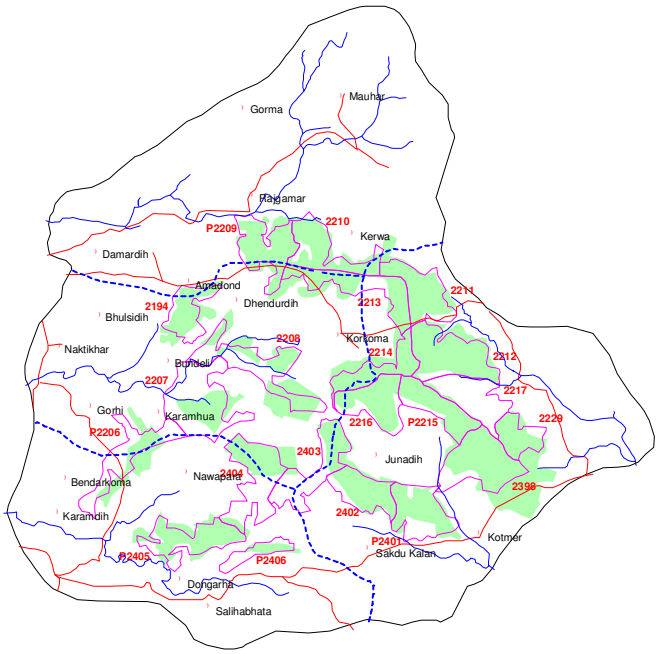
DETAILED PROJECT REPORT

For

ZERO DISCHARGE BASED WATERSHED MANAGEMENT

HILLY/FOREST AREA OF KORBA CIRCLE



In

COMPARTMENT NO.

P-2194

Of

Forest Range:

KORBA

Forest Division:

KORBA

Chhattisgarh

FOREST RANGE: KORBA

FOREST DIVISION: KORBA, DISTRICT- KORBA, CHHATTISGARH

TOTAL AREA - 187.50 HA.

TOTAL PROJECT COST – 3.04 LACS

FROM,

LNC

(MULTI-DISCIPLINARY CONSULTANCY ORGANISATION)

D-8, SECTOR-2, AVANTI VIHAR, RAIPUR, C.G.

PH: 0771 - 2443865, 6453462, FAX: 0771 - 2443765

E-Mail: lncavanti@gmail.com, lncmdco@gmail.com

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Divisional Forest Officer
Forest Division Korba

INDEX

Area at a Glance
Compartment No. P- 2398

GENERAL FEATURES	
Area in Sq.km.	18.75 Sq.km.
Co-ordinates	N 22°14'40" – 22°26' 52"latitude and E 82°45'41" – 82°58'57"
Population	20454
District Head Quarters	Korba
Block	Parts of Korba & Kartala
Villages	21 no.s
AGRICULTURE & IRRIGATION	
Net sown area (ha)	7500
Double cropped area (ha)	1000
Gross cropped area (ha)	8500
Irrigated area (ha)	1200
HYDROMETEROLOGY	
Annual Rainfall 2007	1050 mm
Temperature Maximum	42.5° C
Temperature Minimum	13.5° C
PHYSIOGRAPHY	Structural plain, Pediplain/pediment, Denudational Hills & Valleys
DRAINAGE	Hasdo river tributaries of Mahanadi Basin
SOILS	Alfisols(Red & Sandy, Red & loamy, Red & Gravelly) and Ultisols soil
GEOLOGY	Alluvium, Sandstone, siltstone, shale, coal seams and granite gneiss etc.
HYDROGEOLOGY	
Depth to water level post monsoon	2.50 to 5.90 mbgl
Depth to water level pre monsoon	4.70 to 12.00 mbgl
Fluctuation	1.00 to 6.20 m
Available Vadose zone for artificial recharge	369.37 ham
GROUNDWATER RESOURCES	
Replenisable ground water resourses	1368.75 ham
Available ground water resourses	1642.25 ham
Gross ground water draft	236.25 ham
Ground water balance	1012.5 ham
Stage of Ground water Development	18.75%
Static ground water resources	7415.62 ham
Category	Safe
CHEMICAL QUALITY	Suitable for domestic and Irrigation purposes

1. INTRODUCTION

(Of The Study Area)

Unplanned and rapid exploitation of groundwater to meet increasing demands has resulted groundwater level decline and stress on groundwater resources which ultimately causing threat to groundwater sustainability. Planned watershed management can manage the situation by adopting artificial recharge techniques for conservation and preservation of rainwater.

The artificial recharge of the rainwater to the groundwater augments the groundwater reservoir system by accelerating the natural movement of surface through suitable artificial recharge structures into the aquifer system. This can be done possible through construction of suitable civil structures which enhances the retention time of water to percolate into the aquifers.

The artificial recharge technique utilizes subsurface geological formations for storage of substantial quantity of water received from surplus monsoon run-off under different hydro geological, geomorphic and physiographical conditions. It has various advantages of being free from the adverse effects like submergence of large surface area, loss of cultivable land, displacement of local population, significant evaporation losses and sensitivity to earthquakes. The structure required for recharging the aquifers are of small dimensions and cost effective such as check dams, percolation tanks on barren land, surface spreading basins, recharge pits, subsurface dykes, gully plug, silt traps, stop dams, recharge shafts, de-silting of existing tanks, recharging of existing wells, and construction of dug cum bore wells etc.

1.1 Aims & Objectives of Artificial Recharge and Rain Water Harvesting

The main objectives and aims of the present study is to construct artificial recharge structures and do the rain water harvesting in the hilly/forested part of Korba circle area in which, most of the rain water goes as surface runoff and to have benefits to the users or population residing in downstream areas. The artificial recharge and rainwater harvesting techniques helps in augmenting the groundwater storage and surface storages in the following ways:

1. Enhances the sustainable yield wherever aquifers have depleted due to over exploitation.
2. Conserves the rain water wherever it is received.

3. Conserves and stores the excess run off water going waste for meeting out the future requirements of the users.
4. Improves the quality of groundwater.
5. Keep the soil moisture content intact so that topsoil vegetation is protected.
6. Give the employments to rural youths.

1.2 Background

The State of Chhattisgarh is blessed with good rainfall of 700-1400 mm per annum and out of which around 15-20% is during the winters. The number of rainy days also varies from 40 to 65 and evaporation from free water bodies is around 1.5 - 2.0 m per annum. If the available rainfall is properly harnessed and conserved will provide sufficient water for domestic and agricultural needs. Assessment of water requirement of watershed areas will help to work out the measures to be suggested as to how the water demand and availability can optimize the resources.

1.3 Data Used

Collateral Data

The following collateral data in the form of maps and reports were used and presented in **Table 1** below:

Table 1: Data collection

Topographical maps 1:50,000 Scale& 1:2,50,000 Scale	Survey of India
Rainfall Data	Land Records & Settlement Office, Korba
Census Data	Census department collected from Korba Statistics Department
Hand Pumps Details	Public Health Engineering Department, Korba
Water Resource information	Water Resource Department, Korba and Data Centre, Raipur
Groundwater Information	State Groundwater Survey Circle, Bilaspur , Central Groundwater Board, Raipur
Other District Statistical information	Economics & Statistics Department, Korba
Geological Information	Geological Survey of India, Raipur

The exact location of the compartment no P-2194 is as under;

The Northern boundary marked by the Protected cut line and Aamadih village. The Eastern boundary denoted by the Protected cut line and Tengur Village. The Southern boundary marked by the Protected cut line and Bundeli village. The Western boundary distinguished by the Protected cut line and Bhuulsidih village.

1.4 Methodology

In order to prepare the action plan for the present study both natural and socio-economic resources have been taken into consideration. The thematic maps such as Geological, Geomorphological, Landuse, Soil, Hydrogeological map are prepared from data gathered and available from different Government organisations. Slope map has been generated from elevation information available on topographic maps. Surface water body, drainage and watershed map and transport network, settlement location and villages are marked using collateral data.

The site suitability of rainwater harvesting structures has been proposed after detailed study of the area. Designing, Specification and cost involved in constructing different artificial structures has been thoroughly worked out and presented

1.5 Location, Extent and Accessibility

Korba is situated in the east-central part of Chhattisgarh state. It falls in the Survey of India's Degree Sheet Nos. 64J and 64N (1:250000 Scale) between latitudes 22°01'50" to 23°01'20"N and longitudes 82°07'20" to 83°07'50"E. The district is bounded by Surguja district in the north, Bilaspur district in the west, Raigarh district in the east and Janjgir-Champa district in the south.

The Watershed is known as Hilly and Forested area of Korba circle occupies an area of about 187.50 Sq. km. It lies between N 22°14'40" – 22°26' 52"and 82°45'41" – 82°58'57" E falling in Survey of India toposheet No. 64 J/15 in parts of Korba and Kartala blocks of the Korba district. The area is well connected by road only. The Salient features of the area are depicted in **Table 2** and the location map of the watershed is given in **Fig1.**

Table 2 Salient Features of Korba circle area

1.	Area (Sq.km.)	187.50
2.	Annual Rainfall (mm)	1050
3.	Total Population	20454
4.	Population Density (Person / Sq. Km.)	66
5.	S.C. Population	1493
6.	S.T. Population	13310
7.	Literacy Percentage	55 %
8.	Agriculture Land (Ha)	7500
9.	Forest Area (ha.)	5939

Compartment Map of Watershed

1.6 Transport network and Settlement Location

Communication network plays an important role in the development of a region. Accessibility by roads and rail is essential not only for economic development of a region but also for social and educational development. Accessibility is an indicator of the level of development and development depends on the quality of transport network.

The area is connected with road only. Roads are further classified as metalled and unmetalled road. Unmetalled road are at places are cart track but in most of the areas they have been converted into metalled road under Pradhan Mantri Sadak Yojna.

1.7 Socio Economic data analysis

According to 2001 census the total population of the watershed is 20454 the density of population is 66 person/sq. km. The growth of population and intensive agricultural activities in the area followed by construction of new bore wells in the recent years.

Groundwater resources in the area exclusively meet the drinking water requirement and partially meet the irrigation requirement, where the conditions are favourable for construction of bore well.

Collection of all kinds of groundwater data and there collation with geology, hydrology, pedology of the area becomes extremely essential not only to document the present scenario of groundwater use and its development, but more for planning the future economic development of the area. Socio-economic profile in the form of demographic details is given in the **Table 3**.

Table 3 Demographic Details of the study area

S.N.	Name of the village	Total population	Male population	female population	SC population	Male SC population	Female SC population	ST population	Male ST population	Female ST population
1	Sakdukalan	1049	515	534	41	18	23	884	442	442
2	Hathimud	680	347	333	7	3	4	365	187	178
3	Korkoma	2463	1264	1199	169	89	80	1581	802	779
4	Godma	490	245	245	26	14	12	424	212	212
5	Tewanara	252	114	138	7	3	4	232	106	126
6	Bundeli	1662	821	841	200	112	88	908	439	469
7	Karumauha	780	384	396	322	157	165	332	164	168
8	Kerwa	626	309	317	20	12	8	576	282	294
9	Dhengurdih	631	324	307	0	0	0	603	310	293
10	Mudhunara	622	307	315	15	8	7	503	246	257
11	Mauhar	239	121	118	3	2	1	236	119	117
12	Dumardih	715	352	363	66	29	37	555	276	279
13	Bhulsidih	731	368	363	85	42	43	503	255	248
14	Kesala	658	332	326	6	5	1	532	260	272
15	Geraon	1008	484	524	56	26	30	849	410	439
16	Batati	714	351	363	12	8	4	478	236	242
17	Kerakachhar	1000	485	515	49	30	19	876	416	460
18	Salihabhatha	876	438	438	62	36	26	404	195	209
19	Dongaama	630	318	312	2	1	1	442	216	226
20	Nonbirra	2249	1124	1125	99	48	51	741	370	371
21	Kartala	2379	1204	1175	246	125	121	1286	628	658
	Total	20454	10207	10247	1493	768	725	13310	6571	6739

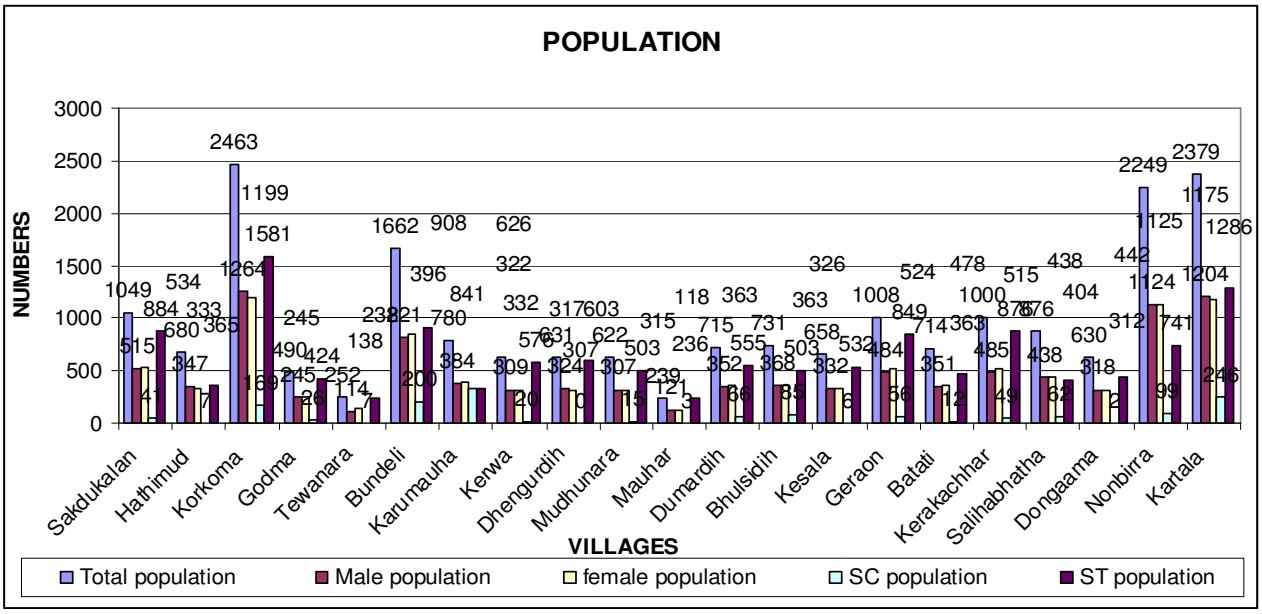
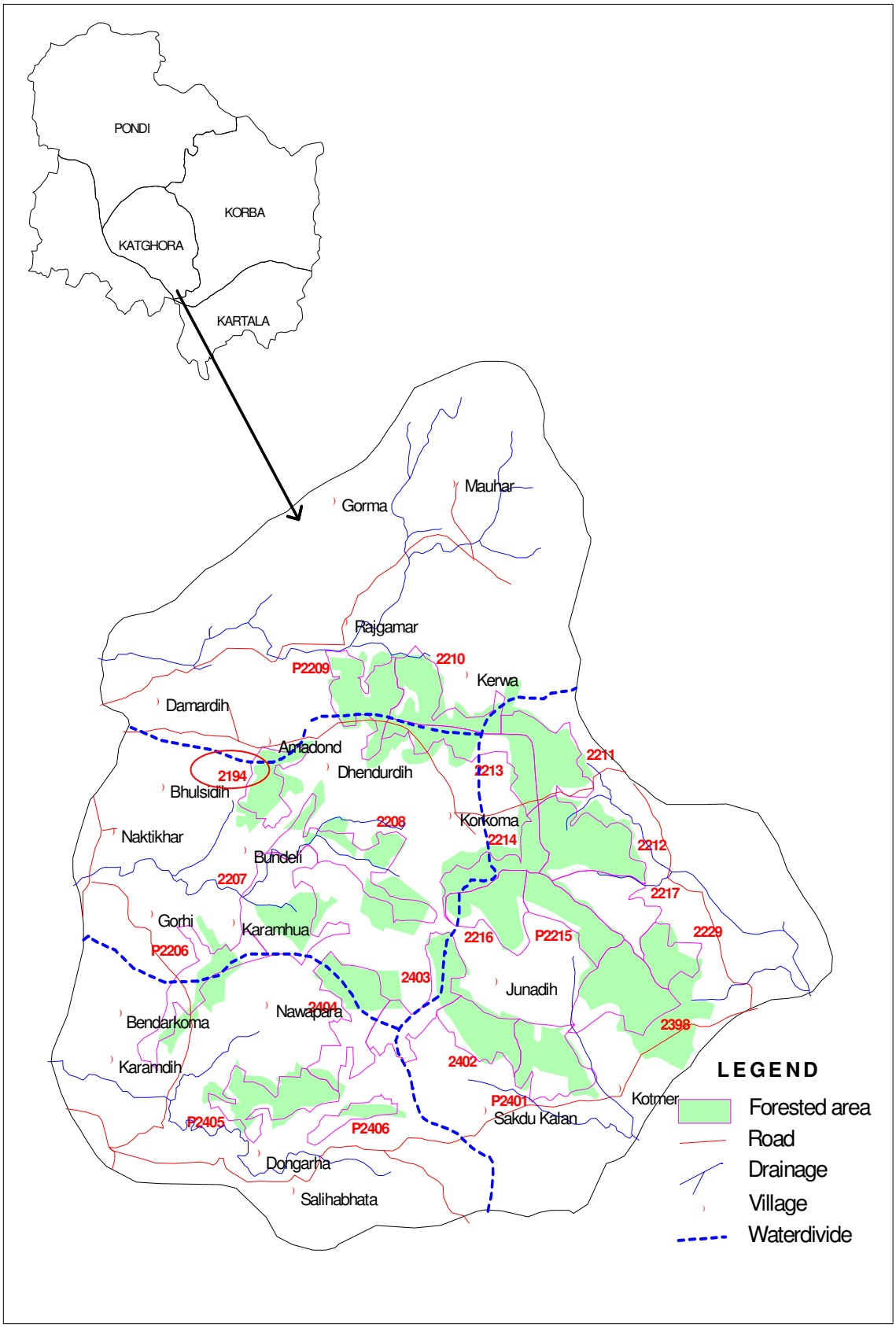


Fig 1 Location map of the study area.



2. HYDROMETEROLOGY

(Of The Study Area)

The Korba circle area enjoys a tropical climate with hot summer followed by well-distributed rainfall through South-West monsoon season. The winter commences from December and last till the end of February. The period from March to the end of May is hot season. The monsoon season starts from the middle of June and last till the end of September. There is only one observatory maintained by Indian Meteorological Department (IMD) at Korba. Besides this ordinary rain - gauges have been installed and maintained by Revenue Department at Korba.

2.1 CLIMATE

a) RAINFALL

The rainfall of the area is dominated by the South West Monsoon, which starts in the middle of June each year and ceases by the end of September or beginning of October. The maximum rainfall of the area recorded in the past is 1210 mm and minimum ever recorded rainfall is 900 mm and is given in **Table 4**. About 90% of the annual rainfall takes place during the South West Monsoon i.e. between June to September. Only 8% of the annual rainfall takes place during the Winter Season from October to February and only 2% of the annual rainfall takes place during summer Season. Hence 10% of the rainfall takes place from October to May.

Table 4 Rainfall data (in mm) of Korba Rainguage station

1	1999	1050
2	2000	950
3	2001	1031
4	2002	985
5	2003	900
6	2004	1109
7	2005	1105
8	2006	1160
9	2007	1210
Average		1050

b) TEMPERATURE

The records of the IMD observatory data indicate that May is the hottest month during which temperatures rises up to 48° C, December is the coolest month during which the temperature decreases to 13.5° C. The daily mean, maximum and minimum temperatures during the summer (May) are 42.5° C and 28.8° C respectively while during winter (December) it is 27.2 to 13.5° C. The average daily annual normal temperature for the area is about 26° C.

c) RELATIVE HUMIDITY

Relative humidity of air at a given temperature is the percent ration of amount of moisture present in the air to the amount necessary to saturate the air at that temperature.

During the driest period i.e. summer season humidity is lowest about 35% and is highest during the South West Monsoon period 85%. The humidity again decreases from October onwards due to rise in temperature and also due to the retreating monsoon. The Relative humidity of air at a given temperature is the percentage ratio of the amount of moisture present in the air to the amount necessary to saturate the air at that temperature.

d) POTENTIAL EVAPO – TRANSPIRATION

The maximum 18.2 mm and minimum 10.5 mm Evapo-transpiration is observed during the month of May. The total Evaporation during the month of may recorded is 406.1 mm. Mean monthly Evaporation the month of May 2006 is 13.1mm. Which indicate maximum Evaporation is takes place during the pre-monsoon period. Monthly data is respect of temperature, Relative Humidity; PET etc.

3. SOILS, LANDUSE AND SLOPE

(Of The Study Area)

3.1 SOILS

The area has been covered by Alfisols and Ultisols. The Alfisols is further divided into Red & Sandy, Red & Loamy and Red & gravelly soils on the basis of major constituents as follows

Alfisols:

i) Red & Sandy soil
ii) Red & Loamy soil.
iii) Red & Gravelly soil

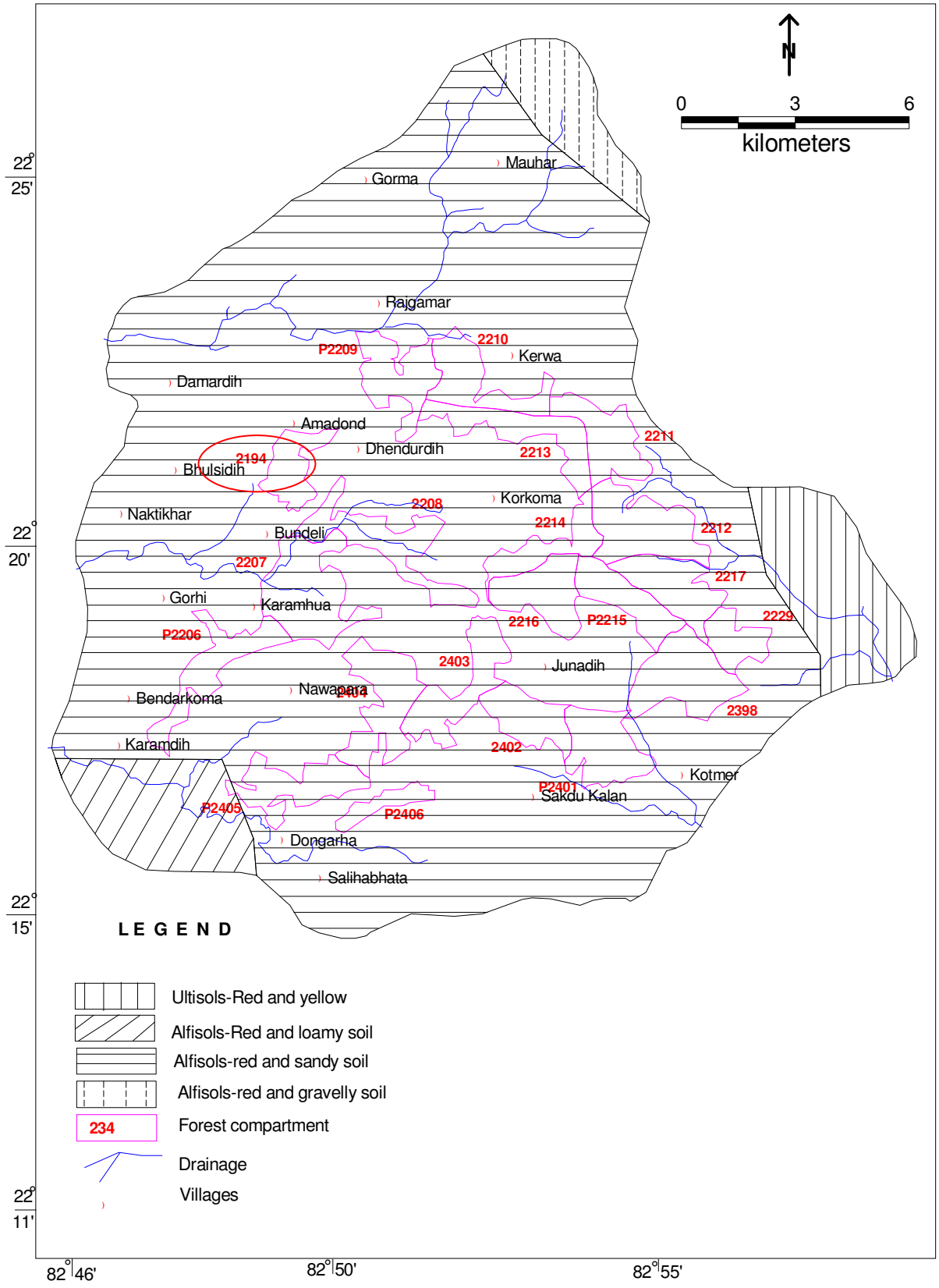
Red & Sandy soil: This soil is exposed in the major part of watershed. It covers an area of about 279.4 sq.km. It mainly consists of sand kankar & pieces of rock fragments (sandstone) and clay.

Red & Loamy soil: This soil is exposed in the extreme south-western side of watershed. It covers an area of about 11.59 sq.km. It mainly consists of sand, loam & clay.

Red & Gravelly soil: This soil is exposed in the extreme northern side of watershed. It covers an area of about 7.39 sq.km. It mainly consists of sand, gravels and ferruginous clay.

Fig 2 is presented here for distribution of soils present in the area.

Fig 2 Soil map of the study area.



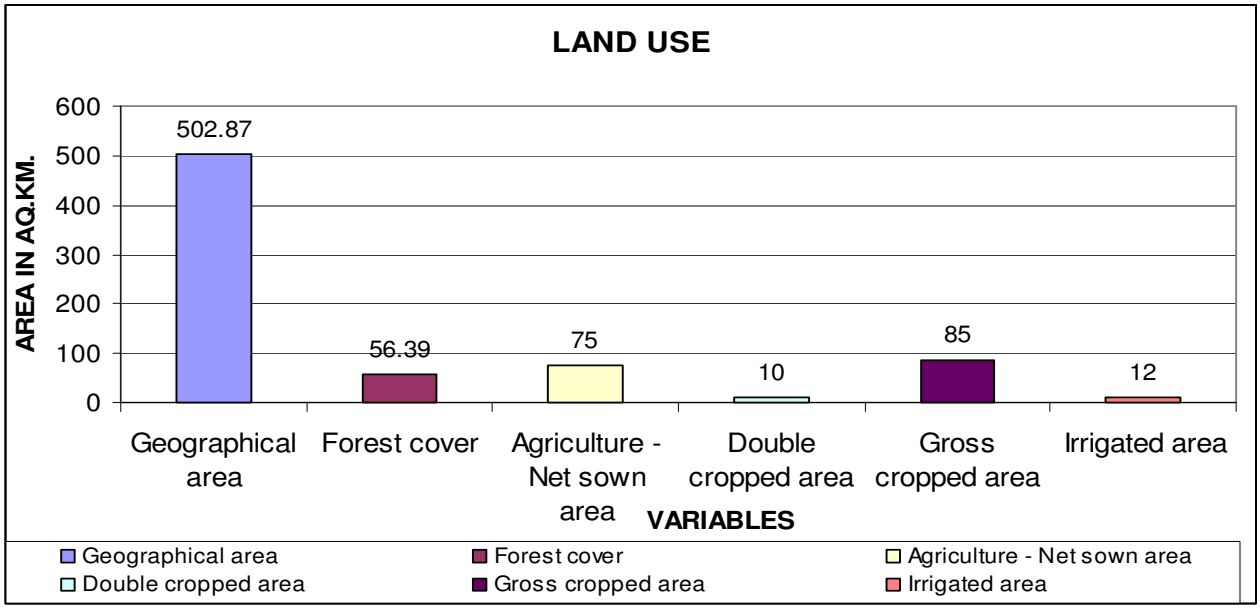
3.2 LANDUSE

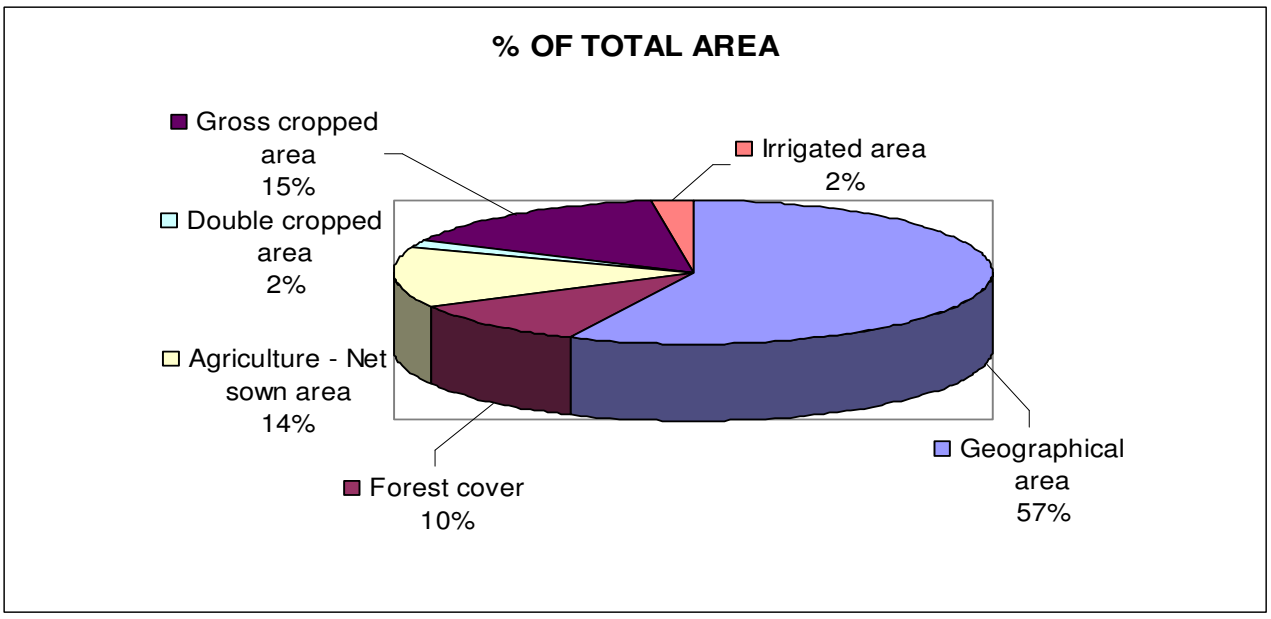
The study of specific aspects of “land use” and “land cover” including both existing as well as anticipated is one of the primary exquisite to assess and evaluate the environmental situation, directly related to land and water environment. The comprehensive study of these aspects includes detailed thematic study for proper management of hydro-ecology of the area. It also requires the study of land, Soil and water for preparation of accurate artificial management plan on watershed basis on single ecological unit.

In the present study area, the aspects of land use and land cover were taken into consideration, for evaluation of overall situation to assess the impact on artificial recharge environment and to the protective and mitigating measures for proper protection of hydro-ecology and preparation of proper water conservation and ground water protection plan and management plan and given in **Table 5**.

Table 5: Land use and land cover in the Korba circle

SN	Land use and land cover	Area in Sq.km.	Percentage to the total area
1	Geographical area	187.50	100.00
2	Forest cover	56.39	18.1
3	Agriculture - Net sown area	75.00	24.00
	Double cropped area	10	3.21
	Gross cropped area	85.00	27.28
	Irrigated area	12.00	3.85





The total geographical area of the Hilly and Forested area of Korba circle water shed is about 187.50 Sq.km. distributed over watershed covering parts of Korba and Kartala blocks of Korba district. Out of the total area of the watershed about 18.1 % comes under hilly and forested area.

The area studied is covered by thick forest and other green belt. The total forested area in the watershed is about 56.39 sq.km. The plant species of the hilly and forested area are Acasia Arbica (Babul with black bark), Acasia Leucoflora (Babul with white dark), Albizzia Lebbek (White Siris), Butea monosperms (Palas), Feronia elephanta (Kathbel), Terminalia tomentiosa (Sar or Asim)and plant species namely Cyanodon dectylon (Dock), Zyzyphus nummuloria (Jharberi), Echinops echinatus) (Gokur) and Terminalia fomentosa (Saj or Asim).

Agriculture and cropping pattern:

The distribution of the landuse which is given in Table 5. From the table it can be seen that, about 24 percentage is net sown area and about 3.85 % is irrigated area by surface water and ground water.

The agriculture in area of the watershed forms the main occupation of major population residing in habitat area and even in hilly area in few pockets. In the study area mainly agriculture land which is paddy single crop area(Kharif) and cultivation practices are mainly dependent upon rain and irrigation from local ponds, lakes, bunds, reservoir etc. The land under present land use practice consists on thick soil cover and moderate potential of ground water which is being used both for cultivation and domestic purposes.

The other sources of water are mini surface water tanks, ponds, small bunds and check dams.

It is suggested that surface and ground water sources may be improved by artificial recharge structure and rain water harvesting to increase agriculture potential and to protect the ground water regime. The other crops are wheat, Gram,Jewar, Bijra, Arhar, Moong etc.which are grown in Rabi period.

3.3 SLOPE

Slope, aspect and altitude are important terrain parameters from land utilization point of view. Among the three, slope is very vital one for land irritability and land capability assessment.

Methodology

Survey of India Topo-sheet on 1:50,000 scale has been used for deriving the formation on slopes, aspect and altitude. A land with five meters of vertical drop over a horizontal distance of 100 meters has 5% slope. Accordingly, 10 m or 20m vertical drop for every 100 meters of horizontal distance is 10% or 20% slope respectively.

Topographical maps on 1:50,000 scale give contours with 20 metre interval. The vertical drop can be estimated/measured from the contour intervals and the horizontal distance in between the contours can be measured from maps by multiplying the map distance with the scale factor. Close spaced contours on the map have higher percentage slope as compared to sparse contours in the same space. Thus density of contours on the map can be used for preparing the slope map that gives various groups / categories of slopes.

To illustrate the four types of slope category which is presented in fig 3 “up to 5% ,5% to 10% and 10% to 20% and more than 20 % slope”, the lower limit of contour spacing 1.33 cm means, over a horizontal distance of 1.33 cm $\times$ 50,000 = 66500 cm = 665 meters there is vertical drop of 20 meters.

Thus the slope percentage is

$(20 \times 100) \div 665$

The upper limit of 4 cm contour spacing means, over a horizontal distance of

4 cm $\times$ 50,000 = 200000 cm

= 2000 metres, there is a vertical drop of 20 metres. Thus the slope percentage is

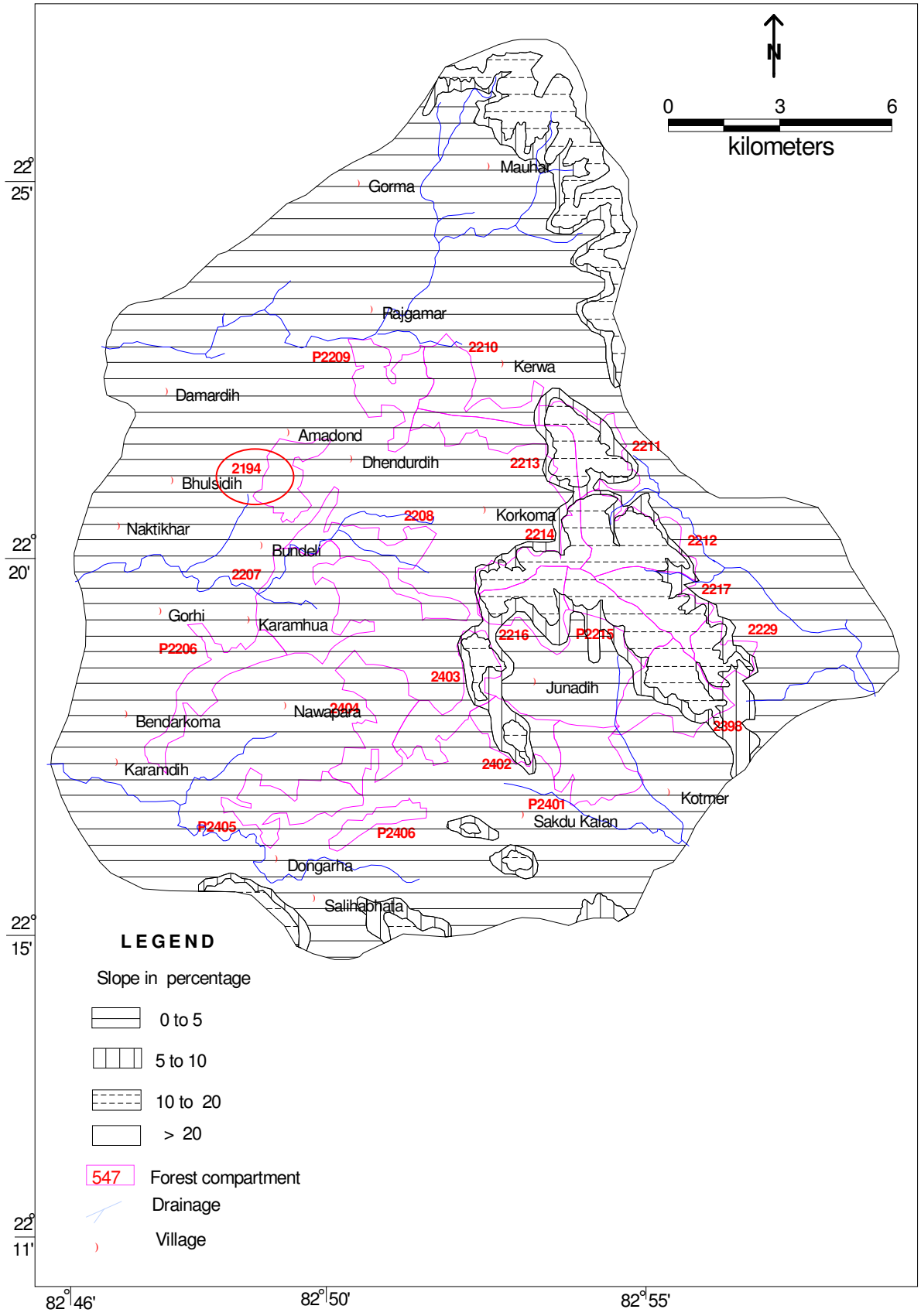
$(20 \times 100) \div 2000$

On the above basis the slope map of the watershed is prepared and presented in **Fig 3** and the major slope categories of the water shed is given in **Table 6**

Table 6: MAJOR SLOPE CATEGORY IN THE KORBA CIRCLE

S.No	Slope Category	Slope (%)
1.	Nearly level	0-5
2	Moderate gently sloping	5-10
3.	Gently sloping	10-20
4.	Steep Slope	>20

Fig 3 Slope map of the study area .



3.4. SOILS, LANDUSE AND SLOPE OF THE STUDY AREA

The soil structure is Solid, Sandy-Dumat. It is soft having moderate level of moisture. There is shallow soil containing medium humus sufficient to support plant growth. The depth of the soil is high, level of moisture and humus is enough to support the forest plant species.

The compartment contained 4th A quality mixed type of forest and Forest density ranges is 0.4 consistence more then 50% of saal forest ,medium and young age class forest.

Main species of the top canopy are Saja, Saja, Dhaeda,Mahua,, Saliha, Khamhar, Tendu, and Dhobin. Middle canopy contains KOrira, Kasai, Dahijhar, Dawai, Karra, under canopy consists are Mahua, Saal, Kuru,Chind, Ber, Musali, And Kevkada. Dawai, Charota, Chind, Marodphal, and Kurur.

The Main species of the Wood land level are Tendu, Saja, Gudsakri, , Haldu, and Papada. Scrub level contains are Karra, Ghont, and Kurru. Filed level contains are Kuru,Chind, Ber, Musali, And Kevkada. Marorphal, Gursukri, and Korea. A few Bhurbhusi, Gunner and Kusal found in the Ground level species. In under growth Bamboo is also thriving.

Lantana is very scanty or may be denoted at negligible. Root stock is enough to thrive, in to a good forest. In under growth Bamboo is also thriving.

The micro level study of the compartment reveals that from total 187.50 ha. Area has following characteristics with respect to precious parameter for water shed i.e. slope

The **whole compartment** extents up to 187.50 ha.

The average slope at the stretch of 100 m. horizontal distance is 11772 m.

Ratio =11772/100 = 11.77 to I m. Say 1:11

Degree = $5^0$08’24”

Percentage = 1/11 x 100 = 9.09%

Value of C = Coefficient showing % of rainfall appearing as runoff, a watershed factor = timber plain = 0.108

4. GEOMORPHOLOGY AND DRAINAGE

(Of The Study Area)

4.1 GEOMORPHOLOGY

The Korba circle area is having somewhat circular Catchment, the maximum length and Width of the Catchment is 22.72 Kms and 22.36 Kms respectively. The elevation of the area varies from 270 to 781 m amsl. In the eastern part the area is hilly and forested. The maximum basin elevation is 781 m amsl in the northern part of the watershedat north of Pawan Akhra Pahar while minimum elevation is present in east-central part along Kortimasara nala.

The Physiography of the basin is controlled by geological formations namely, sandstone, siltstone, shale, coal seams and granite gneiss. The east-west and north-south trending linear elevated surfaces of the area acts as water divide.

The rocks were exposed to renewed post depositional activities and were subjected to intensive and extensive pedimentation, peneplanation and denudation during Pre-Quaternary and Quaternary time. In response to lithology of rocks, their chemical composition, their relative deposition, tectonic set up, they were chiseled into various geomorphic and hydrogeomorphic surfaces namely Structural plain, pediplain/pediment, Denudational hills & valleys.

1. Structural plain:

It is plain area associated with joints and faulting etc. In the area it is exposed in major patch in western, central and eastern part of the watershed. It covers an area of about 186.20 sq.km. It is identified at an elevation of above 270m amsl.

2. Pediplain/Pediment:

It is resultant product of polycyclic erosional and depositional processes. It is concealed and covered under thin soil cover. About 43.20 sq.km. area of the watershed occupying by pediplain/pediment in the southern part of the area in patch. It is identified at an elevation of between 270 –350 m. above m.s.l.

Pediment is identified at an elevation of above 350 m. above m.s.l. It is formed by combine processes of erosion dissection and pedimentation. The surface is dotted by relic very small hills rock sheet area, rocky scree deposits and other relict erosional elements.

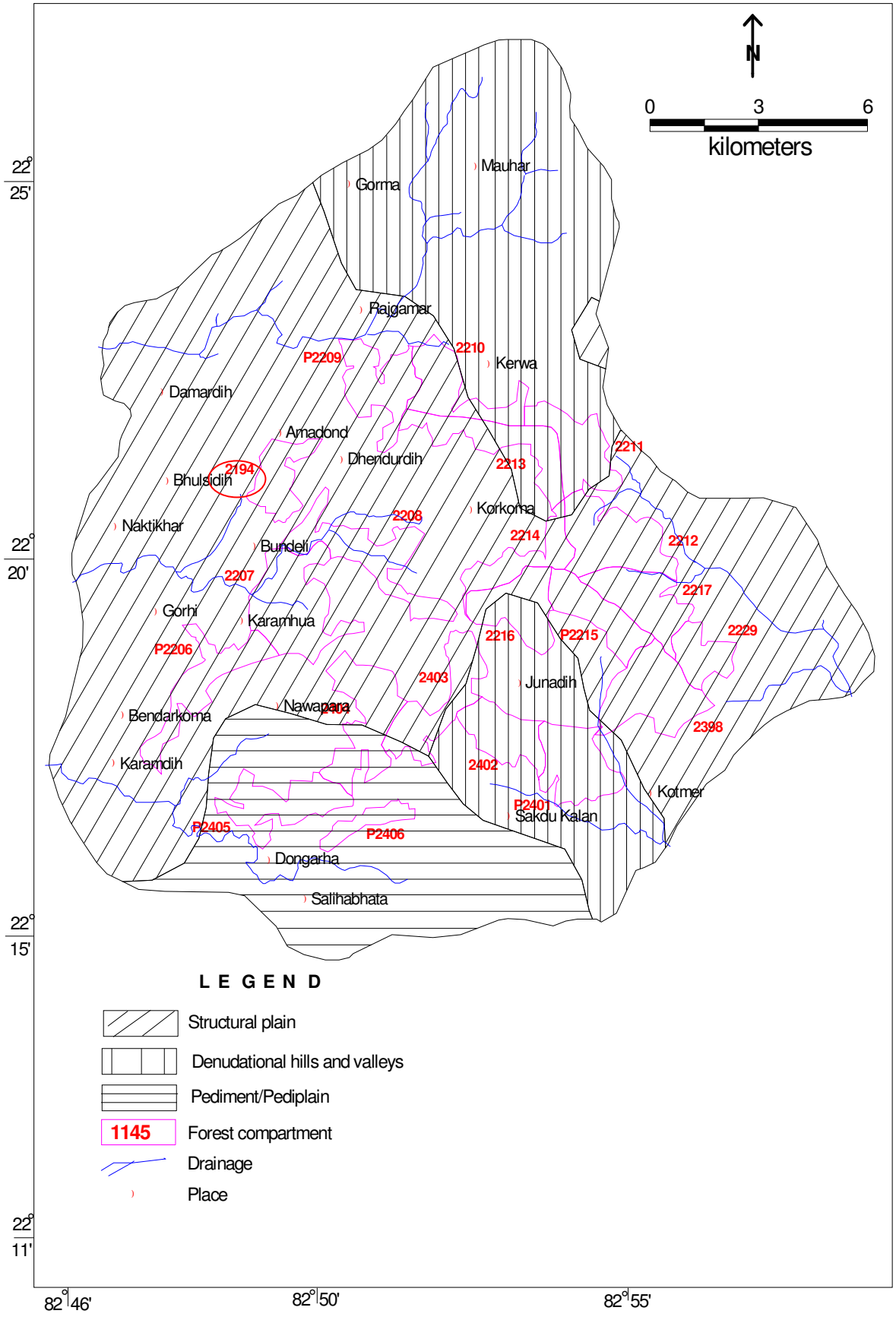
The topsoil is thin and impersistent it grey light red and brownish in colour and is mostly silty in nature with predominant rock fragments.

3. Denudational Hills & Valleys:

It is formed due to differential erosion and weathering, so that a more resistant formation or intrusion stand as mountains/ hills. It is associated with fractures/joints and lineaments. In the area it is exposed in extreme north & southern part of the watershed. It covers an area of about 82.12sq.km. It is identified at an elevation of above 400 m amsl.

Fig 4 is presented here to show the Geomorphic features in the Korba circle area.

Fig 4 Geomorphological map of the study area.



4.2 DRAINAGE

Drainage network are universal feature of landscape on the earth. Various environmental factors such as climate, relief, lithology, and vegetation plays a considerable role in the development of drainage basin. Watershed geomorphology help in understanding the physical and hydrological behavior of the river regime. Hilly and Forested area of Korba circle is the part of Mahandi drainage system.

DATA BASE & METHODOLOGY:-

For determination morphometric variables S. O. I. Toposheets in scale of 1:50,000 has been used. The linear measurements have been carried out by using rotameter.

Watershed Characteristics:-

An attempt is made to analyses the various parameters of fluvial morphometry. The major geomorphic parameters of hydrologic importance have been discussed below:-

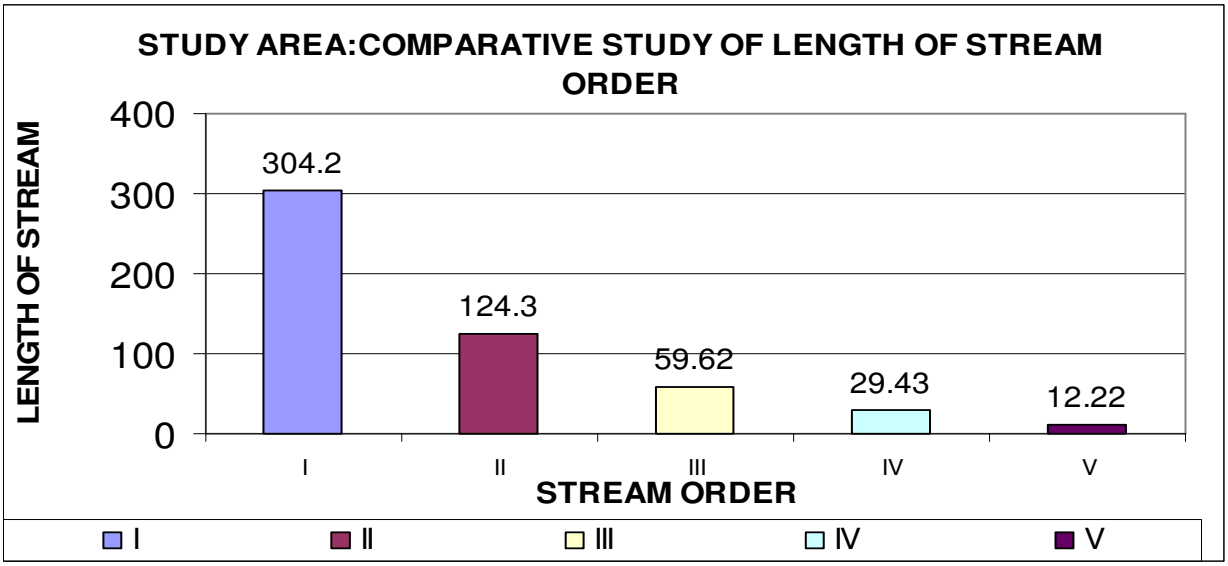
1. Linear Parameters

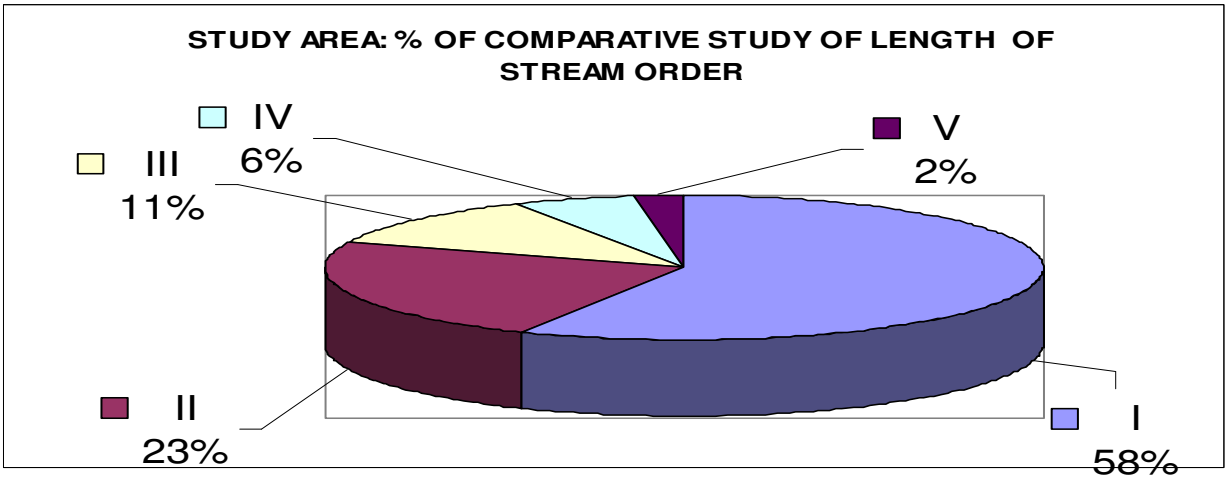
A) Bifurcation Ratio :- In drainage analysis, bifurcation ratio is the foremost important parameter to link the hydrological regime of a watershed under specific lithological and climatic condition is the ratio of the number of streams of one order to the number of streams of the next higher order. In the study area bifurcation ratio varies from minimum 3.83for II nd order stream to 5.00 for 4 th order streams **(Table 7)**. As these values of bifurcation ratio ranges

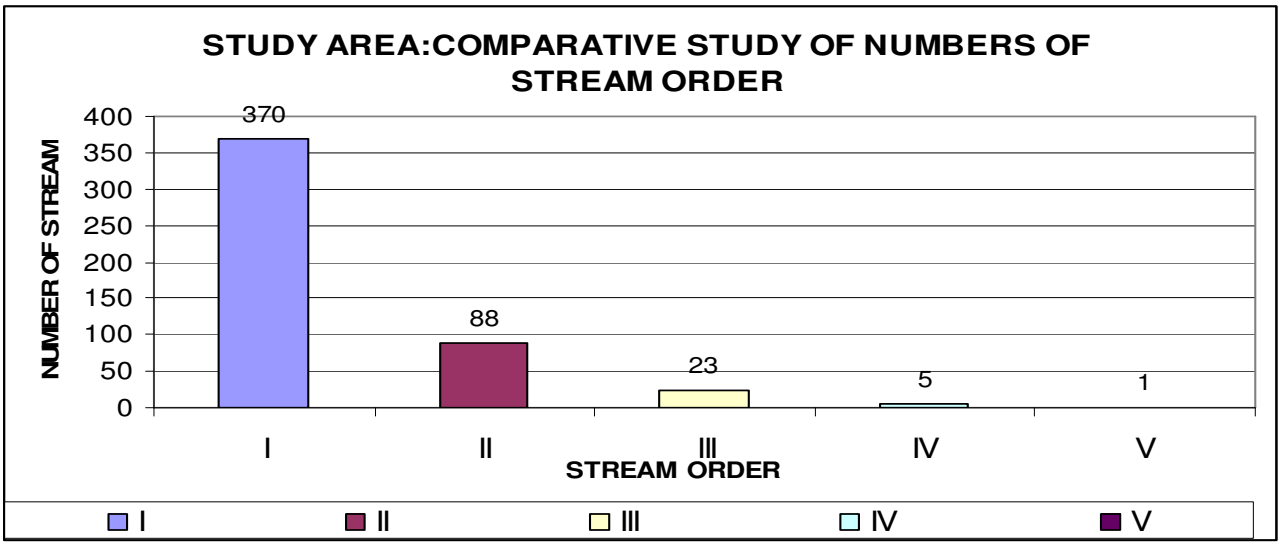
between 3.83 and 5.00, indicating that the river flows through hilly area.

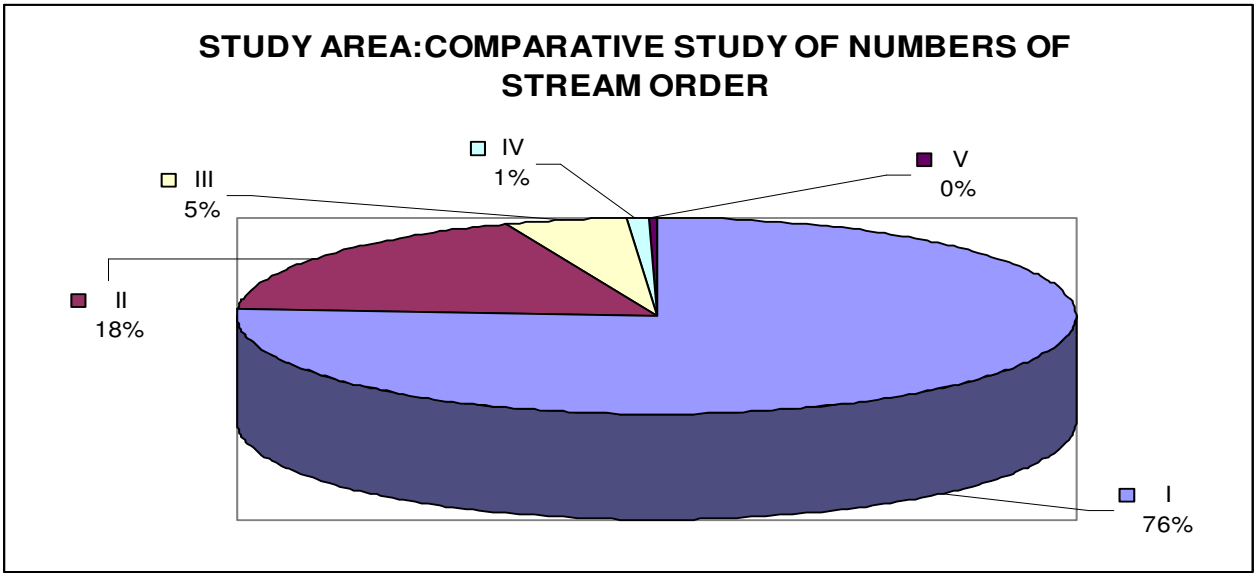
Table 7: Drainage Basin Characteristics of Hilly and Forested area of Korba circle Wateshed

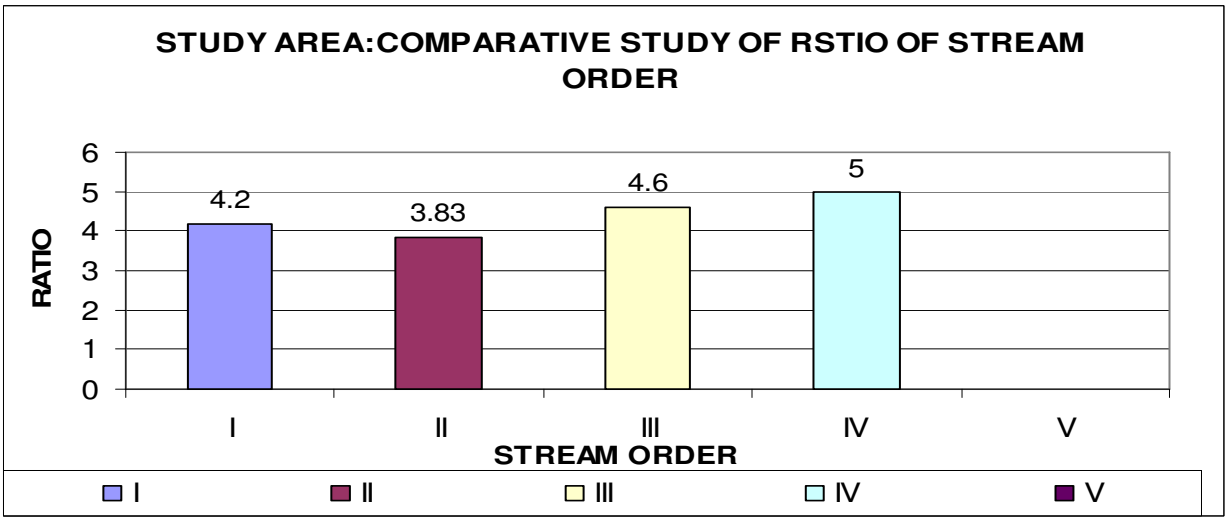
Stream order N	Length	No of Stream	Bifurcation Ratio	Mean stream Length	stream Length Ratio
	Lw	Nw	Rb	Lw=Lw/Nw	RL=Lw/Lw-1
I	304.2	370	4.20	0.82	2.45
II	124.3	88	3.83	1.41	2.08
III	59.62	23	4.60	2.59	2.03
IV	29.43	5	5.00	5.89	2.41
V	12.22	1		12.22	

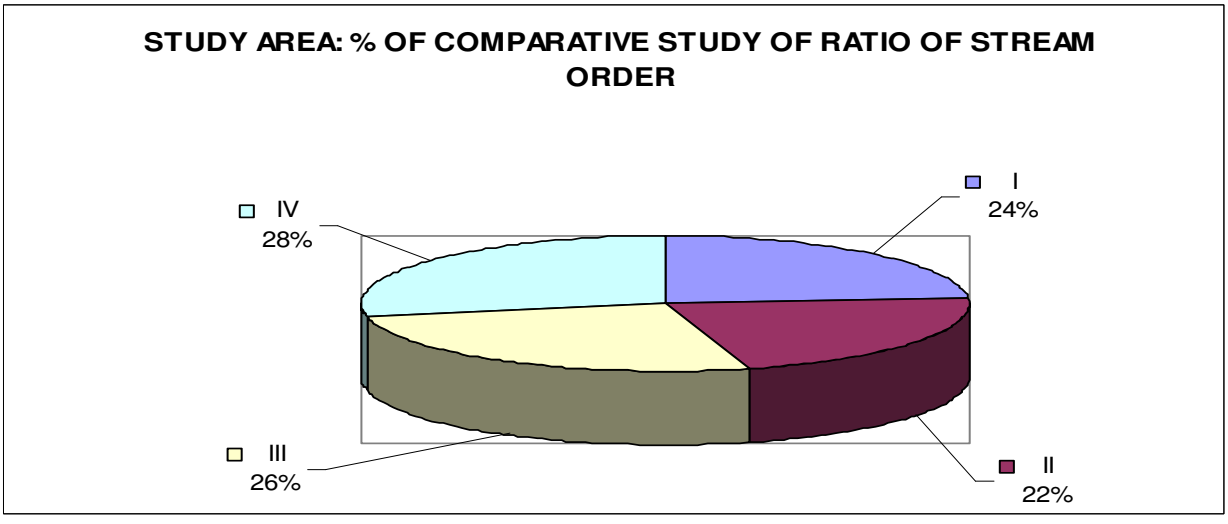

STUDY AREA:COMPARATIVE STUDY OF LENGTH OF STREAM ORDER
LENGTH OF STREAM
400
300
200
100
0
304.2
124.3
59.62
29.43
12.22
I
II
III
IV
V
STREAM ORDER
I
II
III
IV
V


STUDY AREA: % OF COMPARATIVE STUDY OF LENGTH OF STREAM ORDER
IV
6%
III
11%
V
2%
II
23%
I
58%


STUDY AREA:COMPARATIVE STUDY OF NUMBERS OF STREAM ORDER
NUMBER OF STREAM
400
350
300
250
200
150
100
50
0
370
88
23
5
1
I
II
III
IV
V
STREAM ORDER
I
II
III
IV
V


STUDY AREA:COMPARATIVE STUDY OF NUMBERS OF STREAM ORDER
IV
1%
V
0%
III
5%
II
18%
I
76%


STUDY AREA:COMPARATIVE STUDY OF RSTIO OF STREAM ORDER
RATIO
6
5
4
3
2
1
0
4.2
3.83
4.6
5
I
II
III
IV
V
STREAM ORDER
I
II
III
IV
V


STUDY AREA: % OF COMPARATIVE STUDY OF RATIO OF STREAM ORDER
IV
28%
I
24%
III
26%
II
22%

2 Aerial Parameters:-

Drainage pattern shows marked influence of the underlying geologic structure and history of the watershed. The main drainage pattern of area of Korba circle watershed is dendritic which has developed upon the rocks of uniform resistance. The evolution of such dendritic pattern in the area is due to the presence of massive thick bedded sandstone, rhyolites and granites. It is observed that the stream drainage lines exhibit almost parallel appearance in almost all the area. This is due to the fact that stream has been controlled by joints and lineaments.

A) Drainage Density :-

Drainage density is one of the useful parameter in watershed hydrological analysis. It is a measure of the closeness (density) of channel spacing. The area of Korba circle watershed exhibits high drainage density and is presented in **Table 8** below.

Table 8 Morphometric details

Watershed area	Watershed perimeter	Water shed length	Waters hed width	Drainage density	Stream Frequency	Form factor	Shape factor
Km2	Km	Km	Km	Km/ Km2	No/Km2	F=A/L2	B=L2/A
A	P	L	W				
187.50	74.85	22.17	22.9	1.70	1.56	0.63	1.58

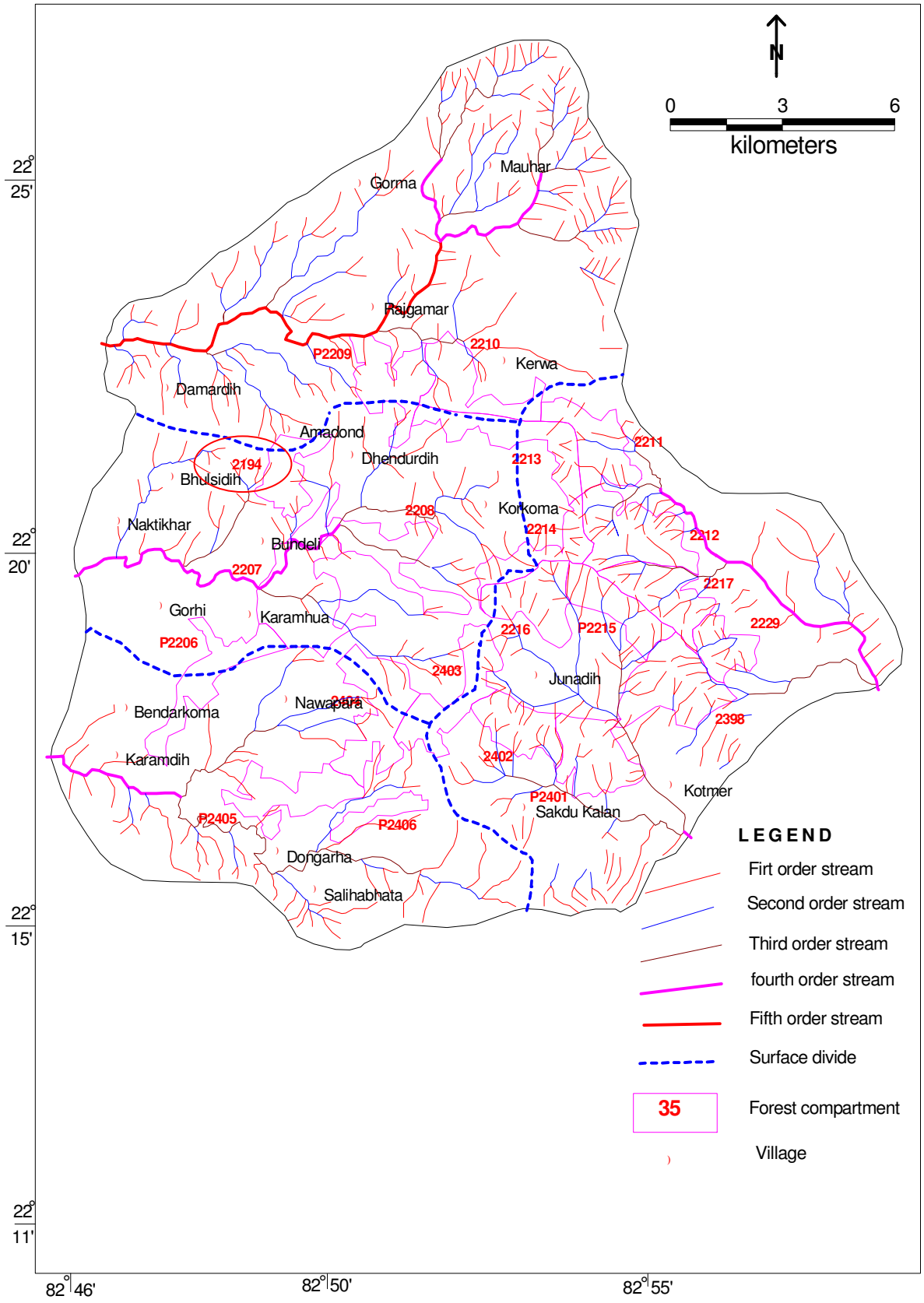
B) Relief - Longitudinal Channel Profile

The longitudinal channel profile represents the relationship between altitude and horizontal distance. It shows relief variation from origin to mouth of river. The Hilly and Forested area of Korba circle attains maximum elevation of 781 metres above and it reached to minimum elevation of confluence point i.e. 270 meter above msl. The river channel profile is normally found to be gentle. The relief details are given in **Table 9**.

Table 9 Relief details			
Max height	Min height mamsl	Basin relief	Average length of overland flow
mamsl		Ratio M	Lo=1/Dd
Z	Zs	H=Z-Zs	
781	270	511	0.59

The nature of this gentleness is a function of the basin geology and precipitation. The profile of Hilly and Forested area of Korba circle make it evident that the river is regarded as a consequent stream. Throughout its course the variation of relief are medium and only humps of sedimentary structure have been observed. In Hilly and Forested area of Korba circle composite profile shows that order - slope vary from 0° to >20°. It is predicted that Hilly and Forested area of Korba circle has a tendency to smooth its profile and no major tectonic structural disturbances has been observed. On the basis of above illustration the drainage map of Korba circle area is presented in **Fig 5.**

Fig 5 Drainage map of the study area.



5. GEOLOGY

(Of The Study Area)

In the area rocks of Gondwana Supergroup, and Bilaspur-Raigarh-Surguja Belt are exposed. The Gondwana Super group is represented by Barakar and Kamthi formation consists of sandstone, siltstone, shale and coal seams etc. while Bilaspur-Raigarh-Surguja Belt consists of Granite gneiss. The generalized stratigraphic sequence of the study area is given in Table 5 below:

Table-5 Generalized stratigraphic sequence of study area

Age	Supergroup	Group	Formation	Lithology
QUATERNARY	Recent to sub-recent		Alluvium	Sand, Silt, Clay
Carboniferous to Cretaceous	Gondwana Supergroup		Kamthi Formation	Sandstone, shale, siltstone, coalseams
			Barakar Formation	Sandstone, shale, siltstone and coal seams
ARCHAEAN to MIDDLE PROTEROZOIC	Bilaspur-Raigarh-Surguja Belt		Unclassified metamorphics	Granite gneiss ,Unclassified meta sediments

Bilaspur-Raigarh-Surguja Belt:

In the area rocks of Bilaspur-Raigarh-Surguja Belt comprising Granite Gneiss and unclassified meta-sediments are exposed in extreme south-western part and extreme eastern part covering an area about 33.63 sq.km.

GONDWANA SUPERGROUP:

In the area Gondwana Supergroup of rocks are represented by Kamthi and Barakar Formation which covers major part of the study area.

Barakar Formation:

In the area Barakar Formation of Gondwana age are exposed in western and southern part of the study area covering an area of about 111.3 sq.km.. It mainly consist of sandstone, siltstone, shale, and coal seams.

Kamthi Formation:

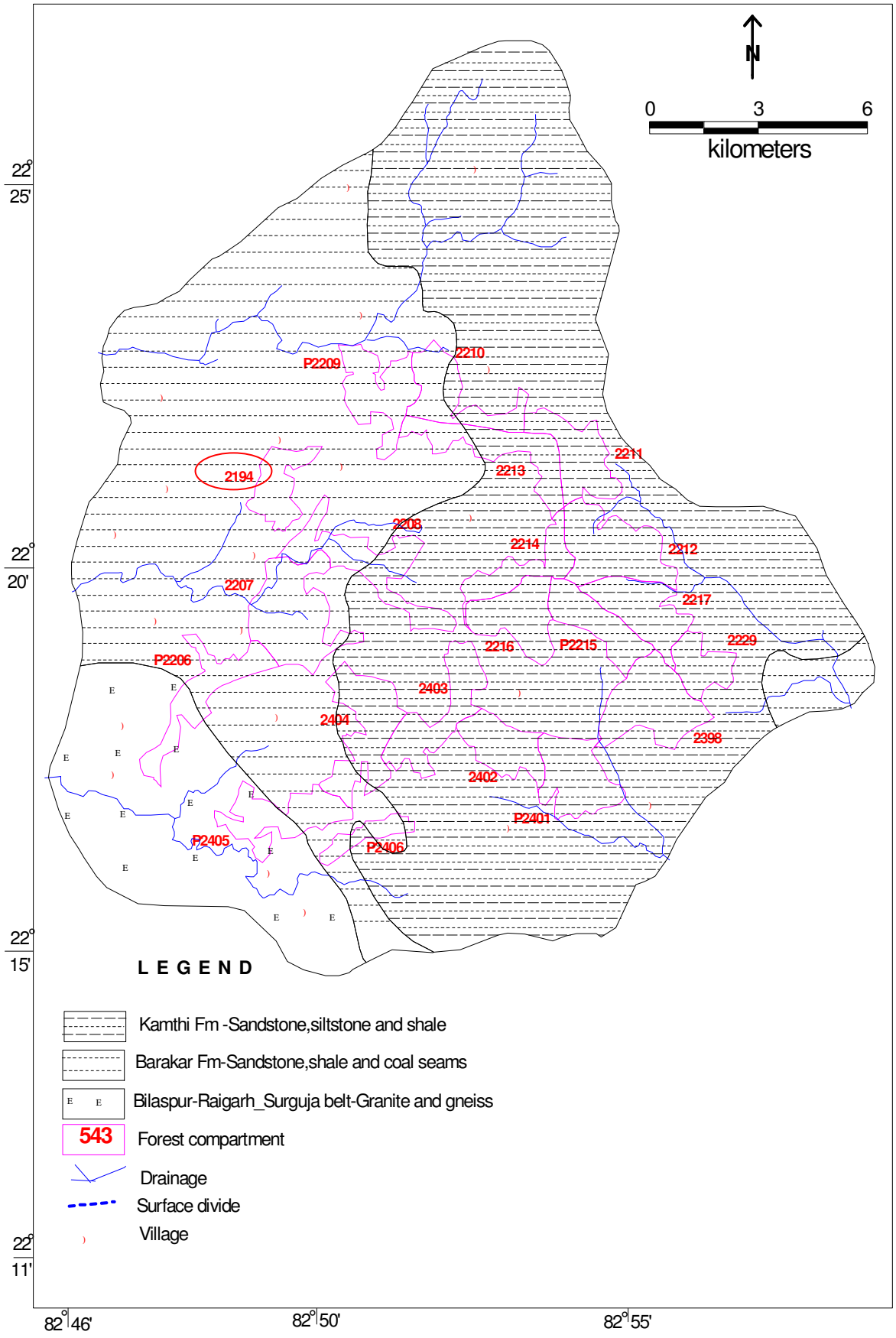
In the area Kamthi Formation of Gondwana age are exposed in major part of the study area in eastern part covering an area of about 166.6 sq.km.. It mainly consist of sandstone, siltstone, shale, and coal seams.

Alluvium:

Alluvium occurs in the area are mainly confined along stream, on either sides extending 0.1 to 0.5 km at places. This comprises mainly sand, clay, silt and kanker. It attains a maximum thickness of 20 meters along the drainage.

The geological map of the Korba circle area is presented in **Fig 6.**

Fig 6 Geological map of the study area.



6. GEOPHYSICAL SURVEY

(Of The Study Area)

The factors favorable for groundwater recharge and movement are usually studied from surface geological evidences as well as from wells that may be existing in an area. Utilizing this information, the attempt has been made to predict the locations favorable for ground water occurrence. But such a study usually meets with little success in areas where the information from wells and that provided by surface geology is either scanty or completely absent. An elegant scientific tool that aids us in discerning the sub surface conditions in such circumstances is the geophysical method of exploration.

Electrical Resistivity Method:

This method makes use of the differences in electrical characteristics of various rock formations occurring in an area. The electrical resistivity which varies from formation to formation also depends on the degree of water saturation in it. Through an indirect measurement at the surface of the variations of electrical resistivity with depth, one infers the structure and nature of subsurface strata aided by other supplementary geological information. Thus one can make a rough estimate of the depth and thickness of geohydrological horizon.

In the Electrical Resistivity method a known amount of electrical current (I) is sent into the ground through a pair of electrodes (current electrodes) and the potential (V) that is developed because of the resistance the ground offers to the passage of electric current, is measured across another pair of electrodes (potential electrodes). The ratio between this potential and current sent, gives the resistance of the ground to a depth which depends on the electrode - spacing.

The measurement of resistance can be made through various arrangements (configurations) of these electrodes. Among these the "Schlumberger" and the "Wenner" configurations are the most widely used. In the present investigations the "Schumbeger" electrode configuration has been used.

In this configuration "Vertical Electrical Sounding" is used to obtain information at a point, regarding the variation of resistivity with depth. In this the centre of the configuration is kept constant and the measurements are made at successively larger electrode spacings, varying the electrode separation from a small value, say one meter, to several tens of meter the depth of investigation increasing with increase in electrode separation.

The resistance (R) corresponding to each electrode separation (a) is computed from the measured values of potential (V) and the current (I). These computed values of "R" are used to determine the thickness and resistivities of various rock formations.

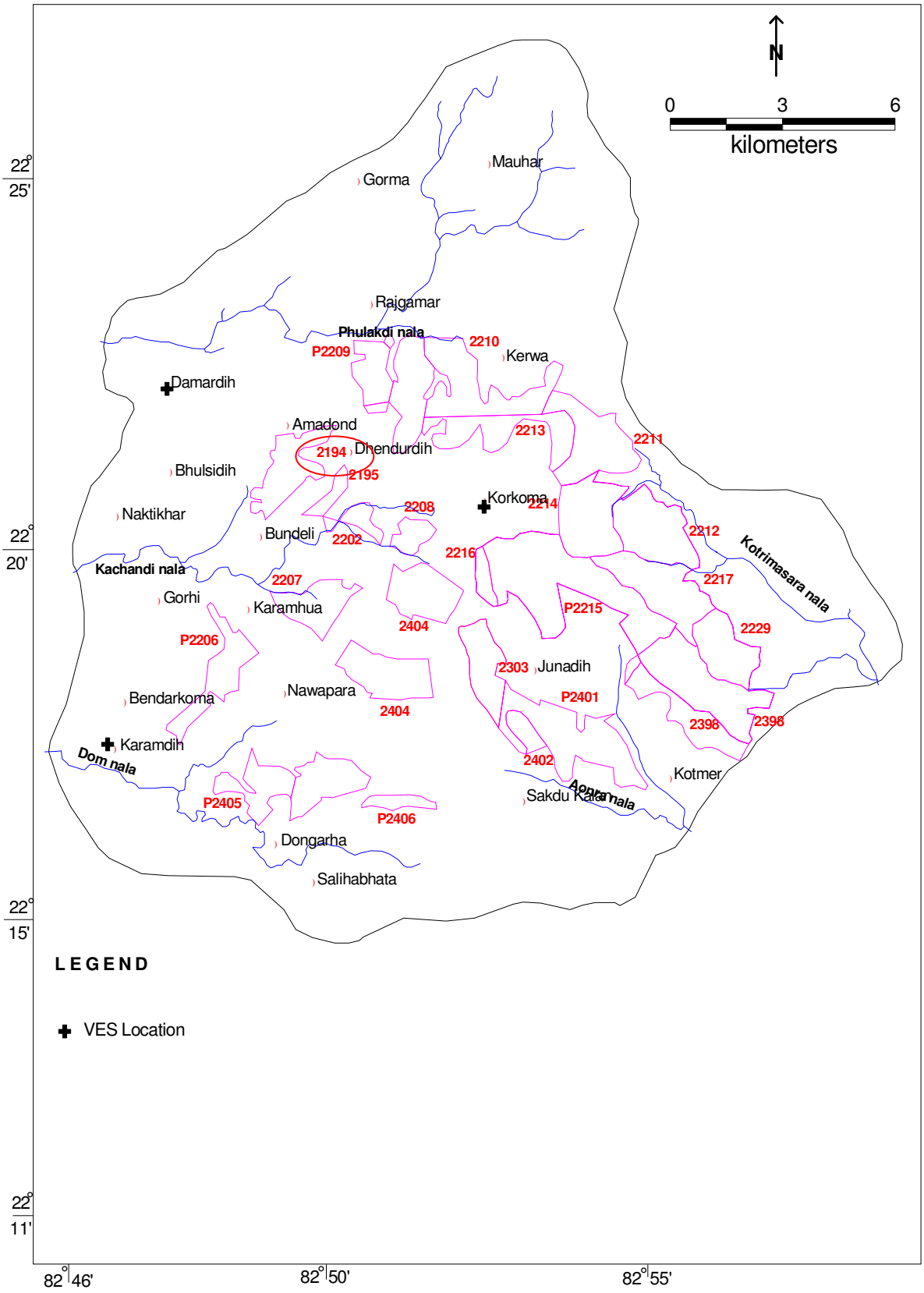
The data of resistivity soundings at three places were considered over the Korba circle area. The maximum current electrode separation ranged between 100 m to 110 m. The sounding results, in terms of resistivity (Ohm - meters) and thickness (h in meters) of the sub surface layers. Most of the sounding curves which were interpreted exhibited a three layer model i.e. a soil zone, followed by a weathered mantle and hard compact rock. The summarized results of some of the VES are given in **Table 11** below and location is presented in **Fig 7**.

Table 11 Summarised result of geophysical soundings

Name of the site	VES no.	esistivity value hm-m)			Layer depth (m)	
		ρ_1	ρ_2	ρ_3	D_1	D_2
kamardih	1	45	75	2100	1.6	15
Dumardih	2	75	80	1200	1.8	12
Korkoma	3	70	75	1100	1.4	13

From the Table 11 it is seen that the first layer is soil zone ranging in thickness from 1.4 to 1.8 while the second layer is a weathered mantle of different rocks types present in the area ranging in thickness from 12 to 15 m and the last layer is a hard and compact rock like sandstone, shale and granite gneiss indicating indefinite thickness.

Fig 7 VES Location in the study area



7. HYDROGEOLOGY

(Of The Study Area)

The occurrence of ground water is different in different formation and rock types. The weathered and fractured zone provides scope of ground water storage and movement. In the area, ground water occurs under phreatic condition in weathered portion and semi-confined to confined conditions in fractures at depths.

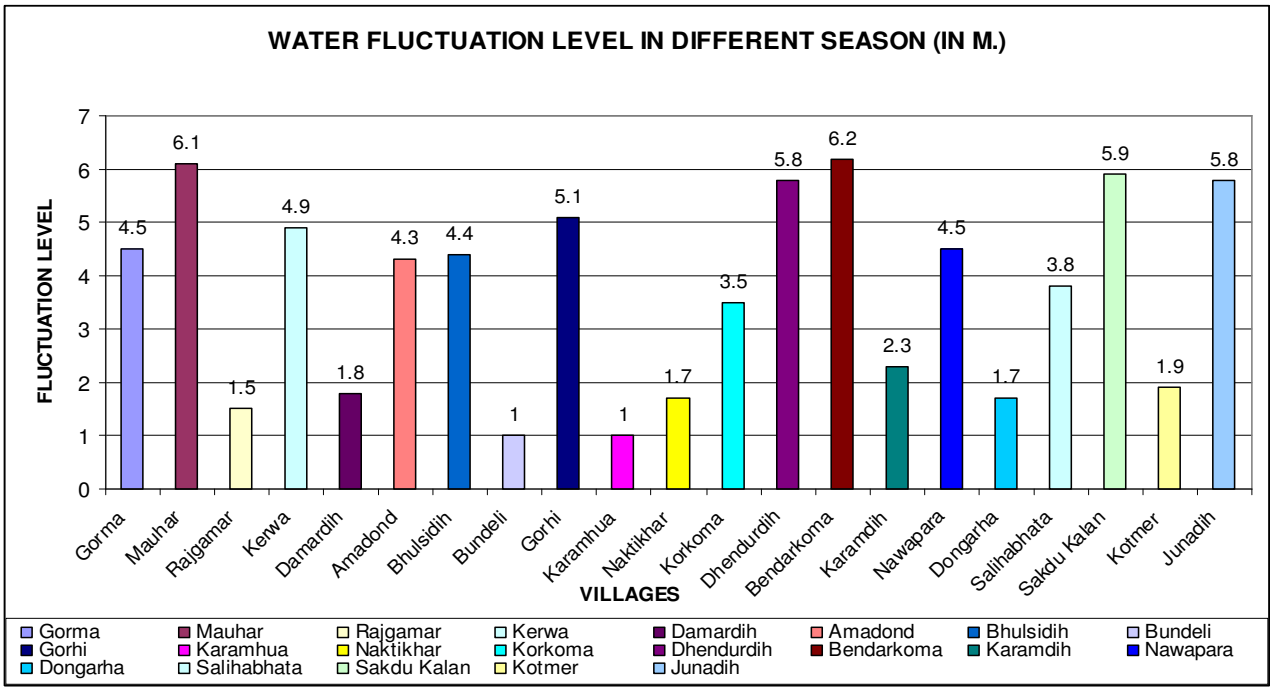
In the area the rocks of Gondwana and Bilaspur-Raigarh-Surguja belt of Archean to Carboniferous age are represented by sandstone, shale ,siltstones, coal seams and granite gneiss. These formation are having good potential from ground water point of view. The thickness of the weathered zone extends down to 15 mbgl, groundwater occurs under phreatic condition while ground water occurs in confined to semi-confined conditions in the deeper part of the aquifers.

7.1 Depth to water levels and Fluctuation:

To know the depth to water levels in pre and post-monsoon period and water level fluctuation in the area water level monitoring for selected villages have been carried out. From the above studies, it is observed that the depth to water level in area during pre monsoon period ranges between 4.70 to 12.00 mbgl. However the depth to water level is deeper in upland and hilly area and shallow water level observed in low-lying area (less than 5 mbgl). For the post monsoon period water level has been reported to be ranging between 2.50 to 5.90 mbgl. The water level fluctuation in the area varies about 1.00 to 6.20 m. The details are given in **Table 12** and the maps for pre-monsoon and post-monsoon period and its fluctuation is presented in **Fig. 8 , 9 and 10** respectively**.**

Table 12 Details of water levels in different season for the study area

S.N.	Village	long	Lat	Spot heigth mamsl	Premon soon depth to water level mbgl	Reduce level of premonsoon depth to water level mamsl	Post-monsoo n depth to water level mbgl	Fluctu ation (m)
1	Gorma	82.8425	22.4164	345.00	10.00	335.00	5.50	4.50
2	Mauhar	82.8764	22.4203	364.00	12.00	352.00	5.90	6.10
3	Rajgamar	82.8458	22.3886	324.00	4.70	319.30	3.20	1.50
4	Kerwa	82.8800	22.3767	335.00	10.50	324.50	5.60	4.90
5	Damardih	82.7925	22.3706	310.00	4.90	305.10	3.10	1.80
6	Amadond	82.8242	22.3614	323.00	10.20	312.80	5.90	4.30
7	Bhulsidih	82.7939	22.3508	310.00	9.20	300.80	4.80	4.40
8	Bundeli	82.8172	22.3364	318.00	4.90	313.10	3.90	1.00
9	Gorhi	82.7908	22.3219	304.00	8.00	296.00	2.90	5.10
10	Karamhua	82.8139	22.3200	324.00	4.80	319.20	3.80	1.00
11	Naktikhar	82.7800	22.3408	290.00	4.80	285.20	3.10	1.70
12	Korkoma	82.8753	22.3444	349.00	9.20	339.80	5.70	3.50
13	Dhendurdih	82.8406	22.3556	330.00	11.00	319.00	5.20	5.80
14	Bendarkoma	82.7819	22.2992	302.00	10.30	291.70	4.10	6.20
15	Karamdih	82.7794	22.2886	290.00	4.80	285.20	2.50	2.30
16	Nawapara	82.8233	22.3011	322.00	10.20	311.80	5.70	4.50
17	Dongarha	82.8211	22.2672	305.00	4.90	300.10	3.20	1.70
18	Salihabhata	82.8308	22.2586	318.00	8.00	310.00	4.20	3.80
19	Sakdu Kalan	82.8853	22.2769	325.00	10.50	314.50	4.60	5.90
20	Kotmer	82.9233	22.2819	311.00	4.80	306.20	2.90	1.90
21	Junadih	82.8883	22.3064	330.00	11.00	319.00	5.20	5.80



7.2 Water Table Contour, Recharge and Discharge area:

In order to study the direction of the ground water flow and to assess the nature of the stream in the watershed, the water table contours have been prepared. The elevation of the water table has been calculated from the spot height of the measuring point from Survey of India Toposheet on 1:50000 scales and is presented in **Fig 11** in Hydrogeological map of Korba circle area. From the figure it may be seen that the water table elevation varies from 300 m amsl in the north-west part to 330 mamsl in southern part. Water table more or less follows the surface topography. The north-western part of the watershed shows higher altitude of water table indicate recharge area for ground water while southern part of the watershed shows lower altitude indicate discharge area**.**

7.3 Aquifer parameters:

The aquifer parameters of the area covered by various existing lithounits are described below.

The transmissivity values of phreatic aquifer tapped in open well varies from 40 to 70 m^2/day while specific capacity ranges form 35 to 80 lpm/day. However for deep aquifer the transmissivity ranges from 60-100 m^2/day and at favorable places it goes up to 200 m^2/day. The potential fractures for boreholes up to 100 mbgl depth in the area are recorded at various depths i.e. 40-45, 60-65, 75-80, 90-95 mbgl and are 3 to 4 in numbers. The hydrogeological map of the study area is also prepared based on geomorphological, Geological and hydrogeological information of the area and is presented in **Fig 11.**

Fig 8 Pre-monsoon Depth to Water Level of the study area.

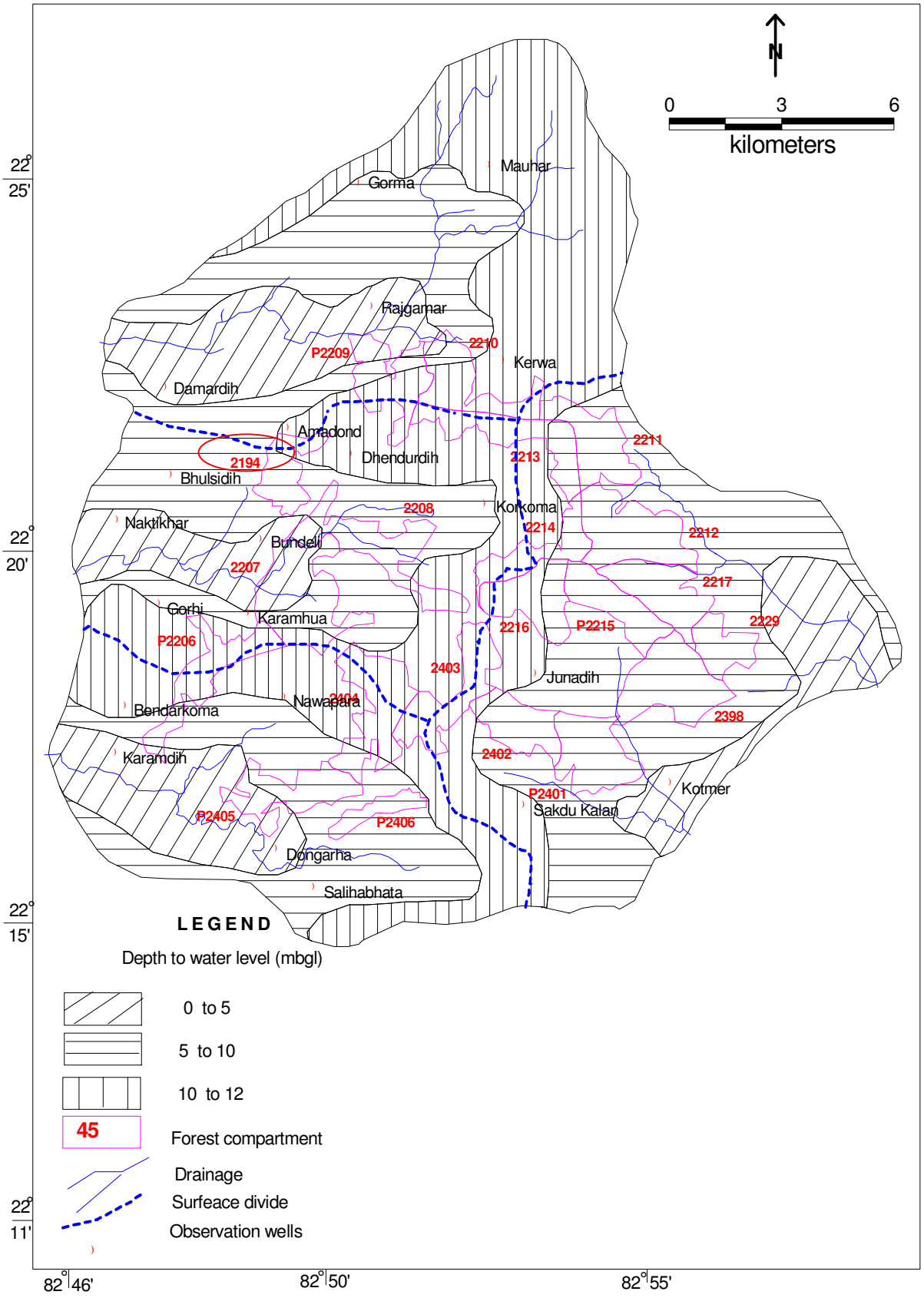


Fig 9 Post-monsoon Depth to Water Level of the study area.

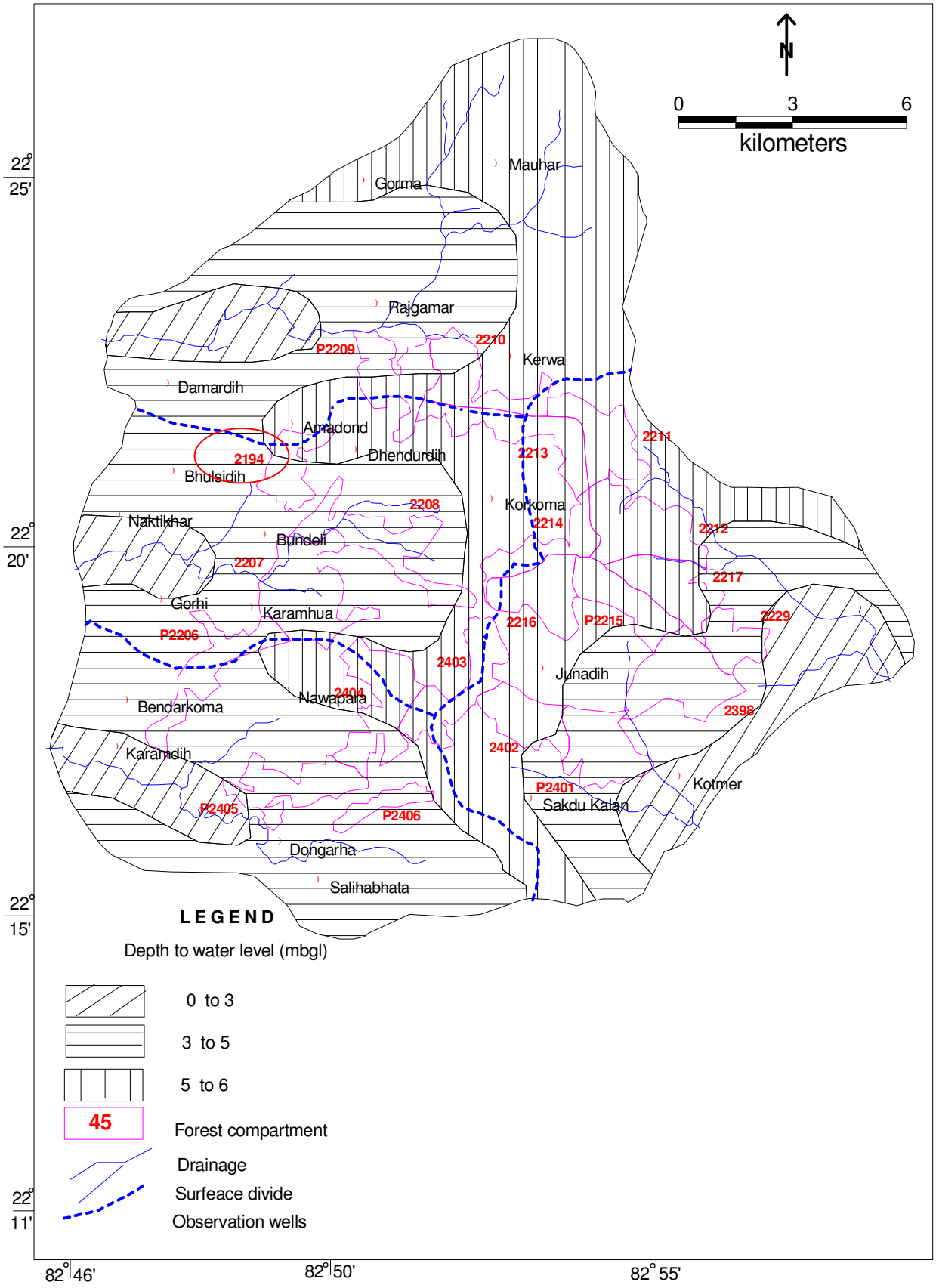


Fig 10 Seasonal ground water level fluctuation map of the study area.

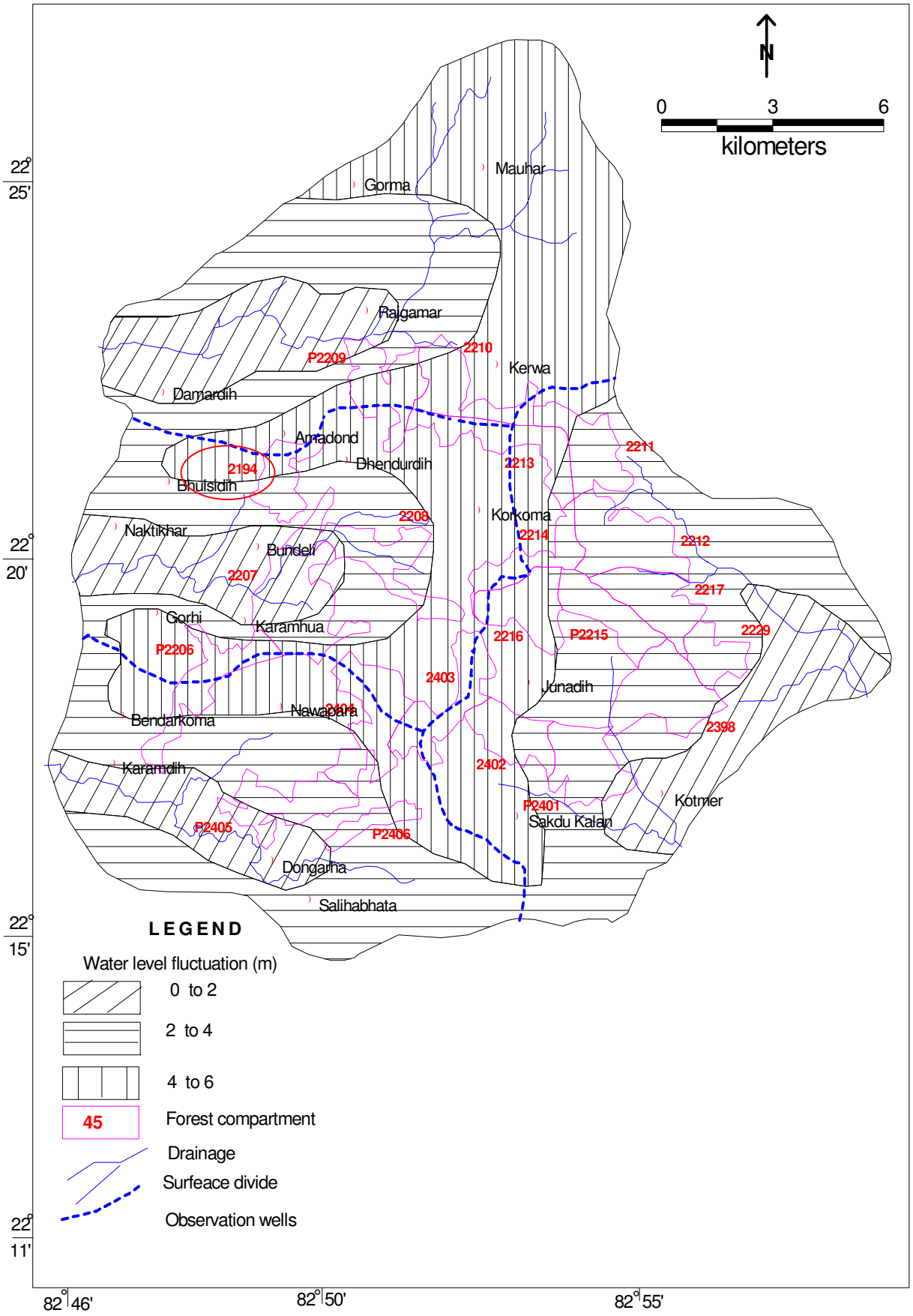
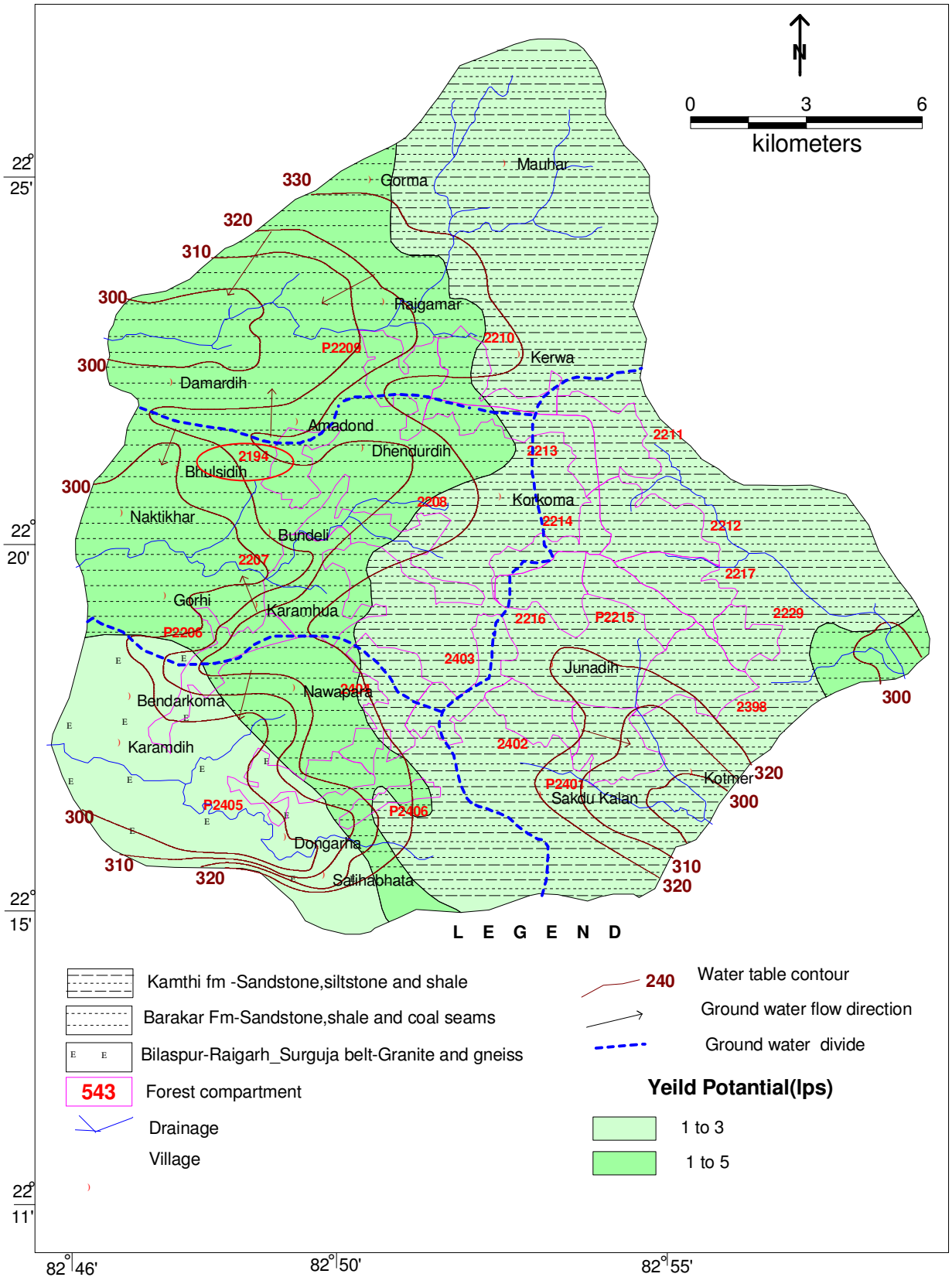


Fig 11 Hydrogeological map of the study area.



8. QUALITY OF GROUNDWATER

(Of The Study Area)

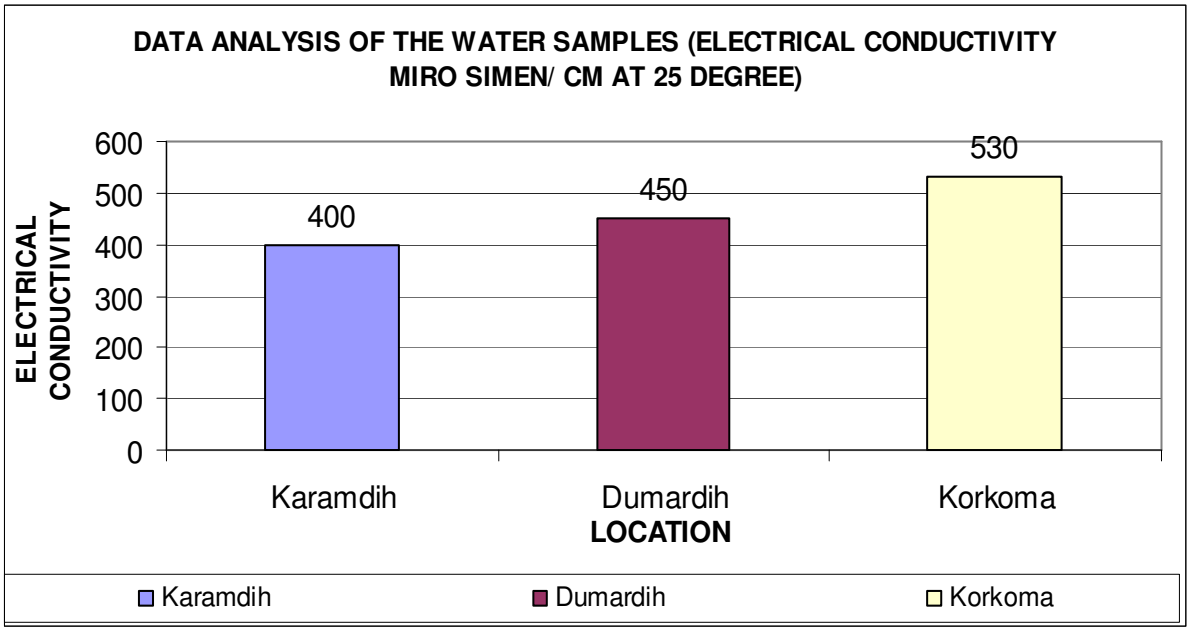
The chemical quality of ground water was evaluated from the water samples collected of selected villages from the phreatic aquifer and shallow deeper aquifer (bore wells).

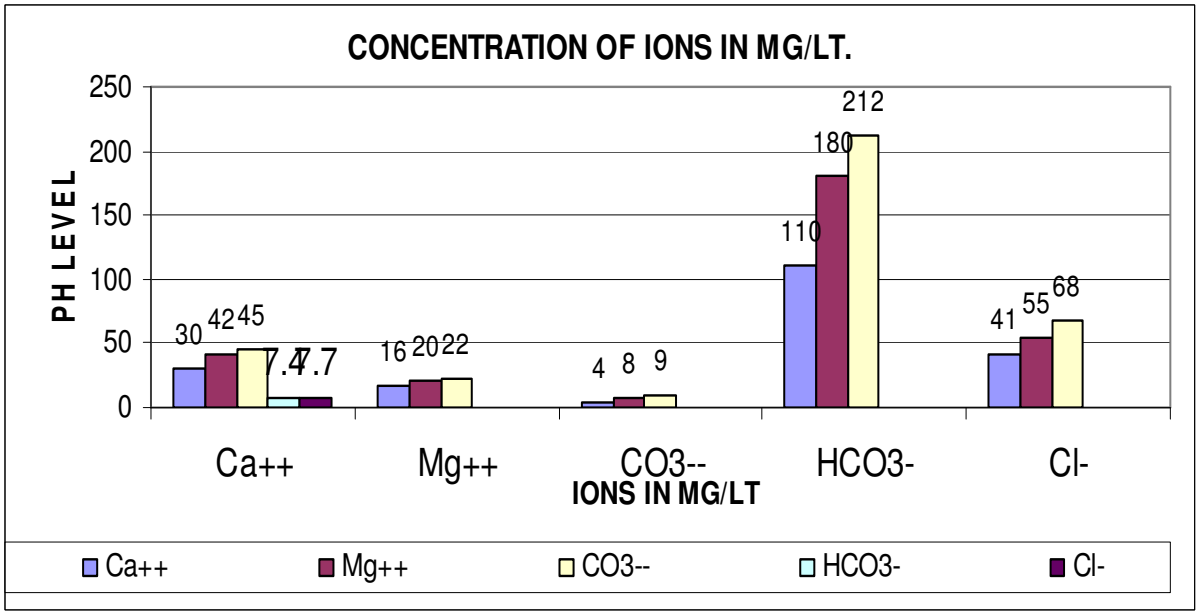
The analysis of the chemical data shows that the quality of ground water in area is generally alkaline to near neutral in nature. Electrical conductivity is a measure of total dissolved solids and ranges from 400 to 530 micro siemens/cm at 25° C. All major ions are within the limits of Bureau of Indian Standards for drinking purposes and meet the quality requirements of irrigation. Analysis of data of the water samples given below in Table 13 (in mg/l).

Table 13 ANALYSIS DATA OF THE WATER SAMPLES

Location	**pH**	**Electrical conductivity miro simen/cm at 25° C**	Concentration of ions in mg/liter				
			Ca^{++}	**Mg^{++}**	**CO_3^{--}**	**HCO_3^-**	**Cl^-**
Karamdih	7.4	400	30	16	04	110	41
Dumardih	7.7	450	42	20	08	180	55
Korkoma	7.8	530	45	22	09	212	68

From the above table it is seen that the water present in the area is suitable for drinking as well as irrigation purposes.


DATA ANALYSIS OF THE WATER SAMPLES (ELECTRICAL CONDUCTIVITY MIRO SIMEN/ CM AT 25 DEGREE)
ELECTRICAL CONDUCTIVITY
600
500
400
300
200
100
0
400
450
530
Karamdih
Dumardih
Korkoma
LOCATION
Karamdih
Dumardih
Korkoma


CONCENTRATION OF IONS IN MG/LT.
PH LEVEL
250
200
150
100
50
0
30
42
45
7.4
7.7
16
20
22
4
8
9
110
180
212
41
55
68
Ca++
Mg++
CO3--
HCO3-
Cl-
IONS IN MG/LT
Ca++
Mg++
CO3--
HCO3-
Cl-

9. GROUNDWATER RESOURCE ESTIMATION AND DEMAND

(Of The Study Area)

The ground water resources for the watershed were assessed as per methodology recommended by ground water estimation committee. The resources were calculated by Infiltration method due to non availability of long term water level data and fluctuation in the area. The rain fall recharge was calculated by Rainfall Infiltration method. Domestic water requirement has been estimated based on population as per Census 2001 by taking the average per capita consumption as 60 liter per day by considering 100% dependence of total population on ground water. The ground water draft for irrigation was calculated from number of ground water abstraction structure.

A. Ground water recharge :

a) **Total geographical area in ha**. = 31150
b) **Area not suitable for ground recharge in ha**. = 350
c) **Area suitable for ground recharge in ha.** = 30800
d) **Average water level:**
   Pre - monsoon = 7.0 mbgl.
   Post - monsoon = 4.5 mbgl.
e) **Normal annual rain fall** = 1.05 m.
f) **Normal monsoon rain fall** = 0.90 m.
g) **Normal non monsoon rain fall** = 0.15 m
h) **Ground Water Recharge by rain fall infiltration method** - The rain fall infiltration factors for different formations have been taken as those recommended by GEC 97 .The equation used for computation of recharge is

R_{rf} = NAR × A × RFI

Where,

R_{rf} = Recharge from rainfall

NAR = Normal annual rain fall

A = Area of the unit in ha

RIF = Rain fall infiltration factor

Recharge from rainfall = 1.05 × 30800× 0.06
= 1940.4 ham.

a. Return seepage from surface water irrigation

Crop type	Area irrigated (ha)	Average depth of water applied (m)	Irrigation water applied (ham)	Water delivered at 80%efficiency	Seepage factor	Seepage (ham)
Paddy	1200	0.4	480	600	0.4	240

b. Seepage from tanks/ ponds

1. No of tanks = 20
2. Total water spreaded area in ha = 200
3. Seepage factor (m/year) = 0.6
4. Total non monsoon seepage (ham) =120

c. Total annual recharge =

Rainfall recharge + Seepage from irrigation + Recharge from tanks/ponds

= 1940.4+ 240+ 120

= 2300.40 ham

d. Net annual ground water availability

Net annual ground water availability has been computed by deducting the unaccounted natural discharge from the total annual recharge as per the criteria recommended by GEC'97.In the study area 8.5% of replenish able ground water is considered to deduct from total recharge as it goes as base flow.

Net ground water availability = Total recharge- Base flow

= 2300.40 ham -195.53 ham

= 2104.87 ham

B. <u>Annual ground water draft :</u>

1) **Domestic purposes -** Water draft has been estimated based on population. The average per capita consumption has been taken as 60 liters per day by considering 100% dependence on the ground water. The total annual demand is calculated as follows

Total annual demand in ham = Population × 60 × 365 /1000 × 10000

= 20454 × 60 × 365 / 1000 × 10000

= 44.79 ham

2) **Ground water draft for irrigation:** Ground water draft for irrigation was calculated from number of ground water abstraction structures present in the area.

Ground water structure	**No of G W structure**	**Unit draft in ham**	**Gross draft in ham**
Dug wells	200	1.0	200
Tube wells	60	2.5	150

C. <u>Ground water balance (ham)</u> :

= Annual utilizable GW resource – Gross ground water draft

= 2104.87 ham-394.79 ham

= 1710.08 ham

From the above it may be seen that the balance ground water resources in the area is of the order of 1710.08 ham.

D. <u>Stage of ground water development</u> :

= Gross ground water draft × 100/Annual utilizable GW resource

= 394.79 *100/2104.87

= 18.75 %

E. Irrigation Potential:

Irrigation potential of groundwater resources is the area that can be irrigated from available groundwater resources.

Irrigation potential where the stage of development below 70%	Irrigation potential where the stage of development up to 90%
1554.2ha	2160.8 ha

According to recommended methodology stage of development below 70% is considered safe under all circumstances whereas stage of development up to 90% is considered safe, if the long-term water levels do not show any declining trends.

F. Static ground water resources:

The static groundwater resources have been computed taking the maximum depth of water level fluctuation, permissible depth of mining, specific yield (Sy) of the area suitable for groundwater recharge. Out of the entire thickness of the formation between the deepest level of water table fluctuation and permissible depth of mining, 2% has been considered as the total fracture zone. The specific yield values have been taken as weighted average of specific yield values for different formations. The formula used for the computations is as follows

$$R_s = A \times S_y \times T_r$$

Where

R_s = Static groundwater resources in ha m

A = Area in ha

S_y = Specific yield

T_f = Total thickness of the fracture zone

&

$$T_r = (Z_2 - Z_1) \times 0.02$$

Where,

Z_1 = Depth of maximum water level fluctuation in m

Z_2 = Permissible depth of mining in m

So static ground water resources are,

$$R_s = 30800 \times 0.02 \times 20$$

$$= 12320.00 \text{ ham}$$

WATER DEMAND ANALYSIS:

a) Domestic Purposes:

Domestic water requirement has been estimated based on projected population in the year 2025 . The projected population in the year 2025 is considered as increase of 25%.The average per capita consumption has been taken as 60 liter per day as 100% dependence on the ground water. The total annual demand is calculated as follows:

Total annual demand in ham = Population × 60 × 365 /1000 × 10000

=25567× 60 × 365 / 1000× 10000

= 55.99 ham

b) Irrigation Purposes:

Water requirement for irrigation was estimated based on available non irrigated land and crop water requirement, land use data were made available by the state Govt. department. Water requirement for unit area is taken as 0.694 m for Rabi and kharif. So the water requirement is as follows:

Total annual demand for irrigation in ham = Area of non irrigated land (ha) × 0.694

= 6300.0 × 0.694

=4372.2 ham

c) Industrial Purposes:

There is no such big industry, so the water requirement is negligible for industrial purposes.

e. Future strategy:

From the above it is clear that the total future water requirement for all uses is coming around 4428.19 ham. The water recharge to the ground water through recommended artificial recharge structure in the water shed is of the order of 388 ham which is calculated based on post-monsoon depth to water level. So additional water requirement for double crop can be mate through surface water resource and ground water to fulfill all demands.

10. GROUNDWATER MANAGEMENT, RAINWATER HARVESTING AND ARTIFICIAL RECHARGE

(Of The Study Area)

The integrated watershed management programme can be developed in the area to have sustainable development and management by harmonizing the use of water, soil and forest resources on basin/ sub basin/ watershed level.

One of the way of by which ground water is augmented at a rate exceeding that of natural conditions of replenishment is Artificial Recharge. It can be done basin or watershed wise.

It is known that the objectives of the present study is to construct artificial recharge structures and do the rain water harvesting in the hilly/forested part of Korba circle area in which, most of the rain water goes as surface runoff and to have benefits to the users or population residing in downstream areas. It is also noted that though the whole Korba circle area has been considered for various geological, hydrogeological studies which was the need to understand the area and to fulfill the present objectives, the main emphasis was given to construct various rain water harvesting and artificial recharge structures in hilly/forested part of Korba circle area. For the above management estimation of available storage space, surface water requirement and availability of surplus water for recharge has been computed for whole watershed and described below in subsequent headings

In the area, the ground water is mainly utilized for domestic and irrigation purposes. The ground water abstraction is mainly through dug wells, bore wells/tube wells. The present estimated ground water draft in the area for the domestic purposes is 44.79 ham and the ground water draft for irrigation is around 350.0ham. The ground water draft for industrial purposes is negligible.

A. Artificial Recharge:

The plan for artificial recharge has been prepared by considering the hydrogeological parameters and hydrological data. The following steps have been taken into consideration.

1. Identification of need based area for artificial recharge to groundwater
2. Estimation of sub-surface storage space and quantity of water needed to saturate the unsaturated zone (upto 3m bgl)

3. Quantification of surface water requirement and surplus annual runoff availability for artificial recharge.
4. Determination of suitable recharge structures as to their numbers, type, storage capacity and efficiency considering estimated storage space and available resource.
5. Working out the cost of artificial structures to be constructed in identified area.

Methodology:

The methodology adopted for artificial recharge is given below:

a. Average post-monsoon depth to water level is prepared.
b. Based on post-monsoon depth to water level area feasible for artificial recharge has been demarcated and put into 3 categories.
    i. Area showing water level 0 to 3 mbgl.
    ii. Area showing water level 3-5 mbgl.
    iii. Area showing water level 5-6 mbgl

1) Estimation of available storage space:

The estimation of subsurface storage space is based on the thickness of available unsaturated zone (below 3 mbgl) in post-monsoon and the specific yield of phreatic aquifer, the limit to saturate the vadose zone below 3 m is kept with a view to avoid water logging and soil salinity. The total volume of unsaturated strata is estimated and actual amount of water required to recharge the aquifer upto 3 m has been calculated by multiplying with specific yield of the area i.e. 0.02%.

Volume of surface water required is calculated by the formula given below:

Volume of surface water required = Area (ha) × Average water level (in Meter) × Specific yield

= 15780* × 1.0 × 0.02 = 314.0 ham (for DTW 3-5 mbgl)
= 6000* 2.5* 0.02 = 300 ham (for DTW 5-6 mbgl)

So the vadose zone of 614.0 ham is available for artificial recharge in the study area.

2) Surface water requirement:

After assessing the actual volume of water required for saturating the vadose zone, the net amount of source water available has been calculated. Based on the field experiment an average recharge efficiency of the individual structure has been worked out by taking 75% efficiency of the artificial recharge structure. The value obtained is multiplied by 1.33 (A reciprocal of 75% efficiency). So the volume of water required for artificial recharge is 816 ham.

3) Availability of surplus water for recharge:

Availability of source water to recharge the subsurface reservoir in the watershed has been assessed in the form of non-committed surplus run-off. The run-off is estimated by using Stranger's Table for the normal monsoon rainfall of the area. The watershed area falls in the category of average catchments. The normal monsoon rainfall of the area being 1050 mm. The percentage of run-off to rainfall as per Stranger's Table is 28.1and the depth of run-off due to rainfall is 31.82 cm. The total yield of run-off generated from watershed having 31150 ha area works out to 9656.5 ham and 30% of the total run-off i.e. 2896.95 ham is considered as surplus monsoon run-off available for artificial recharge.

B) Types, Specification, Design and Feasible no. of recharge structures:

The various recharge structures have suggested by keeping in view the forest compartments falling in the hilly/forested area. The suitable artificial recharge structures in the area which are proposed to construct are mainly Gully plugs, Boulder Check Dam/Gabion structures, Contour bunds/Trench in the upper reaches of the watersheds, percolation tanks, Check dams in the runoff zones and recharge shafts, gravity head wells in down stream areas. The details of artificial recharge structures along with the estimated feasible number of structures and tentative cost is given in **Table 14** and location of proposed artificial recharge structures is presented in **Fig 12**.

Fig 12 Location of the praposed structures

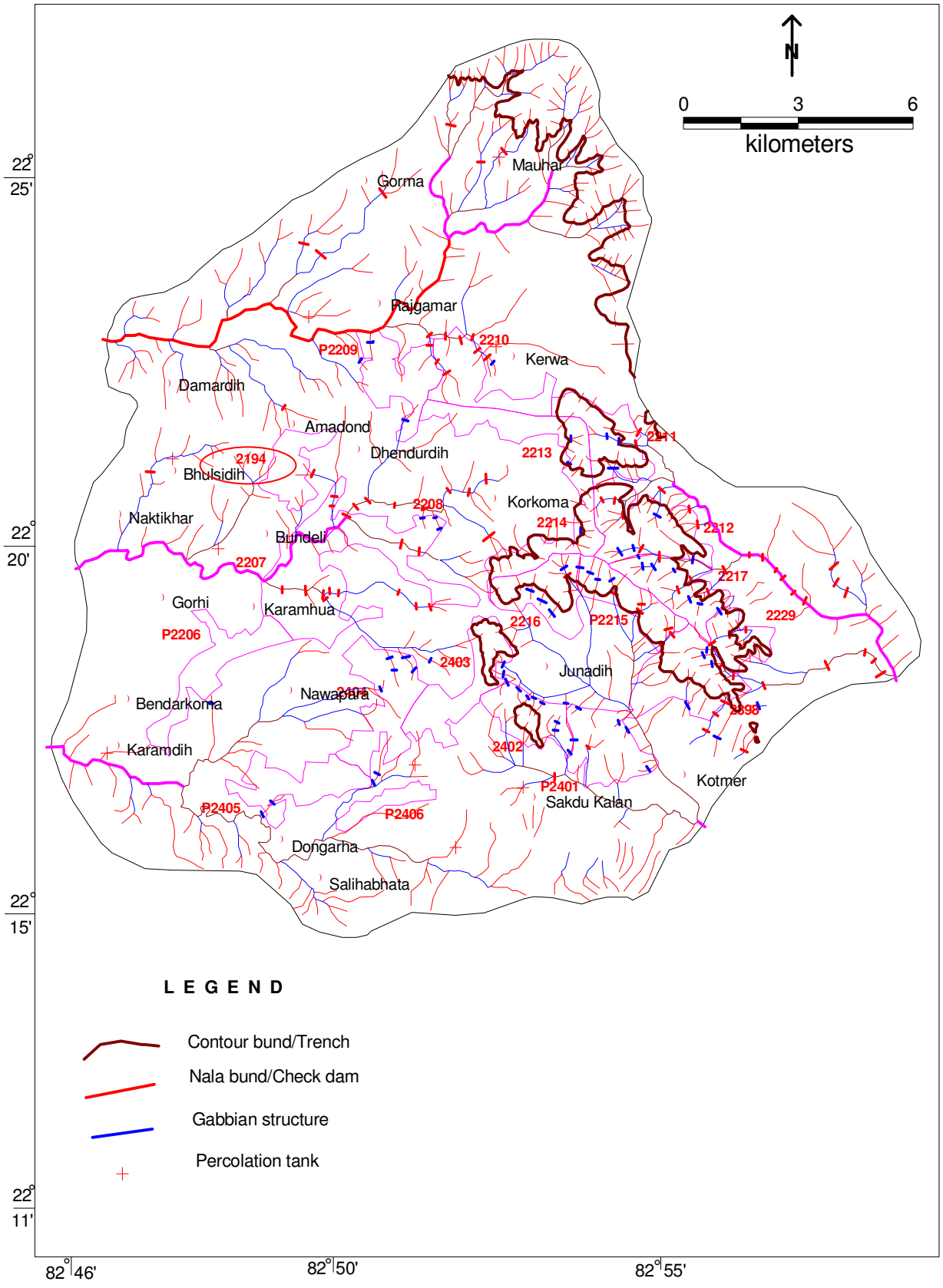


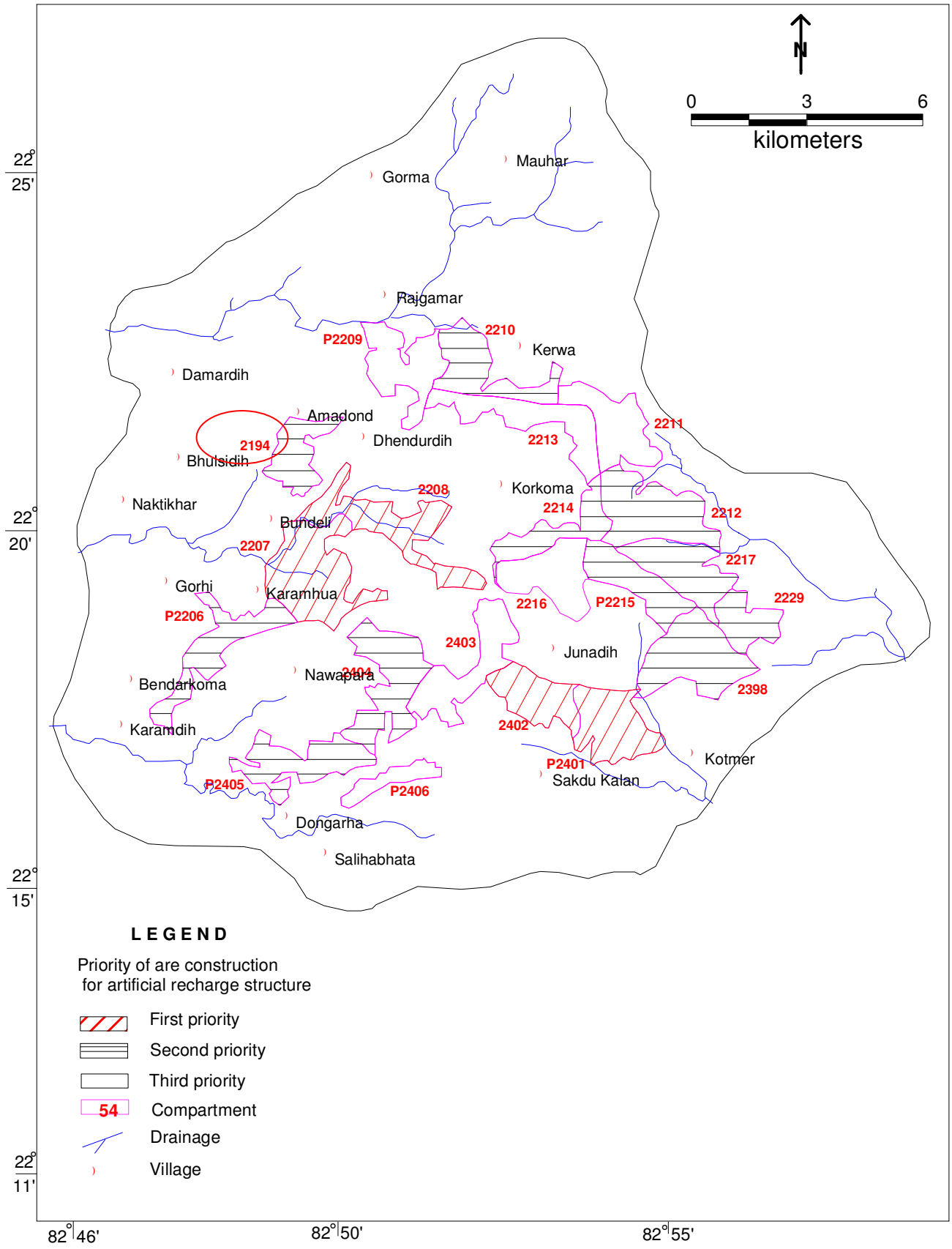
Table 14 Details of Artificial recharge and Rain water harvesting structures to be constructed in Hilly/Forested part of the Korba circle area				
Sr No.	Compartment	Checkdam/nala Bund	Gabbion Structures	Percolation tank
1	2207	6		
2	2206		1	
3	2208	2	3	
4	2209		2	
5	2210	9	1	
6	2211	2	3	
7	2212	3	2	
8	2213		2	
9	2214	3	1	
10	2215	7	8	
11	2216	1		
12	2217	5	10	
13	2303		3	
14	2309	8	6	
15	2229	1	1	
16	2401	1	12	
17	2404		5	
18	2405		4	
19	2406		1	
20	2205	3		
21	2194		1	
22	2195	5		
23	Out side of the Compartment	29		10
Total		85	66	10

Note: The location of Contour trenching is given in map.

From the table 14, it is seen that 85 no.of Nala bunds/ Check dams, 66 no.of Gabbion structures, 10 no. of Pecolation tanks and 81 km*5 (row) long Contour trenching/ Contour bunds to be constructed in the hilly/forested area of the Korba circle area. The tentative estimated cost to construct all these artificial recharge structures is approximately coming around 250 million. It is suggested that the contour trenching and contour bunding may be constructed adjacent to each other and also provided by sufficient break between two adjacent bunds/trenches.

The priority basis for construction of Artificial Recharge Structures have also been demarcated and given in **Fig 13**.

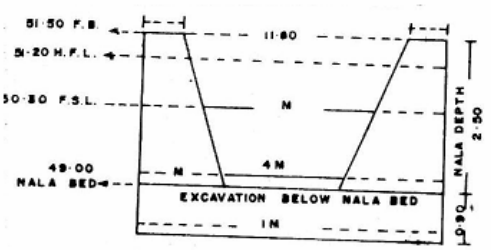
Fig 13 Area Demarcated as per Priority for Construction of Artificial Recharge Structure.

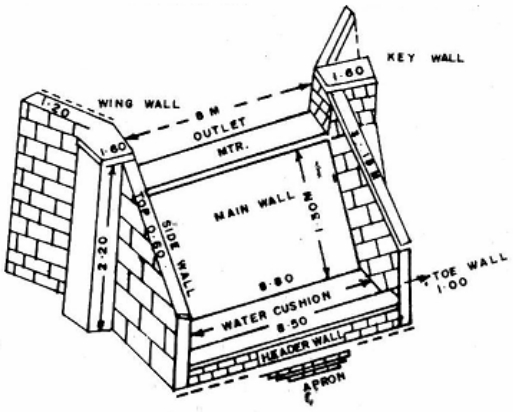


The recharge capacities and cost of construction of these various structures are different. The recharge capacities of recommended structures are given in the form of table below & the model diagrams for some of the structures are also provided.

Recharge capacity of artificial recharge structure in a year (ham)					
S.N	Type of structure	No of structure proposed	Recharge capacity of each structure in a year in ham	Total recharge by structure in a year in hm	Remarks
1	Check dam/ Nala bunding	85	1.5 ham	127.5 ham	Recharge capacity depends upon the dimension of the structure , infiltration rate of soil and availability of non-commuted water As the area is forest and hilly ,given more important for construction of Contour trenching and contour bunding which is best suitable structure in above geomorphic unit
3	Percolation tank	10(about 15 ham capacity)	15 ham	150ham	
4	Contour trenching and Contour bunding	81 km x 5= 405 km	1 ham /km	405ham	
4	Gabbion structure	66	0.5 ham	33 ham	

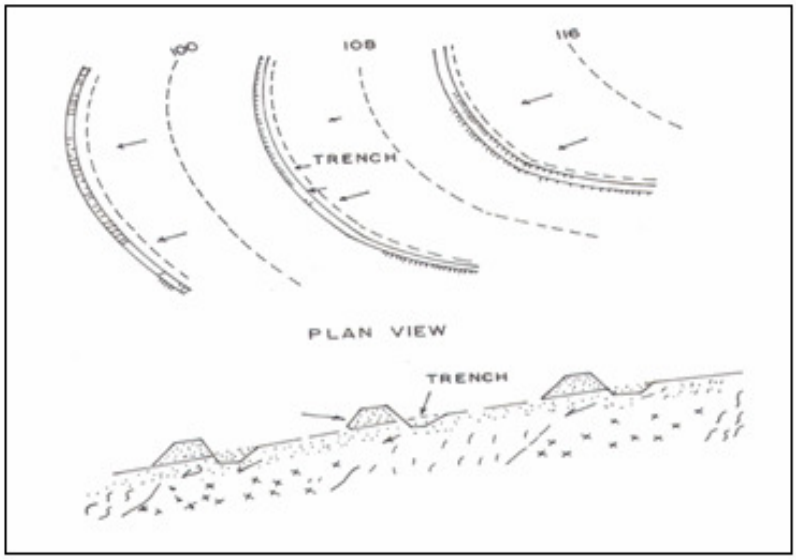
Vertical Section of Check Dam/ Nala Bund



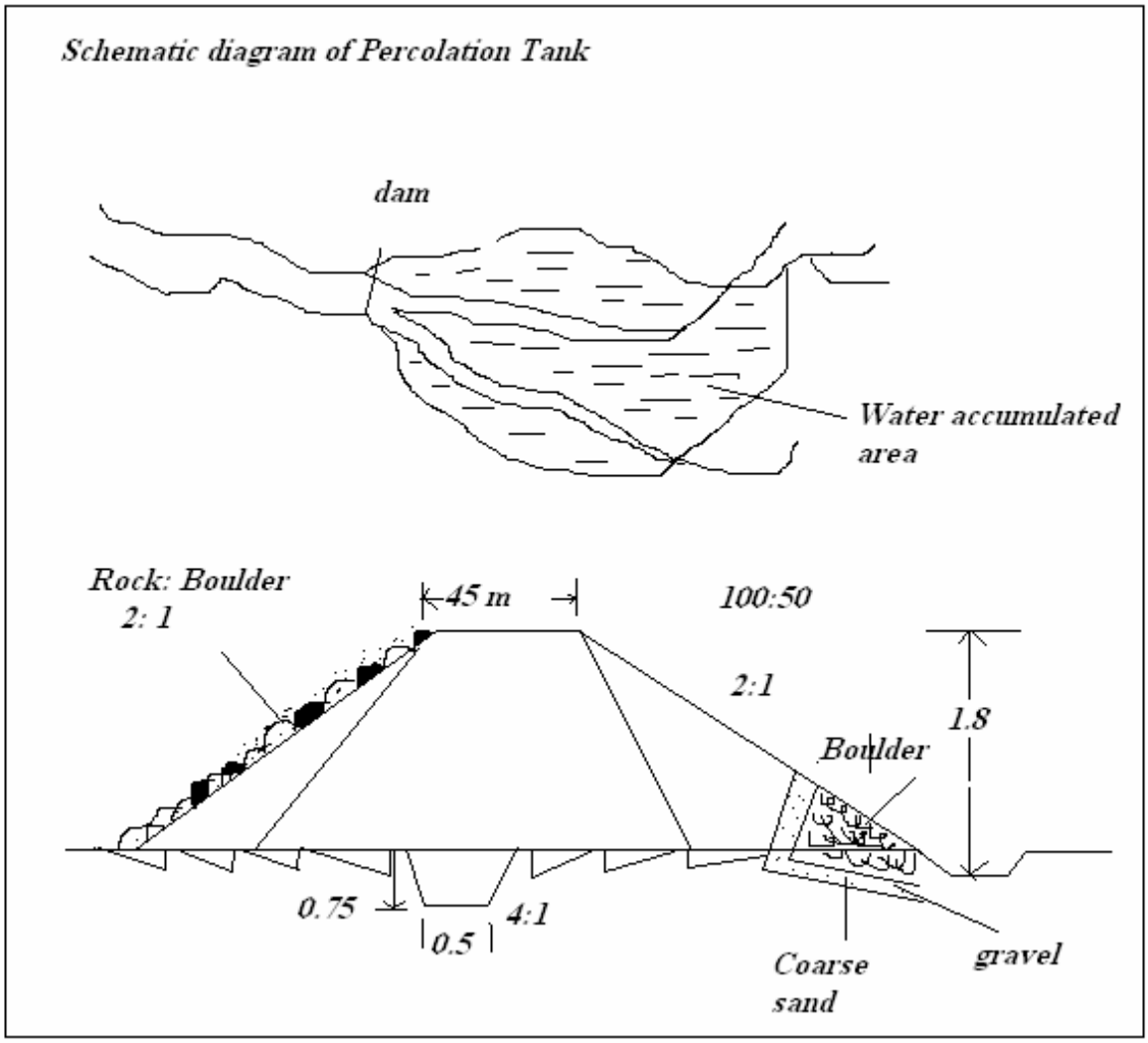


Horizontal Section of Check Dam/ Nala Bund

Sectional View of Contour Trench/ Contour Bund



Schematic diagram of Percolation Tank



11. ZERO DISCHARGE COMPARTMENT – PLANNING AND MANAGEMENT

(Of The Study Area)

The main objectives of the present study is to find out suitable structures, and their appropriate locations to check every drop of water falling within the compartment area and to force percolate down up to aquifers.

The main emphasis is given to prescribe various rain water harvesting and artificial recharge structures within the compartment boundary a part of watershed. The various parameters including but not limited to Estimation of Available Storage Space, Surface Water Requirement, Availability of Surplus Water for Recharge, Type of Soil, Slope, Run off, Precipitation, Transportation, Evaporation, Soil Moisture, etc. have been taken in to account and computed to find out best location and type of appropriate structures.

Apart from studies done at the Master Plan Level for the whole Watershed, following studies are done at the micro level (Compartment) for further strengthening of the area for forcing every drop of water to percolate down to earth with minor structures.

Number of Staggered Contour Trenches, Boulder Check Dams, Earthen Check dams, their size and spacement is derived from the following methodology.

The **First Part** towards the Northern Region extends up to 205.14 ha.

The average slope at the stretch of 100 m. horizontal distance is 2947 m.

Ratio = 2947/100 = 29.47 to I m. Say 1:29

Degree = $1^0$43'06"

Percentage = 1/29 100 = 3.44%

Value of C = Coefficient showing % of rainfall appearing as runoff, a watershed factor = timber plain = 0.036

The **Second Part** towards the Northern Region extends up to 95.33 ha.

The average slope at the stretch of 100 m. horizontal distance is 442.72 m.

Ratio =442/100 = 4.42 to I m. Say 1:4

Degree = $14^0$02'10"

Percentage = 1/4x 100 = 33.33%

Value of C = Coefficient showing % of rainfall appearing as runoff, a watershed factor = timber plain = 0.3

The **Third Part** lies at the Eastern region of the compartment extends up to 77.55 ha.This area has almost plain.

2. HYDROLOGIC CYCLE

This is calculated on the basis of following formula

RO=P – (T + E) +(-) S

Where

RO = Run Off,

P = Precipitation,

T = Transportation,

E = Evaporation,

S = Soil moisture and ground water storage.

3. ESTIMATING MAXIMUM RUN OFF

Q = C I t a

Where

Q = Rate of discharge in cum per second,

C = a coefficient, showing percentage of rainfall appearing as runoff, a watershed factor,

I = Average rainfall intensity, in mm/hour,

A = drainage area, in hectare.

4. DERIVATION OF SIZE OF CT, SPACEMENT AND NOS.

With the help of above formulas shown in no. 2 & 3 computation of data is done and balance between the total volume of water to be stored at maximum run off by the contour trenches and its sizes is made.

Value of C i.e. a coefficient, showing percentage of rainfall appearing as runoff, a watershed factor is calculated on the basis of slope % and kind of watershed. This compartment comes under the pasture hilly and timber rolling kind of watershed.

On the basis of these calculations the no. of CT, Size of CT, and Spacemen between the contour trench line and between the contour trenches is derived. The area is divided on the basis of slope and the structures computed for the compartment no. P-2194are given in the table no. 16.

Table 16 Details of Artificial recharge and Rain water harvesting structures to be constructed in compartment no. P-2194

Type of Structures			
Area of C.N. P-2398	Contour trench (size 3x0.45x0.45m.)Spacement 3x400 m	Earthen check dam	Bolder Check dam
Total Area 187.50	5208	5	3

Note: The location of structures is given in map.

The above structures are optimum to trap each drop of rain water. However out flow of water from the compartment will continue after saturating the aquifers, from sub soil surface in the form of seepage, leaching, oozing and through other under ground natural water channels thus the surface streams will flow naturally without causing any harm to flora and fauna of the compartment and its surrounding areas.

B) Standard types, Specification, Design of recharge structures:

The various recharge structures have been suggested by keeping in view the forest compartment falling in the hilly/forested area. The standard type of suitable artificial recharge structures in the area which are proposed to construct are mainly Gully plugs, Boulder Check Dam, Earthen check dam/Gabion structures, Contour Trench in the upper reaches of the watersheds, masonry check dam, in the runoff zones. The standard type of the structures is attached in the annexure section of the report.

12. SOCIO-ECONOMIC IMPACT OF THE STUDY AREA

In this section the expected/ actual impacts of activities on the natural resources and village economy is discussed. Only soil and water conservation structures are proposed in the project. The Impact of these structures can be divided in to forms.

A. DIRECT IMPACT

1. Socio-economic status of the people working in the project will improve as it would provide them working man days.
2. Recharging of aquifers
3. Increase in the Ground Water Table
4. Increase in average soil moisture
5. Increase in yield capacity of well
6. Increase in ground flora/grasses
7. The project is capable is generating 3793 Maydays.

B. INDIRECT IMPACT

1. Increase in site quality of the area in terms of forest/flora
2. Seed sowing on the bunds of Contour Trenches will increase fuel and fodder yield of the compartment.
3. It would improve the biomass resource in the area.
4. Due to increase in water table of the area people will be able to convert their un-irrigated land in to irrigated land.
5. Double crop area will increase.
6. Area of Kharif and Rabi crops will increase.
7. It is estimated that after the project completion, people farming in low lying areas coming within the underground water channels passing through the treated area will experience 10% to 25 % increase in their respective crop production.
8. on an average, a family in the watershed area, would get a direct consumption benefit of about 300 Kg of food grain per annum in a average rain fall year.
9. On an average Rs. 15,000.00 will be added in to the balance sheet of a house hold affected with this treatment, living within this watershed.
10. Health of live stock will increase getting more green fodder in the area due to increase in moisture level.

Alpana Sharma
(Managing Director)

12. FINANCIAL PROJECTION

PROJECT REPORT

National Rural Employment Guarantee Scheme

SOIL & WATER CONSERVATION WORK IN COMPARTMENT NO. P-2194

AREA =350.04 HA.

GENERAL INFORMATION

1.	Work Name	: Soil & water conservation work
2.	Name of Divisional Forest Office	: Division
3.	Range:	: Korba
5.	Block	: Korba
8.	Budget head	: National Rural Employment Guarantee Scheme
9.	Compartment No.	: P-2194
10.	Compartment Total Area	: 187.50
11.	Treatment area	: 187.50
12.	Rural area	: Aamadih, Dengur, Bundeli, Bhulsidih

Divisional Forest Officer Forest Division Korba	Sub Divisional Forest Officer Sub Division Korba	Range Forest Officer Forest Range Korba Raipur, C.G.

PROJECT REPORT

Soil & water conservation work

Year 2009-10

Compartment. No. P-2194

Total area 187.50 ha. Treatment area 187.50 ha.

Wage rate 75/mandays

AREA = 187.50 HA.

Work Detail	Quantity	Unit	Rate		Unit	Cost in Rs.	Expenditure on material	Expenditure on labour
			Man days	Cost in Rs.				
Survey/Demarcation	187.5	ha.	0.94 MD/ha.	70.94	ha.	13301.25		13301.25
Treatment Map & preparation of project report	187.5	ha.	230/ha.	230	ha.	43125		43125
Cleaning of the area	187.5	ha.	4.00MD/ha.	301.88	ha.	56602.5	2830.125	56602.5
Stacking for layout of contour trench	187.5	ha.	1.85 MD/ha.	139.61	ha.	26176.875	1308.8438	26176.88
Digging of contour trench in 0.6 density forest (size 3.00x0.45x400m.=0.60cmt.)Part I	5208	No.	43.33/cmt.	25.99	Trench	135355.92	6767.796	135355.9
Dry Level Check Dam	3	No.		2500	LS	7500	1500	1200
Earthen Check Dam	5	No.		2500	LS	12500	3125	2500
Other work = Fire protection, seed sowing, maintenance of structures					LS	10000	2000	8000
Total						**304561.545**	**17531.765**	**286261.5**

Divisional Forest Officer
Forest Division Korba

Sub Divisional Forest Officer
Sub Division Korba

Range Forest Officer
Forest Range Korba
C.G.