

KEN-BETWA LINK PROJECT (PHASE-I)

ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL MANAGEMENT PLAN



Catchment Area Treatment Plan



NATIONAL WATER DEVELOPMENT AGENCY
(Ministry of Water Resources, River Development
and Ganga Rejuvenation, Government of India)

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**EIA and EMP Study of
Ken-Betwa Link Project Phase-I
CATCHMENT AREA TREATMENT PLAN
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CATCHMENT AREA TREATMENT PLAN

1.1 NEED FOR CATCHMENT AREA TREATMENT

It is a well-established fact that reservoirs formed by dams on rivers are subjected to sedimentation. The process of sedimentation embodies the sequential processes of erosion, entrainment, transportation, deposition and compaction of sediment. The steady erosion and 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 land productivity in the area. Thus, a well-designed Catchment Area Treatment (CAT) Plan is essential to ameliorate the above mentioned adverse effects 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 and glaciers also cause soil erosion. In a hilly catchment area 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 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.

1.2 APPROACH AND METHODOLOGY

The total catchment areas are taken as directly draining catchment areas and considered for treatment under the present Daudhan dam. The sub-basin wise catchment areas have already been discussed earlier. The catchment area treatment involves

- ❖ Understanding of the erosion characteristics of the terrain ; and
- ❖ Suggesting remedial measures to reduce the rate of erosion.

In the present study 'Silt Yield Index' (SYI), method has been used. In this method, the terrain is sub-divided into various small sub-watersheds and the erodibility is determined on relative basis. SYI's provide comparative erodibility criteria of catchment (low, moderate, high, etc.) and do not provide the absolute silt yield. The SYI method developed by All India Soil and Land Use Survey (AISLUS)¹ is widely used and can be applied to larger areas like sub-watersheds of Ken catchments.

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, all areas do not contribute for erosion equally. Several techniques like manual overlay of spatially index-mapped data have been used to estimate soil erosion in complex landscapes. 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

¹ All India Soil and Land Use Survey (AISLUS) is an ICAR organization and is now known as **National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)**

ground truth studies too have been conducted. The various steps covered in the study are Data acquisition, Data preparation and Output presentation. The steps are briefly described in the following paragraphs.

1.2.1 Data Acquisition

The requirement of the study was first defined and the outputs expected were listed. The various data layers of the catchment area used for the study are as follows:

- Land use Classification map
- Slope map
- Soil map
- Surface Drainage map

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. 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 z their elevation). All this information was in real world coordinates (latitude, longitude and height in meters above mean 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 into classes of slope percentages.

1.2.2 Estimation of Soil Loss Using SYI Method

The Silt Yield Index (SYI), considering sedimentation as product of erosivity, erodibility and aerial extent was conceptualized in the All India Soil and Land Use Survey (AISLUS) in 1972. The methodology has been progressively refined overtime and tested for validity. The sediment detachment process predominates in the upland phase where as sediment transport and deposition are the main processes in low land phase. The most basic sediment yield model that could be conceived should involve precipitation, runoff, infiltration, soil characteristics and transport component. 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. Sediment delivery from a hydrologic unit to a reservoir is a multiplicative function of the potential soil detachment representing the erosivity factor, transportability of the detached material (delivery ratio) and area of hydrologic entity. This can be expressed as

$$\text{Sediment yield} = f \times \text{delivery ratio} \times \text{area.}$$

So, the erosivity is simulated whereas the delivery ratio is adjusted with the sediment yield weightage value, by the likely delivery of the eroded material.

1.2.3 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.

1.2.4 Prioritization of Watersheds / Sub-watersheds

The prioritization of smaller hydrologic units within the vast catchments is 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 area involves the evaluation of following factors:

- ⇒ Climatic factors comprising total precipitation, its frequency and intensity;
- ⇒ Geomorphic factors comprising land forms, physiographic features of the area, slope and drainage characteristics;
- ⇒ Surface cover factors governing the flow hydraulics; and
- ⇒ Management factors.

The data on climatic factors was obtained for different locations in the catchment area from the meteorological stations whereas the field investigators were engaged 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
- ✚ Generation of 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:

$$\text{Silt Yield Index (SYI)} = (A_i \times W_i \times D_i) \times 100 / A_w$$

Where

- i = 1 to n
- A_i = Area of i^{th} unit (EIMU)
- W_i = Weightage value of i^{th} mapping unit
- N = No. of mapping units
- A_w = Total area of sub-watershed
- D_i = Adjusted delivery ratio assigned to mapping unit.

In general no adjustment is initially carried out for sub-watersheds located within the periphery of 40 km from the reservoir site. The SYI values obtained thus are further adjusted by multiplication with a suitable factor to account for the deposition of the material enroute the reservoir site.

The gradation and assignment of priority ratings to the sub-watersheds are based on the descending values of sediment yield index / runoff the potential Index values. An abrupt change in the number of sub-watersheds is indicative of the breaking points and is deciding factor for fixing upper and lower limits of different priority categories. The boundaries for the various categories are shown in **Table 1.1**.

Table 1.1: Boundaries for the Various Categories of Prioritization of Sub-Watersheds		
Sl. No.	Priority categories	SYI Values
1	Very high	> 1300
2	High	1200 – 1299
3	Medium	1100 – 1199
4	Low	1000 – 1099
5	Very low	< 1000
Source: ALUSS		

1.3 RATING AND PRIORITIZATION OF SUB WATERSHEDS

The total catchment area of Ken River up to the proposed dam near Daudhan (v) is worked out with the aid of Remote Sensing Applications as 19633 sq km. For preparation of watershed management plan in respect of Ken river basin (up to dam site), as already mentioned the basin is divided into three sub-basins as below:

- Upper Ken River sub-basin;
- Sonar River sub-basin; and
- Bearma River sub-basin

The sub-basins are further divided into small sub-watersheds for the purpose of prioritization to take up watershed management measures. The prioritization of sub-watersheds in the above cited three sub-basins are discussed below:

1.3.1 Upper Ken Sub-Basin

The total catchment area of Upper Ken sub-basin is 564063 ha. This area has been subdivided into 50 sub-watersheds. The priority ratings of these sub-watersheds based on the descending values of SYI are furnished in **Table 1.2**. Thirteen sub watersheds in this sub-basin are prioritized as high of which eight sub watersheds are in the directly draining catchment of the Daudhan Reservoir. The balance five sub-watersheds are in the catchment area intercepted by the proposed Upper Ken Reservoir.

Table 1.2: DAUDHAN CATCHMENT UPPER KEN RIVER SUB-BASIN - PRIORITY RATINGS OF SUB-WATERSHEDS				
Sl .No.	Watershed code	Area in ha	Sediment Yield Index	Priority
1	2CIC3.19	5,735	1268	High
2	2CIC3.7	2,760	1271	High
3	2CIC3.8	2,894	1272	High
4	2CIC5.3	6,754	1273	High
5	2CIC3.14	7,114	1274	High
6	2CIC3.16	9,452	1275	High
7	2CIC3.18	7,833	1200	High
8	2CIC3.11	4,306	1280	High
9	2CIC3.10	3,506	1275	High
10	2CIC3.9	4,250	1200	High
11	2CIC1.11	6490	1258	High
12	2CIC1.10	6785	1260	High
13	2CIC1.8	7988	1275	High
14	2CIC3.1	26,672	1101	Medium
15	2CIC3.2	32,867	1101	Medium
16	2CIC4.3	15,962	1101	Medium
17	2CIC5.1	7,852	1104	Medium
18	2CIC3.15	14,385	1115	Medium
19	2CIC3.17	33,184	1164	Medium
20	2CIC3.10	4,186	1188	Medium
21	2CIC1.15	4965	1148	Medium
22	2CIC1.16	6857	1170	Medium
23	2CIC1.14	15089	1107	Medium
24	2CIC2.7	12,340	1009	Low
25	2CIC4.1	43,310	1009	Low

Table 1.2: DAUDHAN CATCHMENT UPPER KEN RIVER SUB-BASIN - PRIORITY RATINGS OF SUB-WATERSHEDS				
Sl .No.	Watershed code	Area in ha	Sediment Yield Index	Priority
26	2CIC2.6	17,828	1020	Low
27	2CIC2.5	33,612	1022	Low
28	2CIC2.3	33,023	1028	Low
29	2CIC3.13	14,077	1034	Low
30	2CIC2.4	6,640	1037	Low
31	2CIC3.6	4,487	1046	Low
32	2CIC2.9	8,145	1052	Low
33	2CIC2.8	6,900	1056	Low
34	2CIC2.2	22,733	1063	Low
35	2CIC5.2	4,854	1080	Low
36	2CIC4.2	13,939	1094	Low
37	2CIC1.7	16484	1009	Low
38	2CIC1.2	3278	1035	Low
39	2CIC1.5	5496	1036	Low
40	2CIC1.6	4660	1050	Low
41	2CIC1.12	6503	1059	Low
42	2CIC1.3	3635	1090	Low
43	2CIC1.13	5787	1099	Low
44	2CIC1.9	13032	972	Very Low
45	2CIC1.4	5969	979	Very Low
46	2CIC1.1	14216	980	Very Low
47	2CIC3.4	6,015	881	Very Low
48	2CIC3.3	8,270	904	Very Low
49	2CIC3.12	7,287	913	Very Low
50	2CIC2.1	3,657	944	Very Low
Total		564,063		
<i>Source : Compiled by AFCL on the basis of information from RS imageries, Toposheet and Soil Survey Reports published by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)</i>				

The total area of these eight prioritized sub-watersheds is 38979 ha. The team's discussion with the officials of Water resources Department indicated that the catchment area treatment is essential in two sub-watersheds viz., 2CIC1.6 and 2CIC1.4 even though these two sub-watersheds are prioritized as low and very low. Therefore, catchment area treatment plan was prepared for these two sub-watersheds also. Thus, the catchment area treatment plan is prepared for ten sub-watersheds in this basin. The Total area of these ten sub-watersheds is about 49608 ha. This area accounts for about 8.79 per cent of the area of the sub basin. The Map showing ten prioritized sub-watersheds in the directly draining catchment of Daudhan Reservoir in Upper Ken River sub-basin area is given in Figure I.1.

1.3.2 Sonar River Sub-basin

This river is a tributary of Ken River after Shyamari Nadi on the upstream of the proposed Daudhan Reservoir on the left flank. The catchment area of this sub-basin is 768533 ha, which is about 39.13 percent of the total Ken catchment at Daudhan dam site. The entire area excluding its major tributary called Bearma River is divided into 75 small hydrologic units or sub-watersheds for prioritization as per SYI ratings. The priority ratings of sub-watersheds based on the descending values of SYI are presented in **Table 1.3**.

Table 1.3: DAUDHAN CATCHMENT				
SONAR RIVER SUB-BASIN - PRIORITY RATINGS OF SUB-WATERSHEDS				
Sl.No.	Watershed code	Area in ha	Sediment Yield Index	Priority
1	2CID7.9	10180	1348	Very High
2	2CID9.5	12702	1396	Very High
3	2CID2.27	4891	1338	Very High
4	2CID6.1	17615	1228	High
5	2CID6.2	9540	1202	High
6	2CID6.4	10390	1203	High
7	2CID7.7	9170	1209	High
8	2CID8.7	12126	1282	High
9	2CID7.3	17938	1255	High
10	2CID2.16	4148	1161	High
11	2CID2.18	4092	1258	High
12	2CID2.19	8124	1245	High
13	2CID2.20	1376	1237	High
14	2CID2.21	3782	1254	High
15	2CID2.23	5416	1256	High
16	2CID2.25	5094	1255	High
17	2CID2.9	3888	1188	High
18	2CID2.14	3979	1230	High
19	2CID2.24	9105	1230	High
20	2CID4.8	11789	1108	Medium
21	2CID5.1	16991	177	Medium
22	2CID6.3	14382	1109	Medium
23	2CID6.5	10848	1151	Medium
24	2CID6.6	10653	1160	Medium
25	2CID7.8	7719	1160	Medium
26	2CID8.3	13094	1176	Medium
27	2CID8.4	16731	1168	Medium
28	2CID8.5	11012	1180	Medium
29	2CID8.6	17019	1174	Medium
30	2CID9.6	5150	1131	Medium
31	2CID3.1	18029	1008	Low
32	2CID3.2	11704	1067	Low
33	2CID3.3	11160	1017	Low
34	2CID3.4	15429	1066	Low
35	2CID3.5	21139	1095	Low
36	2CID4.1	13767	1059	Low
37	2CID4.2	3996	1056	Low
38	2CID4.4	12668	1065	Low
39	2CID4.7	11633	1086	Low
40	2CID5.2	17440	1080	Low
41	2CID5.3	12331	1066	Low
42	2CID5.4	5992	1039	Low
43	2CID7.2	24913	1080	Low
44	2CID7.4	17808	1021	Low
45	2CID7.6	22293	1016	Low
46	2CID8.1	10705	1062	Low

Table 1.3: DAUDHAN CATCHMENT				
SONAR RIVER SUB-BASIN - PRIORITY RATINGS OF SUB-WATERSHEDS				
Sl.No.	Watershed code	Area in ha	Sediment Yield Index	Priority
47	2CID8.2	15775	1030	Low
48	2CID9.1	24314	1000	Low
49	2CID9.2	9536	1050	Low
50	2CID9.4	18804	1068	Low
51	2CID9.7	13031	1092	Low
52	2CID2.10	4424	1055	Low
53	2CID2.13	3494	1065	Low
54	2CID2.15	4095	1040	Low
55	2CID2.17	3678	1068	Low
56	2CID2.22	5047	1040	Low
57	2CID2.4	3235	1040	Low
58	2CID2.5	2966	1047	Low
59	2CID2.6	3446	1039	Low
60	2CID2.8	3657	1026	Low
61	2CID4.3	14177	965	Very Low
62	2CID4.5	15634	971	Very Low
63	2CID4.6	10008	972	Very Low
64	2CID4.9	10927	933	Very Low
65	2CID7.1	27097	991	Very Low
66	2CID7.10	13420	961	Very Low
67	2CID7.5	11803	996	Very Low
68	2CID9.3	10258	993	Very Low
69	2CID2.1	1791	977	Very Low
70	2CID2.11	3220	980	Very Low
71	2CID2.12	4162	975	Very Low
72	2CID2.2	2691	972	Very Low
73	2CID2.26	4339	907	Very Low
74	2CID2.3	1722	915	Very Low
75	2CID2.7	1831	974	Very Low
Total		7,68,533		
Source : Compiled by AFCL on the basis of information from RS imageries, Toposheet and Soil Survey Reports published by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)				

Nineteen sub watersheds in this sub-basin are prioritized as very high and high consisting of three sub watersheds in very high priority category and sixteen sub watersheds in high priority category. Out of this 19 sub watersheds only fourteen sub watersheds, consisting of two very high priority sub watershed and twelve high priority sub watersheds, are in the directly draining catchment of Daudhan reservoir. The location of prioritized sub-watersheds in the directly draining catchment at Daudhan dam site in Sonar sub-basin is given in Figure I.2. The total area of 14 prioritized sub-watersheds in the Sonar sub-basin is about 96661 ha and accounted for about 12.58 per cent of the sub-basin area.

1.3.3 Bearma River Sub-basin

Bearma River is one of the main contributors of the catchment area of Ken River at Daudhan dam site. This catchment area is about 621697 ha, which is 31.67 per cent of the total catchment at Daudhan dam site. The river joins Sonar river and then the latter confluences with Ken river well below. The catchment is about 44.73 per cent of Sonar river catchment. The catchment area of Bearma River is sub-divided into 41 small hydrologic units or sub-watersheds for the purpose of prioritization as per SYI

ratings. The priority ratings based on the descending values of SYI are shown in **Table 1.4**. Six sub watersheds in this sub-basin are rated as very high (2 sub watersheds) and high (4 sub watersheds) priority. All the six sub watersheds are in the directly draining catchment of Daudhan reservoir. The prioritization map showing treatment measures of sub-watersheds for Bearma sub-basin catchment is given in Figure I.3

Table 1.4: DAUDHAN CATCHMENT BEARMA RIVER SUB-BASIN - PRIORITY RATINGS OF SUB- WATERSHEDS				
Sl.No.	Watershed code	Area in ha	Sediment Yield Index	Priority
1	2CIE6.1	25459	1328	Very High
2	2CIE7.2	15707	1385	Very High
3	2CIE5.6	9704	1248	High
4	2CIE7.1	10197	1206	High
5	2CIE5.7	16311	1220	High
6	2CIE6.2	17720	1229	High
7	2CIE1.1	10583	1124	Medium
8	2CIE1.3	16112	1132	Medium
9	2CIE4.13	8705	1124	Medium
10	2CIE7.5	6423	1119	Medium
11	2CIE1.4	16573	1073	Low
12	2CIE1.5	13314	1034	Low
13	2CIE2.2	30261	1012	Low
14	2CIE4.11	11734	1009	Low
15	2CIE4.12	9032	1012	Low
16	2CIE7.3	22642	1027	Low
17	2CIE4.2	18765	1079	Low
18	2CIE4.4	9756	1096	Low
19	2CIE4.5	11201	1055	Low
20	2CIE5.4	15530	1092	Low
21	2CIE5.5	7897	1091	Low
22	2CIE7.4	14919	1001	Low
23	2CIE7.6	9914	1084	Low
24	2CIE1.2	24313	895	Very Low
25	2CIE2.1	16796	964	Very Low
26	2CIE3.1	28462	854	Very Low
27	2CIE3.2	21016	802	Very Low
28	2CIE3.3	29535	919	Very Low
29	2CIE4.1	15162	758	Very Low
30	2CIE4.10	16732	964	Very Low
31	2CIE4.3	11589	866	Very Low
32	2CIE4.6	10671	840	Very Low
33	2CIE4.7	16208	940	Very Low
34	2CIE4.8	9803	952	Very Low
35	2CIE4.9	4821	877	Very Low
36	2CIE5.1	19645	865	Very Low

Table 1.4: DAUDHAN CATCHMENT BEARMA RIVER SUB-BASIN - PRIORITY RATINGS OF SUB- WATERSHEDS				
Sl.No.	Watershed code	Area in ha	Sediment Yield Index	Priority
37	2CIE5.2	9330	899	Very Low
38	2CIE5.3	15482	915	Very Low
39	2CIE7.7	13858	921	Very Low
40	2CIE7.8	17340	803	Very Low
41	2CIE7.9	12475	889	Very Low
Total		621697		
Source : Compiled by AFCL on the basis of information from RS imageries, Toposheet and Soil Survey Reports published by National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)				

1.4 CATCHMENT AREA TREATMENT

Areas prioritized in different sub-basins of the free catchment area of Daudhan dam for catchment area treatment are given in **Table 1.5**. The prioritized areas are compared to the total catchment area at Daudhan dam site.

Table 1.5: DAUDHAN CATCHMENT PRIORITISED SUB-WATERSHEDS FOR CATCHMENT AREA TREATMENT						
Sl. No.	Sub-basin	Total Sub-Watersheds		Sub-Watersheds Prioritized as High and Very High		Per cent in Total Area
		Number	Area (ha)	Number	Area (ha)	
1	Upper Ken sub-basin	50	564063	10	49608	8.79
2	Sonar sub-basin	75	768533	14	96661	12.58
3	Bearma sub-basin	41	621697	6	95098	15.30
4	Reservoir	-	9000	-	-	-
Total		166	1963293	30	241367	12.29
Source : Compiled by AFCL on the basis of RS imageries and Toposheets						

It is inferred from the above Table 1.5 that about 15.30 per cent of the area of Bearma sub-basin is prioritized for treatment whereas only 8.79 percent of the area is prioritized in Upper Ken sub-basin. This area accounted for about 12.58 per cent in Sonar sub-basin. It is proposed to treat the catchment area in 28 sub-watersheds which are prioritized as high and very high. In addition catchment area treatment in two sub-watersheds in upper Ken Sub-basin is also proposed even though they are of low and very low priority on the basis of field study and discussion with the officials of Water Resources Department, GoMP. Suitable treatment measures need to be provided in 28 sub-watersheds under very high and high priority categories and in 2 sub-watersheds which are prioritized as low. The other category sub-watersheds have not been recommended for any treatment measures.

Total Catchment area of Ken River at Daudhan dam site is 19633 sq km, out of this 10194 sq. km is intercepted catchment. Therefore the directly draining catchment area of Daudhan dam is 9439.39 sq km or 943939 ha. In the total free catchment area (943939 ha) of Daudhan project 28 sub-watersheds are under very high and high priority and 2 sub-watersheds are of low priority with a total area of

241367 ha (25.57 percent). These sub - watersheds shall be considered for suitable treatment measures. However the following classes of land cover, in the prioritized sub-watersheds, have been excluded as they are not being disturbed.

- Settlements
- Existing water bodies / rivers / streams
- Double crop cultivated area
- Dense forest having more than 30 percent canopy cover

The land use and land cover types considered for catchment area treatment in the sub-watersheds are as follows:

- Agricultural Lands: Current Fallows;
- Agricultural Lands: Single Crop areas;
- Open Forests;
- Open Scrub Forests; and
- Wastelands

The sub-watershed wise land use and land cover in terms of Agricultural Lands: Current Fallows, Agricultural Lands: Single Crop areas, Open Forests, Open Scrub Forests and Wastelands in upper Ken sub-basin are presented in **Table 1.6**. The maximum treatable area in this sub-basin is assessed to be 44995 ha. Open forests accounted for maximum of this area with 22493 ha and is followed by scrub forest and wastelands with 9998 ha and 3832 ha respectively.

S N o	Sub- watershe ds	Total Geographi cal area of the sub- watershed	Agricultu ral Land- Current Fallow	Agricultu ral Land- Single Crop Area	Forest- Deciduous (Dry/Moist/Tho m)-Open	Forest- Scrub Forest	Forest- Tree Clad Area	Wastela nds- Barren, Scrub land- Dense Scrub	Wastelan ds-Scrub land- Open Scrub
1	2C1C1.10	6785	30	48	5,000	1,586			5
2	2C1C1.11	6,490	224	489	3,064	1,655		22	51
3	2C1C1.4	5,969	381	622	2,032	2,652		134	104
4	2C1C1.6	4,660	177	238	3,088	1,020		94	1
5	2C1C1.8	7,988	184	178	5,139	1,993		35	4
6	2C1C3.10	3,506	103	276	903	50		499	314
7	2C1C3.11	4,306	446	1,537	920	230	176	23	1,196
8	2C1C3.7	2,760	198	383	1,448	25		89	122
9	2C1C3.8	2,894	183	585	663	420	55	87	725
10	2C1C3.9	4,250	297	798	236	366	66	16	1,310
	Total	49,608	2,222	5,153	22,493	9,998	297	1,000	3,832

The land use and land cover maps of prioritized sub-watersheds in Upper Ken sub-basin are presented in **Figures 1.4 to 1.5**.

The sub-watershed wise land use and land cover in terms of Agricultural Lands: Current Fallows, Agricultural Lands: Single Crop areas, Open Forests, Open Scrub Forests and Wastelands in upper

Sonar sub-basin along with the total geographical area are presented in **Table 10.7**. The maximum treatable area in this sub-basin is assessed to be 64473 ha. Single crop agricultural land accounted for maximum of this area with 21281 ha and is followed by open forest and wastelands with 19097 ha and 6978 ha respectively. The maximum treatable area is highest in 2C1D7.3 sub-watershed with 15972 ha and is lowest in 2C1D2.20 sub watershed with 743 ha. The average treatable area per sub-watershed for this sub basin is about 4608 ha.

Table 1.7: Watershed Wise Land Use and Land Cover of Prioritized Sub-Watersheds in Sonar Sub Basin

(Area in ha)									
S No	Sub-watersheds	Total Geographical area of the sub-watershed	Agricultural Land-Current Fallow	Agricultural Land-Single Crop Area	Forest-Deciduous (Dry/Moist/Thorn)-Open	Forest-Scrub Forest	Forest-Tree Clad Area	Wastelands-Barren, Scrub land-Dense Scrub	Wastelands-Scrub land-Open Scrub
1	2C1D2.14	3979	132	159	587	20	39	193	526
2	2C1D2.16	4148	425	258	1,219	132	-	162	363
3	2C1D2.18	4092	48	159	1,248	91	6	-	156
4	2C1D2.19	8124	198	603	1,392	178	405	96	187
5	2C1D2.20	1376	57	122	107	-	301	138	18
6	2C1D2.21	3782	56	277	829	5	9	9	141
7	2C1D2.24	9105	509	831	2,765	700	80	59	197
8	2C1D2.25	5094	238	235	1,394	48	151	157	339
9	2C1D2.23	5416	180	272	2,012	68	-	21	117
10	2C1D2.27	4891	498	489	997	383	-	38	1,036
11	2C1D2.9	3888	198	796	590	32	-	28	24
12	2C1D7.3	17938	3,367	10,322	1,455	178	-	304	346
13	2C1D8.7	12126	2,750	3,295	903	179	1,190	229	2,320
14	2C1D9.5	12702	2,075	3,463	3,598	651	4	103	1,208
	Total	96661	10,730	21,281	19,097	2,664	2,186	1,537	6,978

For the purpose of generating the land use and land cover maps the sub-basin is divided into three blocks. The land use and land cover of first block consisting of eleven prioritized sub-watersheds viz., 2C1D2.9, 2C1D2.18, 2C1D2.19, 2C1D2.14, 2C1D2.20, 2C1D2.21, 2C1D2.24, 2C1D2.25, 2C1D2.26, 2C1D2.27 and 2C1D2.16 in Sonar Sub-Basin of Daudhan Catchment is presented in Figure 1.6. All these sub-watersheds are located in Bijawar Tehsil of Chhatrapur district.

These details for second block consisting two sub-watersheds viz., 2C1D7.8 and 2C1D9.5 in Sonar Sub-Basin of Daudhan Catchment are presented in Figure 1.7. One sub-watershed viz., 2C1D9.5 is in Rehli Tehsil of Sagar district whereas sub-watershed 2C1D7.3 is spread in two districts namely Damoh and Sagar.

There is one sub-watershed in third block of Sonar sub-basin of Daudhan catchment. The land use and land cover map of this sub-watershed is presented in Figure 1.8. This sub-watershed is in Rehli tehsil of Sagar district.

The sub-watershed wise land use and land cover in terms of Agricultural Lands: Current Fallows, Agricultural Lands: Single Crop areas, Open Forests, Open Scrub Forests and Wastelands in upper Bearma sub-basin along with the total geographical area are presented in **Table 1.8**. The maximum treatable area in this sub-basin is assessed to be 72027 ha. Open forest land accounted for maximum of this area with 53049 ha and is followed by single crop agricultural land and current fallow land with 9147 ha and 4129 ha respectively. The maximum treatable area is highest in 2C1E5.7 sub-watershed with 15109 ha and is lowest in 2C1E5.6 sub watershed with 7814 ha. The average treatable area per sub-watershed for this sub basin is about 12004 ha.

Table1.8: Sub-Watershed Wise Land Use and Land Cover and Maximum Treatable Area In Bearma Sub-Basin									
(Area in ha)									
S No	Sub-watersheds	Total Geographical area of the sub-watershed	Agricultural Land-Current Fallow	Agricultural Land-Single Crop Area	Forest-Deciduous (Dry/Moist/Thorn)-Open	Forest-Scrub Forest	Forest-Tree Clad Area	Wastelands-Barren, Scrub land-Dense Scrub	Wastelands-Scrub land-Open Scrub
1	2C1E5.6	9704	272	339	6,958	5	2	35	203
2	2C1E5.7	16311	1,391	2,938	8,922	398	23	179	1,258
3	2C1E6.1	25459	603	2,024	10,115	104	257	742	522
4	2C1E6.2	17720	675	2,379	9,611	337	51	28	99
5	2C1E7.1	10197	276	370	7,782			60	490
6	2C1E7.2	15707	912	1,097	9,661	208	33	42	628
	Total	95098	4,129	9,147	53,049	1,052	365	1,086	3,199

For the purpose of generating the land use and land cover maps this sub-basin is divided into two blocks. The land use and land cover of first block consisting of four prioritized sub-watersheds viz., 2C1E5.6, 2C1E5.7, 2C1E7.1 and 2C1E7.2 in Bearma sub-basin of Daudhan Catchment is presented in Figure 1.9. These sub-watersheds are in Rehli Tehsil of Sagar District and Damoh Tehsil of Damoh District.

These details for second block consisting two sub-watersheds viz., 2C1E6.1 and 2C1E6.2 in Bearma Sub-Basin of Daudhan Catchment are presented in Figure 1.10. These two sub-watersheds are in the tri junction of Damoh, Sagar and Narasingpur districts.

Major portion of the forests in all the three sub-basins comprise of forest areas having canopy cover below 30 percent. It is proposed to treat part of these areas with reforestation measures to improve the canopy cover. Open forest areas with higher slopes are considered for various soils conservation measures. In the areas other than forest areas and agricultural areas, open scrub occupies considerable areas which contribute much erosion and transport of sediment to the reservoir, depending upon the erosivity. Therefore, necessary soil and moisture conservation measures have been proposed for controlling the siltation of the reservoir.

Sub basin wise areas proposed for treatment with biological measures are assessed after analyzing the forest compartment wise coverage of each prioritized sub-watershed, forest cover in each compartment and forest working circle of the compartment. The methodology adopted for assessing the extent of

biological measures possible is as follows:

- ⇒ List the forest compartments coverage in each sub-watershed;
- ⇒ Group the forest compartments according to the Forest Division;
- ⇒ Identify the forest area in the category of blank and under stocked in each compartment from the Working Plan of the respective Division; and
- ⇒ Identify Forest Working Circle of each forest compartment

The forest working circles of all the forest compartments in the prioritized sub-watersheds and the type of measures possible, as per discussions with the officials of MP Forest Department, are as follows:

Working Circle	Possible Measures
CP	Plantation
FF	Mainly Pasture Development and Plantation to a limited extent
IFS	Only Soil Conservation measures
RDF	Plantation
SCI	No measures are possible

The grouping of the forest compartments in the prioritized sub-watersheds according to the division indicated that the forest compartments covered five forest divisions. They are as follows:

- Chhatarpur;
- North Panna;
- South Sagar;
- Damoh; and
- Panna Tiger Reserve

The scope for afforestation is assessed on the basis of the norm that about one third of the area available for treatment measures can be taken up for treatment under the CAT plan. It assessed that such a pattern of treatment will arrest the siltation of reservoir in the long run. The Division wise physical targets for various biological measures and soil conservation measures are presented in **Table 1.9**.

Table 1.9: Division Wise Targets for Treatment Measures in Forrest Areas under CAT Plan

Sl. No	Forest Division	No. of Forest Compartments	Targets in ha for				
			Afforest Ation	Pasture Develop ment	Total	Social Forestry	Soil Conser vation
1	Chhatarpur	96	1363	341	1704	338	7914
2	Damoh	55	5908	1477	7384	788	1006
3	North Panna	49	3224	806	4030	405	-
4	South Sagar	50	836	535	1371	720	800
5	Buffer Area of PTR	11	1160	290	1450	-	-
	Total	261	12490	3448	15938	2250	9720

Thus, the total area proposed for treatment in forest under the CAT plan is 25658 ha. In addition the Forest Department will undertake Social Forestry in an area of 2250 ha. Besides this an area of 31532 ha is proposed to be protected with engineering measures in revenue lands and wastelands. In addition about 26329 ha of agricultural land are proposed to be treated with engineering measures for soil and moisture conservation. Hence the total area proposed for treatment is about 85,769 ha and this accounts for about 36 per cent of total area of prioritized sub-watersheds. The division wise listing of forest compartments and corresponding treatment measures are presented in **Annexures I.1 to I.5**.

1.5 CONSERVATION AND MANAGEMENT MEASURES

For a sustainable action plan in catchment area treatment, the watershed development concept has been applied. The approach is holistic, multidisciplinary and practicable approximation of systems planning. Keeping in view, different types of measures have been drawn out on the basis of topography, relief, degree of degradation, classes of land cover, etc. Both biological and engineering measures have been proposed for treatment of the catchment area of the project. Various biological measures proposed for catchment area treatment include the following:

- ❖ Afforestation/Reforestation;
- ❖ Pasture Development; and
- ❖ Social Forestry

The afforestation and pasture development are proposed in forest areas with open canopy, degraded surface, high soil erosion and gentle to moderate slope. Social forestry for fuel wood and fodder is proposed near the settlements to control indiscriminate felling of trees and uncontrolled grazing in forest areas.

The engineering measures, both in agricultural lands and forest areas, proposed for catchment area treatment include the following:

- ✚ Stone Wall Check Dams;
- ✚ Loose Boulder Check Dams,
- ✚ Percolation Tanks;
- ✚ Stone Contour Bunds;
- ✚ Staggered Contour Trenches with plantation; and
- ✚ Graded Bunds in Agricultural Lands

1.5.1 Target of Afforestation / Reforestation Program

It is an established fact that forests and vegetation play the most crucial role in the protection of river catchments in hilly regions. The gap between demand and supply of fuel and fodder has been the most important reason for degradation of the eco-system in many hilly regions. An area of 18188 ha will be treated by Forestry and Silvi-Pastoral measures in the open and scrub forest areas in Daudhan catchment area. It is assessed that about 15938 ha area will be in Government owned open and scrub forests in RF and PF and 2250 ha earmarked for Social Forestry will be revenue land. To be effective in environmental conservation, the target should be achieved in a period of 8 years. The annual targets may not be too heavy for the four main Forest Divisions in the catchment area of the project. Therefore, no additional staff is envisaged for this project at this stage.

1.5.2 Costs of Afforestation/ Reforestation

The Forest Department of the MP State was consulted regarding plantation costs sanctioned by them for similar works at present. Plantation costs are fixed on the basis of Government approved minimum wage rates of labour (unskilled) and considering the gap areas in the existing forests to improve the canopy cover.

Barbed wire fencing which has been found quite useful particularly in plantation of the areas prioritized as very high and high is provided. On the other hand, provision has not been made for engagement of watchers (local persons) for cattle watching during the formative stages of the plantations. Further, it is assessed that it is essential to make provision for soil and moisture conservation measures in the areas proposed for afforestation. Provision had been made for undertaking various necessary soil and moisture conservation measures in these areas. The detailed break-up of item-wise cost for afforestation is furnished in **Table 1.10**.

Table 1.10: Unit Cost for Afforestation in the Catchment Area of Daudhan Dam

Sl. No	Particulars of Work	Unit	Qty	Rate (Rs.)	Amount (Rs.)
1	Survey and Demarcation of Plantation Area including marking of sections, path and preparation of map	ha	1	450	450
2	Bush cutting in the plantation site (Site Cleaning)	ha	1	750	750
3	Lantana Eradication	MD	9	203	1827
4	Preparation of inspection path 60 cm wide	Rmt	250	15	3750
5	Layout of Pits	ha	1	500	500
6	Digging of pits 45x45x45 cm (40% of total)	'00	4.4	1200	5280
7	Digging of pits 30x30x30 cm (60% of total)	'00	6.6	900	5940
8	Filling of pits 45x45x45 cm (40% of total)	'00	4.4	200	880
9	Filling of pits 30x30x30 cm (60% of total)	'00	6.6	150	990
10	Planting of entire Plants raised in P/bags	'00	7	300	2100
11	Nursery cost of Plants	number	1100	9	9900
12	Fire Protection	L/S			350
13	Misc. Expenditure	L/S			2063
14	Total				34780
15	Add on account of increase on wage rate		0.00%		0
16	Total				34780
17	Soil and Moisture conservation works (25% of initial planting cost)		25.00%		8695
18	Total				43475
19	Add cost of B/wire Fencing and provision of gates (See Annexure I.6)	LS			32917
	Grand Total				76392
	Say				76390

Provision is also made for six years maintenance of afforestation undertaken as part of the catchment area treatment. For providing the maintenance it is assumed that mortality during first year will be 25 per cent and will reduce to 20 per cent during second year and to 15 per cent during third and there will

not be any mortality thereafter. The year wise estimated total maintenance cost for afforestation and cost of afforestation are presented in **Table 1.11** whereas the year wise and item wise break up of this maintenance cost is presented in **Annexure I.7** The maintenance cost is assessed to be Rs. 8270 during first year and is expected to be reduced gradually to Rs. 3880 during sixth year. The total maintenance cost for six years is assessed to be Rs. 36570. The unit cost for afforestation including maintenance cost for six years is estimated to be Rs 112960 per ha consisting of Rs 76390 for afforestation including fencing and Rs 36570 for maintenance for six years.

Table 1.11: Unit cost of Afforestation and Maintenance in Catchment Area of Daudhan Reservoir

Sl. No.	Particular	Amount (Rs. Per ha)
1	Cost of afforestation including cost of material (Refer Table-1.10)	76390
2	1st year maintenance (Refer Annexure I.7)	8270
3	2nd year maintenance (Refer Annexure I.7)	7690
4	3rd year maintenance (Refer Annexure I.7)	6940
5	4th year maintenance (Refer Annexure I.7)	5800
6	5th year maintenance (Refer Annexure I.7)	3990
7	6th year maintenance (Refer Annexure I.7)	3880
	Total	112960

Similarly the unit cost of Pasture Development, Social Forestry and Nursery along with the maintenance cost had been assessed. The unit cost for both pasture development and social forestry is assessed to be Rs. 70000 per ha.

On the basis of the study of soils, slope and forest cover in the catchment area of Daudhan reservoir; it had been assessed that the physical target for afforestation, pasture development, social forestry and establishing of nurseries will be as follows:

- Afforestation : 12940
- Pasture Development : 3448
- Social Forestry : 2250

Cost estimate for catchment area treatment with biological measures is presented in **Table 1.12**. The total cost of catchment area treatment with biological measures of Daudhan reservoir is estimated to be **Rs. 20,992.87 lakh.**

Table 1.12: Cost Estimate for Catchment Area Treatment of Daudhan Reservoir - Biological Measures

Sl. No.	Item	Units	Unit Rate in Rs	Target	
				Physical	Financial in Lakh Rs
1	Afforestation	ha	112,960	12,490	14,108.70
2	Pasture Development	ha	70,000	3,448	2,413.60
3	Social Forestry	ha	70,000	2,250	1,575.00

Sl. No.	Item	Units	Unit Rate in Rs	Target	
				Physical	Financial in Lakh Rs
	Sub Total (A)				18,097.30
4	Government Expenditure @ 3% A		3%		542.92
5	Establishment Cost @ 8% of A		8%		1,447.78
6	Contingency @ 5% of A		5%		904.87
	Grand Total				20,992.87

1.5.3 Afforestation Technique and Choice of Species

The choice of species to be sown or planted will depend on the altitude of the site and environmental needs and the local experience and success which will always be an important factor. By and large, the following guidelines are recommended. In category (a) Plantations in RF and PF the emphasis should be on valuable timber species. The forestry species for plantation may be as per the working plans of the respective Forestry Divisions.

In many cases, open scrub areas may be partially stocked with natural growth of colonizing tree species as well as bamboo and enrichment planting at spacing of 5 m x 5 m or 3.5 m x 3.5 m may give the desired results. The costs on such cases will be proportionately less and a comparatively bigger area may be treated.

1.6 SOIL AND WATER CONSERVATION: ENGINEERING / MECHANICAL MEASURES

1.6.1 Objectives and Strategies

Engineering / Mechanical measures are suggested for treatment of excessively erosive and vulnerable areas which have lost considerable soil and vegetative cover. The slope in the upper catchment of the Ken River system is in the range of 15 per cent to 35 percent, whereas in lower reaches, it is in the range of nearly level. Further, about 74 percent of the catchment area is having nearly flat slopes (0-1 percent). Considering the resource potential, socio-economic needs etc of the area, besides the present position of the catchment, i.e. land use / land cover, soil erosion status, basin's relief etc, the soil and water conservation measures / program have been drawn up and designed to suit the specific requirements of such areas as well as to create a long term interest in land and water resources management by the people. The pre-requisite for Soil and Water Conservation Measures are Physiographic conditions, Soil Properties, Vegetative Cover and Land Use Practices and Rainfall and Runoff. These factors have been described in detail in previous earlier Chapters.

1.6.2 Suggested Erosion Control Measures and Design

Engineering measures for such purposes is aimed at constructing barriers across the direction of flow of run-off water to retard or retain the run-off and thereby to reduce the siltation into reservoir. The important principle for conservation treatments is to create favorable conditions by:

- ✚ Increasing the time of concentration and thereby allowing more run-off water to be absorbed and held in the soil profile;

- ✚ Intercepting a long slope into several short ones, so as to maintain less than critical velocity for the run-off water; and
- ✚ Protection against damage owing to excessive run-off.

To achieve the above, engineering measures like Gully Control Structures are suggested. These measures will however be in addition to other measures, like afforestation / reforestation, pasture development, social forestry, etc, suggested separately.

1.6.3 Gully Control Structures or Gully Plugging

Gully erosion is an advanced stage of rill erosion, while the later is an advanced stage of sheet erosion. It is seen during the field survey that at some places in the catchment area, especially in high and very high priority areas, sheet erosion is in process, which if not checked immediately, may take shape of rill erosion and thereafter to gully erosion.

Stabilization of gullies through vegetative or biotic measures is a difficult task as they are mostly used for conveying or temporarily evacuating the run-off during the time when plantations for afforestation, reforestation etc are started. In such cases engineering measures are to be adopted to prevent washing away of the plantations by large volume of run-off, as once the vegetation is established, it will take care of gullies.

1.6.4 Principles

In control of gullies, the erosive velocities are reduced by flattening out the steep gradient of gullies, by constructing a series of check or rock fill dams which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Temporary structures are selected for small and medium gullies to function as a provider or necessary protection, till vegetation is established on their beds. Similarly, semi-permanent or permanent gully control structures are necessary for conservation of water, in addition to stabilization of bed. These are erected across steep gullies traversing hilly or mountainous region and at locations where high degree of safety is needed during disposing time of the peak run-off. Further, the semi-permanent and permanent structures need to be supported by temporary structures for conveying run-off over critical portion of gully. They have longer life and do not require any maintenance. All the three types of gully control structures are generally constructed with locally available materials and thus become cheaper.

1.6.5 Planning

Based on the field survey and other maps generated from Satellite Imageries (drainage system and drainage pattern, lineament maps, soil erosion status maps, slope maps), it is roughly estimated that an area of 41,252 ha is to be protected from soil erosion due to gullies at their different formation stages in respect of Daudhan reservoir catchment area. Practically all the gullies have originated from hill slopes and got aggravated at gentle slope of foot hill areas. Also, it is seen that, in some cases gully erosion is taking place not due to steep gully slopes but is mostly due to poor vegetation and soil condition. After taking care of all such facts in to account gully control measures are proposed.

In planning only two types of gully control structures viz., stone wall check dams and loose boulder check dams have been proposed for construction on the basis of present status of gullies. For land slope up to 5%, these can be spread at 0.90 m to 1.20 m vertical interval, whereas for slope above 5%, the vertical interval may be kept at 1.80 m to 3.60 m. Further, percolation tanks, staggered contour trenches with plantation and stone contour bunds are planned for controlling the soil erosion and

groundwater recharge.

Suggested type and number of Gully Control and Other Structures in prioritized sub-watersheds of Daudhan reservoir catchment are presented in **Table 1.13**. A detailed field survey may need to be undertaken before construction of these structures. About 292 stone wall check dams, 419 loose boulder check dams and 6 percolation tanks are proposed for gully control in prioritized sub-watersheds in the catchment of Daudhan reservoir. For arresting the soil erosion in areas with steep slopes stone contour bunds and staggered contour terraces with plantation are proposed. These structures are expected to control soil erosion in 41252 ha of land in the prioritized sub-watersheds of the catchment of Daudhan reservoir.

Table 1.13: Suggested Type and Number of Gully Control and Other Structures in Prioritized Sub-watersheds – Daudhan Dam catchment

Sl. No.	Sub watershed No	Type and No of Gully Control structures			Percolation tanks (water conservation) (Nos)	Stone Contour Bunds (ha)	Staggered Contour Trenches (ha)	Total area to be protected (ha)
		Stone Wall Check dam	Loose Boulder check dam	Total				
I	UPPER KEN SUB-BASIN							
1	2CIC1.10	27	8	35		1,193	398	1,886
2	2CIC1.11	30	12	42	1	1,296	432	2,218
3	2C1C1.4	4	3	7		2,168	722	2,970
4	2C1C1.6	3	2	5		836	279	1,170
5	2CIC1.8	8	4	12	1	1,524	508	2,252
6	2CIC3.10	6	3	9		647	216	953
7	2CIC3.11	4	6	10		1,087	362	1,589
8	2CIC3.7	8	6	14		177	59	396
9	2CIC3.8	10	22	32		924	308	1,722
10	2CIC3.9	6	9	15		1,269	423	1,902
	Sub- Total	106	75	181	2	11,121	3,707	17,058
II	SONAR SUB-BASIN							
1	2CID2.14	12	12	24		515	220	1,035
2	2CID2.16	8	20	28		441	189	1,070
3	2CID2.18	8	21	29		160	69	689
4	2CID2.19	10	33	43		298	127	1,135
5	2CID2.20	4	5	9		109	47	276
6	2CID2.21	12	27	39		108	46	754
7	2CID2.24	20	48	68	1	571	245	1,976
8	2CID2.25	14	22	36		375	160	1,045
9	2CID2.26	12	25	37		134	58	752
10	2CID2.27	16	24	40		966	414	1,940
11	2C1D2.9	10	21	31		55	23	548
12	2C1D7.3	8	8	16		554	238	992
13	2C1D8.7	8	15	23		1,884	808	3,032
14	2C1D9.5	10	20	30		1,282	550	2,282
	SUB-TOTAL	152	301	453	1	7,452	3,194	17,526
III	BEARMA SUB-BASIN							
1	2CIE5.6	5	6	11	1	146	97	488
2	2CIE5.7	5	4	9	1	1,101	734	2,040
3	2CIE6.1	5	10	15		821	547	1,593
4	2CIE6.2	9	11	20	1	278	186	829
5	2CIE7.1	4	6	10		330	220	690
6	2CIE7.2	6	6	12		527	351	1,028
	SUB-TOTAL	34	43	77	3	3,203	2,135	6,668
	Grand Total	292	419	711	6	21,776	9,036	41,252
Source: Compiled on the basis of information obtained from RS imageries and Toposheets								

1.6.6 Design

a) **Stone wall check dam:** Stone wall dams are also known as stone check-dams or stone dams. The dam structure is a wall built of stones and boulders laid down carefully so that voids are reduced to a minimum. The lowest central part of the stone wall must not reach above the surface of the adjacent land. The ideal height of the spillway is about 0.75 m and it should not exceed 1 m. On steep slopes (>20%), stone wall dams with sloping faces can be placed at 10–30% greater spacing than the double-row post-stone dams. The spacing of stone wall dams is similar to that of double-row post-dams up to 20% gradients. This type of check dam is generally used to control medium and deep gullies (about 2 m to 2.50 m deep and 6 m wide) which have contributory watershed of about 40 ha and more. Before commencing the construction of the check dam, the sides of the gully at the selected sites are sloped to 1:1 and the gully bottom, for the whole length of the dam, is lowered by about 15 cm. Also, 15 cm excavation is carried up into the bank as high as required, to give the necessary notch capacity for discharging the run-off. The cost per stone wall check dam of average size is assessed to be Rs. 6500.

b) **Loose Boulder Check Dam:** This is used for forming check dams when loose boulders of fairly good size are available in large quantities. The site where the dam is to be erected is cleared and the sides are sloped to 1.5:1. The bed of the gully is excavated to a uniform depth of about 0.30 m and dry boulders are packed, over pressed straw, from that level. In the center of the dam portion sufficient waterway is allowed to discharge the maximum run-off from the catchment. The boulder filling should go up to 0.30 m to 0.60 m into the stable portion of the gully side to prevent end cutting. In the rear, sufficient length (0.90 m) and width of apron has to be provided to prevent scour. The thickness of apron packing should not be less than 0.45 m and gully sides above the apron have to be protected with stone pitching to a height of at least 0.30 m above the anticipated maximum water level to prevent side scouring. Cost per each of such check dam of average dimension works out to Rs. 30,950. Item wise break up is presented in Annexure I.3.

1.6.7 Water Conservation Structures

a) **Percolation Tanks (PTs):** At places where there is sudden depression and hump on either side or in wide and deep gullies at the location of entering gentle slope areas where maximum water can be stored an earthen bund with stone revetment on the upstream side and a surplus weir on one side are to be constructed. The catchment constitutes about 81 per cent of the area with slopes up to 2 percent only which enables suitable places for construction of mini percolation tanks in the area prioritized. This helps in good water conservation as well as drinking water facilities to human and cattle in the nearby settlement besides serving as a silt trap. In total 6 numbers of such tanks are proposed under Daudhan project Catchment Area at lump sum cost of Rs. 2,00,000/- for each. The total cost is worked out as Rs. 12.00 lakh.

b) **Stone Contour Bunds:** Laying stone bunds in fields is a well known technique to check runoff and to control erosion and is the most widely practiced technique by farmers in the country particularly in hilly terrains. As a result, various government and non-government programs are promoting the large-scale introduction of the technique and providing technical and logistical backup for collecting and transporting stones. Contour stone bunds are built with quarry rock or stones along the natural contour of the land to a height of 20-30 cm from the ground and spaced 20 to 50 m apart depending on the inclination of the terrain. The stone bunds form a barrier that slows down water runoff, allowing rainwater to seep into the soil and spread more evenly over the land. This slowing down of water runoff helps with building-up a layer of fine soil and manure particles, rich in nutrients. From the perspective of climate change adaptation, contour stone bunds protect the land from heavy rain in years with high rainfall. In drought years, they improve rainwater harvesting, retention and infiltration into the soil,

increasing the amount of water available to plants and guaranteeing the harvest. If a good vegetation cover is developed on the stone bunds, they also lower soil temperature, provide protection against wind erosion and help to conserve biodiversity. In a situation where the required stones are available locally the cost of construction of stone contour bunds will be around Rs. 15000 per ha at current minimum wage rates prevailing in the catchment area of the project. In an area of 21,776 ha is proposed to cover with Stone contour bunds, hence the total cost works out to Rs 3,266.40 lakhs.

c) Staggered Trenches: Staggered trenches with plantation will be constructed for treatment of open scrub / degraded areas for detention and conservation of rain water and eroded soil. Run-off water from mixed crop strips will flow through staggered trenches in silvi-horticultural strip, resulting in settling of sediments and arrest of run-off water to recharge soil profile and ground water. Staggered contour trenches will be constructed in rows spaced at 5 m, with a spacing of 3.30 m within the rows. In the alternate row, the trenches will be located directly below one another. The trenches in successive rows will be staggered, with the trenches in the upper row and inter-space in the lower row being directly below each other. After every 5 rows of staggered trenches on contours, one continuous trench will be laid out to arrest escaped run-off water. The trenches may be of trapezoidal in section with side slope of 1:1 for stability purposes. Each trench will be followed by a bund on the downstream side, with 1.00 m top width, 0.85 m height and 1.1 side slopes. These bunds will be constructed by the excavated materials from the trenches. As per design, there will be 180 trenches of 5.00 m (length) x 0.50 m (depth) x 0.45 m (width) per hectare and their capacity to conserve run-off volume will be 202.5 cum. As this storage will be available reportedly during monsoon period, their total storage capacity will be about 5 times of above volume. In accordance to rate analysis, cost for constructing staggered trenches works out to Rs. 21850/- per hectare. Details of design and cost analysis per ha estimate have been provided in **Annexure- I.9**. Area proposed for formation of staggered trenches in respect of Daudhan dam worked out to be 9036 ha. Therefore the total cost comes to Rs 1974.37 lakh.

1.6.8 Financial Involvement

The total work earmarked under engineering / mechanical measures is proposed to be carried out in 7 years for Daudhan project catchment. The total cost aspects are shown in **Table 1.14**. The total cost of engineering/mechanical soil conservation measures is estimated to be Rs 6265.65 lakh. For estimation of financial requirement the administrative costs under the following three heads, at the rate specified, are provided:

Provision	Rate
• Government Expenditure	3%
• Establishment Cost	8%
• Contingency	5%

Table 1.14: Breakup of Expenditures for Erosion Control by Engineering / Mechanical Measures in Daudhan Catchment

Sl. No.	Item of Works	Unit	Rate	Target	
				Physical	Financial in lakh Rs
I	Gully Control structures				
1	Stone Wall Check Dam	Number	6500	292	18.98
2	Loose Boulder Check Dam	Number	30,950	419	129.68
II	Water Conservation Structures				0.00

Sl. No.	Item of Works	Unit	Rate	Target	
				Physical	Financial in lakh Rs
3	Mini Percolation Tanks	Number	200,000	6	12.00
4	Stone Contour Bunds	ha	15000	21,776	3266.40
5	Staggered Contour Trenches with Plantation	ha	21850	9,036	1974.37
	Total (A)				5,401.43
6	Government Expenditure @ 3% A		3%		162.04
7	Establishment Cost @ 8% of A		8%		432.11
8	Contingency 5% of A		5%		270.07
	Grand Total				6,265.65
Source : Estimated by AFCL Team					

1.7 TREATMENT OF AGRICULTURAL LAND

1.7.1 Formation of Graded Bunds

Graded bunds across the slope are constructed in the Kharif agricultural lands to remove excess water safely out of the field; and erosion of fertile top soil is prevented to conserve rain water. In fact the bund serves only to guide the water to waterway or drain. Graded bunds are designed essentially for diverting excess water safely from the cropped land. Suitable outlets are required to remove the water drained into them. In the absence of natural waterway, artificial water ways are constructed and suitably vegetated. In the catchment up to 1% slope, bund formation is not proposed and soil erosion can be checked by cultural practices like contour cultivation.

While laying out the bunds the vertical interval is fixed on the basis of slope of the land by adopting the following formula.

Vertical interval = $S/2 + 1.0\text{m}$. Horizontal distance = $300/S + 15\text{m}$ ($S = \% \text{ of slope}$).

Grade: The grade depends upon soil type and length of the bund. The grades suitable in different soils are as follows:

Soil Type	Grade (%)
Clay Soil	0.1 to 0.2
Medium (loamy soils)	0.3 to 0.4
Sandy soils	0.5

On an average 0.2% grade can be adopted in this catchment area treatment. If the length of the bund is small i.e., 15m to 200m, a uniform grade is to be given. However, if the length of the bund is large, variable grades are to be given, starting from mild grade initially to higher grade in the last reaches.

1.7.2 Cross Section of the bund

It is suggested to form 0.5 sq m section bunds uniformly. But however in black soils the section can be increased to 0.65 sq m. For total bund length of 400 m per ha, the quantity of earth work will be 200 cum. At a rate of Rs. 60 per cum the rate will be Rs. 12000 per ha. Total rate including vegetation can

be adopted as Rs. 12000/ha. These bunds can be stabilized with vegetation of local grasses. In the areas with higher percentage of slope, species like khus grass, bodh grass, kooper grass, lemon grass, citronella or any other vegetation or fodder crop like stilo hamato may be used.

1.7.3 Financial Requirement

The physical target for treatment of agricultural land is estimated to be 26,329 ha. The financial requirement for treating the same at the rate of Rs 12000 per ha will be Rs. **3,159.48 lakh**. *However, this cost is not included in the total cost of catchment area treatment plan of Daudhan Reservoir since these works are expected to be taken up with the available funds with the State Government under various watershed development projects being implemented in the state.*

1.8 TOTAL COST OF CATCHMENT AREA TREATMENT

1.8.1 Item Wise Cost of CAT

The cost of the catchment area treatment comprises components such as biotic treatment with soil and Water Conservation measures, Engineering and gully control works. The treatment measures are proposed in Government as well as in private lands. The catchment area treatment shall be taken up by Forest Department and Agriculture Department with the funds provided by the project proponents. The total cost estimated is only approximate and may vary depending upon field surveys and designs made by the line departments and the escalation of prices. The estimated cost for the recommended treatment measures is **Rs. 27258.53 lakh** in respect of Daudhan dam catchment excluding compensatory afforestation. The details of amounts for the different types of treatments are given in Table 1.15.

Table 1.15: Total Cost of Catchment Area Treatment

Sl. No.	Recommended Treatment	Area ha or No.	Cost in lakh Rs
I	Forestry and Silvi Pastoral Management		
1	Afforestation/reforestation	12,490	14,108.70
2	Pasture Development	3,448	2,413.60
3	Social Forestry	2,250	1,575.00
	Sub Total (A)	18,188	18,097.30
II	Erosion Control by Engineering / Mechanical Measures		
4	Stone Wall Check dam	292	18.98
5	Loose Boulder check dam	419	129.68
6	Stone Contour Bunds	21,776	3,266.40
7	Staggered Contour Trenches with Plantation	9,036	1974.37
8	Mini Percolation tanks	6	12
	Sub-Total (B)		5,401.43
	Total A+B		23,498.73
III	Administrative Expenditure		
9	Government Expenditure @ 3% A		704.96
10	Establishment Cost @ 8% of A		1879.90
11	Contingency 5% of A		1174.937
	Grand Total		27,258.53

1.8.2 District Wise Cost for CAT Plan

The priority watersheds wherein the CAT is proposed are spread over six tehsils from five districts. The details are as follows:

Sl. No.	Name of District	Name of Tehsil
1	Panna	Panna
2	Chhatarpur	Bijawar
3	Sagar	Rehli
4	Damoh	Damoh
5		Hatta
6	Narsingpur	Narsingpur

The area coverage of priority watersheds in Narsingpur district is relatively small. Therefore, the CAT measures are proposed in four districts viz., Panna, Chhatarpur, Sagar and Damoh only. The district wise treatment measures, in physical terms, for implementation of CAT plan are indicated in **Figures 1.11 to 1.17**.

1.8.3 Division Wise Physical and Financial Targets of CAT Plan

There are two main Departments responsible for implementation of CAT plan of the project. They are as follows:

- Department of Forests in MP; and
- Department of Agriculture in MP

The Forest Department of GoMP is the nodal agency for implementation of CAT plan in Forest areas whereas the Department of Agriculture of GoMP is the nodal agency for CAT plan implementation in revenue land. The Social Forestry component will be implemented by the Forest Department, GoMP in revenue lands. Five divisions of Forest Department viz., Chhatarpur, North Panna, Damoh, South Sagar and PTR of forest department will be responsible for implementation of CAT plan of formulated under the project. It is assessed that about 35 to 40 per cent of gully control structures and other soil conservation structure will be implemented in forest areas.

The division wise and item wise physical and financial targets for CAT plan implementation in forest areas are presented in **Table 1.16**. The total financial target for CAT Plan implementation in Forest areas in five forest divisions is assessed to Rs. 217.67 crore. Damoh division accounted maximum of this financial requirement with Rs. 91.40 crore and is followed by North Panna, Chhatarpur, PTR and South Sagar divisions with Rs. 52.15 crore, Rs. 39.48 crore, Rs. 17.59 crore and Rs. 17.04 crore respectively. The total land treated with biological measures in forest areas is assessed to be 16681 ha. Similarly the area to be treated with engineering measures is estimated to be 9720 ha. In addition it is also proposed to construct 118 stone wall check dams, 168 loose boulder check dams and 4 percolation tanks in the forest areas. These structures may arrest soil conservation in an area of about 3500 ha.

Table 1.16: Division Wise and Item Wise Physical and Financial Targets for CAT plan Implementation in Forest Areas

Sl. No	Component of CAT Plan	Target	Financial Target in lakh Rs					
			Targets for Division					
			Chhatar Pur	North Panna	Damoh	South Sagar	PTR	Total
I	Afforestation	Physical (ha)	1363.00	3224.00	5907.00	836.00	1160.00	12490.00
		Financial	1785.99	4224.52	7740.2	1095.4	1519.99	16366.10
II	Pasture Development	Physical (ha)	341.00	806.00	1477.00	535.00	289.00	3448.00
		Financial	276.89	654.47	1199.3	434.42	234.67	2799.78
III	Social Forestry	Physical (ha)	338.00	405.00	0.00	0.00		743.00
		Financial	274.46	328.86	0	0	0	603.32
IV	Stone Wall Check dam	Physical (No)	70.00	12.00	18.00	18.00		118.00
		Financial	5.28	0.9	1.36	1.36	0	8.90
V	Loose Boulder Check dam	Physical (No)	101.00	17.00	25.00	25.00		168.00
		Financial	36.26	6.1	8.98	8.98	0	60.32
VI	Stone contour Bunds	Physical (ha)	5526.00	0.00	807.00	517.00		6850.00
		Financial	961.52	0	140.42	89.96	0	1191.90
VII	Percolation Tanks	Physical (No)	1.00	0.00	0.00	1.00	2.00	4.00
		Financial	2.32	0	0	2.32	4.64	9.28
VIII	Staggered Contour Trenches	Physical (ha)	2388.00	0.00	199.00	283.00		2870.00
		Financial	605.26	0	50.44	71.73	0	727.43
IX	Total	Physical (ha)	9956.00	4435.00	8390.00	2171.00	1449.00	26401.00
		Financial	3947.98	5214.85	9140.67	1704.21	1759.30	21767.03

The division wise and item wise physical and financial targets for CAT plan implementation in revenue lands are presented in **Table 1.17**. The total financial requirement for implementation of CAT plan in revenue areas is estimated to be Rs. 5491.52 lakh. Majority (Rs. 1745.49 lakh) of this mount is required in Damoh division and is followed by North Panna, South Sagar and Chhatarpur divisions with Rs 1695.90 lakh, Rs 1654.18 lakh and 395.94 lakh respectively. No treatment of revenue lands is proposed in the PTR. The physical target for treatment in revenue areas is assessed to be 26401 ha. In addition the target includes 174 stone wall check dams, 251 lose boulder check dams and 2 percolation tanks. These structures will arrest soil erosion in an area of about 5000 ha.

In case of engineering measures in revenue areas it assessed that the CAT plan of Daudhan reservoir can be implemented over a period of five years. The year wise and item wise physical and financial targets for implementation of CAT plan of Daudhan reservoir in revenue areas are presented in **Table 1.18**.

Table 1.17: Division Wise and Item Wise Physical and Financial Targets for CAT plan Implementation in Revenue Areas

Physical Targets in No. or ha, Financial Targets in lakh Rs								
Sl. No	Component of CAT Plan	Target	Targets for Division of					
			Chhatarpur	North Panna	Damoh	South Sagar	PTR	Total
I	Social Forestry	Physical	0	0	787	720		1507.00
		Financial	0	0	639.04	584.64		1223.68
II	Stone Wall Check dam	Physical	51.00	60.00	47.00	16.00	0.00	174.00
		Financial	3.85	4.52	3.54	1.21	0.00	13.12
III	Loose Boulder Check dam	Physical	125.00	12.00	84.00	30.00	0.00	251.00
		Financial	44.88	4.31	30.16	10.77	0.00	90.12
IV	Stone contour Bunds	Physical	702.00	7017.00	3183.00	4024.00	0.00	14926.00
		Financial	122.15	1220.96	553.84	700.18	0.00	2597.13
V	Percolation Tanks	Physical	0.00	0.00	2.00	0.00	0.00	2.00
		Financial	0.00	0.00	4.64	0.00	0.00	4.64
VI	Staggered Contour Trenches	Physical	888.00	1839.00	2029.00	1410.00	0.00	6166.00
		Financial	225.07	466.11	514.27	357.38	0.00	1562.83
	Total	Physical	1590.00	8856.00	5999.00	6154.00	0.00	22599.00
		Financial	395.95	1695.90	1745.49	1654.18	0.00	5491.52

Table 1.18: Year Wise and Item Wise Physical and Financial Targets for Implementation of CAT Plan's Engineering Measures of Daudhan Reservoir in Revenue Areas

Physical Targets in No. or ha Financial Targets in lakh Rs								
Sl. No	Component of CAT Plan	Target	Targets during					Total
			First year	Second year	Third Year	Fourth year	Fifth year	
I	Stone Wall Check dam	Physical	26	44	44	35	26	174
		Financial	1.97	3.28	3.28	2.62	1.97	13.12
II	Loose Boulder Check dam	Physical	38	63	63	50	38	251
		Financial	13.52	22.53	22.53	18.02	13.52	90.11
III	Stone contour Bunds	Physical	2239	3732	3732	2985	2239	14926
		Financial	389.57	649.28	649.28	519.42	389.57	2597.12
IV	Percolation Tanks	Physical	1	1				2
		Financial	2.32	2.32				4.64
V	Staggered Contour Trenches	Physical	925	1542	1542	1233	925	6166
		Financial	234.42	390.71	390.71	312.57	234.42	1562.83
VI	Total	Financial	641.80	1068.12	1065.80	852.64	639.48	4267.83

The year wise and division wise financial targets for afforestation under the CAT plan of Daudhan reservoir is presented in **Table 1.19**. These financial targets are inclusive of Government Expenditure

(@ 3%), Establishment Cost (@ 8%) and Contingency (@ 5%). The total financial target for afforestation is Rs. 16366.10 lakh. Majority (67.62%) of this amount is required during first year.

Table 1.19: Year Wise and Division Wise Financial Allocation for Afforestation

Physical in ha; and Financial in Lakh Rupees										
Sl. No.	Division	Units	Year After Plantation							Total
			0#	1	2	3	4	5	6	
	Unit Cost (Rs per ha)*		88612	9593	8920	8050	6728	4628	4501	131034
I	Chhatarpur	Physical	1363	1363	1363	1363	1363	1363	1363	1363
		Financial	1207.79	130.76	121.59	109.73	91.70	63.09	61.35	1785.99
II	North Panna	Physical	3224	3224	3224	3224	3224	3224	3224	3224
		Financial	2856.86	309.28	287.59	259.54	216.91	149.22	145.11	4224.52
III	Damoh	Physical	5907	5907	5907	5907	5907	5907	5907	5907
		Financial	5234.33	566.67	526.93	475.54	397.42	273.40	265.86	7740.15
IV	Damoh (Buffer of PTR)	Physical	1160	1160	1160	1160	1160	1160	1160	1160
		Financial	1027.90	111.28	103.48	93.38	78.04	53.69	52.21	1519.99
V	South Sagar	Physical	836	836	836	836	836	836	836	836
		Financial	740.80	80.20	74.57	67.30	56.25	38.69	37.63	1095.44
	Total	Physical	12490	12490	12490	12490	12490	12490	12490	12490
		Financial	11067.69	1198.19	1114.16	1005.49	840.33	578.09	562.15	16366.10

Note: * Indicates the unit cost is inclusive of Government Expenditure (@ 3%), Establishment Cost (@ 8%) and Contingency (@ 5%)
Indicates the site development and plantation is carried out during year '0'.

The year wise and division wise financial targets for Pasture Development under the CAT plan of Daudhan reservoir in forest areas is presented in **Table 1.20**. These financial targets are inclusive of Government Expenditure (@ 3%), Establishment Cost (@ 8%) and Contingency (@ 5%). The total financial target for afforestation is Rs. 2799.78 lakh. Majority (70%) of this amount is required during first year. Maintenance expenditure is provided for three years.

Table 1.20: Year Wise and Division Wise Financial Allocation for Pasture Development

Physical in ha; and Financial in Lakh Rupees							
Sl. No.	Division	Units	Year After Plantation				Total
			0#	1	2	3	
	Unit Cost (Rs per ha)*		56840	9744	8120	6496	81200
I	Chhatarpur	Physical	341	341	341	341	341
		Financial	193.82	33.23	27.69	22.15	276.89
II	North Panna	Physical	806	806	806	806	806
		Financial	458.13	78.54	65.45	52.36	654.47
III	Damoh	Physical	1477	1477	1477	1477	1477
		Financial	839.53	143.92	119.93	95.95	1199.32
IV	Damoh (Buffer of PTR)	Physical	289	289	289	289	289
		Financial	164.27	28.16	23.47	18.77	234.67

Physical in ha; and Financial in Lakh Rupees							
Sl. No.	Division	Units	Year After Plantation				Total
			0#	1	2	3	
V	South Sagar	Physical	535	535	535	535	535
		Financial	304.09	52.13	43.44	34.75	434.42
	Total	Physical	3448	3448	3448	3448	3448
		Financial	1959.84	335.97	279.98	223.98	2799.78

Note: * Indicates the unit cost is inclusive of Government Expenditure (@ 3%), Establishment Cost (@ 8%) and Contingency (@ 5%)
Indicates the site development and plantation is carried out during year '0'.

The year wise and division wise financial targets for Pasture Development under the CAT plan of Daudhan reservoir in forest areas is presented in **Table 1.21**. These financial targets are inclusive of Government Expenditure (@ 3%), Establishment Cost (@ 8%) and Contingency (@ 5%). The total financial target for afforestation is Rs. 1827.00 lakh. Majority (70%) of this amount is required during first year. Maintenance expenditure is provided for three years.

Table 1.21: Year Wise and Division Wise Financial Allocation for Social Forestry

Physical in ha; and Financial in Lakh Rupees							
Sl. No.	Division	Units	Year After Plantation				Total
			0#	1	2	3	
	Unit Cost (Rs per ha)*		56840	9744	8120	6496	81200
I	Chhatarpur	Physical	338	338	338	338	338
		Financial	192.12	32.93	27.45	21.96	274.46
II	North Panna	Physical	405	405	405	405	405
		Financial	230.20	39.46	32.89	26.31	328.86
III	Damoh	Physical	787	787	787	787	787
		Financial	447.33	76.69	63.90	51.12	639.04
IV	Damoh (Buffer of PTR)	Physical	0	0	0	0	0
		Financial	0.00	0.00	0.00	0.00	0.00
V	South Sagar	Physical	720	720	720	720	720
		Financial	409.25	70.16	58.46	46.77	584.64
	Total	Physical	2250	2250	2250	2250	2250
		Financial	1278.90	219.24	182.70	146.16	1827.00

Note: * Indicates the unit cost is inclusive of Government Expenditure (@ 3%), Establishment Cost (@ 8%) and Contingency (@ 5%)

Indicates the site development and plantation is carried out during year '0'.

1.9 DIVISION WISE SUMMARY OF PHYSICAL AND FINANCIAL TARGETS

The division wise summary of physical and financial targets for CAT plan implementation in both forest

and revenue areas are assessed and are presented in **Table 1.22**.

Table 1.22: Division Wise Summary of Physical and Financial Targets for Implementation of CAT Plan of Daudhan Reservoir

Sl. No	Name of Forest Division	Name of Forest Circle	Proposed Area for treatment (ha) and Budget (Crore Rs)					
			Forest Area	Amount	Non-Forest Area	Amount	Total Area	Total Amount
1	South Sagar	Sagar	2171.00	17.04	6154.00	16.54	8325.00	33.58
2	Damoh	Sagar	8390.00	91.41	5999.00	17.45	14389.00	108.86
3	Damoh (Buffer Area of Panna Tiger Reserve)	Sagar	1450	17.60	0	0	1450.00	17.60
	Sub-Total		12011.00	126.05	12153.00	34.00	24164.00	160.05
4	Chhatarpur	Chhatarpur	9956.00	39.48	1590.00	3.96	11546.00	43.44
5	Panna North	Chhatarpur	4435.00	52.15	8856.00	16.96	13291.00	69.11
	Sub-Total		14391.00	91.63	10446.00	20.92	24837.00	112.56
	Grand Total		26402.00	217.68	22599.00	54.92	49001.00	272.60

The total budget provision for implementation of CAT plan of Daudhan Reservoir is estimated to be Rs. 272.60 crore. The breakup of this amount is as follows:

- Forest Area : Rs. 217.68 Crore (79.85%)
- Revenue Area : Rs. 54.92 Crore (20.15%)

1.10 COMPARTMENT WISE AND DIVISION WISE AREAS FOR PLANTATION, PASTURE DEVELOPMENT AND SOIL CONSERVATION

The compartment wise and division wise afforestation details are presented in **Table 1.23**.

Table 1.23: Compartment Wise and Division Wise Afforestation Proposed under CAT Plan of Daudhan Reservoir

Area in ha														
Chhatarpur Division			North Panna Division			Damoh Division			South Sagar Division			Buffer of PTR		
C No	AA	APD	C No	AA	APD	C No	AA	APD	C No	AA	APD	C No	AA	APD
PF 111	56	14	PF416			PF198	4	0	PF1065	17	18	PF 355	40	10
PF 151	75	19	PF436	0	0	RF244	21	10	PF930	18	19	PF 356	91	23
PF 168	61	15	PF454	10	0	PF192	83	21	RF1055	39	41	PF 357	47	12
PF 175	21	0	PF413	21	0	PF193	113	24	RF1050	42	44	PF 358	87	22
PF 188	49	12	PF457	24	10	PF223	0	0	PF881	49	51	PF 360	30	10
PF 191	75	19	PF417	31	10	RF252	55	15	PF882	63	67	PF 361	87	22
PF 192	52	13	PF462	33	11	PF 344	59	15	RF906	10	0	RF 31	119	30
PF 193	28	12	PF396	39	10	PF194	64	15	RF904	11	0	RF 32	155	39
PF 194	8	0	PF415	39	10	PF 346	66	16	PF931	11	0	RF 33	186	46

Area in ha														
Chhatarpur Division			North Panna Division			Damoh Division			South Sagar Division			Buffer of PTR		
C No	AA	APD	C No	AA	APD	C No	AA	APD	C No	AA	APD	C No	AA	APD
PF 195	42	10	PF388	43	11	PF 350	68	17	PF1063	11	10	RF 34	238	57
PF 196	91	23	PF438	46	11	RF251	72	18	RF888	12	10	RF 39	81	20
PF 256	101	25	PF385	47	12	RF 28	74	18	PF883	14	10	Total	1161	291
PF 257	24	10	PF456	50	13	RF 707	76	19	PF1064	15	10			
PF 258	35	12	PF440	51	13	RF 708	78	20	PF1068	17	10			
PF 260	45	11	PF386	54	13	PF 307	82	20	PF878	21	10			
PF 261	47	12	PF387	54	14	RF 709	83	21	PF929	32	16			
PF 281	104	26	PF395	55	14	PF 362	85	21	RF886	39	19			
PF 377	35	11	PF446	56	14	PF 347	85	21	RF885	48	23			
PF 378	70	18	PF447	58	14	PF 349	87	22	RF1045	54	26			
PF 379	19	0	PF377	58	15	RF130	94	24	RF887	54	26			
PF 387	96	24	PF443	62	16	PF195	98	24	PF1051	55	27			
PF 388	84	21	PF437	64	16	RF 40	102	26	PF1024	53	27			
PF 389	44	11	PF410	65	16	RF 37	103	26	PF1053	65	32			
PF 390	11	0	PF414	67	17	RF230	103	26	PF984	85	39			
PF 391	34	12	PF451	68	17	PF 348	115	29	Total	835	535			
PF 392	46	11	PF376	72	18	RF250	119	30						
PF 398	15	0	PF390	73	18	RF129	120	30						
Total	1363	341	PF430	75	19	RF243	122	30						
			PF445	75	19	RF 26	130	33						
			PF422	77	19	PF 308	136	34						
			PF439	78	19	RF240	137	34						
			PF429	79	20	RF 23	138	34						
			PF411	80	20	RF233	139	35						
			PF442	82	20	RF 36	144	36						
			PF444	83	21	RF238	148	37						
			PF433	84	21	RF241	154	39						
			PF452	84	21	RF 21	161	40						
			PF453	84	21	RF235	172	43						
			PF428	84	21	RF242	172	43						
			PF455	87	22	RF236	175	44						
			PF424	87	22	RF237	178	44						
			PF418	88	22	RF 22	184	46						
			PF435	94	24	RF126	192	48						
			PF450	96	24	RF234	206	52						
			PF448	100	25	RF 42	211	53						
			PF76	106	25	RF239	212	53						
			PF432	103	26	RF 35	220	55						
			PF412	108	27	RF232	225	56						
			PF449	148	37	RF128	240	60						
			Total	3224	806	Total	5905	1477						

Area in ha														
Chhatarpur Division			North Panna Division			Damoh Division			South Sagar Division			Buffer of PTR		
C No	AA	APD	C No	AA	APD	C No	AA	APD	C No	AA	APD	C No	AA	APD
Notes: C No. - indicates Compartment Number; AA - indicates Area for Afforestation; APD - indicates Area for Pasture Development														

The compartment wise area proposed for soil conservation in forest area in the Chhatarpur Division is presented in **Table 1.24**. The soil conservation works in this division are proposed in 69 compartments. The area proposed in each compartment is in the range of 7 ha in PF 169 to 372 ha in PF 415.

Table 1.24: Compartment Wise Area Proposed for Soil Conservation in Forest Area in Chhatarpur Division in CAT plan of Daudhan Reservoir

Sl. No.	Compartment No.	Area (ha) for SC	Sl. No.	Compartment No.	Area (ha) for SC	Sl. No.	Compartment No.	Area (ha) for SC
1	PF 152	58	24	PF 259	114	47	PF 394	39
2	PF 153	27	25	PF 264	30	48	PF 395	90
3	PF 154	61	26	PF 265	110	49	PF 396	43
4	PF 155	151	27	PF 266	31	50	PF 397	228
5	PF 156	64	28	PF 267	224	51	PF 399	51
6	PF 157	246	29	PF 268	174	52	PF 400	104
7	PF 167	128	30	PF 269	22	53	PF 401	165
8	PF 169	7	31	PF 270	16	54	PF 402	240
9	PF 171	198	32	PF 271	85	55	PF 403	211
10	PF 172	217	33	PF 272	33	56	PF 404	92
11	PF 173	78	34	PF 273	52	57	PF 407	260
12	PF 174	45	35	PF 276	66	58	PF 408	142
13	PF 176	66	36	PF 277	62	59	PF 409	149
14	PF 177	85	37	PF 278	19	60	PF 410	71
15	PF 178	57	38	PF 280	63	61	PF 411	294
16	PF 179	177	39	PF 311	81	62	PF 412	211
17	PF 180	201	40	PF 312	84	63	PF 413	124
18	PF 181	122	41	PF 313	58	64	PF 414	143
19	PF 182	99	42	PF 314	11	65	PF 415	372
20	PF 183	99	43	PF 315	22	66	PF 417	47
21	PF 184	112	44	PF 316	49	67	PF 418	181
22	PF 185	201	45	PF 380	170	68	PF 433	48
23	PF 186	217	46	PF 393	153	69	PF 440	162
							Total	7914

The compartment wise area proposed for soil conservation in forest area in Damoh and south Sagar Divisions is presented in **Table 1.25**.

Table 1.25: Compartment Wise Area Proposed for Soil Conservation in Forest Area in Damoh and South Sagar Divisions in CAT plan of Daudhan Reservoir

Sl. No	Damoh Division		Sl. No	South Sagar Division	
	Compartment No.	Area (ha) for SC		Compartment No.	Area (ha) for SC
1	RF 27	112	1	PF1052	64.74
2	RF 29	166	2	PF1054	127.16
3	RF 24	192	3	RF1056	174.02
4	RF 25	238	4	RF947	174.08
5	RF231	299	5	RF1046	150.24
	Total	1006	6	PF1066	109.76
				Total	800

1.11 SUFFICIENCY OF CAT PLAN

The requirement of treatment measures under CAT plan of a project depends upon the terrain conditions, level of erosion and slope of catchment area. Normally, the total area of a prioritized watershed need not be treated for arresting or reducing the siltation of the proposed reservoir and only vulnerable areas in the prioritized watersheds are considered for treatment under the CAT plan. These vulnerable areas for treatment are identified on the basis of visual analysis of maps of catchment areas and corresponding satellite imageries. Thus, the extent of area requiring treatment will vary depending on site conditions and normally does not exceed one third of the total area of the prioritized watershed. Adequate treatment measures have been suggested under the CAT plan of the reservoir for arresting or reducing the siltation levels of the proposed reservoir and it is assessed that the suggested measures in this CAT plan will reduce the siltation of reservoir to a tolerable level.

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MAPS

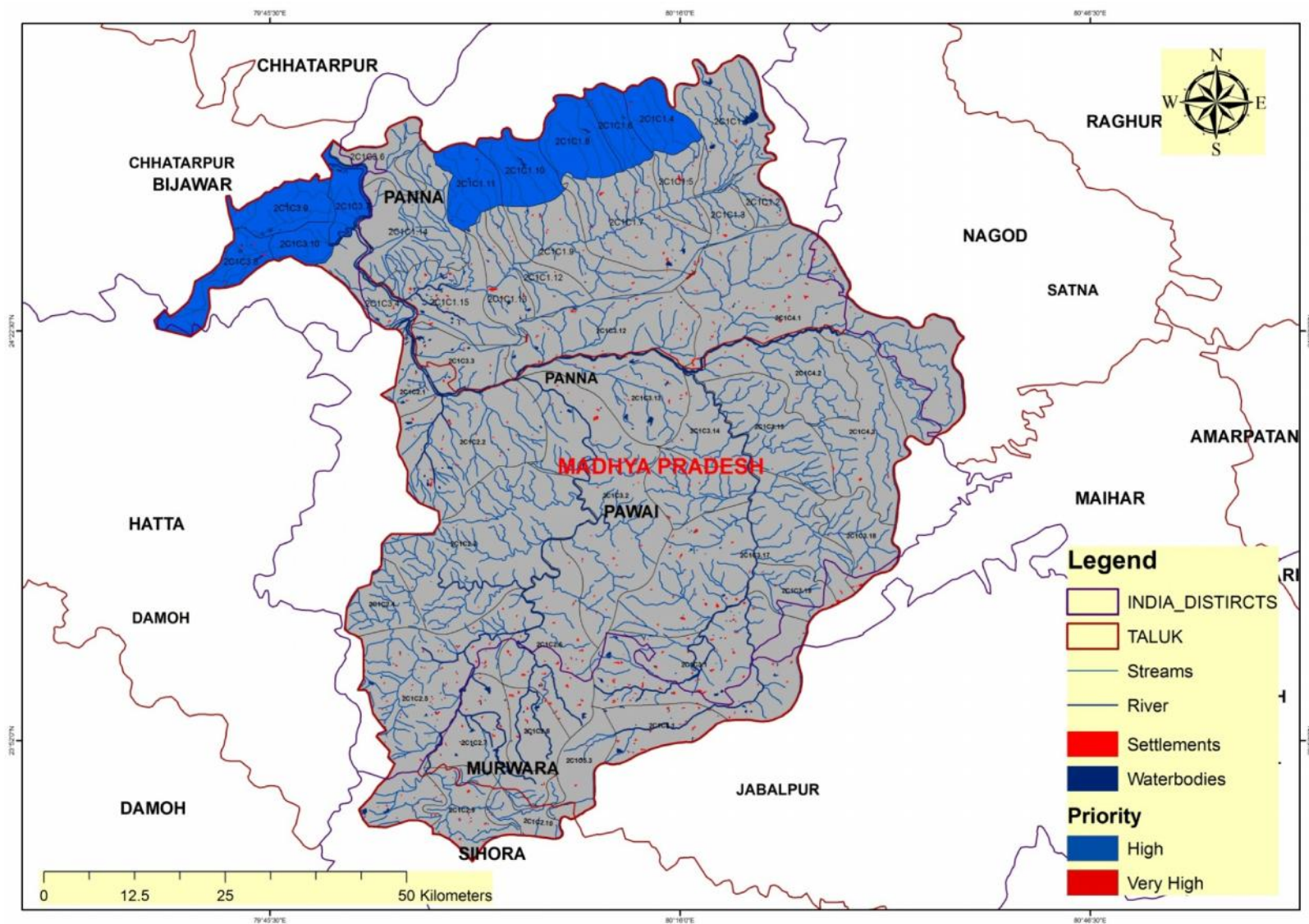


Figure 1.1: Prioritized Sub-Watersheds in Upper Ken Sub-basin

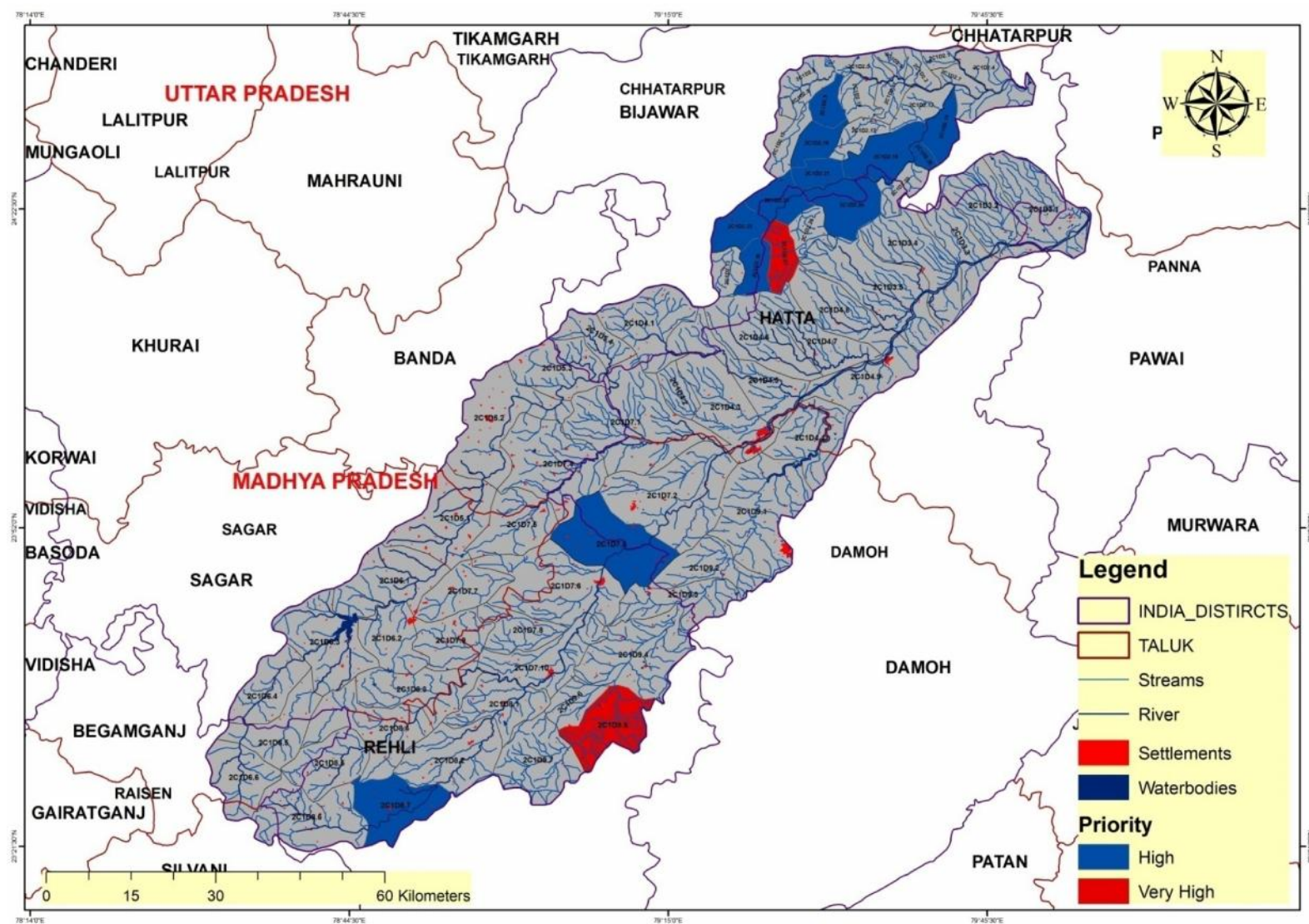


Figure 1.2: Prioritized Sub-watersheds in Sonar Sub-basin

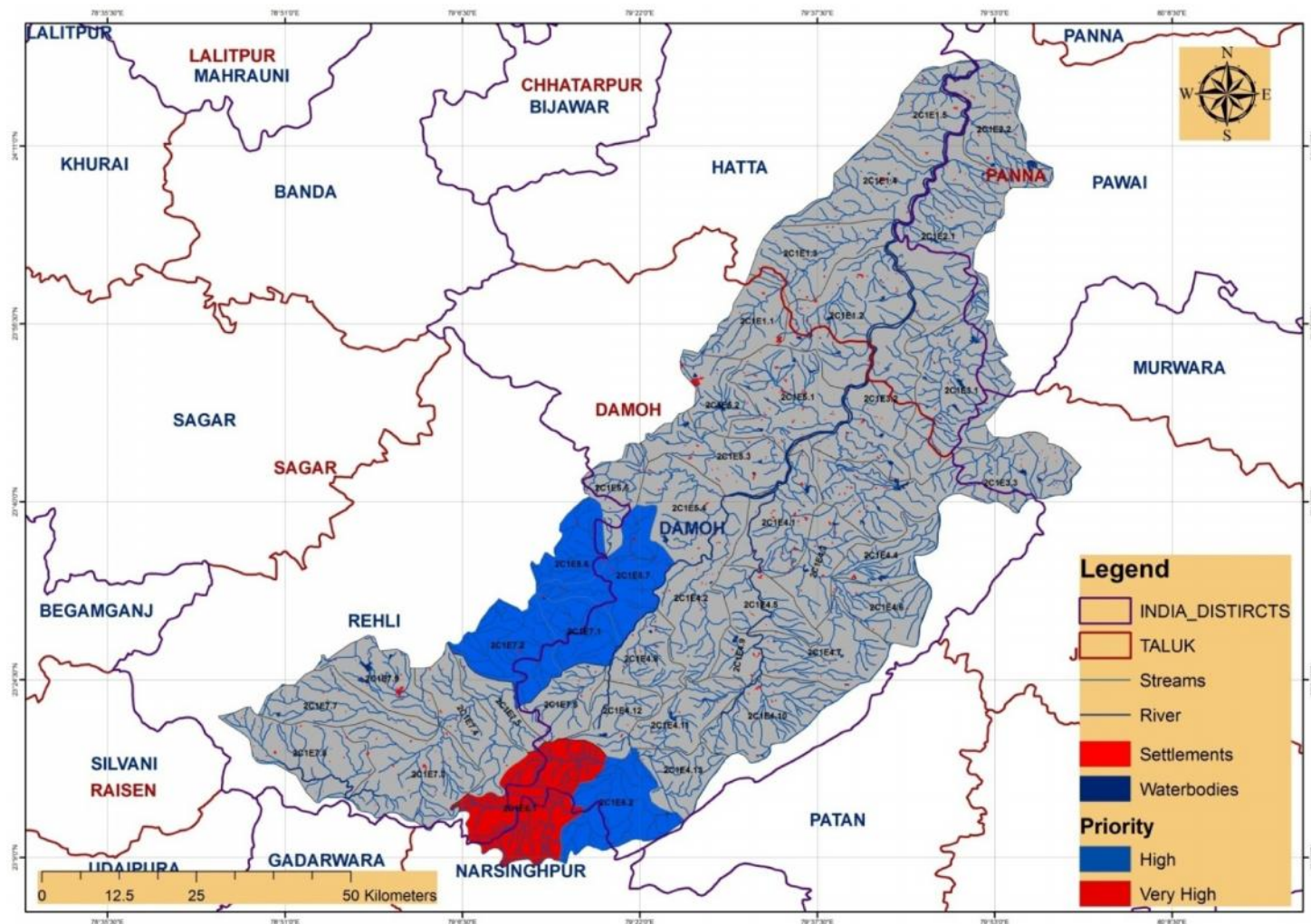


Figure 1.3: Prioritized Dub-watersheds in Bearma Sub-basin

Figure 1.4: Land Use and Land Cover of Five Prioritized Sub-Watersheds (2C1C3.7, 2C1C3.8, , 2C1C3.9, , 2C1C3.10, and , 2C1C3.11) in Upper Ken Sub-Basin of Daudhan Catchment

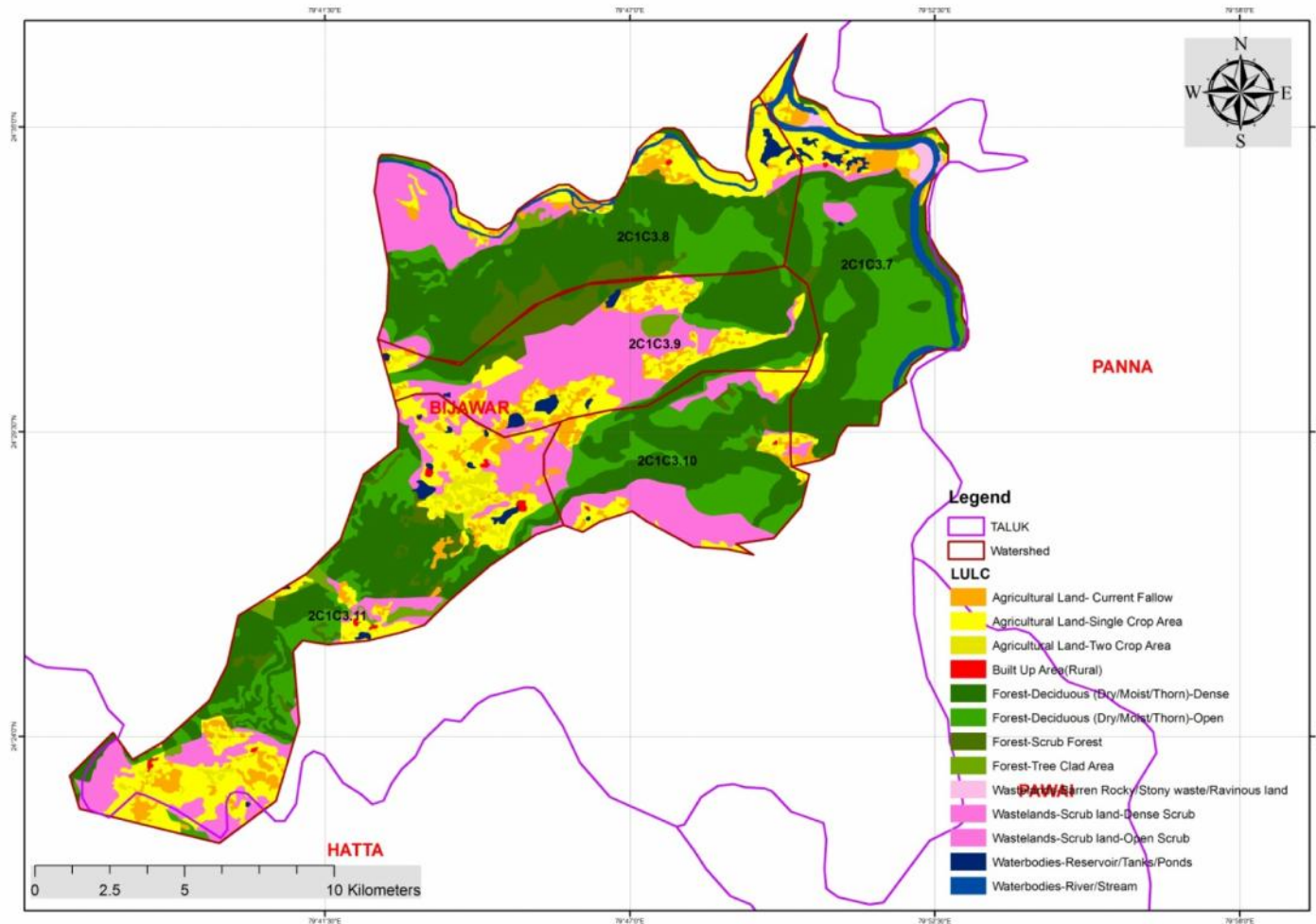


Figure 1.5: Land Use and Land Cover of Five Prioritized Sub-Watersheds (2C1C1.4, 2C1C1.6, 2C1C1.8, 2C1C1.10 and 2C1C1.11) in Upper Ken Sub-Basin of Daudhan Catchment

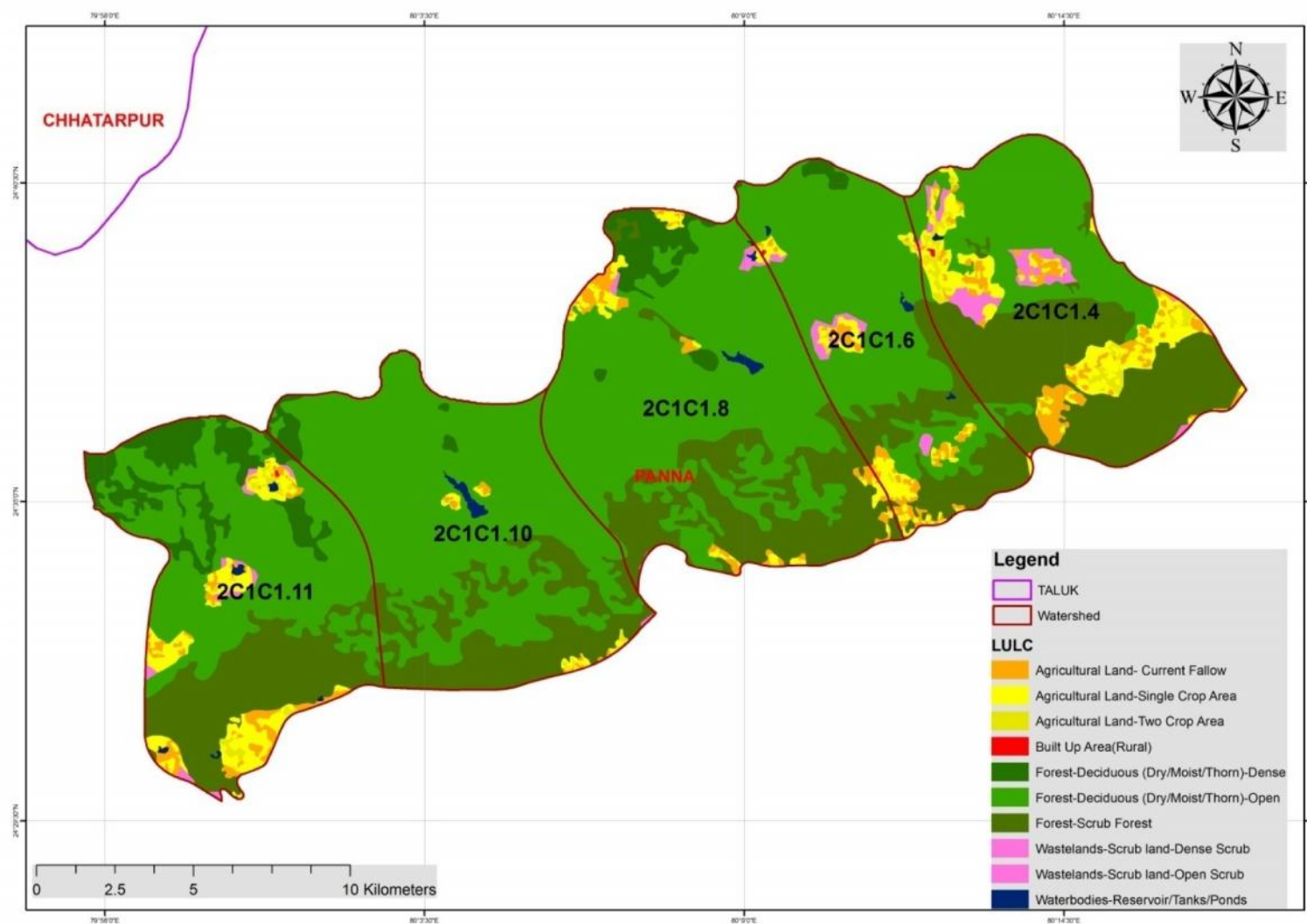


Figure 1.6: Land Use and Land Cover of Eleven Prioritized Sub-Watersheds (2C1D2.9, 2C1D2.18, 2C1D2.19, 2C1D2.14, 2C1D2.20, 2C1D2.21, 2C1D2.24, 2C1D2.25, 2C1D2.26, 2C1D2.27 and 2C1D2.16) in Sonar Sub-Basin of Daudhan C

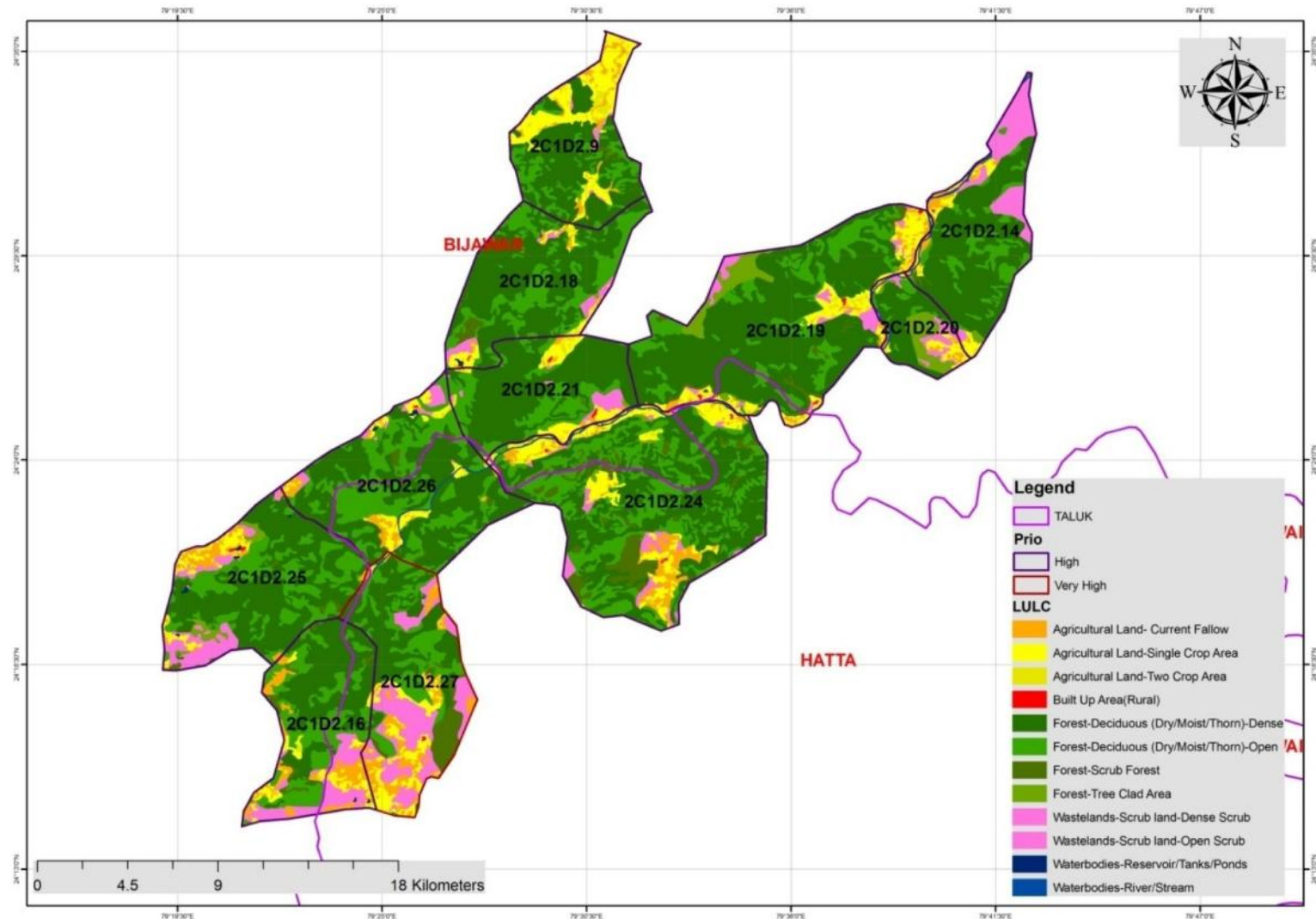


Figure 1.7: Land Use and Land Cover of Two Prioritized Sub-Watersheds (2C1D7.8 and 2C1D9.5) in Sonar Sub-Basin of Daudhan Catchment

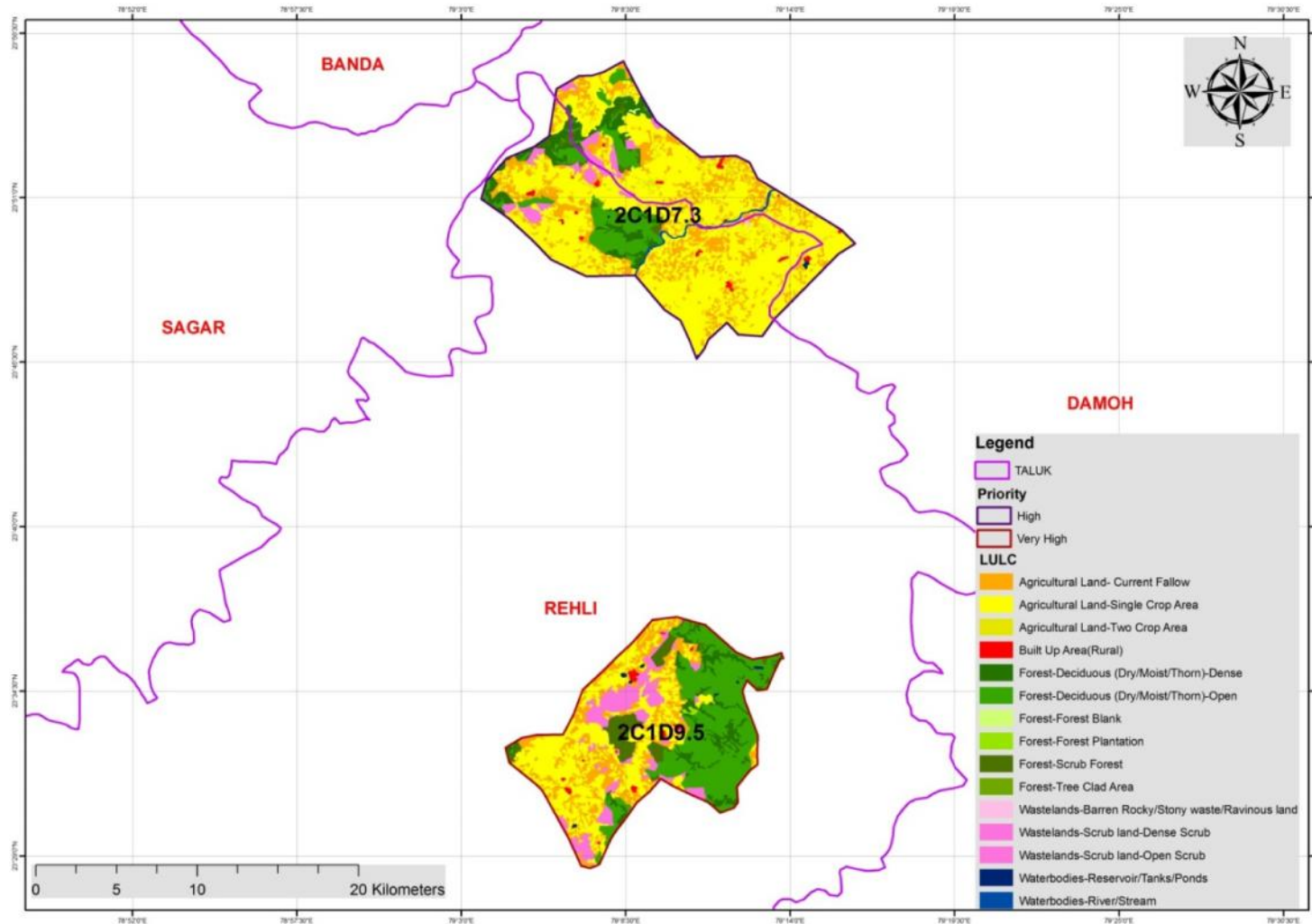


Figure 1.8: Land Use and Land Cover of One Prioritized Sub-Watersheds (2C1D8.7) in Sonar Sub-Basin of Daudhan Catchment

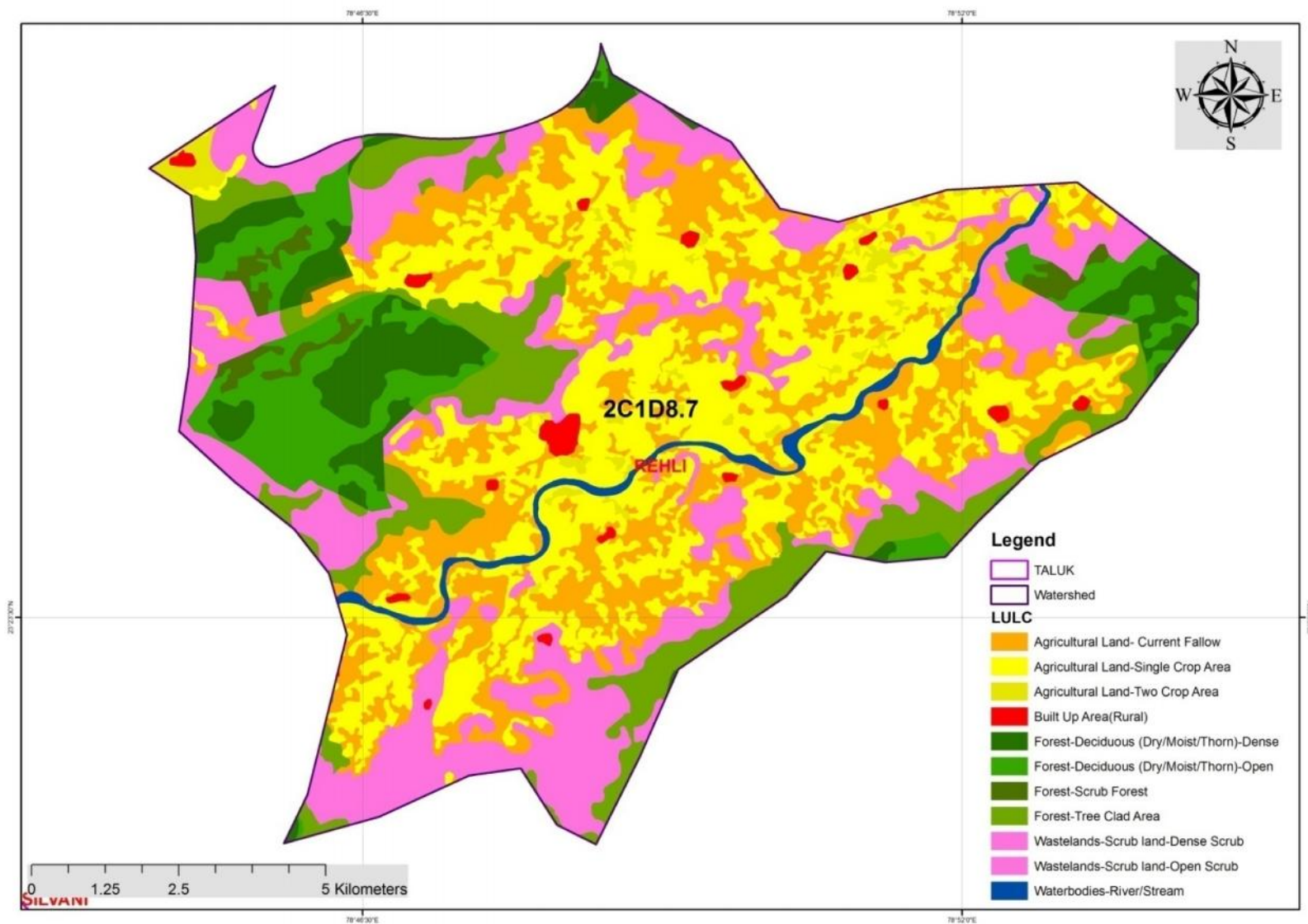


Figure 1.9: Land Use and Land Cover of Four Prioritized Sub-Watersheds (2C1E5.6, 2C1E5.7, 2C1E7.1 and 2C1E7.2) in Bearma Sub-Basin of Daudhan Catchment

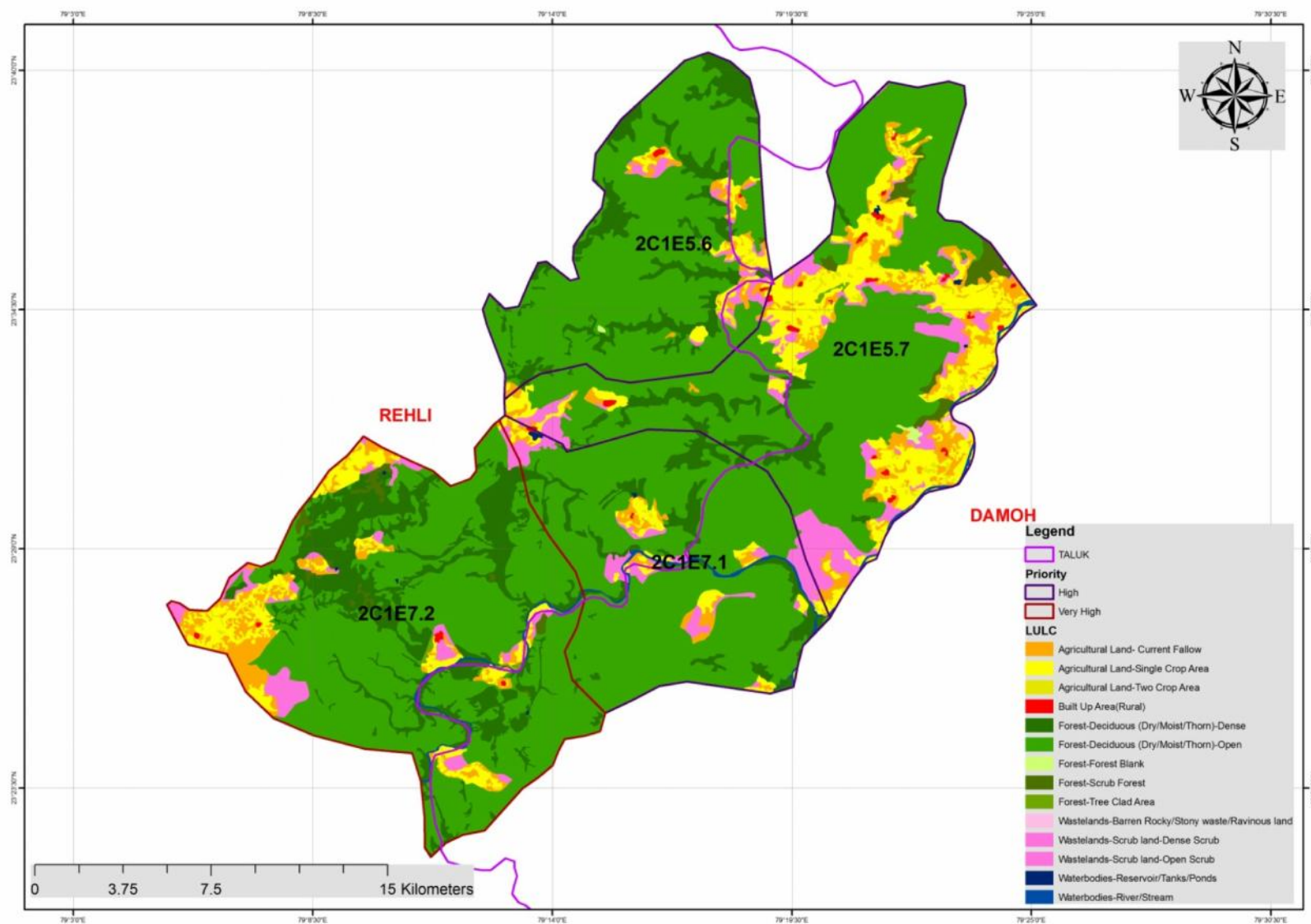


Figure 1.10: Land Use and Land Cover of Two Prioritized Sub-Watersheds (2C1E6.1 and 2C1E6.2) in Bearma Sub-Basin of Daudhan Catchment

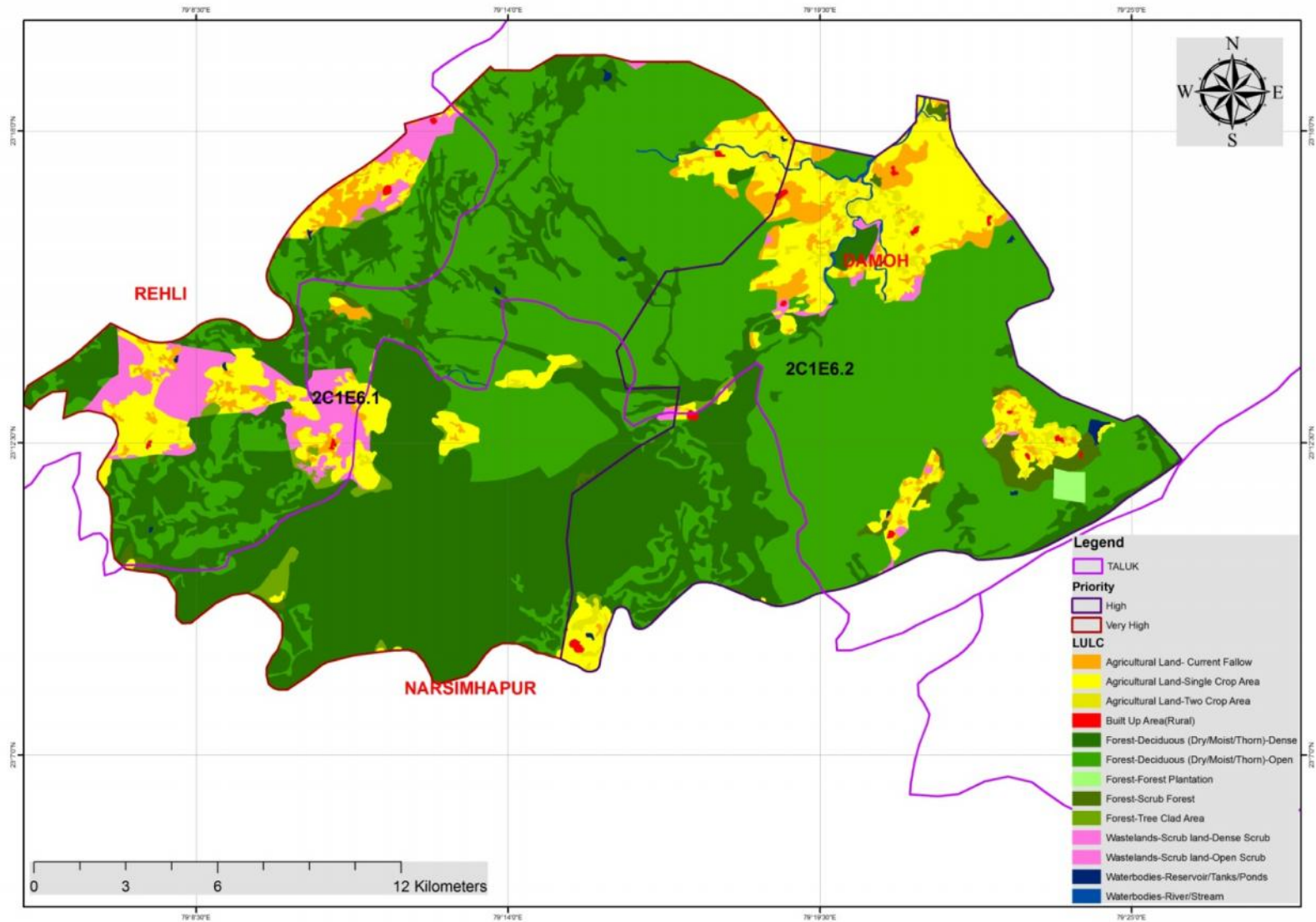


Figure 1.11: Tehsil Wise and Watershed Wise Proposed Treatments in Five Prioritized Sub-Watersheds (2C1C3.7, 2C1C3.8, 2C1C3.9, 2C1C3.10, and 2C1C3.11) in Upper Ken Sub-Basin of Daudhan Catchment

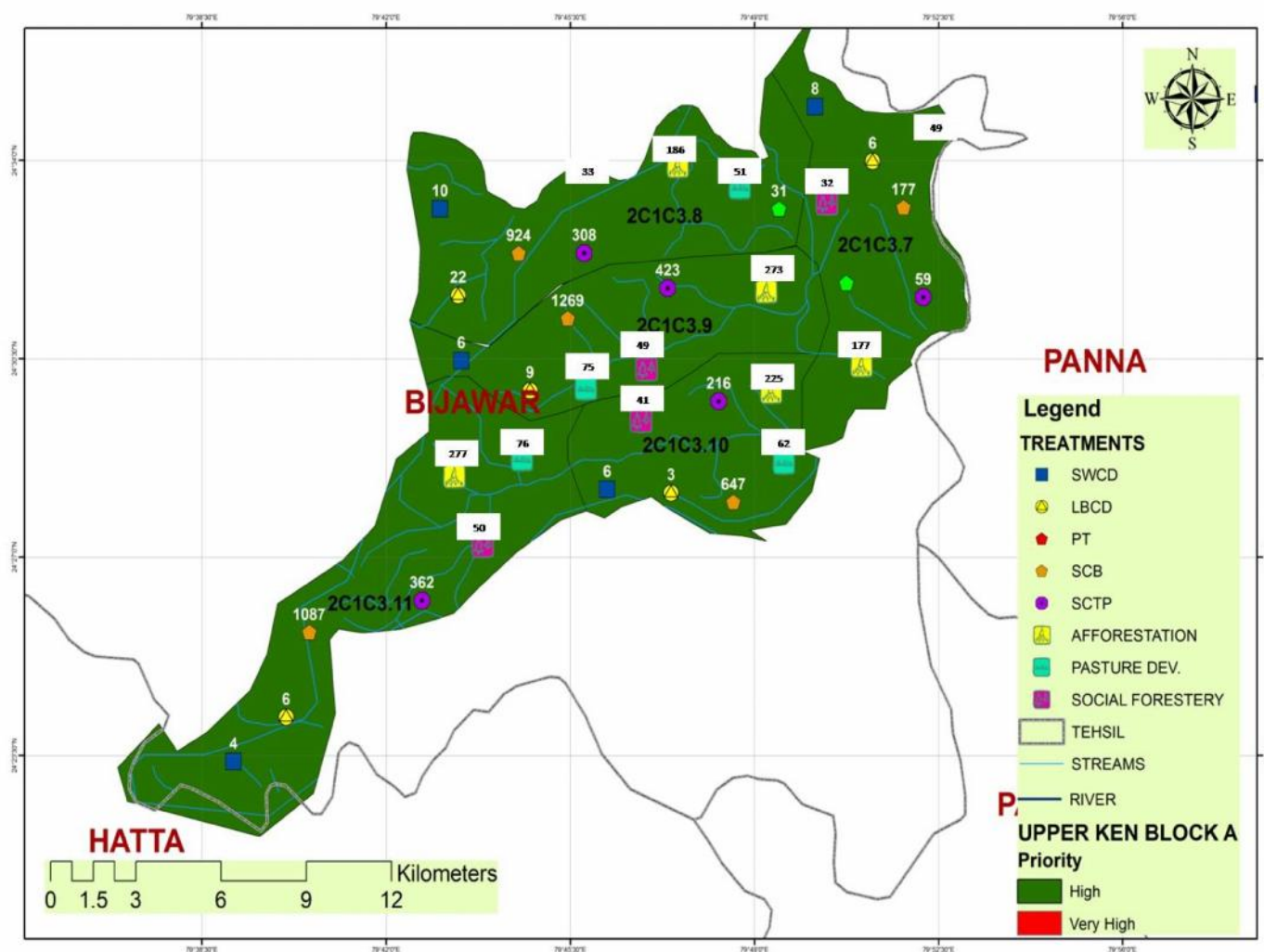


Figure 1.12: Tehsil Wise and Watershed Wise Proposed Treatments in Five Prioritized Sub-Watersheds (2C1C1.4, 2C1C1.6, 2C1C1.8, 2C1C1.10 and 2C1C1.11) in Upper Ken Sub-Basin of Daudhan Catchment

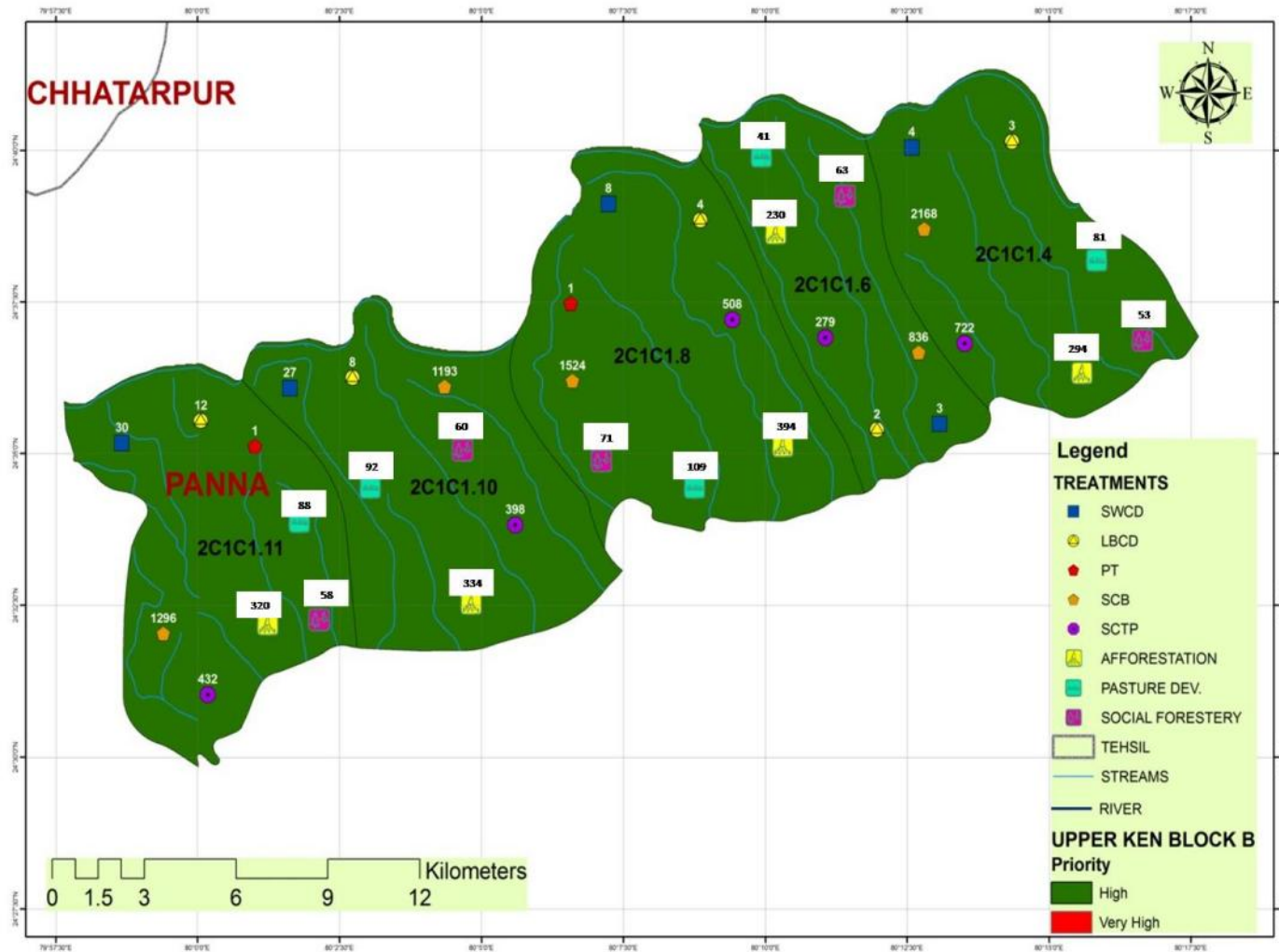


Figure 1.13: Tehsil Wise and Watershed Wise Proposed Treatments in Eleven Prioritized Sub-Watersheds (2C1D2.9, 2C1D2.18, 2C1D2.19, 2C1D2.14, 2C1D2.20, 2C1D2.21, 2C1D2.24, 2C1D2.25, 2C1D2.26, 2C1D2.27 and 2C1D2.16) in Sonar Sub-Basin of Daudhan

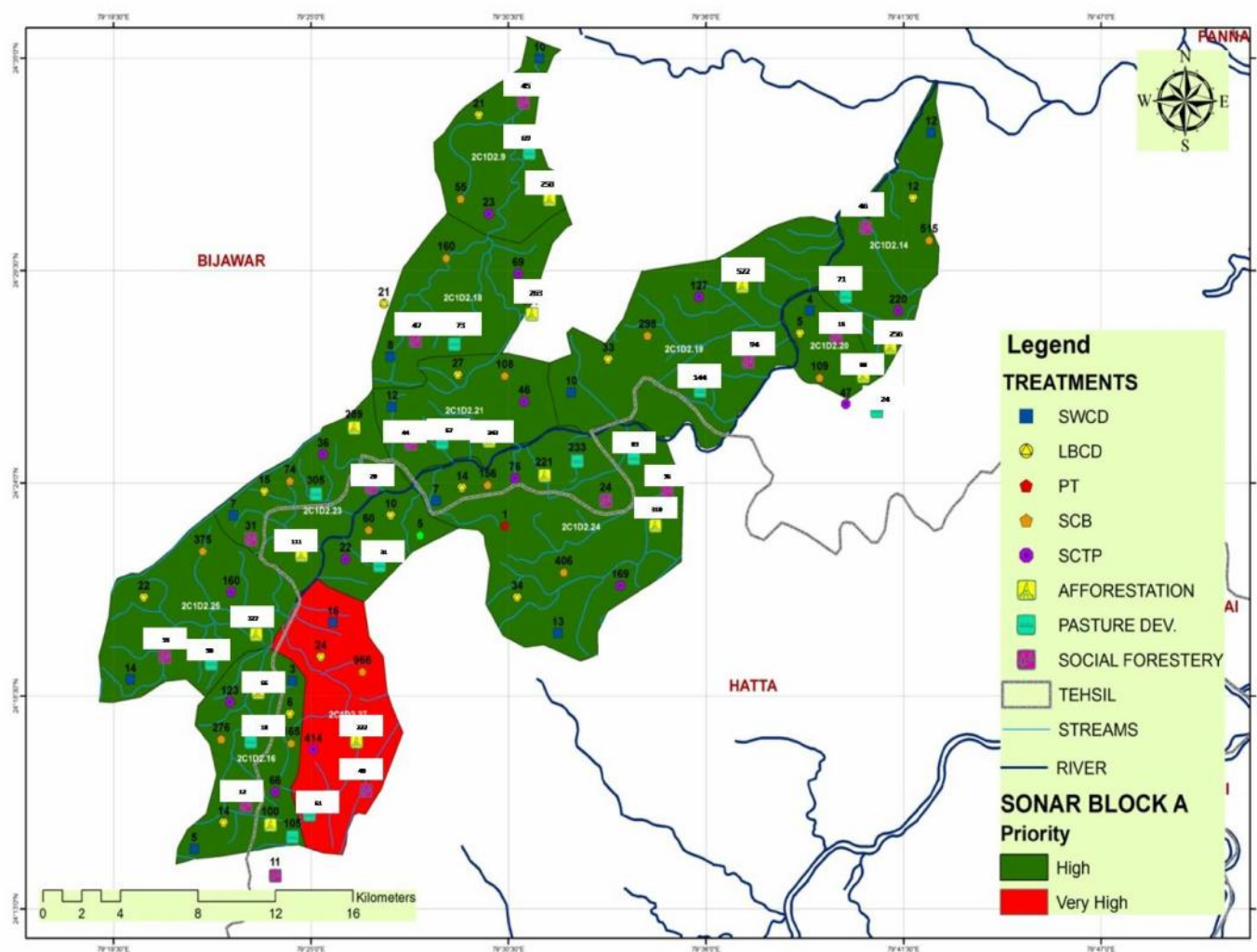


Figure 1.14: Tehsil Wise and Watershed Wise Proposed Treatment of Two Prioritized Sub-Watersheds (2C1D7.8 and 2C1D9.5) in Sonar Sub-Basin of Daudhan Catchment

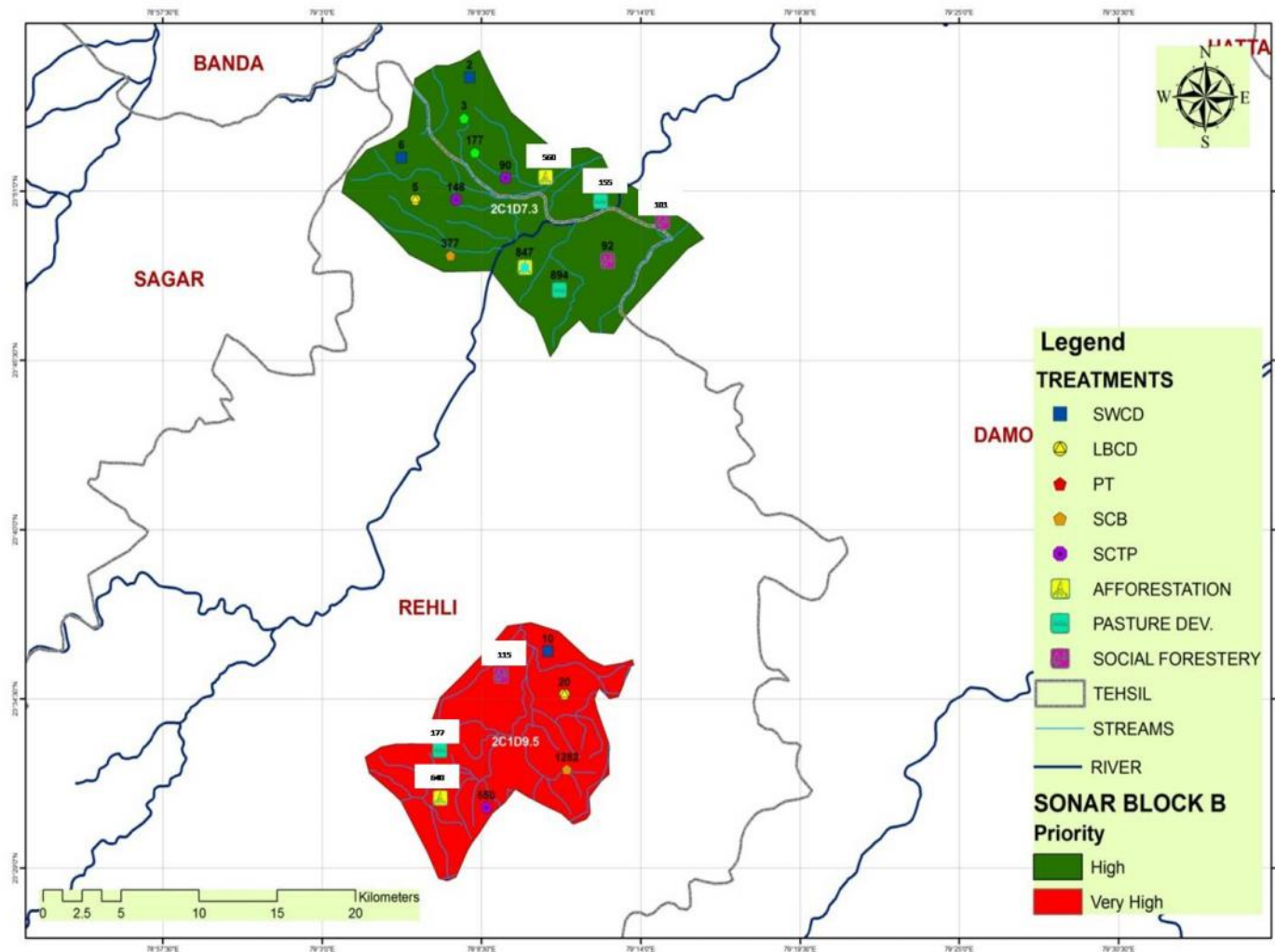


Figure 1.15: Tehsil Wise and Watershed Wise Proposed Treatments of One Prioritized Sub-Watersheds (2C1D8.7) in Sonar Sub-Basin of Daudhan Catchment

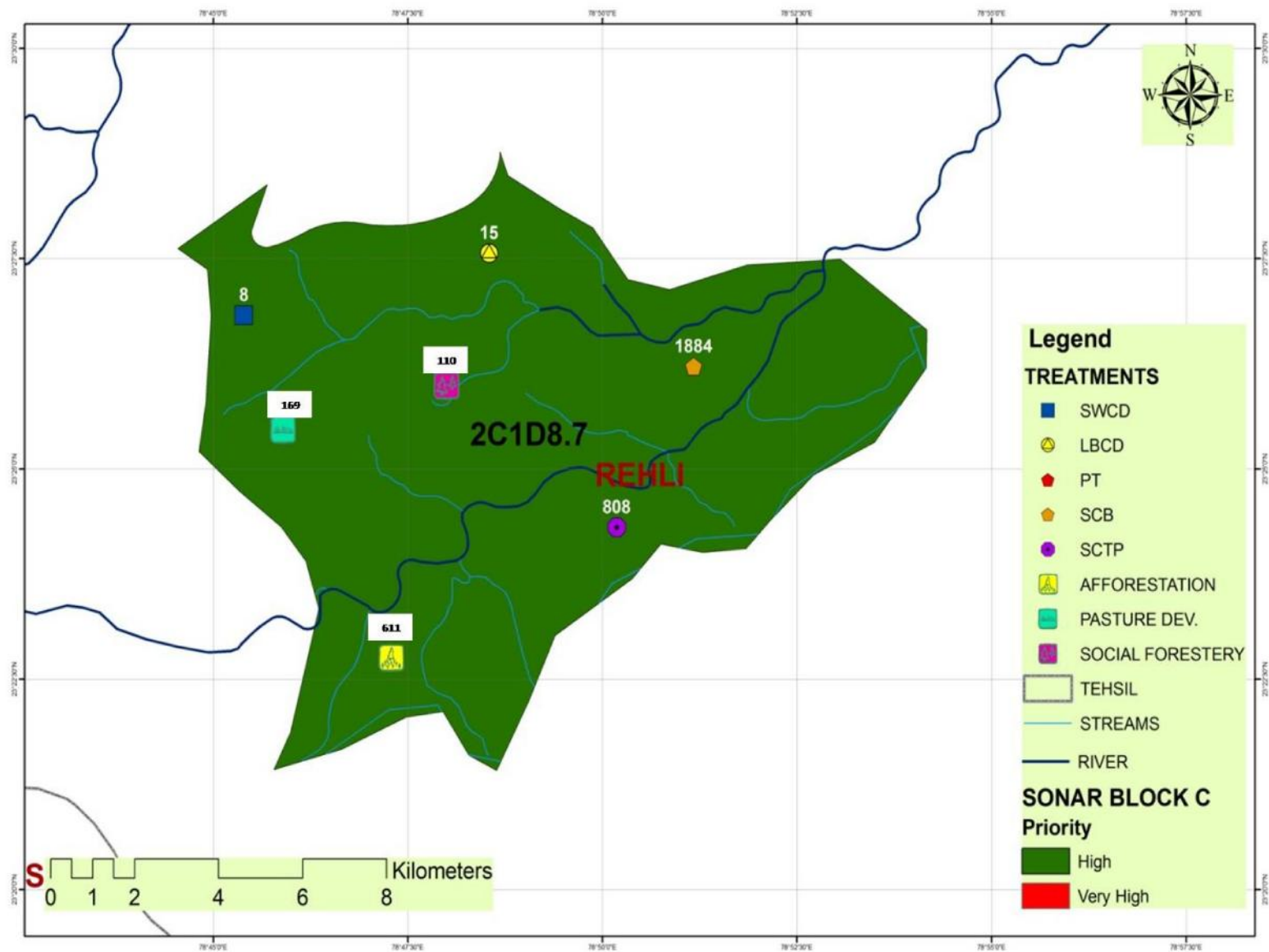


Figure 1.16: Tehsil Wise and Watershed Wise Proposed Treatments of Four Prioritized Sub-Watersheds (2C1E5.6, 2C1E5.7, 2C1E7.1 and 2C1E7.2) in Bearma Sub-Basin of Daudhan Catchment

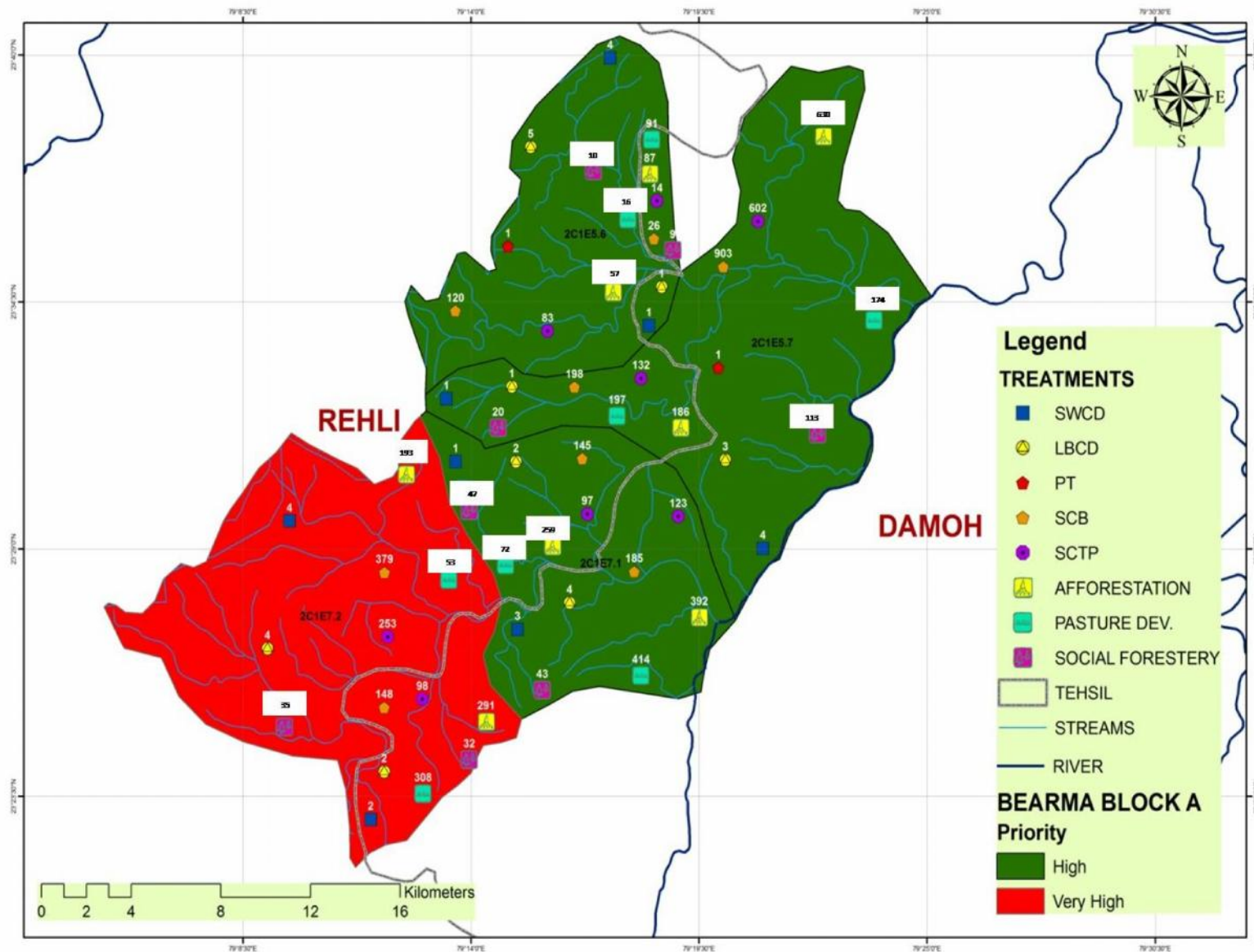
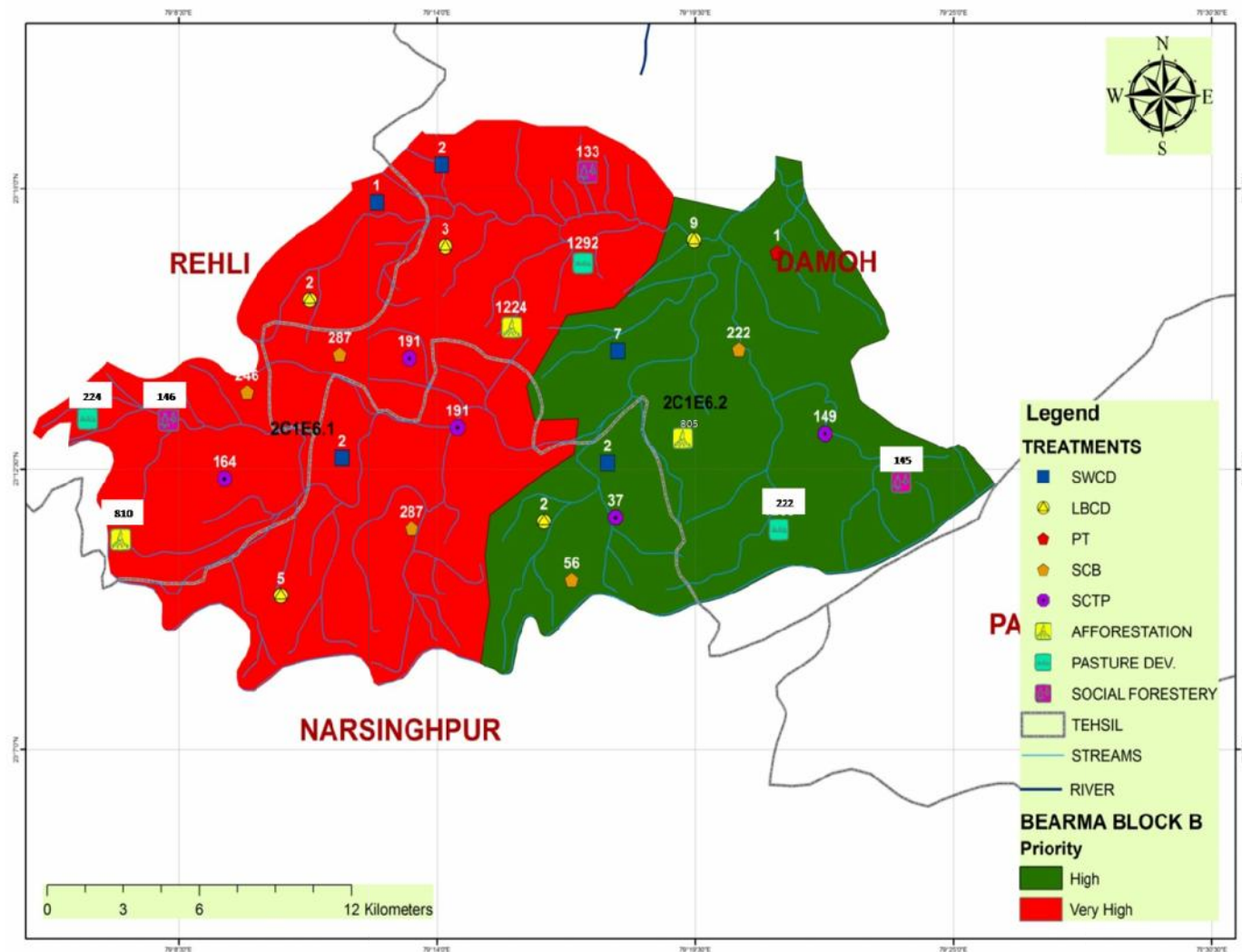


Figure 1.17: Tehsil Wise and Watershed Wise Proposed Treatments of Two Prioritized Sub-Watersheds (2C1E6.1 and 2C1E6.2) in Bearma Sub-Basin of Daudhan Catchment



**EIA and EMP Study of
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ANNEXUTES

Compartment Wise Plantation and Pasture Development Plan of Chhatarpur Division

Area in ha

Compartment No.	Area of compartment	Under Stocked Area	Blank Area	Total Available Area	WC	Plantation	Pasture Development	SC
PF 152	350.28	57.93	0.00	57.93	IFS			57.93
PF 153	306.33	27.36	0.00	27.36	IFS			27.36
PF 154	366.18	60.59		60.59	IFS			60.59
PF 155	325.63	121.74	29.30	151.04	IFS			151.04
PF 156	263.35	63.88		63.88	IFS			63.88
PF 157	319.06	246.13		246.13	IFS			246.13
PF 167	321.93	36.24	91.43	127.67	IFS			127.67
PF 169	251.98	6.83		6.83	IFS			6.83
PF 171	345.91	197.57		197.57	IFS			197.57
PF 172	240.93	180.86	35.96	216.82	IFS			216.82
PF 173	219.88	77.54		77.54	IFS			77.54
PF 174	242.08	45.28		45.28	IFS			45.28
PF 176	193.03	36.69	29.53	66.22	IFS			66.22
PF 177	404.69	65.76	19.39	85.15	IFS			85.15
PF 178	241.46	46.32	11.11	57.43	IFS			57.43
PF 179	293.54	176.99		176.99	IFS			176.99
PF 180	247.02	198.48	2.91	201.39	IFS			201.39
PF 181	221.82	121.93		121.93	IFS			121.93
PF 182	336.45	78.12	20.98	99.10	IFS			99.10
PF 183	239.94	76.11	23.20	99.31	IFS			99.31
PF 184	333.15	112.41		112.41	IFS			112.41
PF 185	262.13	164.39	36.80	201.19	IFS			201.19
PF 186	378.58	78.58	138.14	216.72	IFS			216.72
PF 259	276.46	114.06		114.06	IFS			114.06
PF 264	312.01	29.69		29.69	IFS			29.69
PF 265	212.94	109.77		109.77	IFS			109.77
PF 266	237.84	22.64	8.79	31.43	IFS			31.43
PF 267	397.92	224.32		224.32	IFS			224.32
PF 268	390.51	80.15	93.58	173.73	IFS			173.73
PF 269	200.00	21.99		21.99	IFS			21.99
PF 270	359.06	16.21		16.21	IFS			16.21
PF 271	325.26	85.42		85.42	IFS			85.42
PF 272	222.21	33.47		33.47	IFS			33.47
PF 273	268.20	52.23		52.23	IFS			52.23

Area in ha

Compart ment No.	Area of compare t ment	Under Stocked Area	Blank Area	Total Available Area	WC	Plantation	Pasture Development	SC
PF 276	325.53	66.28		66.28	IFS			66.28
PF 277	269.01	62.15		62.15	IFS			62.15
PF 278	246.28	18.84		18.84	IFS			18.84
PF 280	360.85	29.36	33.64	63.00	IFS			63.00
PF 311	162.11	81.21		81.21	IFS			81.21
PF 312	266.63	83.53		83.53	IFS			83.53
PF 313	386.20	37.03	21.27	58.30	IFS			58.30
PF 314	289.97	10.95		10.95	IFS			10.95
PF 315	232.44	22.21		22.21	IFS			22.21
PF 316	230.36	48.75		48.75	IFS			48.75
PF 380	451.59	169.68		169.68	IFS			169.68
PF 393	425.88	107.01	46.22	153.23	IFS			153.23
PF 394	361.79	38.67		38.67	IFS			38.67
PF 395	286.85	90.21		90.21	IFS			90.21
PF 396	481.40	43.23		43.23	IFS			43.23
PF 397	228.10	137.30	90.80	228.10	IFS			228.10
PF 399	453.91	50.69		50.69	IFS			50.69
PF 400	380.52	104.41		104.41	IFS			104.41
PF 401	382.34	164.75		164.75	IFS			164.75
PF 402	312.79	239.94		225.94	IFS			239.94
PF 403	469.21	239.96		198.96	IFS			210.96
PF 404	286.91	91.96		91.96	IFS			91.96
PF 407	271.51	260.12		249.12	IFS			260.12
PF 408	326.51	59.31	83.18	142.49	IFS			142.49
PF 409	541.08	149.03		149.03	IFS			149.03
PF 410	612.42	71.28		71.28	IFS			71.28
PF 411	528.67	293.59		293.59	IFS			293.59
PF 412	236.04	211.05		211.05	IFS			211.05
PF 413	458.45	124.11		124.11	IFS			124.11
PF 414	247.64	142.68		142.68	IFS			142.68
PF 415	495.81	371.81		371.81	IFS			371.81
PF 417	339.53	46.72		46.72	IFS			46.72
PF 418	363.06	72.89	108.37	181.26	IFS			181.26
PF 433	48.00	40.69	7.31	48.00	IFS			48.00
PF 440	355.30	156.42	5.73	162.15	IFS			162.15
				7914.00				7914.00
PF 111	327.89	123.67	75.50	199.17	RDF	56	14	

Area in ha

Compart ment No.	Area of compart ment	Under Stocked Area	Blank Area	Total Available Area	WC	Plantation	Pasture Development	SC
PF 151	402.87	234.82	32.61	267.43	RDF	75	19	
PF 168	299.10	161.68	57.16	218.84	RDF	61	15	
PF 175	138.75	49.56	23.70	73.26	RDF	21	0	
PF 188	174.94	91.76	83.18	174.94	RDF	49	12	
PF 191	299.92	138.28	128.24	266.52	RDF	75	19	
PF 192	212.02	100.52	84.55	185.07	RDF	52	13	
PF 193	183.30	53.73	45.89	99.62	RDF	28	12	
PF 194	166.23	27.27		27.27	RDF	8	0	
PF 195	251.68	132.33	16.40	148.73	RDF	42	10	
PF 196	323.65	268.27	55.38	323.65	RDF	91	23	
PF 256	365.99	175.34	184.37	359.71	RDF	101	25	
PF 257	206.06	84.05		84.05	RDF	24	10	
PF 258	330.10	124.39		124.39	RDF	35	12	
PF 260	253.64	159.09		159.09	RDF	45	11	
PF 261	186.03	139.12	29.23	168.35	RDF	47	12	
PF 281	515.01	168.68	201.75	370.43	RDF	104	26	
PF 377	210.88	126.48		126.48	RDF	35	11	
PF 378	250.62	250.62		250.62	RDF	70	18	
PF 379	67.03	67.03		67.03	RDF	19	0	
PF 387	472.32	265.77	75.89	341.66	RDF	96	24	
PF 388	344.12	279.17	20.90	300.07	RDF	84	21	
PF 389	296.03	155.52		155.52	RDF	44	11	
PF 390	298.73	37.53		37.53	RDF	11	0	
PF 391	219.46	123.06		123.06	RDF	34	12	
PF 392	283.33	163.11		163.11	RDF	46	11	
PF 398	357.63	52.61		52.61	RDF	15	0	
Sub-Total				4868.21		1363	341	

**Compartment Wise Plantation and Pasture Development Plan of
North Panna Division**

Area in ha

Compartment Number	Total Area of Compartment	Under stocked Area	Blank	Area available	Working Circle	Plantation	Pasture Development
PF416	294.94	0.00	134.94	134.94	Plantation		
PF436	26.09	0.00	26.09	26.09	RDF	0	0
PF454	177.19	0.00	27.19	27.19	RDF	10	0
PF413	326.60	0.00	76.60	76.60	RDF	21	0
PF457	185.75	0.00	84.75	84.75	RDF	24	10
PF417	310.55	0.00	110.55	110.55	RDF	31	10
PF462	367.53	45.38	72.15	117.53	RDF	33	11
PF396	278.58	40.22	98.36	138.58	RDF	39	10
PF415	269.68	0.00	139.68	139.68	RDF	39	10
PF388	303.19	48.88	104.31	153.19	RDF	43	11
PF438	259.32	0.00	163.29	163.29	RDF	46	11
PF385	276.28	96.69	69.40	166.09	RDF	47	12
PF456	386.47	0.00	178.78	178.78	RDF	50	13
PF440	253.90	0.00	182.90	182.90	RDF	51	13
PF386	261.71	150.44	41.82	192.26	RDF	54	13
PF387	288.83	193.09	0.00	193.09	RDF	54	14
PF395	305.86	0.00	195.86	195.86	RDF	55	14
PF446	301.49	0.00	201.49	201.49	RDF	56	14
PF447	306.26	64.53	141.23	205.76	RDF	58	14
PF377	208.57	133.39	75.18	208.57	RDF	58	15
PF443	248.96	0.00	222.71	222.71	RDF	62	16
PF437	244.51	0.00	229.51	229.51	RDF	64	16
PF410	235.81	142.50	89.94	232.44	RDF	65	16
PF414	247.92	70.82	170.10	240.92	RDF	67	17
PF451	243.94	0.00	243.94	243.94	RDF	68	17
PF376	257.86	255.83	0.00	255.83	RDF	72	18
PF390	259.32	210.93	48.39	259.32	RDF	73	18
PF430	266.93	266.93	0.00	266.93	RDF	75	19
PF445	267.82	254.51	13.31	267.82	RDF	75	19
PF422	284.05	0.00	274.05	274.05	RDF	77	19
PF439	281.66	0.00	277.40	277.40	RDF	78	19
PF429	283.11	148.32	134.79	283.11	RDF	79	20

Compart ment Number	Total Area of Compart ment	Under stocked Area	Blank	Area available	Working Circle	Plantation	Pasture Development
PF411	332.65	270.63	14.82	285.45	RDF	80	20
PF442	296.39	0.00	292.73	292.73	RDF	82	20
PF444	298.17	298.17	0.00	298.17	RDF	83	21
PF433	299.26	0.00	299.26	299.26	RDF	84	21
PF452	307.24	0.00	301.24	301.24	RDF	84	21
PF453	302.94	0.00	301.69	301.69	RDF	84	21
PF428	301.73	0.00	301.73	301.73	RDF	84	21
PF455	318.36	179.25	131.36	310.61	RDF	87	22
PF424	314.52	0.00	311.95	311.95	RDF	87	22
PF418	314.96	241.72	73.24	314.96	RDF	88	22
PF435	336.05	0.00	336.05	336.05	RDF	94	24
PF450	351.10	0.00	344.22	344.22	RDF	96	24
PF448	366.19	0.00	358.19	358.19	RDF	100	25
PF76	371.46	0.00	361.46	361.46	RDF	106	25
PF432				367.64	RDF	103	26
PF412	398.54	384.19	0.00	384.19	RDF	108	27
PF449	530.30	0.00	527.10	527.10	RDF	148	37
				11512.87		3224	806

Compartment Wise Plantation and Pasture Development Plan of Damoh Division

Area in ha								
Compartment Number	Total Area of Compartment	Working Circle	Under Stocked	Blank	Total Available Area	Plantation	Pasture Development	SC
RF 27	486.23	IFS		111.53	111.53			111.53
RF 29	570.92	IFS	139.38	26.61	165.99			165.99
RF 24	564.62	IFS	191.93		191.93			191.93
RF 25	559.61	IFS	237.68		237.68			237.68
RF231	635.75	IFS	298.78		298.78			298.78
	Sub-Total				1005.91			1005.91
PF198	21.96	Plantation		14.53	14.53	4	0	
RF244	124.65	Plantation	15.00	59.65	74.65	21	10	
PF192	290.54	Plantation	206.00	84.54	290.54	83	21	
PF193	398.94	Plantation	348.36	50.58	398.94	113	24	
PF223	10.73	RDF	10.73		10.73	0	0	
RF252	193.07	RDF	193.07		193.07	55	15	
PF 344	208.29	RDF	208.29		208.29	59	15	
PF194	216.32	RDF	216.32		216.32	64	15	
PF 346	237.81	RDF	231.87		231.87	66	16	
PF 350	337.83	RDF	238.16		238.16	68	17	
RF251	253.98	RDF	253.98		253.98	72	18	
RF 28	443.65	RDF	260.08		260.08	74	18	
RF 707	267.09	RDF		267.09	267.09	76	19	
RF 708	274.97	RDF		274.87	274.87	78	20	
PF 307	288.33	RDF		288.33	288.33	82	20	
RF 709	297.26	RDF		293.61	293.61	83	21	
PF 362	298.13	RDF	187.23	110.9	298.13	85	21	
PF 347	300.11	RDF	193.5	106.61	300.11	85	21	
PF 349	316.45	RDF	250.53	55.75	306.28	87	22	
RF130	423.35	RDF		330.96	330.96	94	24	
PF195	344.51	RDF	344.51		344.51	98	24	
RF 40	360.17	RDF	360.17		360.17	102	26	
RF 37	361.80	RDF	361.8		361.8	103	26	
RF230	558.96	RDF	362.6		362.6	103	26	
PF 348	548.32	RDF	405.34		405.34	115	29	
RF250	418.03	RDF	205.93	212.1	418.03	119	30	

Area in ha								
Compart ment Number	Total Area of Compart ment	Working Circle	Under Stocked	Blank	Total Available Area	Plantation	Pasture Develop ment	SC
RF129	831.51	RDF	181.72	241.63	423.35	120	30	
RF243	514.91	RDF	429.41		429.41	122	30	
RF 26	458.06	RDF	458.06		458.06	130	33	
PF 308	479.73	RDF		479.73	479.73	136	34	
RF240	482.15	RDF	401.45	80.7	482.15	137	34	
RF 23	737.00	RDF	484.5		484.5	138	34	
RF233	490.86	RDF	15	475.86	490.86	139	35	
RF 36	525.51	RDF	508.05		508.05	144	36	
RF238	521.16	RDF	521.16		521.16	148	37	
RF241	543.60	RDF	375.37	168.23	543.6	154	39	
RF 21	566.99	RDF	169.07	397.92	566.99	161	40	
RF235	604.33	RDF	171.89	432.44	604.33	172	43	
RF242	607.29	RDF	607.29		607.29	172	43	
RF236	616.34	RDF	547.23	69.11	616.34	175	44	
RF237	625.48	RDF	625.48		625.48	178	44	
RF 22	1137.61	RDF	649.48		649.48	184	46	
RF126	674.98	RDF	674.98		674.98	192	48	
RF234	726.50	RDF	294.22	432.28	726.5	206	52	
RF 42	922.88	RDF	743.2		743.2	211	53	
RF239	746.07	RDF	746.07		746.07	212	53	
RF 35	775.93	RDF	775.93		775.93	220	55	
RF232	792.21	RDF	792.21		792.21	225	56	
RF128	402.17	RDF	718.86	112.65	831.51	240	60	
PF255	15.43			15.43	15.43	0	0	
		Sub-total			20020.94	5687	1422	
55					20799.6	5908	1477	

Compartment Wise Plantation and Pasture Development Plan of South Sagar Division

Area in ha								
Compartment Number	Total Area of the compartment	Under stocked	Blank	Total Area Available	Working circle	Plantation	Pasture Development	SC
RF901	55.45	10.44	45.01	55.45	CP			
RF894	62.58	21.23	41.35	62.58	CP			
RF920	167.70		167.70	167.7	CP			
RF921	187.98		185.05	185.05	CP			
Sub-Total				470.78				
PF1065	110.1	35.31	65.92	101.23	FF	17	18	
PF930	115.1	33.21	72.51	105.72	FF	18	19	
RF1055	295.82	104.82	123.76	228.58	FF	39	41	
RF1050	247.68	99.21	148.47	247.68	FF	42	44	
PF881	292.1		287.11	287.11	FF	49	51	
PF882	372.02	131.27	240.74	372.01	FF	63	67	
Sub-Total				1342.33		229	241	
PF1052	89.63	44.24	20.5	64.74	IFS			64.74
PF1054	275.11	127.16		127.16	IFS			127.16
RF1056	292.88	174.02		174.02	IFS			174.02
RF947	258.45	87.5	86.58	174.08	IFS			174.08
RF1046	260.97	175.24		150.24	IFS			150.24
PF1066	186.34	132.34	47.42	109.76	IFS			109.76
Sub-Total				800				800
RF906	63.08	31.94		31.94	RDF	10	0	
RF904	55.58	39.36		39.36	RDF	11	0	
PF931	47.61	27.98	19.63	47.61	RDF	11	0	
PF1063	53.32	42.53	8.07	50.6	RDF	11	10	
RF888	52.48	44.27	8.22	52.49	RDF	12	10	
PF883	62.26		62.26	62.26	RDF	14	10	
PF1064	65.33	65.33		65.33	RDF	15	10	
PF1068	74.63	74.63		74.63	RDF	17	10	
PF878	94.89		93.19	93.19	RDF	21	10	
PF929	140.94	85.47	55.47	140.94	RDF	32	16	
RF886	172.39	117.39	52.69	170.08	RDF	39	19	
RF885	213.87	114.6	96.02	210.62	RDF	48	23	
RF1045	239.57	158.55	79.44	237.99	RDF	54	26	

Area in ha								
Compart ment Number	Total Area of the compart ment	Under stocked	Blank	Total Area Available	Working circle	Plantation	Pasture Develop ment	SC
RF887	242.87	204.46	35.68	240.14	RDF	54	26	
PF1051	241.26	213.65	27.61	241.26	RDF	55	27	
PF1024	245.46	180.72	63.26	243.98	RDF	53	27	
PF1053	287.81	247.74	39.28	287.02	RDF	65	32	
PF984	389.99	369.84	16.07	385.91	RDF	85	39	
Sub-Total				2675.35		607	294	
RF903	61.24	9.04		9.04	SCI			
RF893	43.73	9.22		9.22	SCI			
RF1086	220.85		12.12	12.12	SCI			
RF948	177.99	12.22		12.22	SCI			
RF895	48.13	13.61		13.61	SCI			
RF1085	179.94	13.71		13.71	SCI			
RF890	62.12	16.28		16.28	SCI			
RF902	59.64	16.38	4.51	20.89	SCI			
RF891	63.49	21.46		21.46	SCI			
RF896	72.74	22.26		22.26	SCI			
RF1047	258.29	33.49		33.49	SCI			
RF898	68.13		33.98	33.98	SCI			
PF1009	90.36	33.66	6.78	40.44	SCI			
RF892	79.13	44.26		44.26	SCI			
PF1067	254.06	48.15	60.49	108.64	SCI			
Sub-Total				411.62				
				4017.68		836	535	800

Buffer Area Considered for CAT plan

Compartment Number	Division	Available Area in ha		Working Circle	Target in ha for Afforestation	Target in ha for Plantation
PF 355	PTR Division	120.019	Buffer	RDF	40	10
PF 356	PTR Division	271.635	Buffer	RDF	91	23
PF 357	PTR Division	140.275	Buffer	RDF	47	12
PF 358	PTR Division	261.860	Buffer	RDF	87	22
PF 360	PTR Division	88.600	Buffer	RDF	30	10
PF 361	PTR Division	261.730	Buffer	RDF	87	22
RF 31	PTR Division	356.270	Buffer	RDF	119	30
RF 32	PTR Division	463.681	Buffer	RDF	155	39
RF 33	PTR Division	556.211	Buffer	RDF	186	46
RF 34	PTR Division	714.043	Buffer	RDF	238	57
RF 39	PTR Division	241.818	Buffer	RDF	81	20
	Total	3476.142			1160	290

Detailed Cost Estimate for B/Wire Fencing of 50 ha Area during First Year
(Assumed Wages at the rate of Rs 235.00 Per Person Day)

Sl. No	Particulars of Work	Unit	Qty	Man days	Rate (Rs.)	Amount (Rs.)
1	Fixing of cement concrete (CC) pillars at a maximum interval of 3 m. The pillars will have maximum 3 mm clips. It is proposed to provide support with two additional pillars	Rmt	3300			
	1.1 Purchase of CC Pillars with specifications of length 200 cm, base of 10x10 cm and top of 8x8 cm	Number	1375		290.00	398750.00
	1.2 Purchase of Chain links of 1.5 m X 3300 m	CMT	4950		95.00	470250.00
	1.3 Binding Wire	Kg	55		80.00	4400.00
	1.4 Barbed wire for supporting chain linking	Qtl	14		8000.00	112000.00
	1.5 Digging of pits for CC pillars of 30x30x45 cm	Per '00	1340	3.80	8.93	11966.20
	1.6 Filling the pits with 1:3:6 cement concrete for erecting pillars $820 \times 0.30 \times 0.45 = 53.46$ CMT (-) $820 \times 0.10 \times 0.10 \times 0.45 = 5.93$	CMT	47.53			
	1.6.1 Purchase of cement	Bags	142		300.00	42600.00
	1.6.2 Purchase of sand	CMT	14.5		1200.00	17400.00
	1.6.3 Purchase of concrete of 40 mm size	CMT	30		1100.00	33000.00
2	Fixing of CC pillars in the pits with CC mix	LS				50000.00
3	Spreading the Chain links and compacting	LS				25000.00
4	Barbed wire fixing in the pillars with the help of clips	Rmt	3300	0.16	37.60	124080.00

Sl. No	Particulars of Work	Unit	Qty	Man days	Rate (Rs.)	Amount (Rs.)
5	Digging of Pits for foundation of pillars	LS				25000.00
6	For erecting pillars prepare CC mix and fill the foundation pits	Number	1375		80.00	110000.00
7	Carriage of CC pillars from dumping centre to plantation site		1375		30.00	41250.00
8	Wet treatment of pillars		1375		40.00	55000.00
9	Painting of Pillars	LS	1375			15000.00
10	Trench digging (45x45 cm)	LS	3200	0.08	18.80	60160.00
11	Iron gates					
	11.1 Bigger iron gate	LS				20000.00
	11.2 Small iron gate	LS				15000.00
12	Other Miscellaneous Expenses	LS				15000.00
	Total for 50 ha plot					1645856.20
	Cost per ha					32917

Year Wise Expected Mortality and Cost of Maintenance and Gap Replacement

1st Year Maintenance 25% Mortality					
Sl. No.	Particulars of works	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	First Weeding (Cost of Wages)	No	10.90	203	2213
2	Second Weeding (Cost of Wages)	No	10.00	203	2030
3	Planting of polythene bags plants	"00	1.75	300	525
4	Nursery cost of plants	"00	275.00	9	2475
5	Fire Protection	L/S			278
6	Total				7521
7	Add on account of increase on wage rate	10.00%			752
8	Total				8273
9	Grand Total				8273
10	Say				8270

2nd Year Maintenance 20% Mortality					
Sl. No.	Particulars of works	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	First Weeding (Cost of Wages)	No	10.90	203	2213
2	Second Weeding (Cost of Wages)	No	8.00	203	1624
3	Planting of polythene bags plants	"00	1.40	300	420
4	Nursery cost of plants	"00	220.00	9	1980
5	Fire Protection	L/S			172
6	Total				6409
7	Add on account of increase on wage rate	20.00%			1282
8	Total				7690
9	Grand Total				7690
10	Say				7690

3rd Year Maintenance 15% Mortality					
Sl. No.	Particulars of works	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Weeding (Cost of Wages)	No	10.90	203	2213
2	Planting of polythene bags plants	"00	1.05	300	315
3	Nursery cost of plants	"00	165.00	9	1485
4	Repair of soil and moisture conservation works	L/S			1000
5	Fire Protection				324
6	Total				5337
7	Add on account of increase on wage rate	30.00%			1601
8	Total				6938
9	Grand Total				6938
10	Say				6940

Annexure I.7 continued

	Fourth Year Maintenance				
Sl. No.	Particulars of works	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Fire Protection	LS			399
2	Watch and Ward	LS			4198
3	Other Misc. Expenditure	LS			1205
4	Total				5802
	Say				5800

	Fifth Year Maintenance				
Sl. No.	Particulars of works	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Fire Protection	LS			439
2	Watch and Ward	LS			2714
3	Singling Expenditure	LS			600
4	Other Misc. Expenditure	LS			240
5	Total				3994
	Say				3990

	Sixth Year Maintenance				
Sl. No.	Particulars of works	Unit	Qty.	Rate (Rs.)	Amount (Rs.)
1	Fire Protection	LS			483
2	Watch and Ward	LS			2981
3	Other Misc. Expenditure	LS			420
4	Total				3884
	Say				3880

Unit Cost of Loose Boulder Check Dam

Sl. No.	Particulars	Quantity	Unit	Rate per unit in Rs	Amount in Rs
1	Survey and Alignment	LS			170
2	Excavation of Earth work for Foundation and Both Banks	28.78	Cum	26	748
3	Bund Construction: Collection of Dry Rubbles	36.25	Cum	44	1595
4	Foundation for Pitching on Banks	2.94	Cum	26	76
5	Pitching on Both Banks	10.9	sq m	262	2856
6	Transportation Charges	39	Cum	145	5655
7	Galvanised Wire Mash 15x15 cm Wire mash having 3 mm dia	150	sq m	120	18000
8	Transportation of wire mash up to 50 km	1	one time		200
9	Survey during Construction	LS			170
	Total				29471
	Contingencies @ 5 per cent of total				1474
	Grand Total				30944

DESIGN AND ESTIMATED COST OF STAGGERED CONTOUR TRENCHES (For Plantations)

Slope of land	-	10% to 35%
Average depth of soil	-	0.90 m
Length of contour trench	-	5.00 m
Width of trench	-	45 cm
Depth of trench	-	50 cm
CS of trench	-	2.25 sq m
Spacing between the trenches in same row	-	3.30 m
Horizontal spacing	-	5.00 m

Continuous trench after every 5 rows of trenches may need to be provided to arrest excess run-off and silt. The trenches will be constructed across the slope and along the contour line to make it efficient system for conservation of soil and water

Total no. of trenches per ha	-	180 nos.
Total length of trenches per ha including 3 nos. continuous trenches	-	1,200 m
Earth work involved	-	270.0 cum
Jungle area to be cleared @ 1 sq m throughout the length	-	1,200 sq m
Cost of jungle clearing etc @ Rs. 1.50 per sq m	-	Rs. 1200.00
Cost of excavation of trenches : 270.0 cum x Rs. 45.00	-	Rs. 12150.00
Total cost	-	Rs. 13950.00
Cost of Plantation (Lump Sum)	-	Rs. 7900.00
Grand total	-	Rs. 21850.00 per ha