5.1. REVISED CATCHMENT AREA TREATMENT PLAN

5.1.1 INTRODUCTION

Developmental projects can be followed by a number of related activities like deforestation, urbanization and faulty management practices, etc. which cause degradation of the catchment area. All these processes damage soil environment which ultimately leads to rapid sedimentation of reservoirs. Accelerated soil erosion in the catchment areas of the reservoir and transport of detached materials through the drainage network give rise to a series of problems, notably steady loss of storage capacity, consistent drop in hydro-electric power generation in lean season and landslides. The loss of active storage leads to heavy economic losses due to reduced lean season generation. Therefore, extensive soil conservation and watershed management programmes are needed to minimize the damages to the catchment area and to mitigate soil erosion problems. Erosion and sediment yield in Yarjep valley and sediment accumulation in the fertile flood plains of Brahmaputra and lower regions represent a loss and gain phenomenon. In the upper regions of the valley, active processes of slope denudation are operative and loss of fertile soil is taking place. The so generated sediments are brought down into the man-made reservoir which gets filled with silt and other channel eroded materials.

In the catchment area of the proposed Heo HE project, there is a very large plain in the upstream of the proposed Heo Dam, known as Mechuka Plain where both slope of the river bed (average of 0.26% over 16km long stretch) and velocity of the water in the river (0.5m/s to 2 m/s) are very low. Most of the silts get deposited there. Downstream of this plain and upstream of Heo HEP, Pauk HEP is being developed by Velcan Energy Ltd. The Arch Dam of Pauk HEP creates a reservoir 11.5 Mm^3 storage capacity, covering a 34 ha area. The water velocity in the reservoir will fall down to less than 0.05 m/s, whereas the water velocity is never less than 0.2 m/s even in a desilting basin. Hence the upstream Mechuka Plain and Pauk Reservoir will be acting as a desilting basin for the HEO HEP.

However, as an additional precautionary environmental measure, a treatment of the catchment area of the proposed Heo HE project is proposed. In such catchment, splash, sheet, rill and gully are the main types of erosion. The total catchment area of the proposed Heo HE project up to dam site is around 106500 ha and the free draining catchment area of the project is around 8300 ha. In this defined region the total area under different categories of erosion intensity (very severe, severe, moderate and slight) is 8273.44 ha, the remaining mere amount is constitute of river and snow. However, only the area under very severe and severe erosion has to be considered for treatment in free draining catchment, which is around 1348.75 ha. Indeed, traditionally, only the area with very severe and severe erosions is considered for treatment. However, in the present CAT plan, the area considered only 927.27 ha for treatment, which is around 11.17 per cent of the total effective free draining catchment area and around 68.75 per cent of the area under very severe and severe erosions. Only 927.27 ha out of 1348.75 ha will be treated, because the area come below 3000 m elevation and are made of slopes of less than 45^{o}. The remaining 31.25 per cent are not suitable for treatment, either due to high elevation (above 3000 m) or too steep slopes (slopes above 45%). The part of the catchment area which is taken for treatment is divided into 9 sub-watersheds. Various biological and engineering measures have been suggested for the treatment of these areas. Total budget for the catchment area treatment plan is kept **Rs. 711.40 lakhs** and proposed schedule for the execution of the planned work is 4 years and thereafter, I year is kept for the maintenance of the work carried out in the catchment. Zero year is also considered in the schedule for the development of nursery, raising of saplings.

5.1.2 OBJECTIVES

The CAT plan has been prepared sub-watershed-wise. In all, 9 sub-watersheds have been considered for CAT plan. In the present plan, thrust has been given for sustainable development of the catchment area as well as to protect and conserve the local environment with the active involvement of local people. In the CAT plan equal emphasis has been given to the economic needs of the local people, greening of the region, strengthening the local wildlife management and the integration of these activities with a view to finally avoid soil erosion and decrease the silt load, if any, in Yarjep River and silt load in its tributaries. Various mechanical and biological measures have been suggested to treat the region to meet the following objectives.

1. Ecological rehabilitation of the region for the sustainable development of local economy.
2. Greening the region.

3. To protect the region from soil loss.
4. Enrichment/rejuvenation of water resource in the region.
5. Increase the employment opportunities for local communities to decrease their dependency on natural resources for their livelihood.
6. Management plan to protect the wildlife.
7. Initiation of research activities to use and protect natural resources in a scientific way.

5.1.3 SOIL EROSION AND CAUSES

Different types of erosion that are observed in the catchment are: i) sheet erosion, i.e. washing of surface soil from arable land; it is considered to be the first step in soil erosion, ii) gully erosion; it is the aggravated form of rill erosion (heavy rainfall associated with rainstorms, the overland flow or sheet flow is transformed into linear flow), and iii) stream bank erosion.

Water, which comes in the form of precipitations or drainage, is the single most important agent of erosion. Whenever water moves, it erodes the boundaries alongside. Rainfall, streams and rivers all scour soil with their action. The erosion, therefore, is essentially a process of smoothening or leveling in which soil and rock particles are carried, rolled or washed down the slope under the influence of both gravity and water.

5.1.4 ESTIMATION OF SOIL EROSION

In order to formulate appropriate soil conservation measures, it is essential to estimate the extent of soil erosion and its spatial context in the treated catchment area. Brief description of various factors (Drainage, Slope, Soil & soil depth and Land use/ Land cover) that are responsible for soil erosion are being discussed below. Sub-watershed of the free draining area was delineated from the Survey of India Toposheets and nine sub-watershed were delineated (**Fig. 5.1.1**).

5.1.4.1 Drainage

Left Bank of Yarjep: As shown in the **Fig. 5.1.2,** the headwater region of the Songshi Bu originates from the Northern part of the free draining area. It flows from the Northern part of the free draining area and flows southwards and meets with Libong Sokong near the Showongshi Comp. Libong Sokong also originates from the snow clad mountains. Showong Sokong flows for 5 km southwestwards and drains into Songshi Bu. There are several un-named tributaries joining from the

both banks. Some of the tributaries have slopes susceptible to landslide. Tributaries along the right bank are smaller and lesser dendrite in pattern. Songshi Bu flows southeastward for ~9 km and drains into Yarjep River near the dam site.

Right Bank of Yarjep: Right bank tributaries are smaller in nature and short traversed. There are two prominent rivers along the right bank. Shene Korong flows northwards and drains into Yarjep near Purying. Besides in the upstream Shuku Sokong also flows northwards and drains into the main river channel.

5.1.4.2 Slope

Slope was extracted from the digital elevation model (DEM). DEM is in turn extracted from contour map. The contour map was digitized on computer for further processing and analysis using combination of ArcGIS 9.0 and GeoMedia Professional 5.2. Digitization of the contour map was carried out and later contour interpolation technique was use to create DEM. Further, slope map (percentage) was extracted from the DEM. As shown in the **Fig. 5.1.3** and Table 5.1.1 the moderately steep is prevalently spread in the free draining area, covering about 61.44% of the total free draining area. This slope class is more prominent in the sub watersheds of Sb6 and Sb9 with area coverage of 751.73 ha and 869.46 ha respectively. Steep slope class is the second prominent slope class in the free draining area with area coverage of about 26.68% of the total free draining area. Sub watersheds Sb3, Sb6 and Sb8 have area coverage in the range of 360.70 ha, 411.39 ha and 334.10 ha respectively. Loose soils on steep slope and moderately steep slope are more susceptible to soil erosion than other slope classes.

Table 5.1.1 Slope class and its associated area (ha) in the free draining area of Heo HE Project

Sub-watershed	Gently Sloping	Moderately Sloping	Strongly Sloping	Moderately Steep	Steep	Very Steep	Total
Sb1	0.98	10.87	55.87	489.57	252.74	0.00	**810.03**
Sb2	1.35	44.81	177.72	717.65	118.17	0.00	**1059.7**
Sb3	3.94	40.81	102.15	683.07	360.70	31.14	**1221.81**
Sb4	1.61	12.06	62.17	305.84	88.07	0.00	**469.75**
Sb5	2.28	12.87	84.42	528.68	235.44	0.24	**863.93**
Sb6	1.60	21.39	95.37	751.73	411.39	0.99	**1282.47**

Sb7	0.38	0.00	9.01	213.75	198.04	0.00	**421.18**
Sb8	0.69	10.25	50.19	539.81	334.10	7.72	**942.76**
Sb9	0.3	33.28	107.88	869.46	216.20	1.27	**1228.39**
Total	**13.13**	**186.34**	**744.78**	**5099.56**	**2214.85**	**41.36**	**8300.02**

5.1.4.3 Land use/ Land cover

The project area designated for the free draining catchment area treatment plan covers 8300.07 ha. The recent land use/ land cover of this area was interpreted from the satellite images and confirmed by the field surveys. A false color composite (FCC) was generated for the entire free draining area as well as for all the 9 sub-watersheds (**Fig. 5.1.4**). The land use /land cover of the free draining area of HE project area as well as of all the 9 sub-watersheds was classified under Dense Forest, Open Forest, Scrub, Degraded Forest, Cultivation, Moraines, Barren, River and Snow (**Fig. 5.1.5**).

Land use and land cover mapping was carried out by standard methods of analysis of remotely sensed data followed by ground truth collection and interpretation of satellite data. For this purpose digital data on CDROMs were procured from National Remote Sensing Agency, Hyderabad. Digital image processing of the satellite data and the analysis of interpreted maps were carried out at the Computer Centre at CISMHE using ERDAS Imagine 8.7. Several techniques and geo statistical approaches were used for the image processing of the Catchment area. Techniques such as supervised classification and later on a spatial statistic model (Maximum likelihood classifier) applied for the sample set of the trained pixel were used to classify the satellite imagery.

Digital data of IRS P6 LISS-3 and Landsat-7 full scene were used for image processing and thematic map preparation. For the secondary data, Survey of India toposheets on 1:50,000 and 1:25,000 were referred to for the preparation of base map and drainage map. With the objective of preparation of environment management plan and an action plan for watershed management and a catchment area treatment, the classification scheme adopted for the preparation of land use/ land cover maps and related thematic maps on 1:50,000 scale is as follows. Two forest density classes were interpreted for the forest cover mapping. The forests with >40% canopy cover were delineated as dense forests and between 10% and 40% crown density as open forest. Furthermore, degraded forests (with <10% canopy cover) and scrubs were also delineated for the purpose of erosion

mapping. The cropland (agriculture) was also delineated for the calculation of erosion intensity classification.

The base map, drainage map and land use/land cover map were prepared using the satellite data. The sub-watershed boundaries were then overlaid on the drainage map and land use map of the free draining area in order to extract the drainage and land use of the sub-watersheds, which were further used for overlay analysis by Geographic Information System (GIS) techniques. In the free draining area of Heo H.E. Project the most prominent form of land cover is dense forest with area coverage of 48% of the total free draining area of Heo H.E Project (**Fig. 5.1.5**). In northern part of the watershed this land cover is prevalently spread in the sub-watershed of Sb1, Sb2 and Sb3 with area coverage of 440.15 ha, 796.26 ha and 496.23 ha respectively. Similarly sub watersheds Sb5, Sb6 and Sb9 in the southern part have area in the range of 454 ha, 603.47 ha and 516.90 ha respectively (Table 5.1.2).

The second prominent land cover in the free draining area is the degraded forest with area coverage of almost 20% of the free draining area with largest area coverage of about 298.49 ha in the sub watershed of Sb3. Sb5, Sb6, Sb8 and Sb9 have area coverage in the range of about 250 ha. Subsequently scrub and open forest are spread in an area of 16.8% and 13.8% of the total free draining area, respectively. Open forest is more prominent in the sub watersheds of Sb3, Sb6, Sb8 and Sb9 having area coverage in the range of 150 ha to 300 ha. Likewise scrub is proportionately spread in all the sub-watersheds, except sub-watersheds of Sb4 and Sb7 all the sub watersheds have a scrub area larger than 100 ha.

The remaining land use such as cultivation, settlement and erodible land classes such as barren land and moraines are merely present in the free draining area. Therefore the lands on the slopes in the free draining area are lesser susceptible to soil erosion.

Table 5.1.2 Land cover/ land use class and its associated area (ha) in the free draining area of Heo HE project

Sub-watershed	Dense Forest	Open Forest	Scrub	Degraded Forest	Cultivation	Moraines	Barren	River	Snow	Total
Sb1	440.15	111.72	126.70	32.80	11.04	47.56	34.82	0.00	5.23	**810.02**
Sb2	796.26	59.04	143.50	60.11	0.80	0.00	0.00	0.00	0.00	**1059.71**

Sb3	496.23	161.09	253.55	298.49	0.42	0.00	0.00	12.04	0.00	**1221.82**
Sb4	251.53	27.19	97.77	93.18	0.08	0.00	0.00	0.00	0.00	**469.75**
Sb5	454.00	40.18	164.39	202.55	0.34	0.17	2.32	0.00	0.00	**863.95**
Sb6	603.47	190.83	225.64	261.55	1.00	0.00	0.00	0.00	0.00	**1282.49**
Sb7	149.06	92.50	48.36	131.26	0.00	0.00	0.00	0.00	0.00	**421.18**
Sb8	308.37	168.98	197.20	257.04	1.83	0.00	0.17	9.16	0.00	**942.75**
Sb9	516.90	290.27	142.82	273.95	3.74	0.00	0.00	0.72	0.00	**1228.4**
Total	**4015.97**	**1141.8**	**1399.93**	**1610.93**	**19.25**	**47.73**	**37.31**	**21.92**	**5.23**	**8300.07**

5.1.4.4 Soil class and Soil depth

As shown in the **Fig. 5.1.6** and Table 5.1.3 all the soil classes are proportionately spread in the free draining area. In the northern part of the free draining area the soil class S3 is more prominent. It is largely spread in the sub-watershed of Sb2 with area coverage of 998.34 ha of land and it is completely devoid in the sub-watersheds of Sb5, Sb7, Sb8 and Sb9 in the southern part. Subsequently, S1 is more prominent in the southern part of the catchment with largest area coverage of 1228.39 ha in the sub-watershed of Sb9. Again it is devoid in the sub-watersheds of the northern part and therefore Sb1, Sb2, Sb4 and Sb5 are completely devoid of this soil class. However, soil class S4 is more prevalent in the middle part of the free draining part of the catchment. Hence, S4 soil class is more prevalently spread than the former ones with largest area coverage in the sub-watershed of Sb6 with area coverage of 1201.43 ha.

Table 5.1.3 Sub watershed & area (ha) associated with different soil class in the Heo H.E project

Sub watershed	S1	S3	S4	Total
Sb1	0	810.02	0	**810.02**
Sb2	0	998.34	61.36	**1059.7**
Sb3	633.38	190.72	397.70	**1221.8**
Sb4	0	198.85	270.90	**469.75**
Sb5	0	0	863.94	**863.94**
Sb6	25.65	55.40	1201.43	**1282.48**
Sb7	348.77	0	72.40	**421.17**
Sb8	916.36	0	26.40	**942.76**
Sb9	1228.39	0	0	**1228.39**
Total	**3152.55**	**2253.33**	**2894.13**	**8300.01**

The whole free draining catchment area is characterized with shallow soil (**Fig. 5.1.7**).

5.1.4.5 Erosion Intensity Mapping

Soil erosion intensity mapping was carried out using the above thematic layers. Soil erosion is mainly caused by moving water and gravity. It varies from place to place. Furthermore, it is intensified by human induced developmental projects. Within the Himalayan river basins, water is the main agent of erosion. Erosion by water is most complex process and takes place due to rain splash, sheet wash or rill wash, channel erosion in rivers or gullies. The catchment area of the proposed Heo HE Project experiences silt loads in the major river and its tributaries. In the present context, one of the significant negative impacts of soil erosion is the reduction of the life of reservoir of a hydroelectric project. The increased silt in the rivers has severe adverse impacts on the micro- and macro-organisms, above and below ground as well as for the aquatic biodiversity including fishes. There are a number of factors in the Yarjep river basin which are responsible for extensive soil erosion and heavy silt load in the river. In the following section we have described on how to use soil erosion process on Silt Yield Index (SYI).

5.1.4.5.1 *Estimation of Soil Erosion in Catchment*

The entire catchment area has been delineated into 9 sub-watersheds. Detailed drainage map for the entire free draining as well as for each sub-watershed was prepared at 1:50,000 scale. All the rivers and streams have been delineated in each sub-watershed. The areas under different erosion intensities were calculated using GIS software. For the estimation of erosion intensity three spatial factors, soil depth, slope and land use, each with five to seven parameters, were considered during hierarchical querying. For soil depth, deep (score 1), moderately deep (score 2) and moderately shallow (score 3), were used. In case of slope, five parameters, Gently Sloping (score1) to Steep (score 5) were considered and similarly for land use, seven categories of Dense forest (score 1), Open Forest (score 2), Scrub (score 3), Degraded Forest (score 4), Cultivation (score 5), Settlements (score 6), moraines and Barren (score 7) was taken into account for calculating erosion in the catchment area. After running the queries, an area with the final score of 12 or above was designated as having very severe erosion, the score 10 to 12 was designated as severe, 7 to 9 was classified as moderate erosion and score up to 6 was classified as having slight erosion.

As shown in the **Fig.5.1.8,** area with moderate erosion is largely spread in the free draining area with a coverage of 6819.28 ha of land i.e., about 82% of the total free draining area. It is prevalently spread throughout the sub-watersheds. Very severe erosion is the second prevalent form of soil erosion in the free draining area with area coverage of almost 947.86 ha of land, i.e 11%. It is more prominent on the left bank of Yarjep River immediately upstream of the dam site. Very severe erosion is prevalently spread in the sub watersheds of Sb3, Sb4, Sb5, Sb6, Sb7 & Sb8 respectively. Severe erosion is spread in an area of about 400.89 ha of land. It is also prevalent on left bank (see Table 5.1.4).

Table 5.1.4 Area (ha) under different intensity of erosion in the free draining area of Heo HEP

Erosion class	Area (ha)	%
Slight	**105.41**	1.27
Moderate	**6819.28**	82.16
Severe	**400.89**	4.83
Very Severe	**947.86**	11.42
River	**21.58**	0.26
Snow	**4.98**	0.06
Total	**8300**	100.00

5.1.4.5.2 *Sediment Yield Index*

To calculate sediment yield index, methodology developed by All India Soil & Land Use Survey (Department of Agriculture, Govt. of India) was followed, where each erosion intensity unit is assigned a weightage value. When considered collectively, the weightage value represents approximately the relative comparative erosion intensity. A basic factor of K = 10 was used in determining the weightage values. The value of 10 indicates a static condition of equilibrium between erosion and deposition. Any addition to the factor K (10+X) is suggestive of erosion in ascending order whereas subtraction, i.e. (10-X) is indicative of deposition possibilities.

Delivery ratios were adjusted for each of the erosion intensity unit. The delivery ratio suggests the percentage of eroded material that finally finds entry into dam/ reservoir or river/ stream. Area of each composite unit in each sub-watershed was then measured.

Sediment yield index (SYI) was calculated using following empirical formula (for SYI of individual sub-watersheds see Annexure-I).

$$SYI = \frac{\sum (A_{ei} \times W_{ei} \times DR)}{AW} \times 100$$

where,

SYI =Sediment yield index

A_{ei} = Area of composite erosion intensity unit

W_{ei} = Weightage of composite erosion intensity unit

DR = Delivery ratio

AW = Total area of the sub-watershed

5.1.4.5.3 *Erosion Intensity and Delivery Ratio*

Determination of erosion intensity unit is primarily based on the integrated information on soil characters, physiography, slope and land use/land cover. This is achieved through super-imposition of different thematic map overlays. Based on the ground-truth, carried out during the field work, weightage value and delivery ratio were assigned to each erosion intensity unit.

Delivery ratio, which depends on the type of material, soil erosion, relief length ratio, land cover conditions, etc. were assigned to all erosion intensity units depending on their distance from the nearest stream. The criteria adopted for assigning the delivery ratio are as follows:

Nearest Stream	Delivery ratio
0 - 0.9 km	1.00
1.0 - 2.0 km	0.95
2.1 - 5.0 km	0.90
5.1 - 15.0 km	0.80
15.1 - 30.0 km	0.70

5.1.5 PRIORITISATION OF SUB-WATERSHEDS FOR TREATMENT

As previously seen, only the area under very severe and severe erosion has to be considered for treatment in free draining catchment, which is around 1348.75 ha. Out of 1348.75 ha, only 927.27 ha will be treated, because they come below 3000 m elevation and are made of slopes of less than 45°. The remaining 421.48 ha are not suitable for treatment, either due to too high elevation (above 3000 m) or too steep slopes (slopes above 45%).

Based on the Sediment Yield Index (SYI), sub-watersheds that require treatment measures were prioritized using the simple rule that the sub-watersheds with a higher SYI were ranked higher in priority for treatment (Table 5.1.5; see Annexure-I). The sub-watersheds would be treated on priority basis in the treatment scheme to be followed (Table 5.1.5). An index map giving physical targets of the year-wise treatment measures to be undertaken in different sub-watersheds according to their priority ranking for treatment was prepared and is given in **Fig. 5.1.9**.

Table 5.1.5 SYI for different sub-watersheds for Heo H.E Project free draining catchment

Sub-watersheds	Area* (ha)	Gross silt yield	Sediment yield index
Sb1	810.02	11381	1397.37
Sb2	1059.70	15585	1453.15
Sb3	1221.80	17389	1420.30
Sb4	469.75	6634	1395.46
Sb5	863.94	9703	1109.68
Sb6	1282.48	17595	1355.61
Sb7	421.17	5217	1223.94
Sb8	942.76	10600	1121.85
Sb9	1228.39	14387	1157.94
Total	**8300.01**		

5.1.5.1 Year-wise Treatment of Watersheds

Silt yield index (SYI) has been calculated for all the 9 sub-watersheds, following the All India Soil and Land Use Survey (AISLUS) method and the sub-watershed were accordingly prioritized for treatment (Table 5.1.6).

Table 5.1.6 Year-wise treatment of the sub-watersheds

Years	Sub-watershed Name	SYI	Priority Ranking	Treatment Area (ha)
Ist	Sb2	1453.15	1	29.91
	Sb3	1420.30	2	241.28
Total				**271.19**
IInd	Sb1	1397.37	3	7.57

	Sb4	1395.46	4	28.16
	Sb6	1355.61	5	144.67
	Sb7	1223.94	6	85.77
Total				**266.17**
IIIrd	Sb9	1157.94	7	150.76
	Sb5	1109.68	9	44.00
Total				**194.76**
IVth	Sb8	1121.85	8	**195.15**
Grand Total				**927.27**

5.1.6 ACTIVITIES TO BE UNDERTAKEN

For undertaking soil conservation measures in the Heo H.E. Project catchment area up to barrage site various indirect or preventive measures like biological measures and direct or remedial measures like engineering measures have been discussed in the following paragraphs. Even as suggestions have been made regarding certain specific treatment measures to be undertaken in a particular sub-watershed, these measures, however, may require further micro-planning during the implementation stage (Table 5.1.7).

5.1.6.1 Preventive Biological Measures

It is always better to undertake preventive measures than to mitigate the factors that ultimately lead to soil erosion. Such preventive measures will indirectly help to conserve soil in the long run, keeping in view the importance of integrating eco-restoration strategy with socio-economic needs of the local community wherein both ecology and economics are developed. The preventive measures that are suggested for the project area have been discussed below.

a) ***Afforestation***

In the upland region like this project area, the trees and vegetation cover play an important role in the conservation of soil and ecology. Afforestation program would be taken up in such forest areas that contain large patches of barren grassy slopes and are generally devoid of trees. In critically degraded areas, plantation of locally useful, diverse and indigenous plant species such as *Alnus nepalensis, Alangium chinense, Altingia excelsa, Bischofia javanica, Pterospermum acerifolium*, etc. would be undertaken. Afforestation measures would be taken up under catchment area treatment plan on 256.36 ha. An outlay of **Rs.140.22 lakhs** (0.55 Lk / ha) has been provided to cover various areas under afforestation in different sub-watersheds.

Table 5.1.7 Watershed-wise details of various activities

S.No.	Name of Sub-watershed	Component								
		Engineering Measures				Biological Measures				
		Gully Control			Bench Terracing	Afforestation	NTFP Regenera-tion/ Medi-cinal Plants Cultivation	Assisted Natural Regenera-tion	Pasture Improve-ment	Total
		Brushwood Check dams (Nos.)	DRSM checkdams (Nos.)	Contour Bunding (ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)
1.	Sb1	2	5	1	3	2.07	1	0	0.5	**7.57**
2.	Sb2	6	4	5.25	8.46	6.75	2.82	1.80	4.83	**29.91**
3.	Sb3	12	20	35.50	48.70	75.42	25	20.16	36.50	**241.28**
4.	Sb4	3	9	10.15	5.75	5.72	3	1	2.54	**28.16**
5.	Sb5	11	13	5.50	4.25	9.85	8.10	7.10	9.20	**44.00**
6.	Sb6	20	25	28.25	35.50	30.80	15	12.17	22.95	**144.67**
7.	Sb7	15	11	10.67	16	21.10	12	8	18	**85.77**
8.	Sb8	28	30	42.20	55.35	48.80	12	15.70	21.10	**195.15**
9.	Sb9	21	28	27.45	32.28	55.85	14	11.10	10.08	**150.76**
	Total	**118**	**145**	**165.97**	**209.29**	**256.36**	**92.92**	**77.03**	**125.70**	**927.27**

Afforestation Programme

Different types of plantations would be undertaken under afforestation programme according to the methodology described below. The plantations that would be undertaken in the forest (scrub/degraded forest) would have a planting density of 1600 plants per ha and vegetative hedge in contour trenches. Contour planting conserves soil and enhances moisture regime and adverse effect of surface run off of rain water is reduced considerably. Trenches, pits and plants along the contour reduce velocity of water, increase soil moisture and facilitate seepage of water in soil and reduce soil loss resulting in better growth of plants. Hence, soil working and planting along contours would be strictly followed in the project.

In the afforestation areas, the digging of trenches and pits would be along the contour. About 20 to 30 m long contour trenches would be dug leaving a space of 50 cm (septa) between the two consecutive trenches. Soil would be dug on the lower side of the trench and after removing pebbles and weeds, the trench would be half refilled with soil and remaining soil would be collected to form berm on lower side of trench. On the berm, seeds of shrubs/hedges like *Arenga saccharifera*, *Calamus erectus, Bambusa tulda, Debregeasia longifolia*, *Mussaenda roxburghii,* etc. would be sown to raise vegetative barrier. The size of pits would be 45 cm^3. The contour trenches would be at an interval of 5 m.

For digging 1600 pits per ha, pits would be dug 15 cm uphill side from the contour trenches. The spacing of pits along contour trench will not be closer than 1.25 m. In afforestation areas soil working would be started in October-November and would be completed by March. It is important that filling of pits and half filling of trenches is completed before the onset of monsoon, otherwise dug soil will be washed away by rains leaving only stones and pebbles near the pit. Extreme care would be taken in transporting the plants from nurseries to the plantation site to avoid any damage. Planting would be completed before the monsoon period is over. With a view to conserve not only soil and water but also for fuelwood production, it is important to raise the vegetative barrier of hedge plants. The seeds of hedges like Bambusa, *Debregeasia*, *Melocalamus*, *Pinanga,* etc. will be sown in contour trenches before the onset of monsoon. When the water of surface run-off reaches the line of hedges, its speed is checked and silt is stopped by the hedge plants and only percolated water passes down slowly. Hedges spread and grow well in the silt left behind and form a natural terrace. The plants planted in the pits near contour trenches get more moisture and grow fast.

Choice of Species

The species for plantations would be selected after considering altitude, aspect, biotic pressures, soil depth, moisture, etc. As there is pressure of cattle grazing, non-fodder/ fuelwood species would also be planted in suitable proportion in between the fodder species. The tree species that would be planted under this programme are: *Actinodaphne obovata, Altingia excelsa* (Jutli), *Castanopsis indica* (Hingori)*, Cinnamomum tamala* (Tej Pata)*, Ficus benjamina, Gynocardia odorata, Toona ciliata* (Poma), etc.

There are many shrubby plant species which are suitable for fodder/ fuelwood plantations, which are**:** *Bambusa tulda, B. pallida, Bauhinia variegata, Ficus auriculata* and *Morus alba.* The important legumes and grasses that would be planted are C*hrysopogon gryllus*, *Lolium perenne*, *Pennisetum purpureum*, *Thysanolaena latifolia* and *Themeda arundinacea* among grasses and White clover (*Trifolium repens*), Red clover (*Trifolium pratense*), Lucerene (*Medicago sativa*), Vetch (*Vicia villosa*), and Caucasian clover (*Trifolum ambiguum*) among legumes. The plant species suitable for avenue and ornamental purposes are: *Altsonia scholaris, Bauhinia variegata*, *Cassia fistula*, *Delonix regia, Erythrina stricta*, *Exbuclandia poulnea*, *Hibisicus rosa-sinensis* and *Polyalthia longifolia*.

Fencing

Stone wall 120 cm high and 45 cm wide or 4 strand barbed wire fencing would be erected during first year along with soil working. The cooperation of local villagers would be sought for the success of the plantation programmes.

Weeding and Mulching

Weeding, hoeing and mulching would be carried out during October-November. Weeding and loosening of soil by hoeing break the capillary action in soil and thus reduce the moisture loss. Mulching reduces evaporation and conserves soil moisture and adds humus to soil. Cut and uprooted weeds and grasses used as mulching material would be spread around the plant.

Watch and Ward and Fire Protection

Protection of plantation is the greatest challenge as some inhabitants and their livestock may damage the plantation before it is established. Hence the protection of plantation particularly in the

juvenile stage is of paramount importance and watchmen/ guards would be engaged from the nearby villages for the required job. Besides the above, other appropriate measures would be adopted to ward off these potential threats.

b) ***Assisted Natural regeneration in existing forest***

In some of the forest areas, conditions are conducive to natural regeneration provided that some sort of assistance is provided. Such areas shall be taken up under this component. The areas shall be closed to exclude biotic interference. Forest floor will be cleared of slash; debris and felling refuse to afford a clean seedbed to the falling seed. At certain places some soil raking may also have to be done to facilitate germination of seeds. Where natural regeneration is found deficient, it will be supplemented by artificial planting. Patch sowing in suitable areas may also be done. Bush cutting & cleaning operations are done depending on necessity. Up to 800 plants or patches per hectare will be planted /sown to hasten the process of regeneration in the area uniformly. An outlay of **Rs.11.49 lakhs** @ Rs 14,612/- per ha (see Annexure II) has been made to cover 77.03 ha.

c) NTFP Regeneration

Arunachal Forest Division is rich in a variety of Non Timber Forest Produce (NTFP). However, because of over-exploitation of NTFP in the past there has been depletion of this valuable resource. Therefore, in order to augment natural stock of NTFP in the forests, it is proposed to take up planting of NTFP and establishing nurseries. An outlay of **Rs.50.20 lakhs** @ Rs. 45,422/- per ha (Annexure II) has been suggested to cover about 92.92 ha for establishing (Rs.42.21 lakhs) and maintenance (Rs.7.99 lakhs) of this facility for three years.

d) Grazing Land/Pasture Improvement

The livestock owned by the local communities exert significant pressure on the natural habitats. In order to improve the grazing areas/pastures and to make these sustainable, the degraded areas, particularly among community lands will be taken up for treatment under silvi-pastoral model. An outlay of **Rs.32.14 lakhs** @ Rs.24,765/- per ha (Annexure II) has been earmarked for this purpose and it will cover about 125.70 ha of land for development at a cost of Rs.13.13 lakhs and its maintenance will cost Rs.0.90 lakhs for four years.

e) Forest infrastructure development

For efficient management of forest resources, it is essential that field infrastructure of the State Forest Department of the area is adequately developed. Given the rugged mountainous terrain, there is a need to improve the existing forest roads and paths. Motorable roads would be avoided in the forests of the catchment area as this would lead to habitat fragmentation, degradation and soil erosion will lead to increased siltation. Only bridle paths, inspection paths and footbridges shall be constructed or improved for which an amount of **Rs. 80.00 lakhs** has been earmarked (Table 5.1.8). Similarly, in remote localities of the Forest divisions there are no places for shelter for the staff, local people, tourists or trekkers. Therefore, following provisions will be undertaken in the CAT Plan.

5.1.6.2 Treatment Measures: Engineering Measures

Gully erosion is one of the concerned soil erosion in the slope and hilly areas. The gullies would be treated with the help of engineering/ mechanical as well as vegetative methods. Check dams would be constructed in some of the areas to promote growth of vegetation that will consequently lead to the stabilization of the slopes/area and prevention of further deepening of gullies and erosion. For controlling the gullies, the erosive velocities are reduced by flattening out the steep gradient of the gully. This is achieved by constructing a series of checks which transform the longitudinal gradient into a series of steps with low risers and long flat treads. Different types of check dams would be required for different conditions comprising different materials depending upon the site conditions and the easy availability of material at local level.

In addition to the vegetative measures used for stabilization of gullies, temporary or permanent mechanical measures will be used as supplementary measures to prevent the washing away of young plantations by large volume of runoff. The gullies get stabilized over a period of time with the establishment and growth of vegetation cover. With the passage of time mechanical structures weaken and vegetative measures get strengthened.

For engineering measures following types of checkdams are suggested.

a) *Brushwood checkdams*

The main advantage of brushwood checkdams is that they are quick and easy to construct and are inexpensive as they are constructed by using readily available materials at the site. In

brushwood checkdams, small branches preferably of coppice species are fixed in two parallel rows across the gully or nala and packed with brushwood between the rows of these vertical stakes. The vertical stakes are tied down with wires or fastened with sticks across the top. The important consideration in erecting brushwood checkdams is to pack the brushwood as tightly as possible and to secure it firmly. This type of checkdam is generally constructed over small gullies or at the starting stretch of gullies (see **Plate 5.1.1**). In all, 118 brushwood checkdams/ vegetative spurs would be constructed to check gully erosion, stream bank protection and slope stabilization works (Table 5.1.7).

b) ***Dry Rubble Stone Masonry (DRSM) checkdams***

The site where DRSM checkdams are to be constructed is cleared and the sides are sloped 1:1. The bed of gully is excavated for foundation to a uniform depth of 0.45 m to 0.60 m and dry stones are packed from that level. Over the foundation, DRSM super structure of checkdam is constructed. The stones are dressed and properly set in with wedges and chips. The width of checkdam at the base should be approximately equal to maximum height and successive courses are narrower so the section is roughly a trapezium. It is common to find upstream face of checkdams vertical with all slopes on the downstream face but while there is sound engineering reason for this in case of large checkdams, it is not of any use in small gully control dams. In the centre of the dam portion sufficient waterway is allowed to discharge the maximum run off. The dry stone work should go up to 0.30m to 0.60m in the stable portion of the gully side to prevent end-cutting. Sufficient apron is provided to prevent scouring of the structure. The thickness of the apron packing would be about 0.45 m and gully sides above the apron have to be protected with packing to a height of at least 0.30 m above the anticipated maximum water level to prevent side scour being formed by the falling water. For gully control measures, 145 DRSM checkdams would be constructed (Table 5.1.7, **Plate 5.1.2**).

c) ***Slope modification by Stepping/ Bench Terracing***

Bench terracing is one of the most popular mechanical soil conservation practices adopted by farmers in India and many other countries. It is constructed in the form of step like fields along contours by half cutting and half filling and would result in the conversion of the original slope into leveled fields. Thus, hazards of erosion are eliminated and manure and fertilizers applied are retained in the leveled fields. The sloping fields in the valley need to be bench terraced by cutting and filling

with the latter supported by retaining stone walls. While making bench terraces, care will be taken not to disturb the top soil by spreading earth from the lower terraces to higher terraces. The vertical intervals between the terraces will not be more than 1.5 m and cutting depth would be kept at 50 cm. The minimum average width of the terrace would be 4 to 5 m to enable the usage of prolong hinge. The shoulder bunds of 30 x 15 cm would also be provided. The excess water from the terraces will be drained off by staggered channels. An area of 209.29 ha will be covered under this plan.

5.1.6.2.1 Socio Economic Development for PAFs

Socio Economic Development component for project affected families has been incorporated as per MoEF guidelines to be implemented by Van Panchayats or Joint Forest Management Committees. A lump sum amount of Rs.50.00 lakhs has been allotted for this component.

5.1.6.2.2 *Administrative Setup*

The catchment area treatment (CAT) project involves intensive and highly technical operations, which require the expertise of technical personnel. It is, therefore, recommended that the existing forest staff of Arunachal Pradesh Forest Division in the area look after all the works to be carried out under the CAT plan including plantation and maintenance as all the areas to be covered under CAT plan fall under these divisions. However, temporary staff may be engaged for the purpose during the project implementation period, i.e. for about five years.

Beside, several parallel activities should be undertaken to meet the various biological and engineering measure in process. These activities are Nursery development and forest infrastructure development. Other than that, some financial activities are also projected in the CAT plan. Activities such as Ecotourism and Eco-restoration can be promoted, and are formulated to improve the unemployment situation at local level.

a) *Baseline survey and study*

An amount of Rs. 10.00 lakhs has been proposed for Baseline survey and study purpose.

b) *Nursery Development*

Proper development of nursery and allied services, like drip irrigation or micro-irrigation, will be crucial for successful execution of CAT plan. It will be important to prepare a stock of plant material for the supply of saplings for afforestation program and various other activities. Main nursery

may be developed near the dam site and the proposed colony areas, preferably along the road side for easy accessibility. This area possesses necessary infrastructure and various raw materials for nursery development can be easily made available. In addition, provision will also be made for two green-houses/chick houses for maintaining plant saplings. The estimated cost for the development of nursery and greenhouses will be around **Rs.25 lakhs**. Development of nursery will start from the zero year and will continue for 5 years. During maintenance year (2 to 5 year) nursery will supply plants wherever required for the replacement.

c) *Forest Infrastructure Development*

The works of the catchment area treatment plan will be executed by the Forest Department, Government of Arunachal Pradesh. These works will be an additional responsibility for the Forest Department that may not have adequate facilities and infrastructure to execute the work as suggested in the plan. Therefore, provision has been made in the CAT plan to develop the infrastructure of Forest Department in the region and accordingly a budget of **Rs. 80.00 lakhs** is proposed for this purpose (Table 5.1.8).

Table 5.1.8 Budget for development of State Forest Department infrastructure

S.No.	Components	Qty./Unit	Total Amount (Rs. In Lakhs)
1.	Forest Office Establishment (one office)	-	27.00
2.	Forest Fire Fighting System	-	7.00
3.	Office Vehicle	1 No.	8.00
4.	Road and Foot Path Development	-	9.00
4.	Machinery & Equipment*	-	6.00
4.	W & W	8 Nos.	7.00
5.	Monitoring & Evaluation	-	4.00
6.	Adm. Cost	-	7.00
7.	Contingency	-	5.00
	Total		**80.00**

* Machinery & Equipment : Computers, Laptop, Photocopier, Digital Camera, etc.

5.1.6.2.3 *Eco-restoration*

There is urgent need to reduce the dependency of local population on the forest and other natural resources which are under severe pressure. The eco-restoration works and other activities

related to area development and employment generation are suggested and should be carried out through community welfare committees (CWC) of local villages. These should include the following measures, which would help in rejuvenating the ecosystems and in reducing the soil erosion in the region.

- Plantation in the degraded patches of community/civil/ forest land.
- Water conservation and harvesting in the villages.
- Soil conservation measures in village areas.
- Improvement in agricultural and horticultural practices.
- Technical and financial support for harnessing alternate energy sources such as micro-hydel and non-conventional energy (solar power and solar heating) to reduce pressure on the forest for fuel wood
- Rural technology support programmes.
- Awareness programmes for conservation of wildlife and natural resources.
- Promotion of income generating schemes like ecotourism.
- The total cost estimate for these activities is proposed as **Rs. 4.87 lakhs** (Table 5.1.9).

5.1.7 SCHEDULE OF TREATMENT PLAN

The total time scheduled for the execution of the planned CAT works has been kept at 5 years (including 1 year for maintenance). Accordingly, areas from each sub-watershed have been prioritized for treatment and a year-wise plan has been assigned (**Fig. 5.1.10**). Zero Year has been kept for the development of nursery and raising sapling for plantation. Maximum area for treatment will be taken up in the first year and minimum will be taken up in the third year. In the first and second years the areas taken up for treatment are 271.19 ha and 266.17 ha, respectively and in the fourth year the area to be taken up for treatment is 195.15 ha. Accordingly, a separate budget for the maintenance is given in Table 5.1.9.

5.1.7.1 Monitoring and Evaluation

Monitoring and evaluation will be developed as in built part of the project management. Thus, a process of self-evaluation at specified intervals of time will ensure the field worthiness and efficacy of the CAT plan.

Annual work plan for each sub-watershed would be prepared well in advance specifying physical and financial targets, sites, locations and beneficiaries of each component of the project activity. Month-wise work scheme of various items of each component for the financial year would also be prepared in advance and its timely implementation would be ensured. Monthly progress report on all activities would be submitted by the Range Officers to Divisional Forest Officer for its subsequent submission to the project authorities and Ministry of Environment & Forests, Government of India. The monitoring committee appointed for this purpose would also monitor on a regular basis the quality and quantity of works carried out in the area.

For monitoring, reference points of silt load observation in the river are suggested to install silt recording station upstream of dam site in Yarjep River to evaluate the impact of the soil conservation measures. A sum of **Rs. 56.89 lakhs** has been provided for monitoring and evaluation.

5.1.8 PERIOD AND SCHEDULE OF IMPLEMENTATION

The execution of CAT plan in Heo H.E. Project area would require extensive efforts on the part of executing agencies. Keeping in view the local topography and climate, it is being estimated that the entire treatable area would require at least 4 years to be completed. However, the maintenance of plantations would continue for one year and accordingly CAT plan has been prepared for 5 years. All these works would have to start with the pre-construction activities especially the studies in respect to micro-planning for each sub-watershed, which would require further detailed investigations. Based on the silt yield index of the sub-watersheds, the conservation measures would be first taken up in sub-watershed Sb2, Sb3, etc. (For details see Annexure-1). The year-wise index map of schedule of implementation of different conservation measures under CAT plan has been given in **Figure 5.1.10**. Table 5.1.10 gives the year-wise physical details of various engineering and biological treatment measures to be undertaken.

5.1.9 COST ESTIMATES

The total estimated cost of catchment area treatment plan to be spent over a period of five years is **Rs. 711.40 lakhs**. The details of cost estimates and physical work schedule as well as phasing of expenditure are given as follows in Tables 5.1.9. All the costs towards the administration during the implementation work have been included in the cost estimates of CAT (Table 5.1.9).

Table 5.1.9 Component-wise cost estimate for catchment area treatment works

S. No.	Item of Work	Unit	Qty.	Rate (Rs.)	Amount (Rs. in lakhs)
A.	**Engineering Measures**				
1.	Gully Control				
	a) Brushwood checkdams	Nos.	118	32,300/-	38.11
	b) DRSM checkdams	Nos.	145	41,345/-	59.95
	c) Contour Bunding	ha	165.97	31,100/-	51.62
2.	Bench terracing	ha	209.29	9,300/-	19.46
	Total (1+2)				**169.14**
	Add 5% for maintenance of structures				8.46
	Sub-total (A)				**177.60**
B.	**Biological Measures**				
1.	Afforestation				
	i) Creation	ha	256.36	48,500/-	124.33
	ii) Maintenance			6,200/-	15.89
2.	Assisted natural regeneration in existing forests				
	i) Creation	ha	77.03	14,612/-	11.26
	ii) Maintenance (see Table 2.14)			300/-	0.23
3.	NTFP Regeneration				
	i) Creation	ha	92.92	45,422/-	42.21
	ii) Maintenance (see Table 2.15)			8,600/-	7.99
4.	Pasture development				
	i) Creation	ha	125.70	24,765/-	31.12
	ii) Maintenance			715/-	0.90
5.	Nurseries				25.00
	Sub-total (B)				**258.94**
C.	**Socio – Economic activities**				**50.00**
	Sub-Total (A+B+C)				**486.54**
D.	**Micro-planning @ 3% of (A+B)**				14.60
E.	**Baseline survey and study**				**10.00**
F.	**Establishment Cost @ 7%**				34.06
E.	**Forest Infrastructure** Vehicles, machinery & equipment, paths, etc.				80.00
F.	**Eco-restoration @ 1%**				4.87

G.	**Contingency @ 5%**	24.33
H.	**Monitoring and evaluation**	57.00
	Grand Total (A to H)	**711.40**

Table 5.1.10 Physical and Financial layout plan of Catchment Area Treatment for Heo H.E. Project — **Amount in lakhs**

S. No.	Item of Work	Unit	0th Year		Ist Year		IInd Year		IIIrd Year		IVth Year		Vth Year		Total	
			Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin	Phy	Fin
A.	**Engineering Measures**															
1	Gully Control															
	a) Brushwood checkdams	Nos.			34	10.98	33	10.66	26	8.4	25	8.07			118	38.11
	b) DRSM checkdams	Nos.			42	17.36	41	16.95	32	13.23	30	12.4			145	59.94
	c) Contour Bunding	ha			48.13	14.97	46.47	14.45	36.51	11.36	34.86	10.84			165.97	51.62
2	Bench terracing	ha			60.69	5.64	58.6	5.45	46.04	4.28	43.95	4.09			209.28	19.46
	Total (1+2)															
	Add 5% for maintenance of structures					2.45		2.38		1.86		1.77				
	Sub-total (A)					**51.4**		**49.89**		**39.13**		**37.17**				
B.	**Biological Measures**															
1	Afforestation															
	i) Creation	ha			74.34	36.05	71.78	34.81	56.4	27.35	53.84	26.11			256.36	124.32
	ii) Maintenance							4.61		4.45		3.5		3.34		15.90
2	Assisted natural regeneration in existing forests															
	i) Creation	ha			22.34	3.27	21.57	3.15	16.95	2.48	16.17	2.36			77.03	11.26
	ii) Maintenance (see Table 2.14)							0.07		0.06		0.05		0.05		0.23
3	NTFP Regeneration															
	i) Creation	ha			26.95	12.24	26.02	11.82	20.44	9.29	19.51	8.86			92.92	42.21
	ii) Maintenance (see Table 2.15)							2.32		2.24		1.76		1.68		8.00
4	Pasture development															
	i) Creation	ha			36.45	9.03	35.2	8.72	27.65	6.85	26.4	6.54			125.7	31.14
	ii) Maintenance							0.26		0.25		0.2		0.19		0.90
5	Nurseries	ha		6.25		5.5		4.25		3.75		3		2.25		25.00
	Sub-total (B)			**6.25**		**66.09**		**70.01**		**56.72**		**52.38**		**7.51**		**258.96**
C.	**Socio - Economic Activities**					15		15		15		5				50.00
	Sub-Total (A+B+C)			**6.25**		**132.49**		**134.9**		**110.85**		**94.55**		**7.51**		**486.55**
D.	**Micro-planning @ 3% of (A+B+C)**					4.38		3.65		2.92		2.19		1.46		14.60
E.	**Baseline survey and study**					10										10.00
F.	**Establishment Cost @ 7%**			0.44		9.27		9.44		7.76		6.62		0.53		34.06
G.	**Forest Infrastructure**					24		20		16		12		8		80.00
	Vehicles, machinery & equipment, paths, etc.															
H.	**Eco-restoration @ 1%**			0.06		1.32		1.35		1.11		0.95		0.08		4.87
I.	**Contingency @ 5%**			0.31		6.62		6.75		5.54		4.73		0.38		24.33
J.	**Monitoring and evaluation**					17.1		14.25		11.4		8.55		5.7		57.00
	Grand Total (A to H)			**7.06**		**205.18**		**190.34**		**155.58**		**129.59**		**23.66**		**711.4**

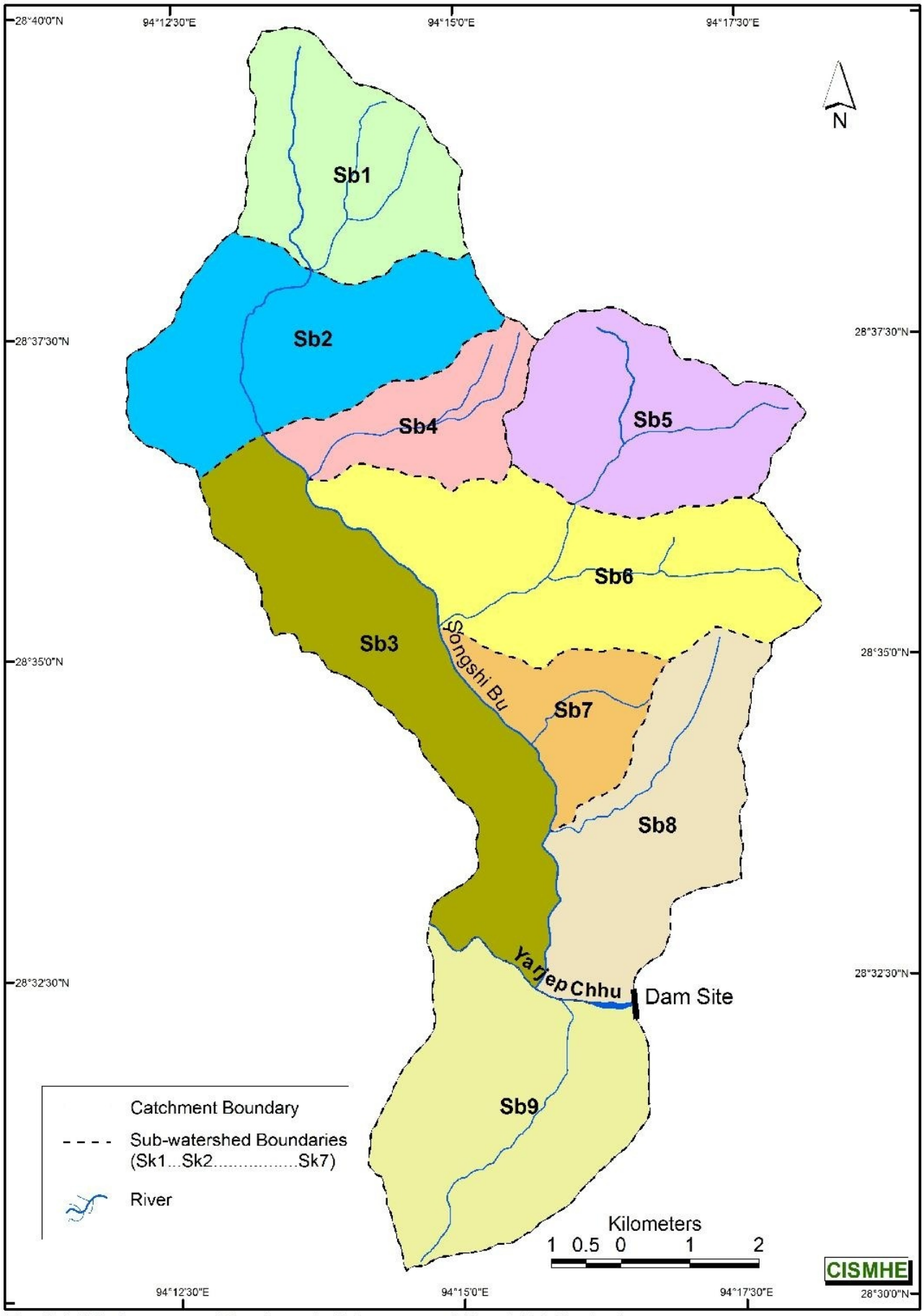


Fig.5.1.1 Index map of the free-draining area of Heo H.E. Project

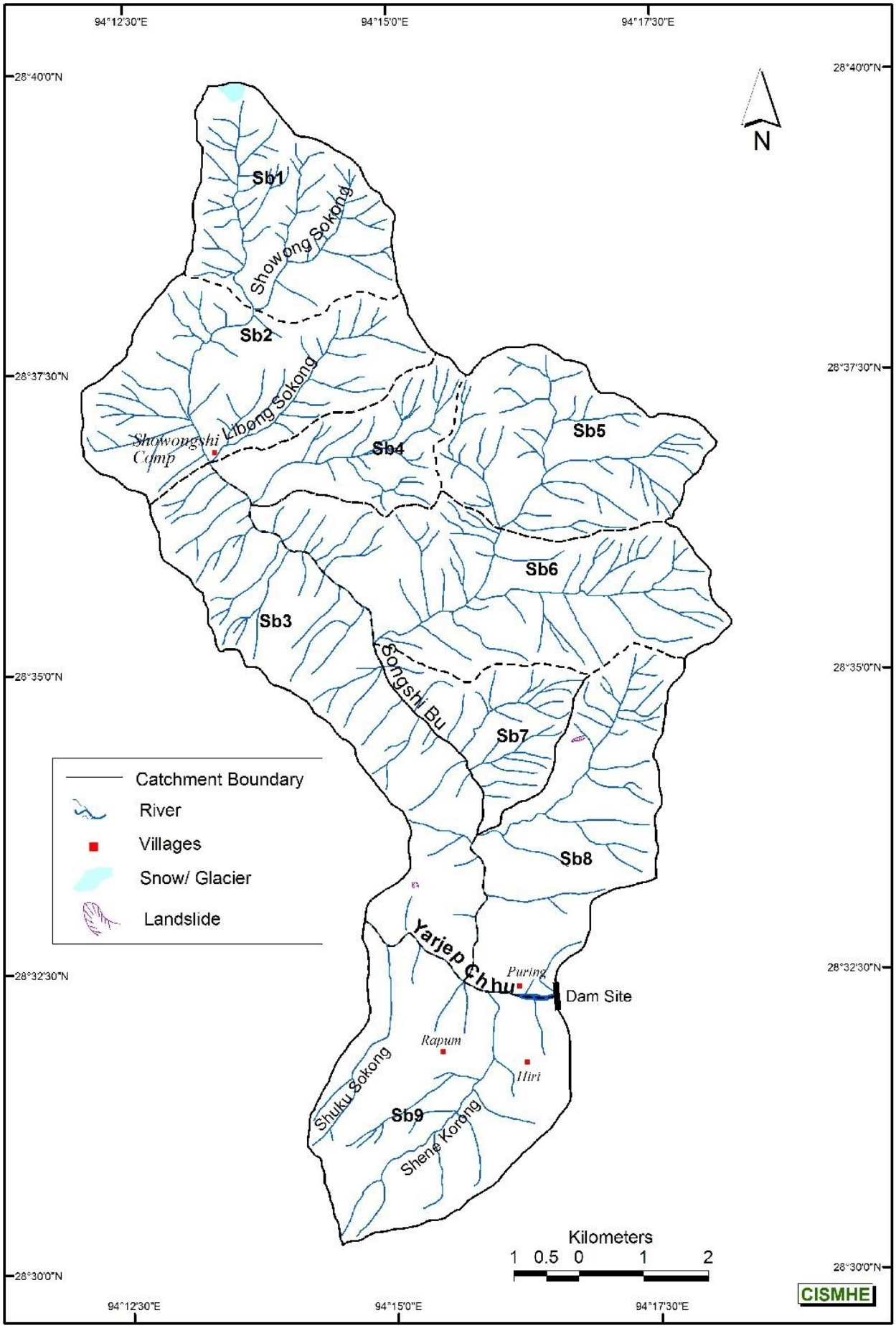


Fig.5.1.2 Drainage map of free-draining area of the Heo H.E. Project

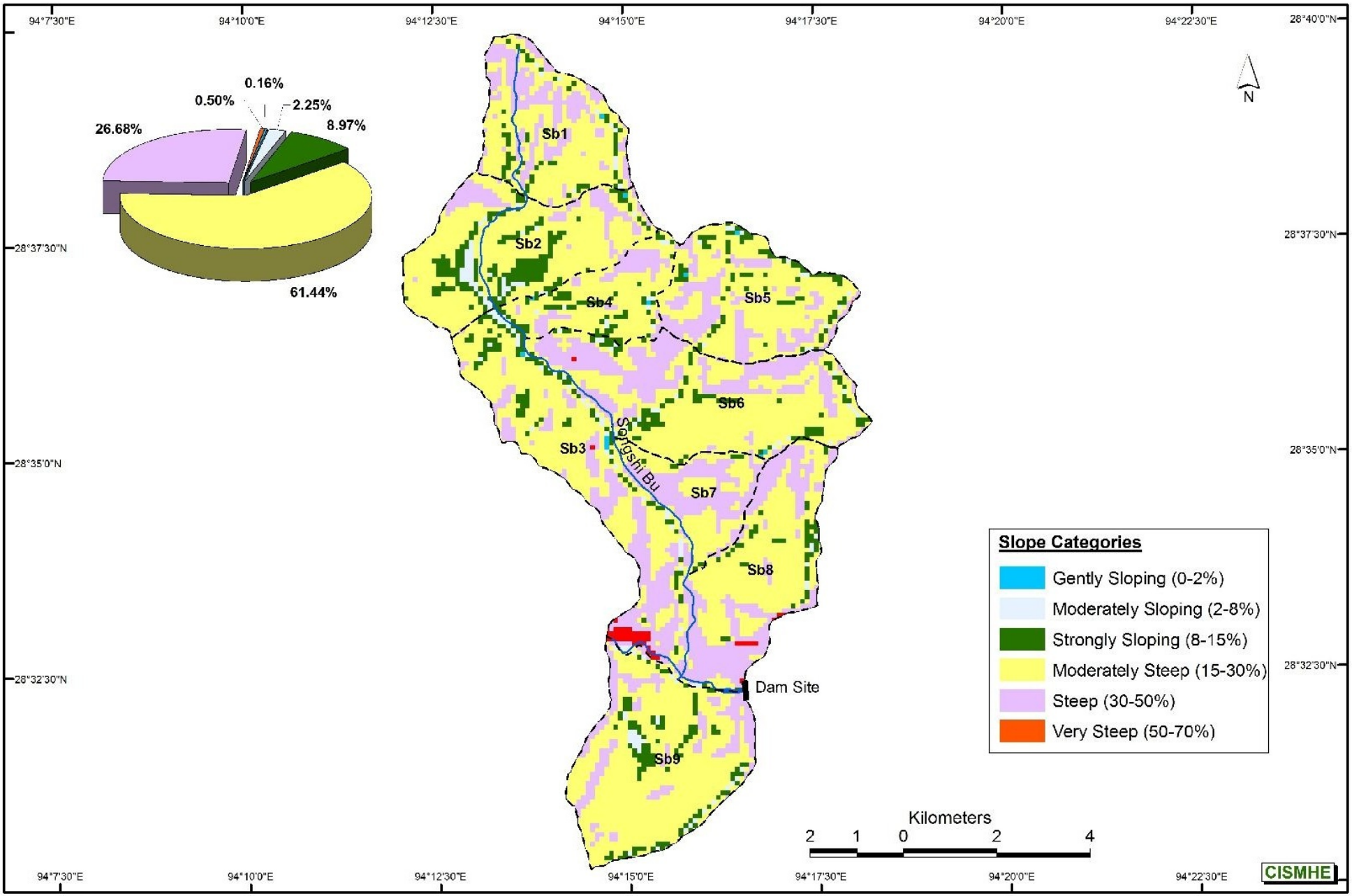


Fig.5.1.3 Slope map of the Heo H.E. Project free-draining area

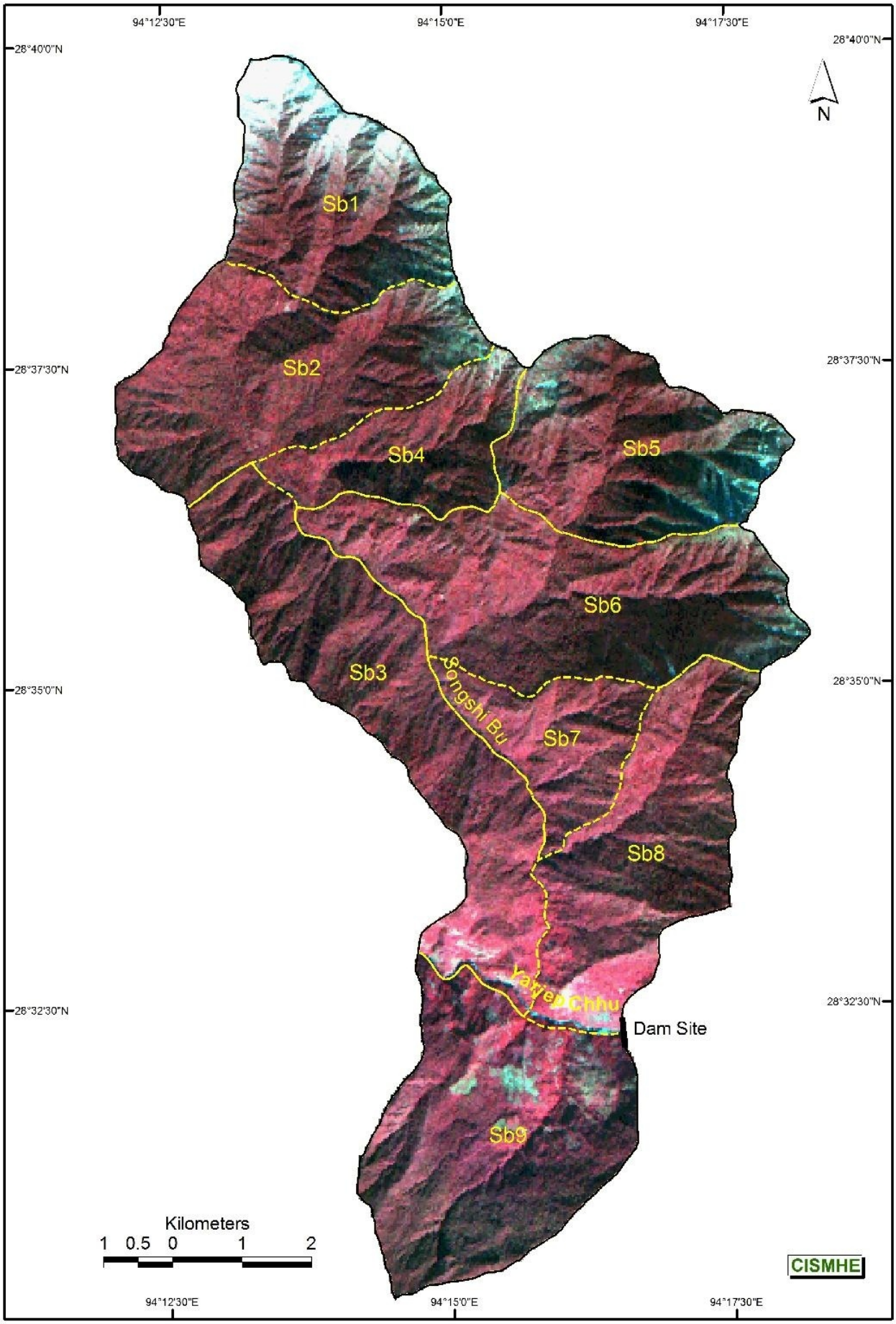


Fig.5.1.4 False Colour Composite (FCC) generated from IRS-P6 LISS-III, 2006 of the proposed Heo H.E. Project

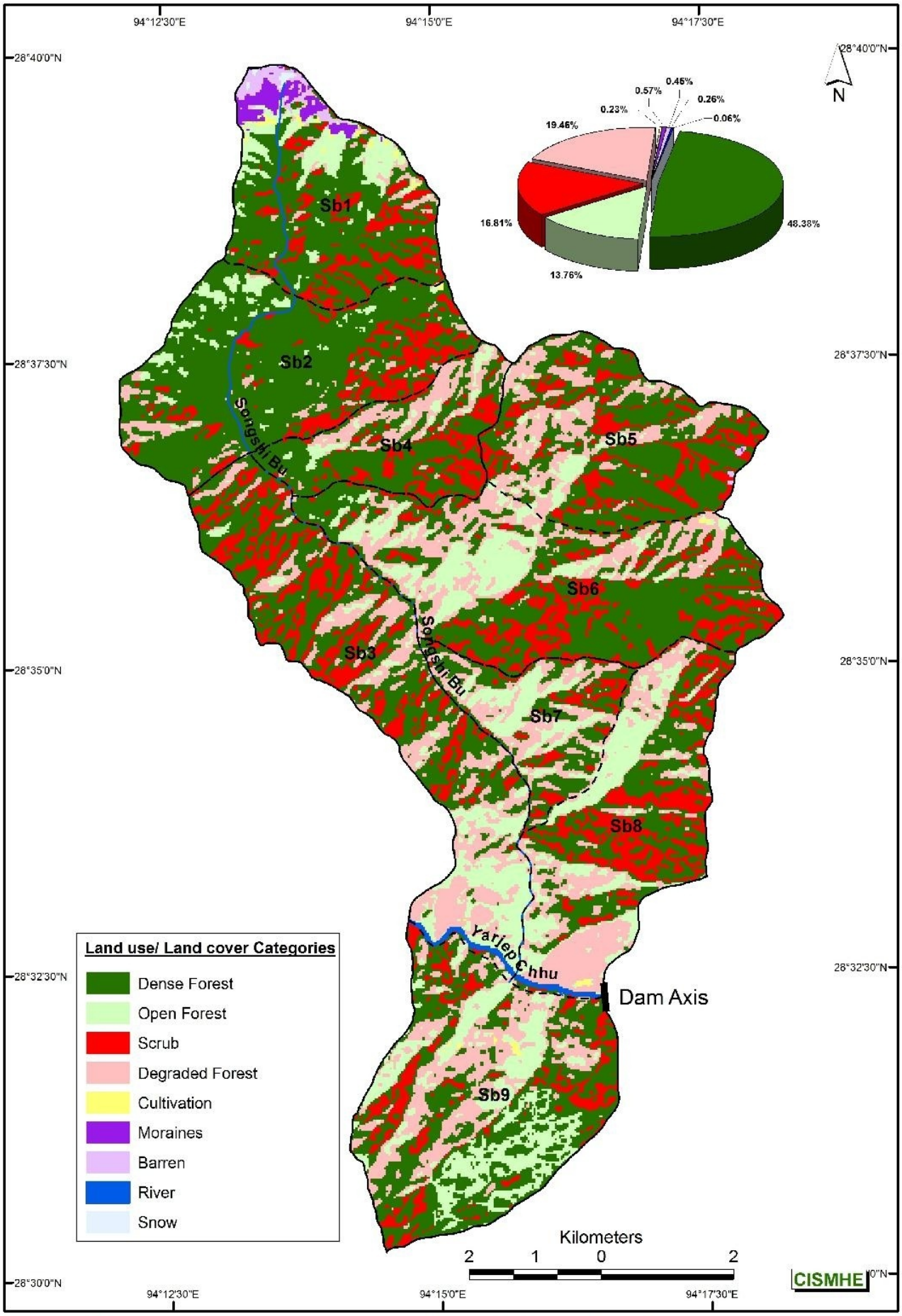


Fig.5.1.5 Land use/ land cover map of the Heo H.E. Project free-draining area

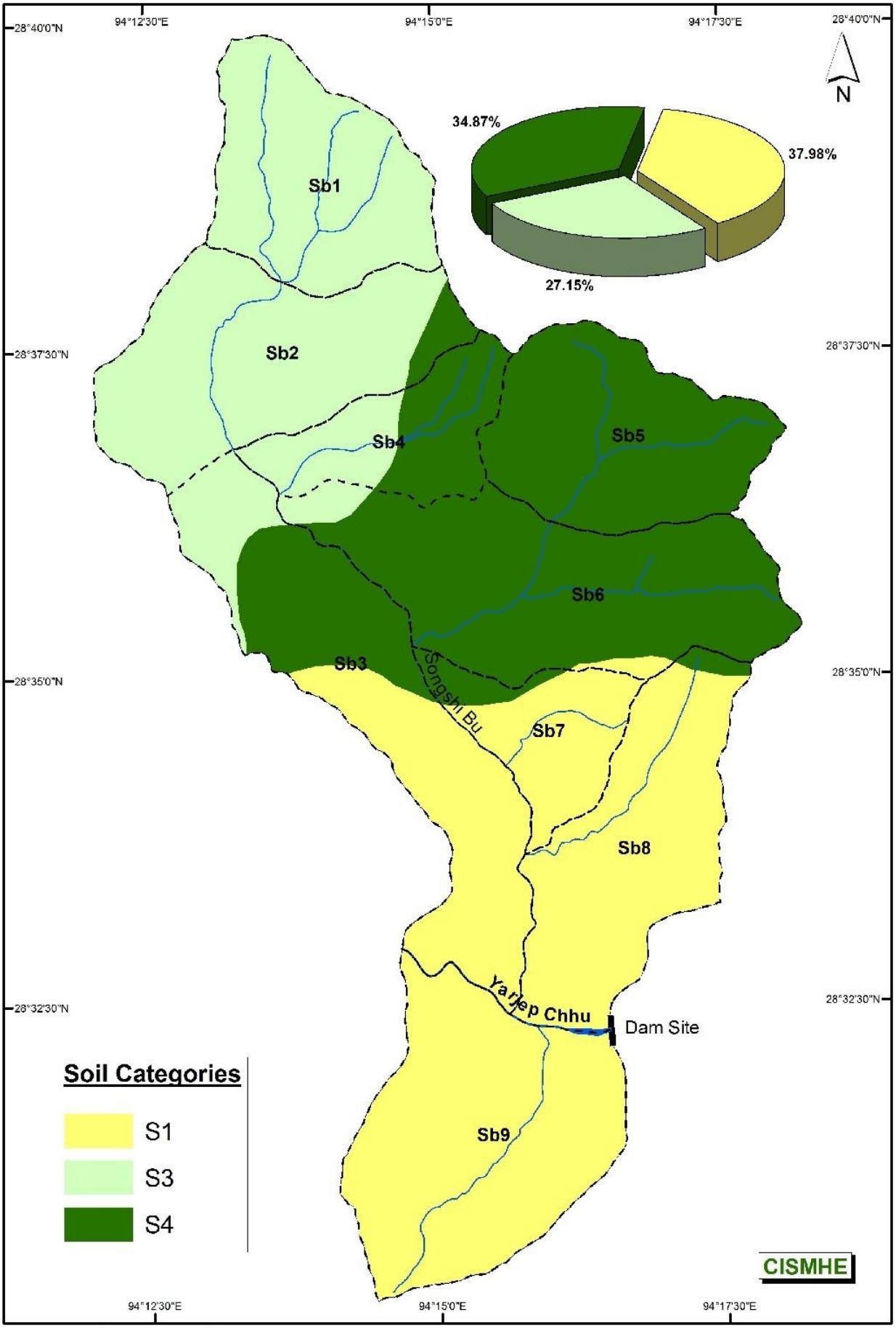


Fig.5.1.6 Soil map of the Heo H.E. Project free-draining area

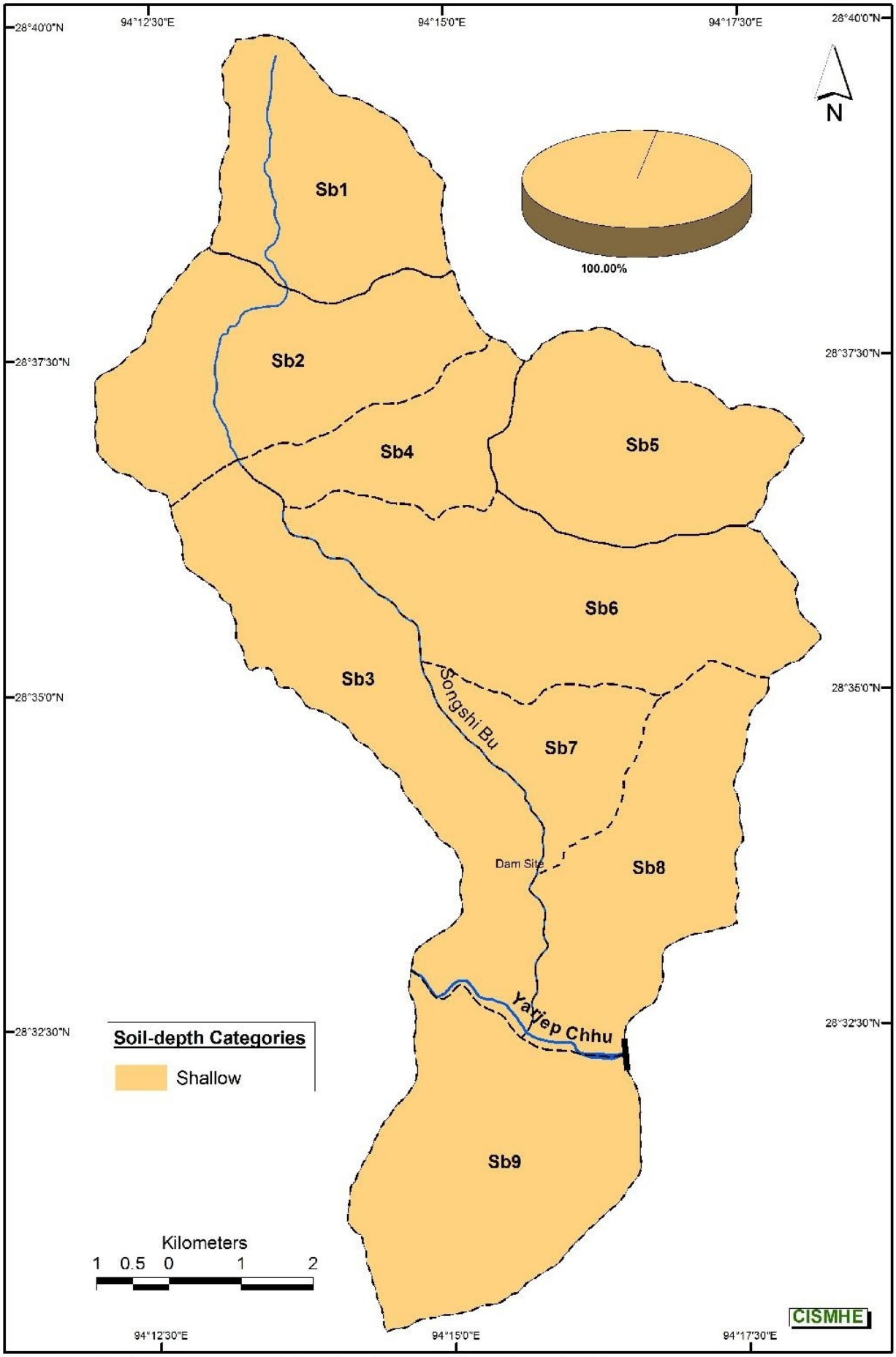


Fig.5.1.7 Soil-depth map of the Heo H.E. project free-draining area

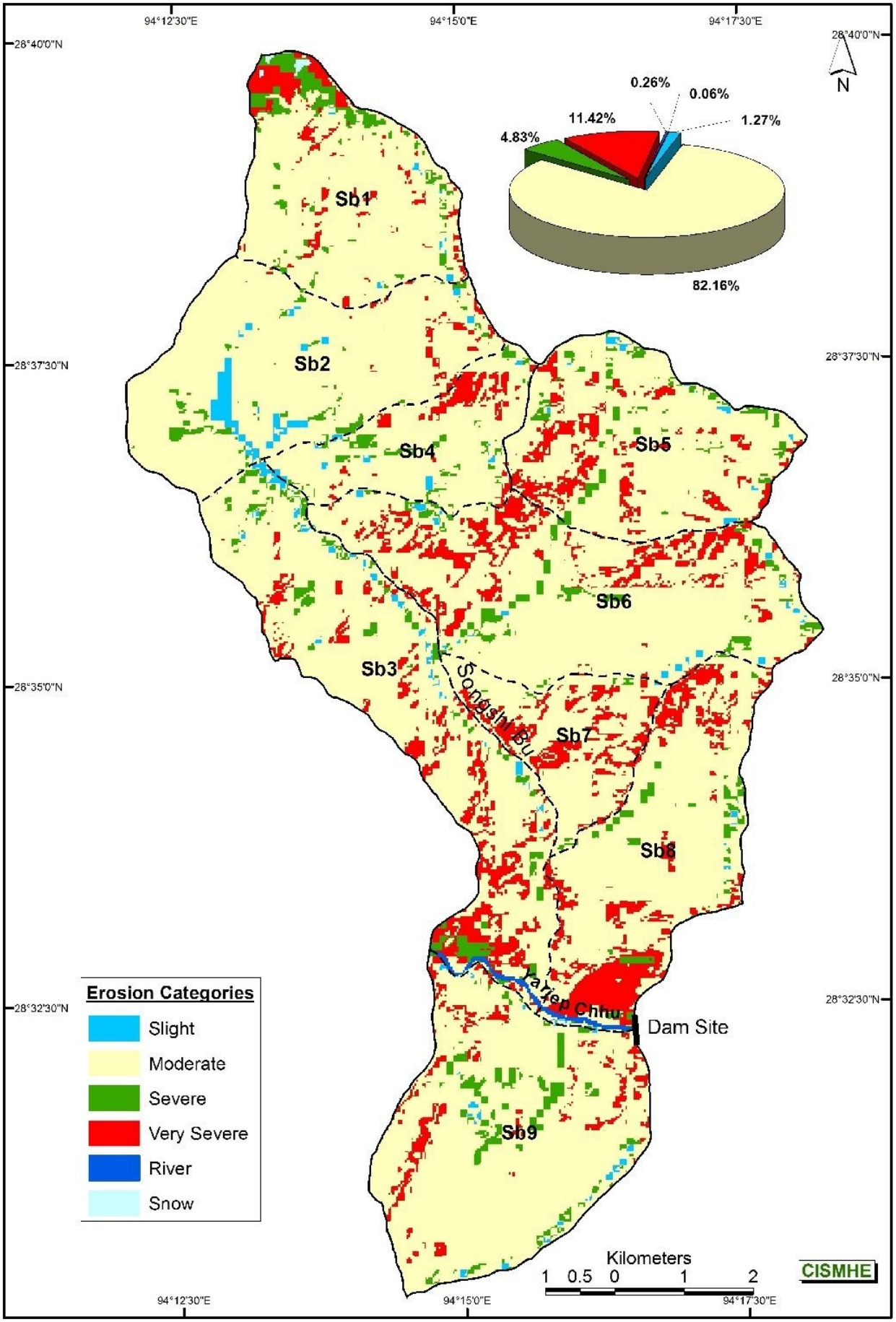


Fig.5.1.8 Erosion map of the Heo H.E. Project free-draining area

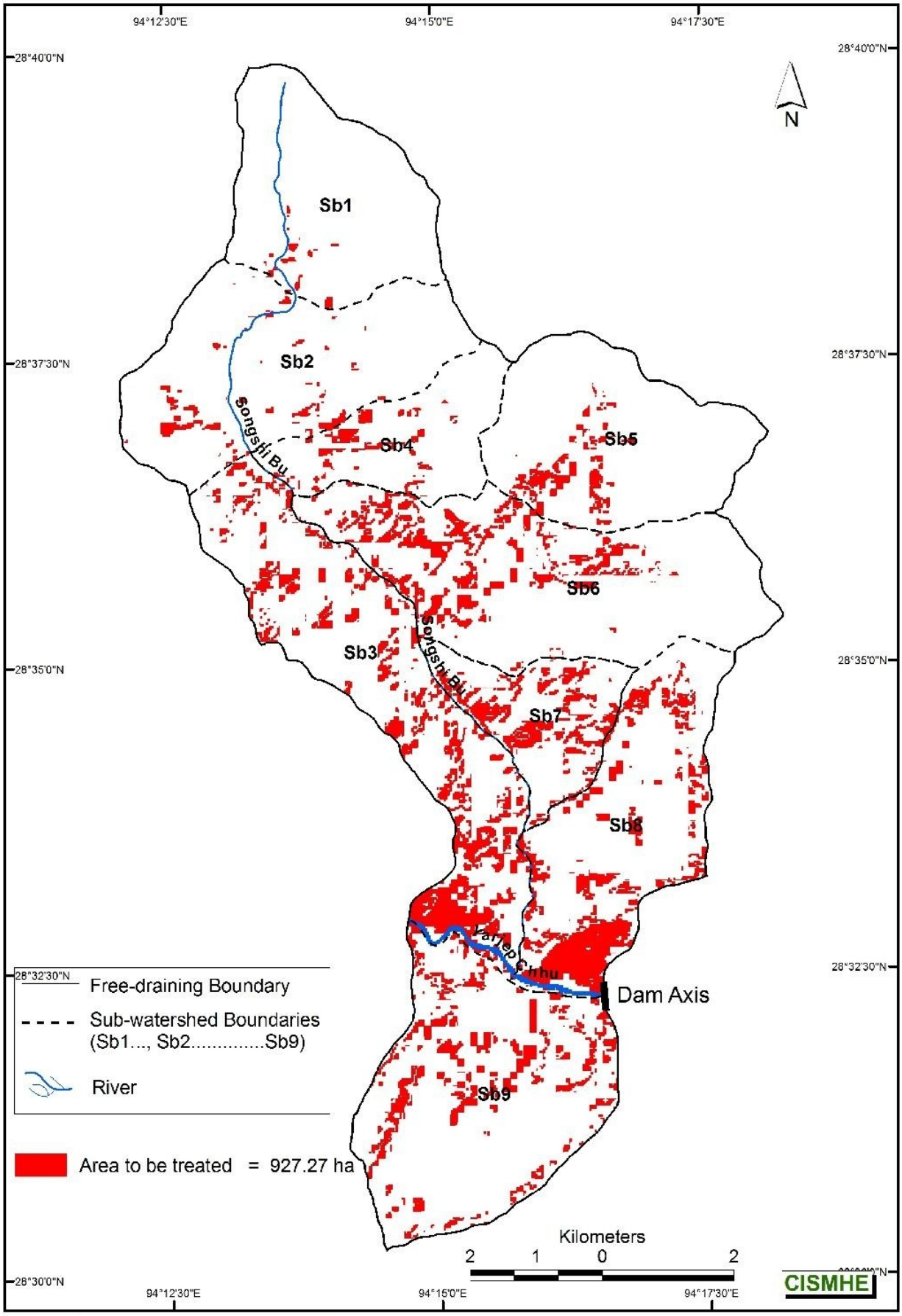


Fig.5.1.9 Treatment map of the Heo H.E. project free-draining area

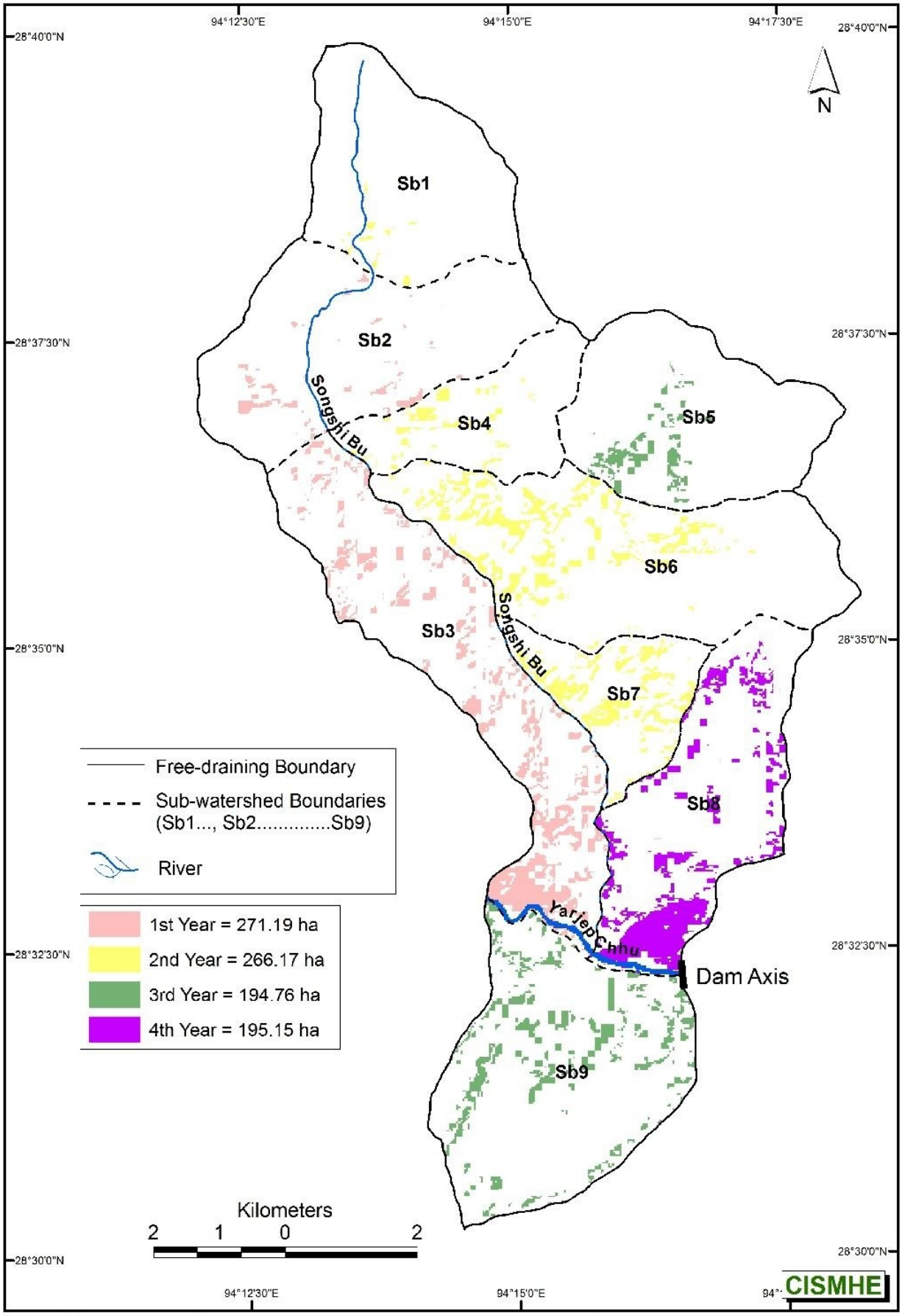
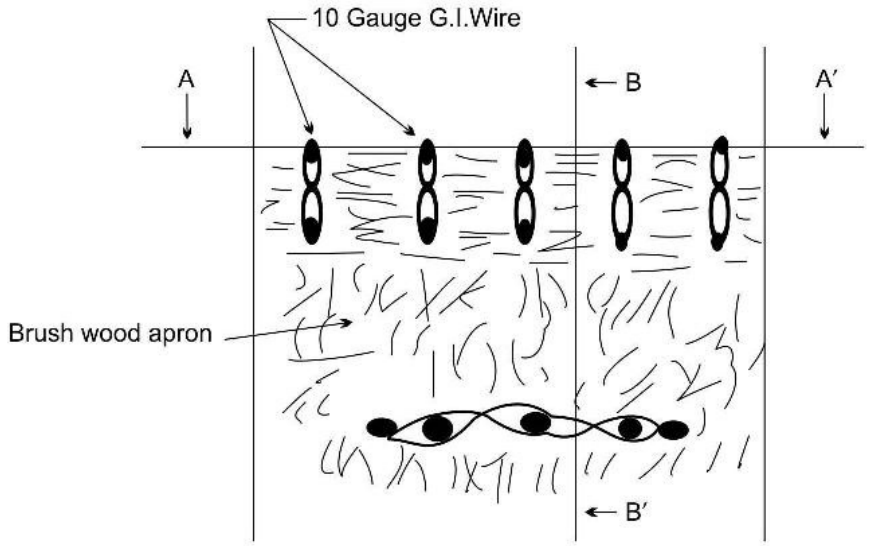
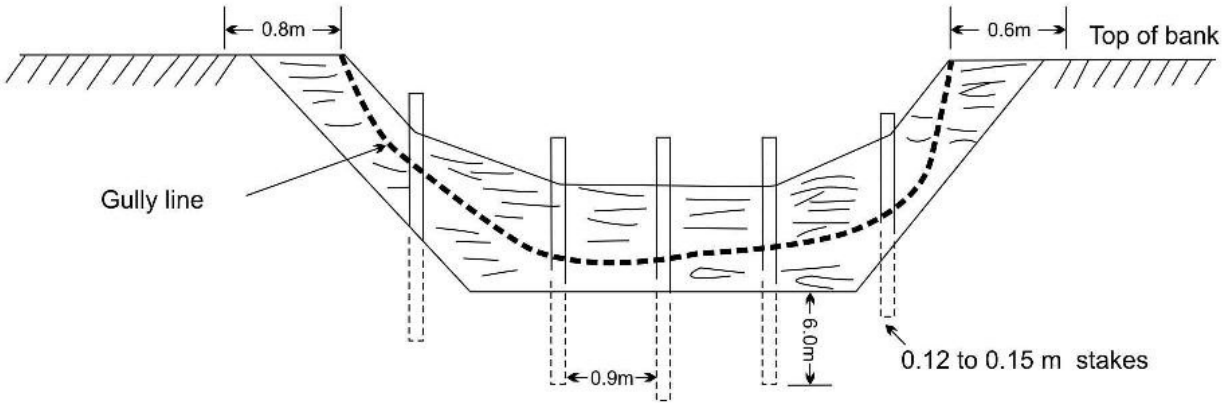


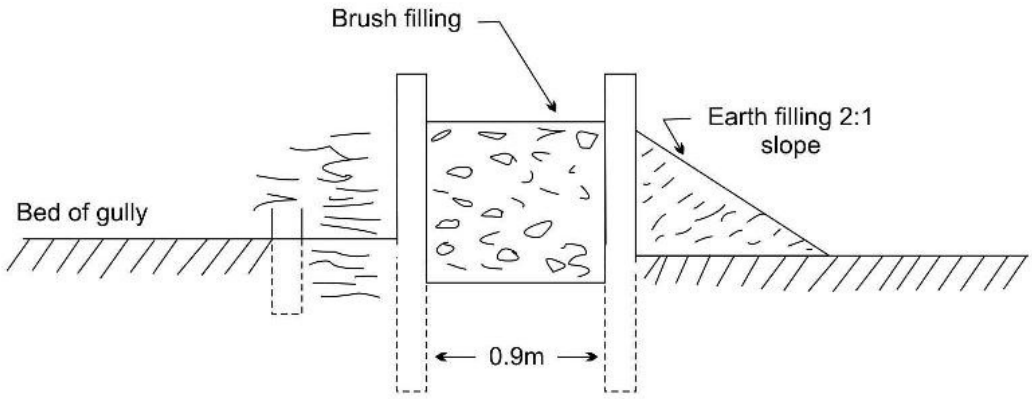
Fig.5.1.10 Yearwise treatment map of the Heo H.E. project free-draining area



a) A double-row post brush dam

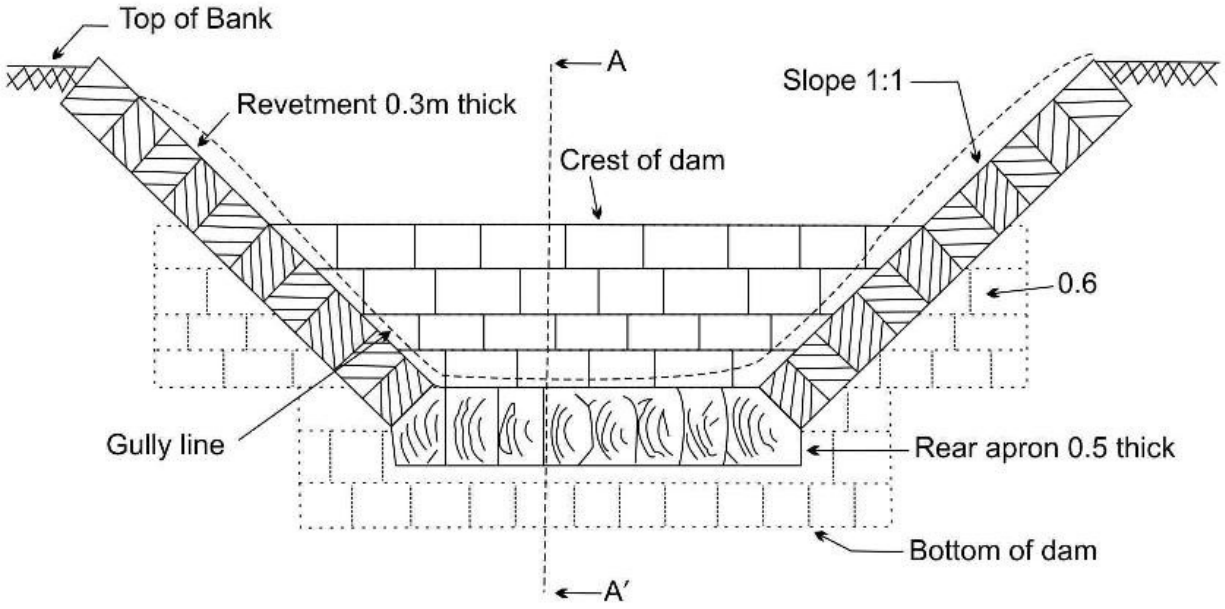


b) Section along A-A′

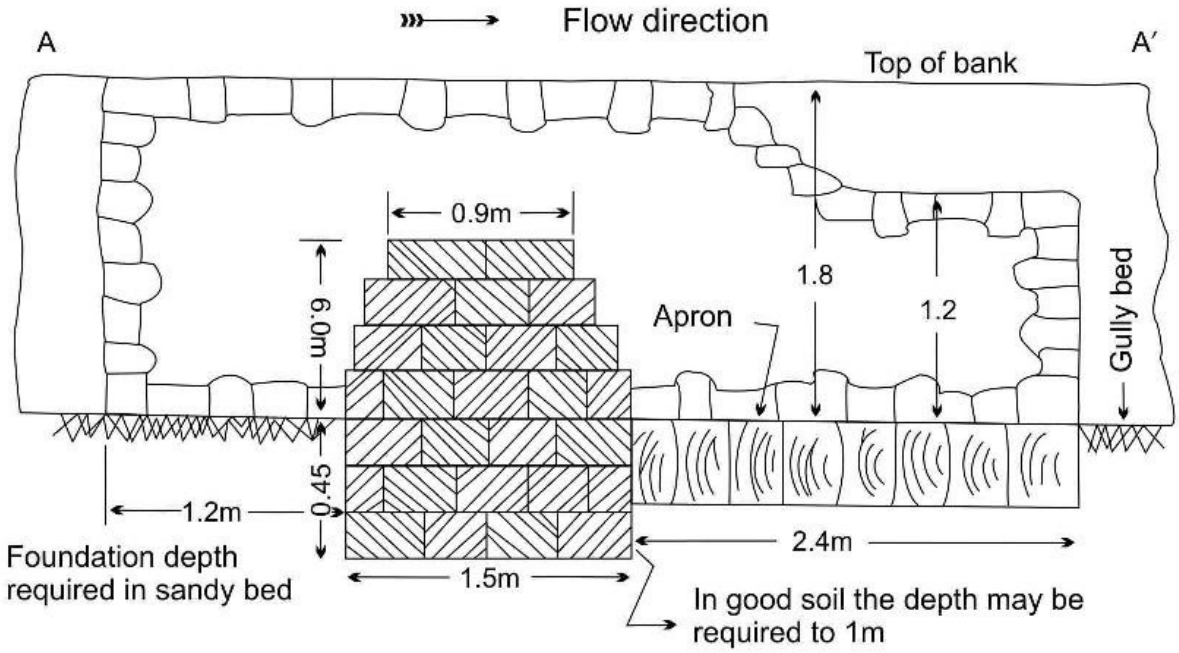


c) Section along BB′

Plate 5.1.1 A Schematic diagram of a double row brush wood check (a) and its cross section along the dam A-A′ (b) and across the dam (c).



a) Section of Dry rubble stone check dam along the structure



b) Section across the structure on A A′

Plate 5.1.2 A Schematic diagram of a Dry rubble stone check dam showing section along the dam looking up gully (a) and section along A-A′ on diagram(b) .

Annexure - I

Table for Computation of Silt Yield Index

Sub-watershed code	Erosion intensity	Area* (ha)	Weightage	Area x weight-age	Delivery ratio	Gross silt yield	Sediment yield index
Sb1	a	76.18	18	1371.24	0.95	1303	
	b	68.46	17	1163.82	0.85	989	
	c	666.03	16	10656.48	0.85	9058	
	d	3.82	11	42.02	0.75	32	
Total		**814.49**				**11381**	**1397.37**
Sb2	a	19.49	19	370.31	0.95	352	
	b	33.22	19	631.18	0.9	568	
	c	978.13	17	16628.21	0.85	14134	
	d	41.64	15	624.6	0.85	531	
Total		**1072.48**				**15585**	**1453.15**
Sb3	a	170.31	19	3235.89	0.95	3074	
	b	70.97	17	1206.49	0.85	1026	
	c	963.07	16	15409.12	0.85	13098	
	d	19.99	12	239.88	0.8	192	
Total		**1224.34**				**17389**	**1420.30**
Sb4	a	7.18	18	129.24	0.90	116	
	b	396.28	17	6736.76	0.85	5726	
	c	27.07	15	406.05	0.8	325	
	d	44.88	13	583.44	0.8	467	
Total		**475.41**				**6634**	**1395.46**
Sb5	a	114.86	18	2067.48	0.95	1964	
	b	43.48	16	695.68	0.85	591	
	c	708.38	15	10625.7	0.85	9032	
	d	7.63	13	99.19	0.8	79	
Total		**874.35**				**9703**	**1109.68**
Sb6	a	176.02	19	3344.38	0.95	3177	
	b	52.99	17	900.83	0.85	766	
	c	1056.35	16	16901.6	0.8	13521	
	d	12.58	13	163.54	0.8	131	
Total		**1297.94**				**17595**	**1355.61**
Sb7	a	87.66	19	1665.54	0.85	1416	
	b	4.35	17	73.95	0.8	59	
	c	333.86	14	4674.04	0.8	3739	
	d	0.38	11	4.18	0.7	3	

Total		**426.25**				**5217**	**1223.94**
Sb8	a	187.98	16	3007.68	0.90	2707	
	b	36.27	14	507.78	0.80	406	
	c	717.80	13	9331.4	0.8	7465	
	d	2.80	11	30.8	0.7	22	
Total		**944.85**				**10600**	**1121.85**
Sb9	a	81.78	18	1472.04	0.85	1251	
	b	68.98	17	1172.66	0.8	938	
	c	1081.18	14	15136.52	0.8	12109	
	d	10.52	12	126.24	0.7	88	
Total		**1242.46**				**14387**	**1157.94**

Annexure-II(a)

Afforestation cost/ ha of plantation

S. No.		Description	Cost
A.	**Execution**		
I.	**Wage Component**		
1.	Survey of plantation area and preparation of maps	@ Rs. 68.21	68.21
2.	Climbers cutting, removal of brushwood	@ Rs.292/ha	292.00
3.	Construction of inspections path 60cm 180Rmt	@ Rs.5.05/Rmt	909.00
4.	Fencing of area of barbed wire 4 strands horizontal and 2 strands diagonal (mp-5cm 400m/ha)	@ Rs. 27/running metres	10800.00
5	Digging of pits 45 cm^3	700 nos @ Rs.638.20/ 100	4467.96
6.	Digging of pits 30 cm^3	400 nos @ Rs. 318.20/100	1272.80
7	Filling of pits 45 cm^3	700 nos @ Rs. 182.28/100	1275.96
8.	Filling of pits 30 cm^3	400 nos @ Rs. 157.21/100	628.84
9.	Plantation of plants in pits	1100 nos @ Rs. 140.85/100	1549.35
10.	Cost of raising seedlings in nursery	@ Rs. 3.00/ plant	3300.00
	Total (A)		24564.12
11.	Add 18.93% increase		4649.99
	Total		**29214.11**
II.	**Cost of material**		
i)	Cost of materials for raising saplings	1100 nos @ Rs.4 / plan	4400.00
ii)	Cost of compost	Lump sum	2000.00
iii)	Filling of polybag and maintenance	Lump sum	200.00
	Total		**6600.00**
III.	**Maintenance of saplings planted saplings during execution period**		
11	Cost of protection (Lump sum)	@ Rs. 500.00	
12.	1st weeding during (July/August)	@ Rs. 850/500 san	1700.00
13.	2nd weeding during (Aug/Sep)	@ Rs. 850/1500 san	566.00
14.	Add 18.93% increase		428.95
	Total		**2694.95**
Total (A)			**38509.06**
			Say Rs. 39000/-
	Add escalation for 3 years (2014 to 2017) @ 7.5%/year = 48,850/-		**Say Rs. 48,500/-**
B.	**Maintenance cost**		**5000.00**
	Adding escalation for 3 years (2014 to 2017)		**6200.00**

Annexure-II(b)

Assisted Natural Regeneration Area (per ha)

S. No.		Description	Cost
A	**Execution**		
I.	**Wage Component**		
1.	Survey of Plantation area and preparation of maps	@ Rs. 66.85/ha	66.85
2.	Cleaning and un-saleable thinning (non commercial) in regeneration	@ Rs. 1158.22/ha	1158.22
3.	Bush cutting	@ Rs. 57.95/ha	57.95
4.	Digging of pits 45 cm^3	700 nos @ Rs.623.56/100	4364.92
5.	Filling of pits 45 cm^3	700 nos @ Rs. 178.64/100	1250.48
6.	Planting of Plants in pits	700 nos @ Rs. 87.25/100	610.75
7.	Carriage of Plants in polythene bags and nacked root plants at least 4½ km	700 nos @ Rs.12.00/100/km	378.00
8.	Moisture retention Intervention	@ Rs. 1500.00/ha	1500.00
9.	Cost protection	Lump sum	502.25
	Total		9889.42
	Add 18.93% increase		1872.49
	Total		**11,761.91**
	Add escalation for 3 years (2014 to 2017) @ 7.5%/year =		**Rs. 14,612**
B.	**Maintenance**		**247.64**
	Adding escalation for 3 years (2014 to 2017)		**Rs. 300.00**

Annexure-II(c)

NTFP REGENERATION / MEDICINAL PLANTS CULTIVATION

Planting norms	= 1500 patches /ha
2/3 (66.66%) patches are suitable for planting	= 1000 patches /ha
No. of plants to be planted per patch	= 15
Therefore No. of plants required per ha	= 15000

S.No.	Description	Cost (Rs.)
A.	**Execution**	
1.	Procuring planting materials (including planting out the patches)= 15000 Nos. @ Rs.2.016	30,240.00
	Add 18.93% increase	5724.43
2.	Fencing of individual plant sapling or patch of land	598.10
	Total	**36562.53**
	Adding escalation for 3 years (2014 to 2017)	**Rs. 45,422**
B.	**Maintenance**	**6894.74**
	Adding escalation for 3 years (2014 to 2017)	**Rs. 8,600**

Annexure-II(d)

Pasture Important

S. No.		Description	Cost
A.	**Execution**		
I.	**Wage Component**		
1.	Climber cutting/bush cutting in Plantation area ½ ha	@ Rs. 68.21	146.00
2	Survey of Plantation area and preparation of maps	@ Rs. 68.21/ha	68.21
3.	Digging of pits 45 cm^3	700 nos @ Rs. 936.25/100	6553.75
4.	Filling of pits 45cm^3	700 nos @ Rs. 482.28/100	3375.96
5.	Planting of Plants in pits for 45cm^3	700 nos @ Rs.233.85/100	1636.95
6	Carriage of Plants	700 nos @ Rs. 167.5/100/km	1172.5
7	Preparation of patches for	250 nos @ Rs. 266.85/100	667.12
8	Sowing of patches for grass sowing	250 nos @ Rs. 48.70/100	121.75
9	Cost of protection	Lump sum	400.00
10.	Collection of grass seed		97.00
	Total		**14239.24**
	Add 18.93% increase		2695.49
	Total (A)		**16934.73**
II.	**Cost of Material**		
	Cost of compost		3,000.00
	Grand Total (A+B)		**19934.73**
	Adding escalation for 3 years (2014 to 2017)		**Rs. 27,765**

B.	**Maintenance**	**607.41**
	Adding escalation for 3 years (2014 to 2017)	**Rs. 715**