GOVERNMENT OF ODISHA
DEPARTMENT OF WATER RESOURCES

CATCHMENT AREA TREATMENT (CAT)

FOR

JEERA DAM PROJECT

DIST: BARAGARH

Padampur, Baragarh
June 2015

Executive Engineer
Padampur Investigation Division
Padampur, Baragarh

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, and its utility in maintaining the eco-tourism. It also aims to reduce fuel wood consumption at least during the interregnum till the plantations become utilizable.

The CAT Plan would cover the following aspects:

Identification of directly / free draining catchment to be done basing on Remote sensing 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 mitigative measures will include recommendation from State Forest Department for all forest lands and from the Soil Conservation Department for non – forest land.

2. Need

Reservoirs formed by dams 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 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 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, 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 and website 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 LISS-IV MX Satellite image

Contour digitization from Survey of India 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 shall was done using relevant map layers in GIS.

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

increase infiltration into soil

control excessive runoff

manage & utilize runoff for useful purpose

4. Salient feature of Jeera Dam Catchments

Jeera River is a tributary to Mahanadi River, which is a major river system of Odisha. The river originates in Chhatisgarh and enters Odisha near village Pipalkhunta and joins Mahanadi on right about 40 km downstream of Sambalpur. The total length of the stream from the origin to confluence is about 87 km, the dam intercepts the river at RD 27.00 km.

The total catchment area of the proposed project at dam site is 187 km^2 (99 km^2 in Chhatisgarh and 88 km^2 in Odisha). As per Inter-State agreement between Odisha and Chhatisgarh, Odisha will get the yield from 36.90 km^2 of Chhatisgarh catchment. So the utiisable free catchment available for Jeera Project is 124.90 km^2. The catchment map of Jeera Dam 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) plat form. For seamless integration of different thematic layers and interactive spatial analysis, the themes were generated in a real world coordinate system, i.e UTM (Universal Transverse Mercator). This projection system is used in the recent publication Open Series Map (OSM) of SoI and is also

suggested in National Map Policy. Datum used for the projection is WGS 1984 and Zone is UTM 44 North.

5.1. Catchment and Watershed map

The catchment boundary of Jeera dam was delineated from SoI topo sheets F44-R7, looking at then 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 4G1H8 (Jeera, Ranj Jore and Girishul Jore) as per the Watershed Atlas of India published by SLUSI. The total area of the Watershed is 1162.01 km^2. As the catchment is show small, it was decided to prepare the CAT plan at Micro Watershed level instead of Watershed level. The micro watersheds are prepared using the information available in Watershed Atlas of India and website of and Land Use Survey of India (SLUSI) and the micro watershed boundary collected from Watershed Mission of Odisha. The micro watershed map is enclosed at *Plate-3*.

5.2. Slope Map

The Slope was prepared using the derived contours from SoI topo sheet. These contours were used for preparation of Digital Elevation Model (DEM) of the catchment area before preparation of the slope map.

A surface was created 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 with 'Z' value (height above MSL in m) as well as spot heights in form of x, y & z points. (x- Longitude, y- Latitude and z - Elevation above MSL). As the area is mostly flat and there are wide horizontal gaps between contours, the spot heights collected in DGPS (differential GPS) during ground trothing of land use are also used as an input.

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 map is enclosed at *Plate-4*.

Table-1: Area falling under different slope category

Slope Category	Slope (%)	Area in Km^2	Area in %
Gently Slopping	0-15	168.39	90.05
Moderately sloping	15-30	3.12	1.67
Strongly sloping	30-45	14.69	7.86
Steeply sloping	45-60	0.80	0.43
Very steeply sloping	60-75	0	0
Extremely sloping	>75	0	0
Total		187	100

5.3. Land Use/ Land Cover Map

Land Use map was prepared from recent LISS-IV Multi Spectral satellite image collected from National Data Centre of National Remote Sensing Agency (NRSA).

Satellite: IRS-P6

Sensor: LISS-IV MX (Multi Spectral)

Date of Pass: 1st April 2015

Path: 103

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 standard data preparation techniques in standard image processing software. The map of the satellite image 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 trothing 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 %
Open Forest	15.57	8.33
Wasteland with scrub	14.02	7.50
Agricultural	153.20	81.92
Barren Rocky	0.70	0.37
Settlement	1.34	0.71
River & Water body	2.17	1.16
Total	187.00	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 and undivided Madhya Pradesh. 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	Very deep poorly drained fine soils on very gently sloping inland plain with loamy surface and slight erosion	Loamy	52.38	28.01
2	Deep, well drained, fine soils on moderately steeply sloping hill slope with loamy surface and severe erosion	Loamy	6.08	3.25
3	Very deep, poorly drained fine-loamy soils on nearly level inland plain with sandy surface and slight erosion	Sandy	12.63	6.75
4	Moderately deep, well drained, coarse-loamy soils on gently sloping denuded hills with loamy surface and severe erosion	Coarse-Loamy	52.51	28.08
5	Deep Moderately Well Drained, Clayey Soils on Gently Slopping Undulating Plateau with Mounts & Valleys with Moderate Erosion	Clayey	63.40	33.90
	Total		187.00	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:

$$SYI = \frac{(Ai \times Wi) \times Di \times 100}{Aw} \quad [\text{where } i = 1 \text{ to } n \text{ (n is the No. of EIU)}]$$

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

Wi = Weightage value of the i^{th} unit EIU

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

Aw = Total area of Micro-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 micro 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 - 0.9 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

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 Micro Watershed based on SYI findings

The objective of the SYI method is to prioritize micro watershed in a catchment area for treatment. For prioratizing the micro 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 micro watershed wise SYI and category of erosion is depicted in *Table-4* and *Plate-8*

Table-4: Soil Erosion Priority Category of Micro Watersheds

SL	MWS Code	SYI	Priority
1	4G1H8H1	1196	Medium
2	4G1H8H2	1175	Medium
3	4G1H8I2	1168	Medium
4	4G1H8P2	1136	Medium
5	4G1H8A6	1133	Medium
6	4G1H8P4	1128	Medium
7	4G1H8A5	1124	Medium
8	4G1H8A4	1124	Medium
9	4G1H8P5	1119	Medium
10	4G1H8A1	1105	Medium
11	4G1H8S1	1104	Medium
12	4G1H8P3	1102	Medium
13	4G1H8A3	1096	Low
14	4G1H8A2	1093	Low
15	4G1H8A7	1088	Low
16	4G1H8R7	1071	Low
17	4G1H8R4	1061	Low
18	4G1H8A8	1061	Low
19	4G1H8R6	1056	Low
20	4G1H8I1	1052	Low
21	4G1H8S2	1044	Low
22	4G1H8R3	1044	Low
23	4G1H8R2	1041	Low
24	4G1H8R5	1039	Low
25	4G1H8R1	1037	Low
26	4G1H8S3	978	Very Low

As referred from the above table that, there isn't any watershed of very high and high category, therefore the area under medium erosion categories is to be treated at the project proponent's cost. Hence, CAT plan is planned for medium erosion categories, as a part of the EIA study, the expenses of which have to be borne by project proponents. The

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. Engineering measures -

- Loose boulder wall-gully plugging in small hilly streams
- Stone masonry check dams – in major drains
- Digging of trenches for silt trap

b. Biological measures

- Plantation/Afforestation
- Re-densification of open forest
- Pasture development

As the majority of the area is agricultural land (81.92%), awareness campaign will be done for farm management (don't burn farm residuals, adoption of proper cropping pattern etc.), digging of farm pond, control grazing in graze land etc.

Two silt observation locations for regular monitoring of silt load coming in Jeera River and other tributary Tera River have been suggested. This would ensure monitoring efficacy of implementation various treatments measures suggested as in CAT plan. Monitoring would be undertaken for a period of 10 years including 5 years for CAT plan implementation period.

9. Cost Estimate

SL	Item	Rate in Rs.	Unit	Physical	Financial (Rs, in Lakh)
Biological Measure					
1	Afforestation including maintenance	1,00,000	Ha	30	30.00
2	Enrichment of Plantation/Re-densification	25,000	Ha	200	50.00
3	Pasture Development	25,000	Ha	40	10.00
4	Nursery Development	15,00,000	No	1	15.00
Engineering Measure					
5	Masonry Stone Check Dam	2,00,000	No	2	4.00
6	Loose Boulder wall gully plugging	20,000	No	10	2.00
7	Digging of trench for silt trapping	60,000	Km	5	3.00
Others					
8	Silt Observation	-	-	-	24.00
9	Awareness campaign for farm management, control grazing etc.	-	-	-	15.00
	Total				153.00

Total cost of Biological, Engineering measure an silt observation at site	=	Rs. 153.00 lakh
Micro Planning Cost @ 5%	=	Rs. 7.65 lakh
Sub Total	=	Rs. 160.65 lakh
Contingency cost @ 5%	=	Rs 8.03 Lakh
Sub Total	=	Rs. 168.68 lakh
Administrative Expenditure @12%	=	Rs. 20.14 Lakh
Total	=	Rs. 188.82 lakh

Silt observation

Cost of one laboratory = Rs 5 Lakh

One hot at each site (@ 1 lakh) = Rs 2.0 Lakh

Cost of hiring service of one person (Rs 10,000/- per month for 120 months) = Rs. 12 Lakhs

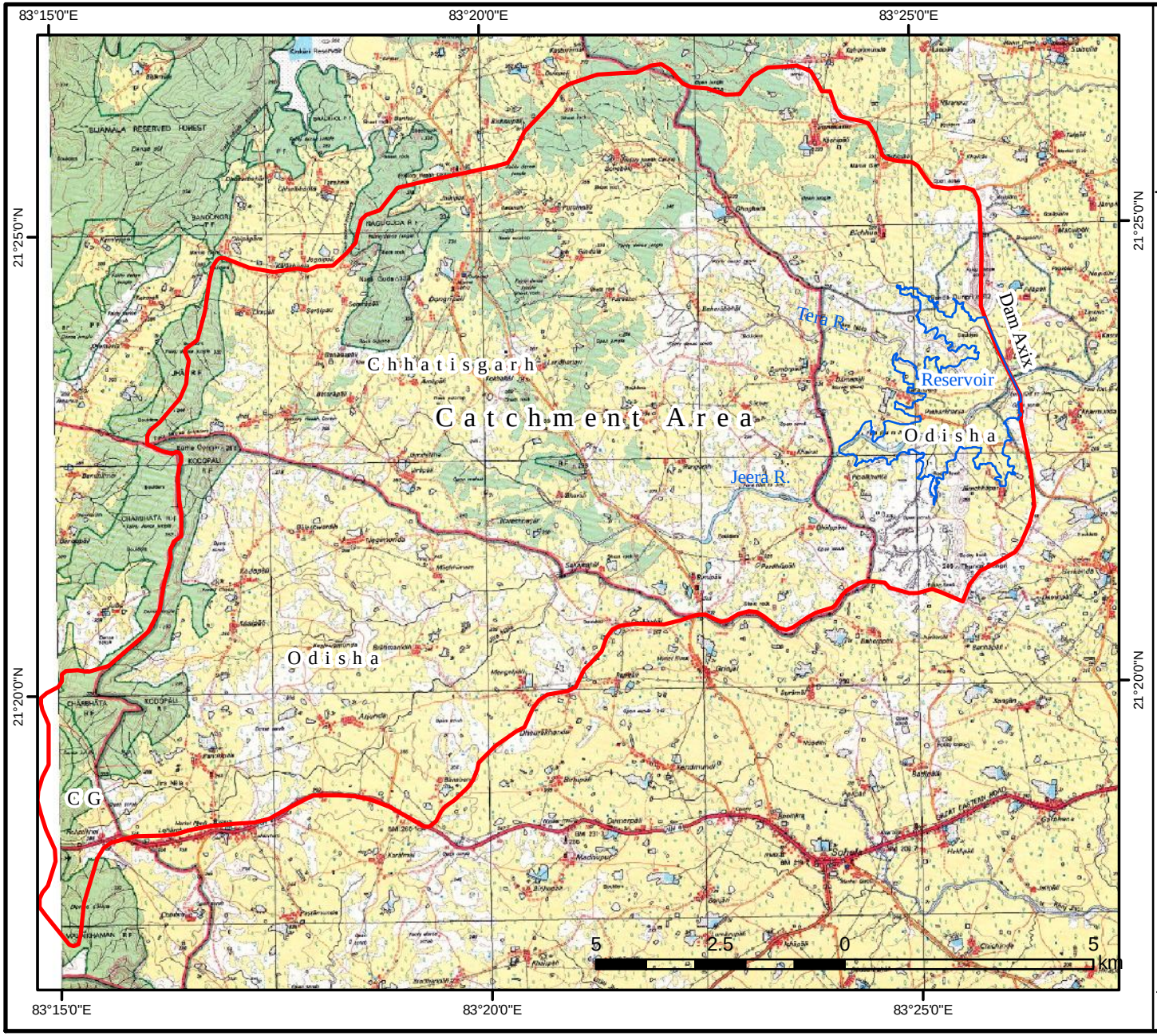
Consumable @ 0.50 Lakh per year for 10 years = Rs. 5.0 Lakhs

Plate-1

Catchment Area Treatment Plan

Jeera Dam Project

Catchment Map



Legend

- Catchment
- Reservoir

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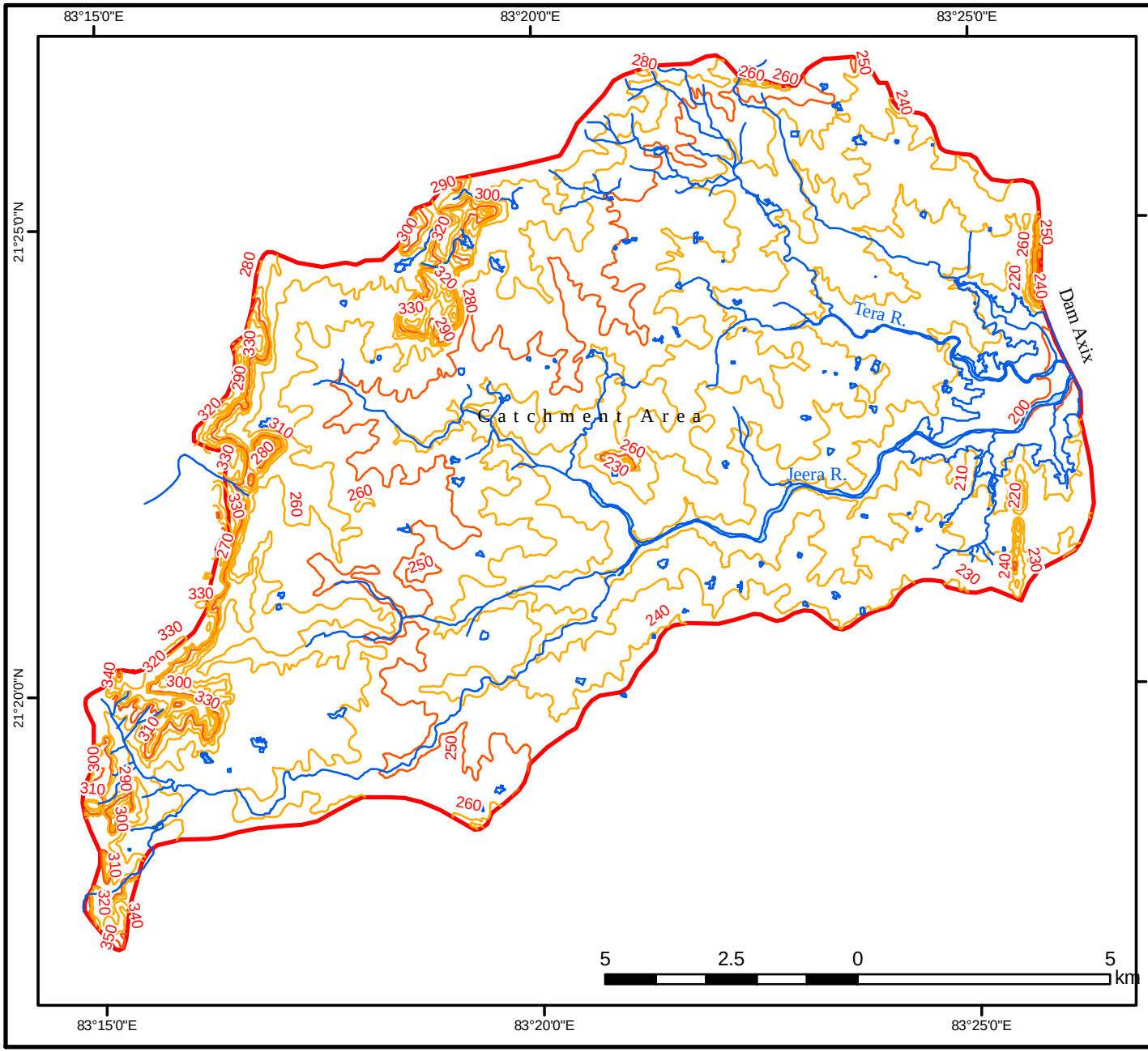
Plate-2

Catchment Area Treatment Plan

Jeera Dam Project

Drainage Map



Legend

- Catchment
- Drain
- River/Reservoir/Water Body
- Contour (50 m Interval)
- Contour (10 m Interval)

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Plate-3

Catchment Area Treatment Plan

Jeera Dam Project

Micro Watershed Map

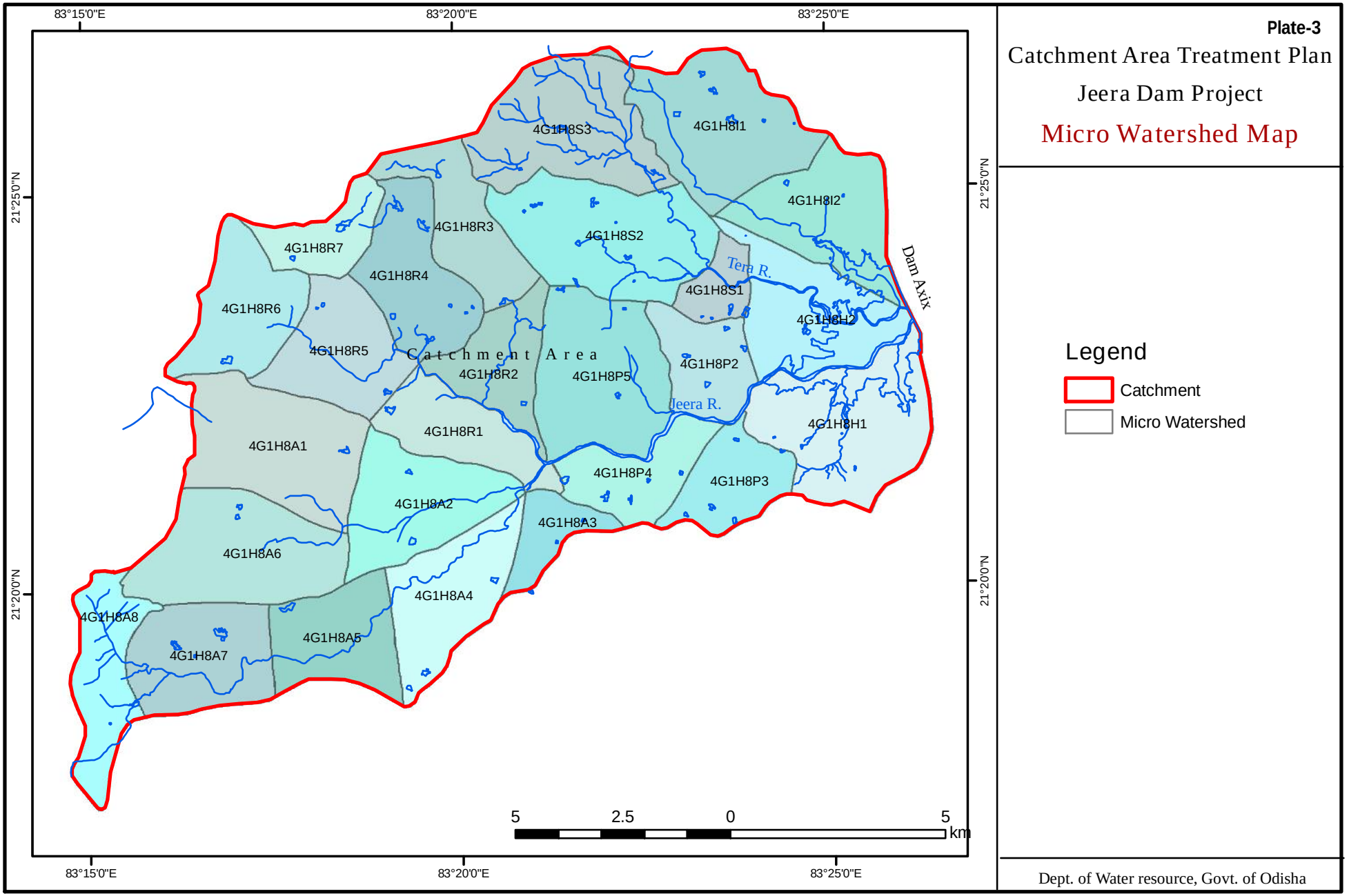

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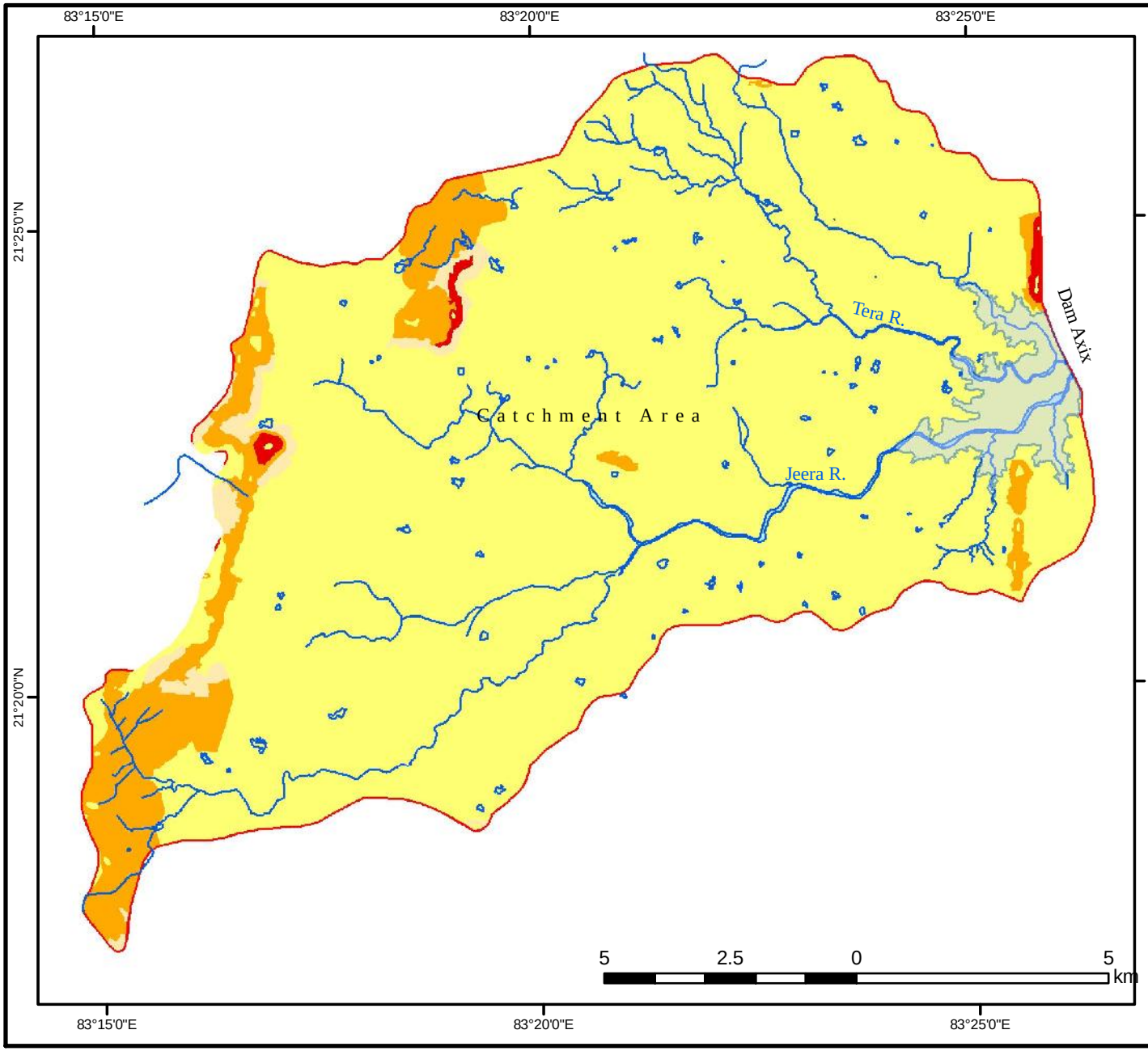
Plate-4

Catchment Area Treatment Plan

Jeera Dam Project

Slope Map



Legend

- Strongly Steep
- Steep
- Moderatly Steep
- Gentlly Sloping

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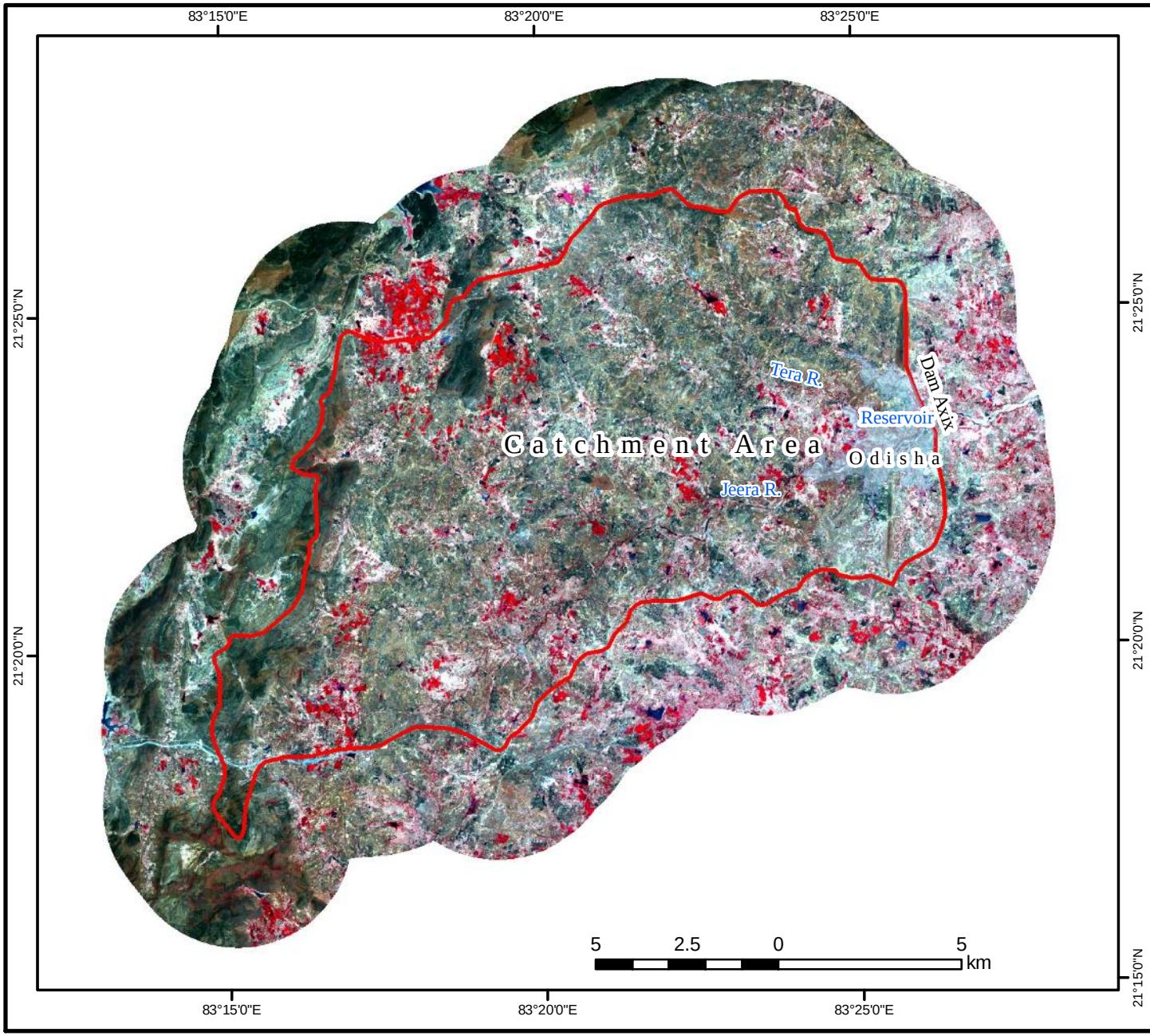
Plate-5

Catchment Area Treatment Plan

Jeera Dam Project

LISS-IV MX, SatelliteImage



Legend

- Catchment
- Reservoir

Satellite:	IRS-P6
Sensor:	LISS-IV MX (Multi Spectral)
Date of Pass:	1st April 2015
Path:	103
Row:	057

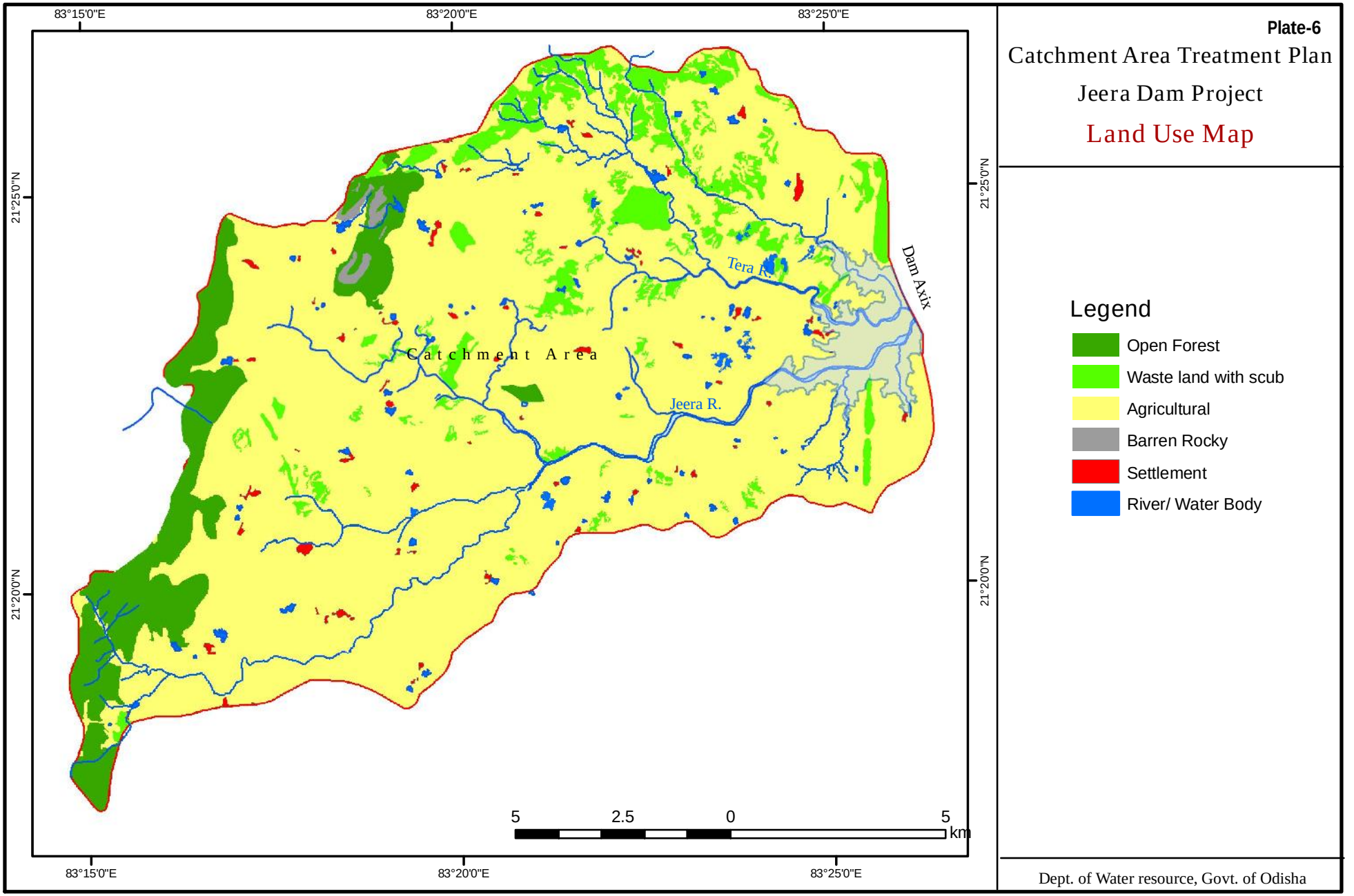
Dept. of Water resource, Govt. of Odisha

Plate-6

Catchment Area Treatment Plan

Jeera Dam Project

Land Use Map



Legend

- Open Forest
- Waste land with scub
- Agricultural
- Barren Rocky
- Settlement
- River/ Water Body

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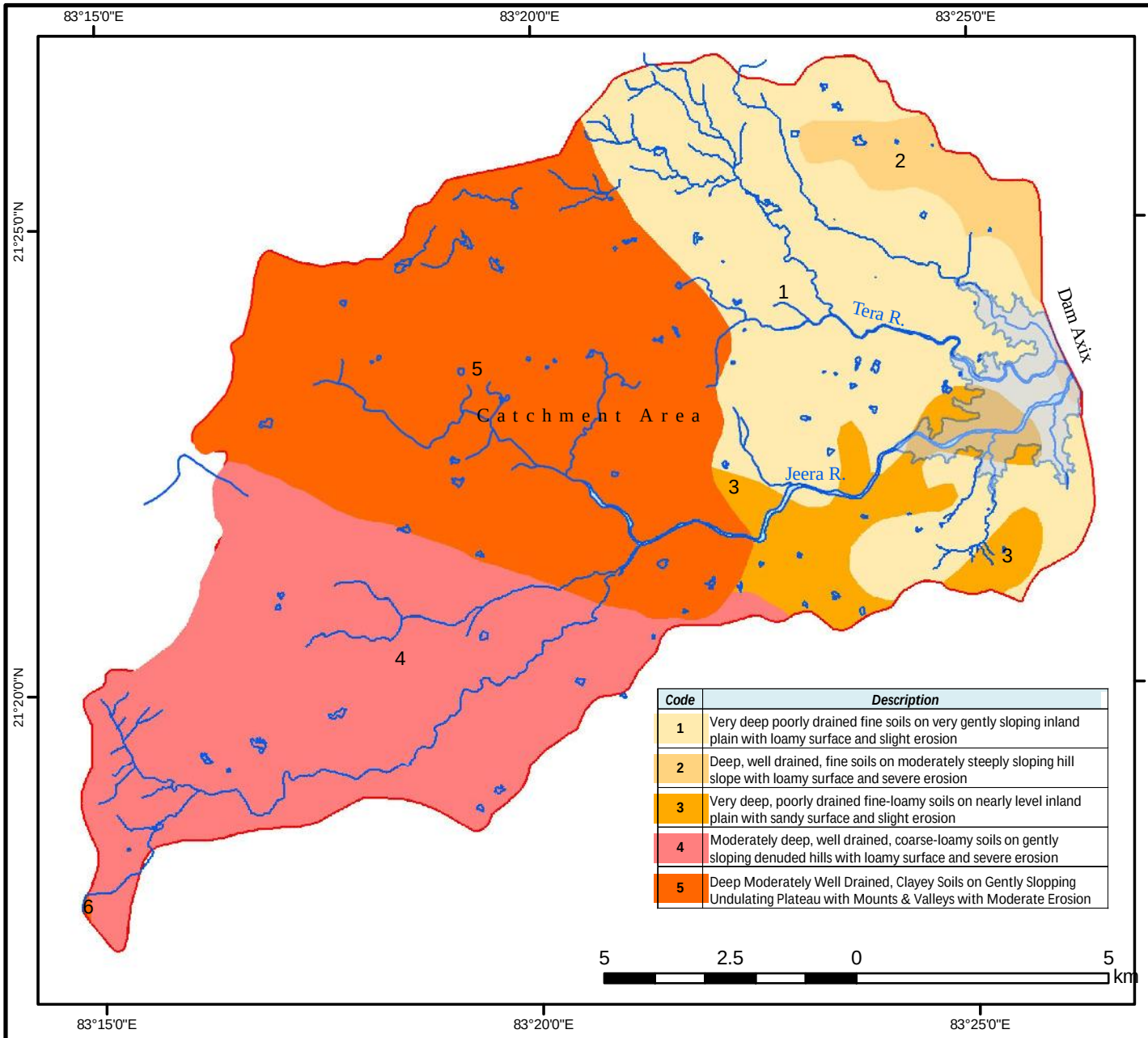
Plate-7

Catchment Area Treatment Plan

Jeera Dam Project

Soil Map



Code	Description
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2	Deep, well drained, fine soils on moderately steeply sloping hill slope with loamy surface and severe erosion
3	Very deep, poorly drained fine-loamy soils on nearly level inland plain with sandy surface and slight erosion
4	Moderately deep, well drained, coarse-loamy soils on gently sloping denuded hills with loamy surface and severe erosion
5	Deep Moderately Well Drained, Clayey Soils on Gently Slopping Undulating Plateau with Mounts & Valleys with Moderate Erosion

Legend

Soil Series (Code)

- 1
- 2
- 3
- 4
- 5

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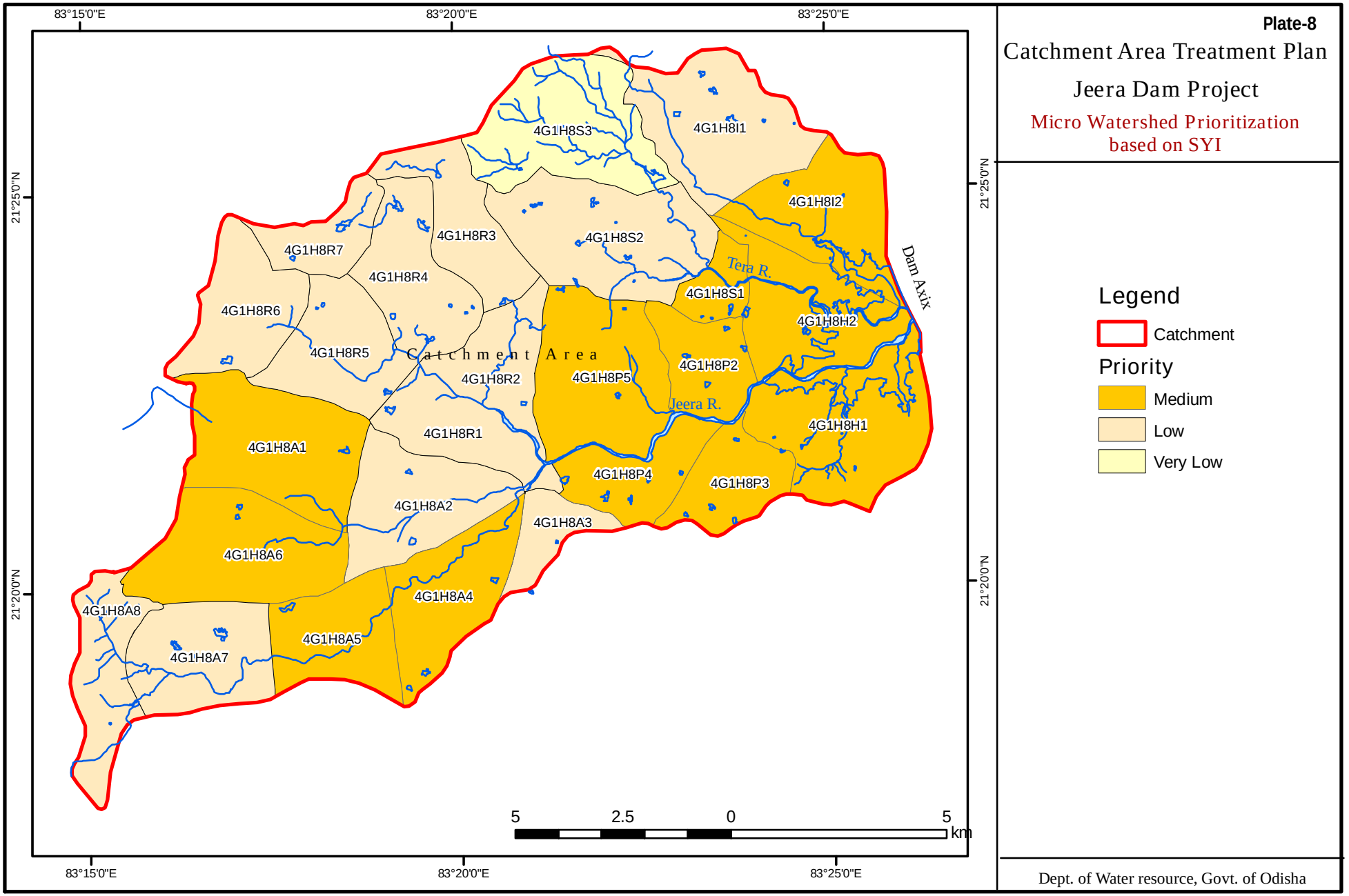
Plate-8

Catchment Area Treatment Plan

Jeera Dam Project

Micro Watershed Prioritization based on SYI



Legend

- Catchment
- Priority
  - Medium
  - Low
  - Very Low

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