per 10 ha	15,05,000	Ha	50	75.25
Engineering Measure (Water Harvesting Structures)					
4	Loose Boulder wall gully plugging	3524	No	30	0.11
5	Masonry Stone Check Dam	2,24,400	No	30	67.32
Others					
6	Awareness campaign for farm management, control grazing etc.	-	-	-	15.00
7	Drinking Water Facility to Villagers				25.00
	Total				313.63

Total cost of Biological, Engineering measure an silt observation at site = Rs. 313.63 lakh

Micro Planning Cost @ 5% = Rs. 15.68 lakh

Sub Total = **Rs. 329.31 lakh**

Contingency cost @ 5% = Rs 16.47 Lakh

Sub Total = **Rs. 345.78 lakh**

Administrative Expenditure @12% = Rs. 41.49 Lakh

Total = **Rs. 387.27 lakh**