DETAILED PROJECT REPORT

For

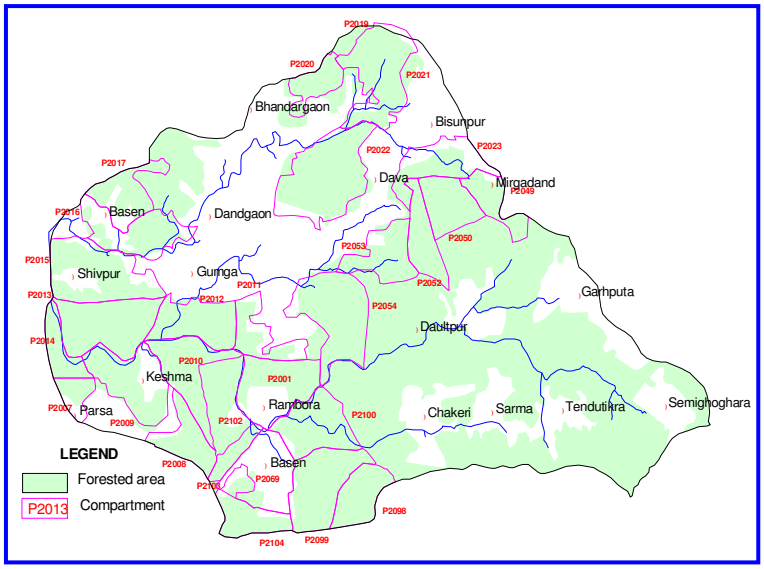
ZERO DISCHARGE BASED WATERSHED MANAGEMENT

Artificial Recharge and Rainwater Harvesting

In

4G2D5H1 & 4G2D5H3,

Surguja District, Chhattisgarh



In

COMPARTMENT NO. P2009

Of

Forest Range:

UDAIPUR
Forest Division:

SOUTH SURGUJA
Chhattisgarh

FOREST RANGE: UDAIPUR

FOREST DIVISION: SOUTH SURGUJA, DISTRICT- SURGUJA, CHHATTISGARH

TOTAL AREA – 322.45 HA.

TOTAL PROJECT COST – 9.47LACS

FROM,

LEARN NATURE CONSULTANTS

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DETAILED PROJECT REPORT

FOR

ZERO DISCHARGE BASED WATERSHED MANAGEMENT

ARTIFICIAL RECHARGE AND RAINWATER HARVESTING IN 4G2D5H1 & 4G2D5H3, SURGUJA DISTRICT, CHHATTISGARH

OF

FOREST RANGE: UDAIPUR
FOREST DIVISION: SOUTH SURGUJA

DISTRICT - SURGUJA,

CHHATTISGARH

TOTAL PROJECT AREA = 322.45 HA.

PROJECT COST: RS. 9.47 LACS

Divisional Forest Officer
South Surguja Forest
Division

INDEX

Area at a Glance
Compartment No. P2009

GENERAL FEATURES	
Area in Sq.km.	322.45 ha.
Co-ordinates	N 22°49'07" – 22°56'41"and 82°47'54" – 82°59'09" E
Population	12632
District Head Quarters	Ambikapur
Block	Udaipur
Villages	19 no.s
AGRICULTURE & IRRIGATION	
Net sown area (ha)	3000
Double cropped area (ha)	500
Gross cropped area (ha)	3500
Irrigated area (ha)	500
HYDROMETEROLOGY	
Annual Rainfall 2007	1365 mm
Temperature Maximum	42.5° C
Temperature Minimum	13.5° C
PHYSIOGRAPHY	Structural plain, Denudational Hills & Valleys and Pediplain/pediment
DRAINAGE	Tributaries of Atem river of Mahanadi Basin
SOILS	Red Sandy, Red yellow soil
GEOLOGY	Sandstone shale ,conglomerate, coal seams & granite gneiss
HYDROGEOLOGY	
Depth to water level pre monsoon	4.7 to 11.2 mbgl
Depth to water level post monsoon	2.9 to 6.8 mbgl
Fluctuation	1.3 to 6.0 m
Available Vadose zone for artificial recharge	386.94 ham
GROUNDWATER RESOURCES	
Replenisable ground water resourses	2534.45 ham
Available ground water resourses	2318.41 ham
Gross ground water draft	309.55 ham
Ground water balance	2005.63 ham
Stage of Ground water Development	13.41 %
Static ground water resources	11266.40 ham
Category	Safe
CHEMICAL QUALITY	Suitable for domestic and Irrigation purposes

1. INTRODUCTION

1.1 Background:

Ground water, which is the source for more than 85 percent of India's rural domestic water requirements, 50 percent of its urban water requirements and more than 50 percent of its irrigation requirements is depleting fast in many areas due to its large-scale withdrawal for various sectors.

There have been continued efforts in India for development of ground water resources to meet the increasing demands of water supply, especially in the last few decades. In certain high demand areas, ground water development has already reached a critical stage, resulting in acute scarcity of the resource. Over- development of the ground water resources results in declining ground water levels, shortage in water supply, intrusion of saline water in coastal areas and increased pumping lifts necessitating deepening of ground water structures. Geogenic contamination of ground water due to concentration of Arsenic, Fluoride and Iron in excess of limits prescribed for drinking purposes (BIS, 2004) have also been observed in many parts of the country. To tackle the twin hazards of de-saturation of aquifer zones and consequent deterioration of ground water quality, there is an urgent need to augment the ground water resources through suitable management interventions. Artificial recharge has now been accepted world-wide as a cost-effective method to augment ground water resources in areas where continued overexploitation without due regard to their recharging options has resulted in various undesirable environmental consequences.

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.

1.2 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 4G2D5H1 & 4G2D5H3 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.

1.3 Advantages of artificial Recharge:

Artificial recharge is becoming increasingly necessary to ensure sustainable ground water supplies to satisfy the needs of a growing population. The benefits of artificial recharge can be both tangible and intangible. The important advantages of artificial recharge are

i) Subsurface storage space is available free of cost and inundation is avoided
ii) Evaporation losses are negligible
iii) Quality improvement by infiltration through the permeable media
iv) Biological purity is very high

v) It has no adverse social impacts such as displacement of population, loss of scarce agricultural land etc

vi) Temperature variations are minimum

vii) It is environment friendly, controls soil erosion and flood and provides sufficient soil moisture even during summer months

viii) Water stored underground is relatively immune to natural and man-made catastrophes

ix) It provides a natural distribution system between recharge and discharge points

x) Results in energy saving due to reduction in suction and delivery head as a result of rise in water levels

1.4 Data Used:

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

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

1.5 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.

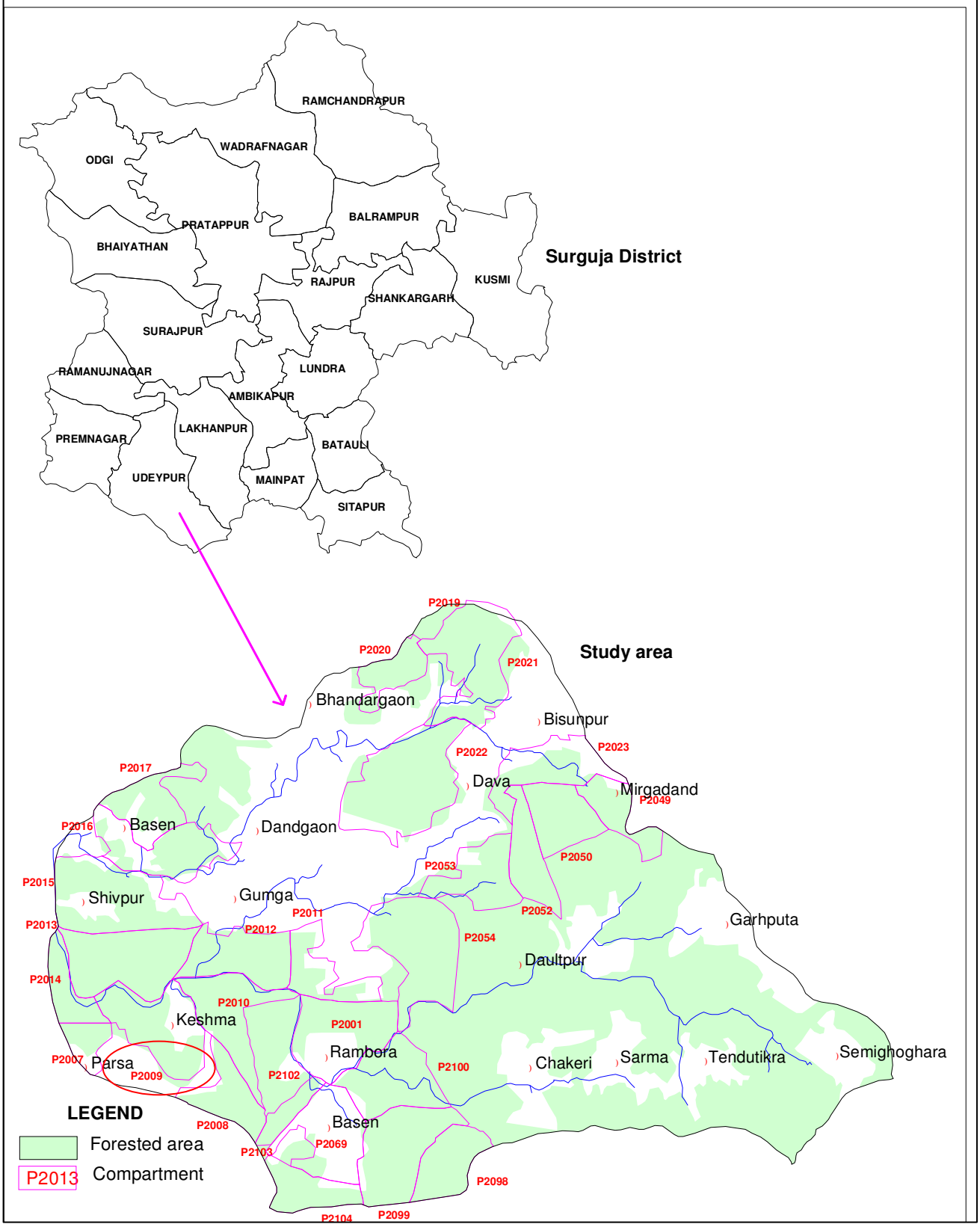
Table 2 Salient Features of Mukdega R. A. Circle		
1.	Area (Sq.km.)	158.2
2.	Annual Rainfall (mm)	1365
3.	Total Population	12632
4.	Population Density (Person / Sq. Km.)	80
5.	S.C. Population	702
6.	S.T. Population	8687
7.	Literacy Percentage	30%
8.	Agriculture Land (Ha)	3000
9.	Forest Area (ha.)	10500

1.6 Location, Extent and Accessibility:

Surguja is one of the northernly located District of Chhattisgarh state. The district extends between 22° 38′30''to 24°05' 55''North latitudes and 82°30′00'' to 84°04′25'' East longitudes and is bounded on north by Jashpur & Jharkhand state west by Koriya district while on south by Korba & Raigarh and north by Uttar Pradesh state.

The Watershed is known as 4G2D5H1 & 4G2D5H3 occupies an area of about 158.2 sq. km. It lies between N 22°49'07" – 22°56'41"and 82°47'54" – 82°59'09" E falling in Survey of India toposheet No. 64 J/13 in the part of Udaipur block of the Surguja 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 **Fig 1.**

Fig 1 Location map of the study area.



The exact location of the compartment no.P2009 is as under;

The Northern boundary marked by the dividing Atem River of Compartment no. 2013. The Eastern boundary denoted by the Nala and Munara no. 68 to 72. The Southern boundary marked by the Munara no. 56 to 67. The Western boundary distinguished by the dividing Nala of Compartment no. P2007. The compartment is situated at the Northern side of village Parsa.

1.7 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.

1.8 Socio Economic data analysis

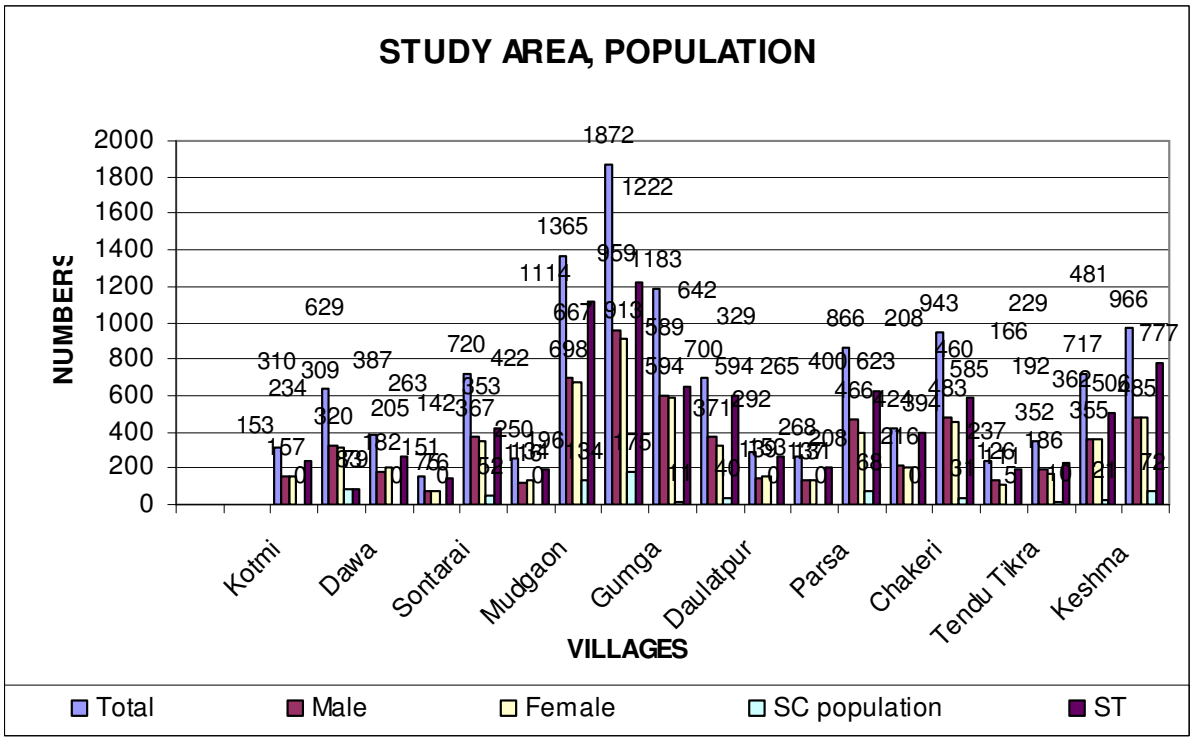
According to 2001 census the total population of the watershed is 12632 the density of population is 80 person/sq. km. The growth of population and intensive agricultural activities in the area followed by construction of new bore wells in the recent years.

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	Kotmi	310	157	153	0	0	0	234	115	119
2	Pandripani	629	320	309	83	42	41	79	42	37
3	Dawa	387	182	205	0	0	0	263	117	146
4	Vishunpur	151	75	76	0	0	0	142	69	73
5	Sontarai	720	367	353	52	23	29	422	220	202
6	Manoharpur	250	116	134	0	0	0	196	88	108
7	Mudgaon	1365	698	667	134	60	74	1114	576	538
8	Dandgaon	1872	959	913	175	98	77	1222	618	604
9	Gumga	1183	594	589	11	6	5	642	321	321
10	Salba	700	371	329	40	23	17	594	313	281
11	Daulatpur	292	139	153	0	0	0	265	127	138
12	Bangru	268	137	131	0	0	0	208	107	101
13	Parsa	866	466	400	68	37	31	623	339	284
14	Basen	424	216	208	0	0	0	394	196	198
15	Chakeri	943	483	460	31	14	17	585	290	295
16	Sarma	237	126	111	5	2	3	192	98	94
17	Tendu Tikra	352	186	166	10	5	5	229	117	112
18	Sanibarra	717	355	362	21	10	11	506	263	243
19	Keshma	966	485	481	72	40	32	777	386	391
Total		**12632**	**6432**	**6200**	**702**	**360**	**342**	**8687**	**4402**	**4285**



2. HYDROMETEROLOGY

The 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 Ambikapur. Besides this ordinary rain - gauges have been installed and maintained by Revenue Department at Udaipur.

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 1680 mm and minimum ever recorded rainfall is 978 mm and is given in **Table 4**. The average annual rainfall of the area is around 1350 mm. 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 Udaipur Rainguage station

1	1999	1300
2	2000	978
3	2001	1680
4	2002	1300
5	2003	1425
6	2004	1278
7	2005	1340
8	2006	1400
9	2007	1600
10	2008	1350
Average		1365

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, LAND USE AND SLOPE

3.1 SOILS

The 4G2D5H1 & 4G2D5H3 has been covered by two types of soil namely Alfisols & Ultisols which is further divided in two types namely Red Sandy and Red yellow soil. The classification is adopted as per the soil orders in US soil taxonomy and their Indian equivalents.

Alfisols

There is one type of Indian equivalent of this soil out of three is found in the study area namely Red sandy. Red Sandy soil is exposed in major part of the study area and covers an area of about 140.2 sq.km. Alfisols is a fertile leached soil found in humid areas which is alkaline in nature and contains clay-rich layer. They are less extensively leached of metal ions and develop in cooler climates. These soils formed where annually dropping leaves form a thick humus layer with the time, under which by decomposition processes the characteristic loam layers are formed which generally refers high age of the soil. They are considered as very fertile soils and are frequently used for agriculture. This soil exhibit well developed contrasting soil horizons depleted in calcium carbonate but enriched in aluminum and iron bearing minerals. In this soil, below surface horizon accumulation of migrated layer silicate clay is present which is called as argillic horizon and is characterized by a relatively high content of available calcium, magnesium, potassium and sodium ions.

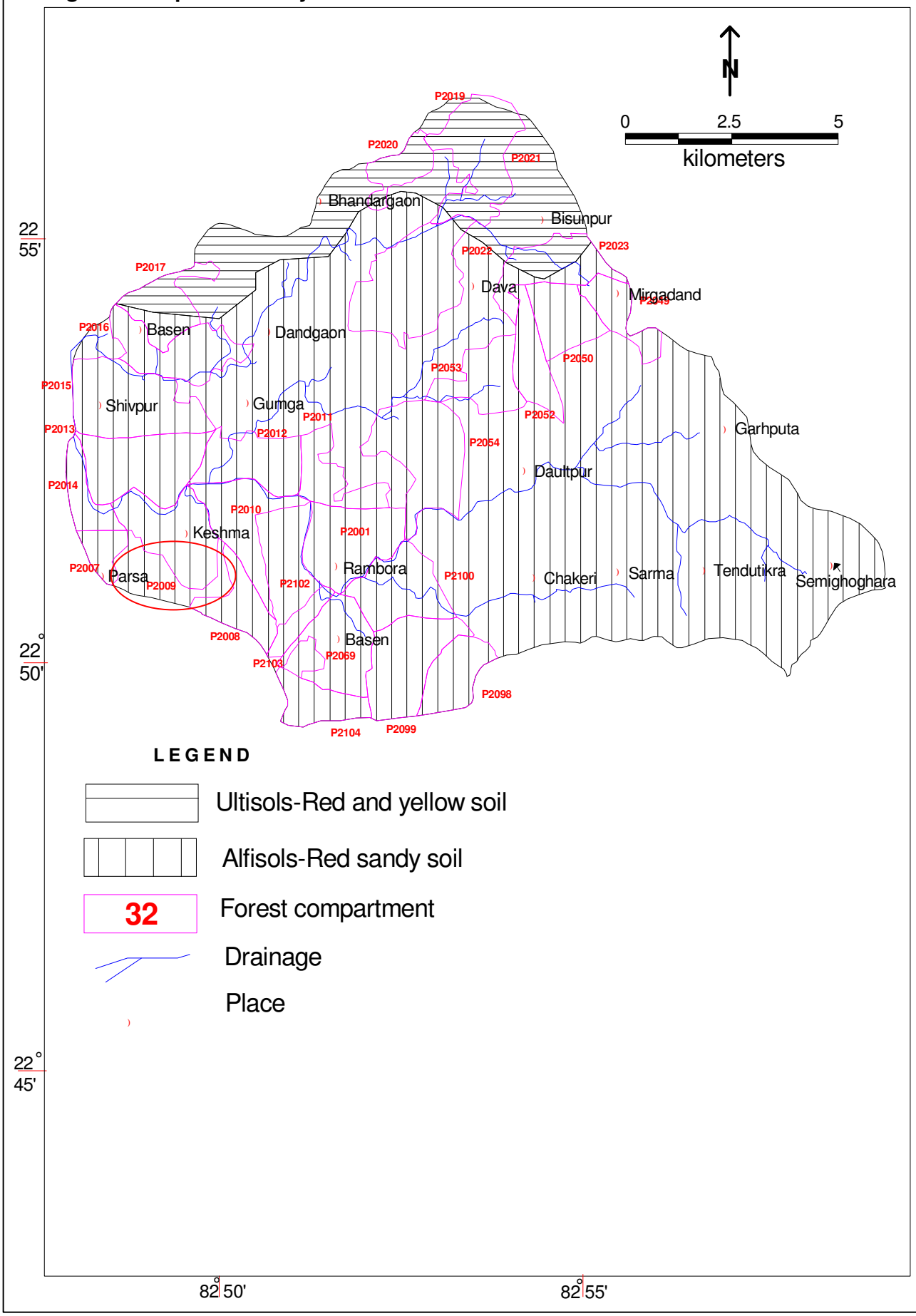
Ultisols

There is also one type of Indian equivalent of this soil out of three is found in the study area namely Red yellow. Red yellow soil is exposed in northern part of the study area and covers an area of about 18 sq.km.

Ultisols are generally red and yellow in colour, acidic and are rich in iron oxide, which is highly insoluble in water. They are characterised by humus-rich surface horizon and contain variety of clay minerals but having dominant kaolinite mineral. This soil has good bearing capacity and no shrink-swell property. They are also rich in aluminium.

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

Fig 2 Soil map of the study area.



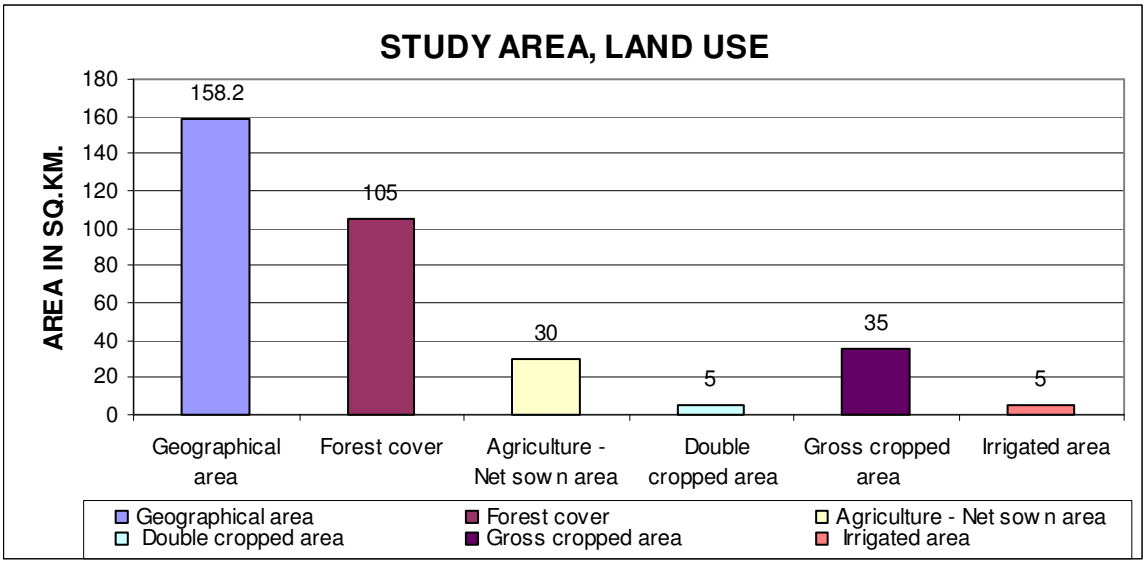
3.2 LANDUSE

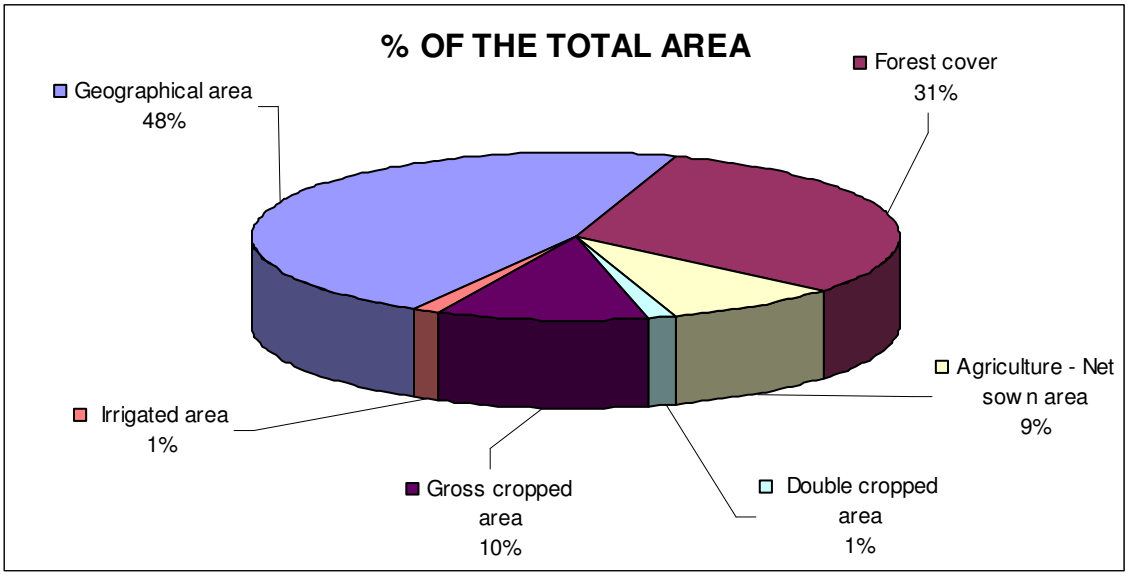
The study of specific aspects of “land use” and “land cover” including both existing as well as anticipated is one of the primary exquisite to assess and evaluate the environmental situation, directly related to land and water environment. The comprehensive study of these aspects includes detailed thematic 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 Study area

SN	Land use and land cover	Area in Sq.km.	Percentage to the total area
1	Geographical area	158.2	100.00
2	Forest cover	105.00	66.37
3	Agriculture - Net sown area	30	18.96
	Double cropped area	5	3.16
	Gross cropped area	35	22.10
	Irrigated area	5	3.16





The total geographical area of the water shed is about 158.2 Sq.km. situated in the southern portion of the Surguja district covering parts of Udaipur block of Surguja district. Out of the total area of the watershed about 66.37 % 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 105.00 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 18.96 percentage is net sown area and about 3.16 % 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 irrigability 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

$$4 \text{ cm} \times 50{,}000 = 200000 \text{ cm}$$

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

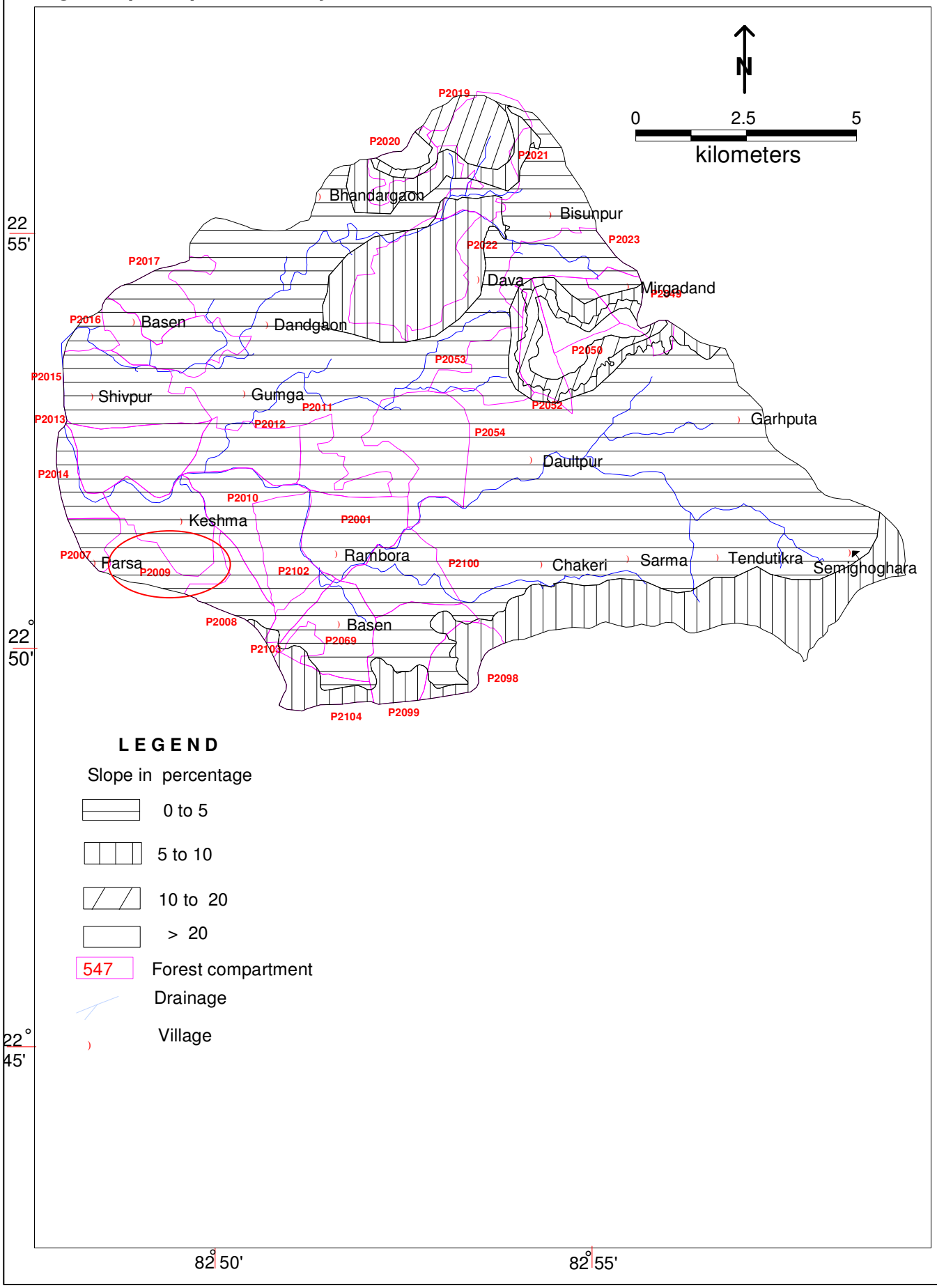
$$(20 \times 100) \div 2000$$

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 STUDY AREA

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

Fig 3 Slope map of the study area .



3.4. SOILS, LANDUSE AND SLOPE OF THE STUDY AREA

The soil structure is Balui-Dumat. It is soft having moderate level of moisture. There is type soil is average basic configuration, containing medium humus sufficient to support plant growth. The depth of the soil is average, level of moisture and humus is enough to support the forest plant species.

The compartment mainly contains 3rd quality type of mixed and Saal forest and the Forest density ranges from is 0.5 to 06 consistent of mixed, medium and young age class forest. Root stock is enough to thrive, in to a good forest. In under growth Bamboo is also thriving.

Main species of the top canopy are Salai, Saja, Silha, Mundi, Bija, Bahera, Dhavada, and Karmi. Middle canopy contains Achar, Aouwala, Tendu, Kari,Kekad, and Doban. Under canopy consists of Retiya, Demetoran, Galgali, Nil, Dhavaiphool, Gudsukdi, Marodpali, Charaota, and Davai.

Major kinds of forest produce species are, Saal, Tendu, Harra, Aouwal, and Baheda Shrubs species contents Dhavai, and Chind few Charota found in Herbs species. Palatable grass species are Dhubi and Bhurbhusi and a few Amjaan found in woody climber species category and Sherdatta is Non woody climber species. Lentana 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 322.45 ha. Area has following characteristics with respect to precious parameter for water shed i.e. slope

The **whole compartment** extents up to 322.45 ha.

The average slope at the stretch of 100 m. horizontal distance is 3061.26 m.

Ratio =3061/50 = 61.22 to I m. Say 1:61

Degree = $1^0$43’06”

Percentage = 1/61 x 100 = 1.63%

Value of C = Coefficient showing % of rainfall appearing as runoff, a watershed factor = timber plain = 0.024

4. GEOMORPHOLOGY AND DRAINAGE

4.1 GEOMORPHOLOGY

The Study area area is having somewhat elongated Catchment, the maximum length and Width of the Catchment is 19.38 Kms and 14.12 Kms respectively. The elevation of the area varies from 490 to 976 m amsl. The north-east area is hilly and forested. The maximum basin elevation is 976 m amsl at Ramgarh pahar while minimum elevation is present at west of basen village along Atem river in western part.

The Physiography of the basin is controlled by geological formations namely, sandstone, shale, conglomerate, coal seams & granite gneiss etc.

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 and Denudational hills & Valleys.

1. Structural Plain

It is plain covered with thin soil and forest. In the area it is exposed in major part of the watershed. It covers an area of about 136.5 sq.km. It is identified at an elevation of above 490 m amsl.

2. Pediplain/Pediment:

It is resultant product of polycyclic erosional and depositional processes. It is concealed and covered under thin soil cover. It is exposed in western part of the watershed covering an area of about 10.39 sq.km. of the area of the watershed in south-western part. It is identified at an elevation of between 500 –530m. above m.s.l.

Pediment is identified at an elevation of above 530 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

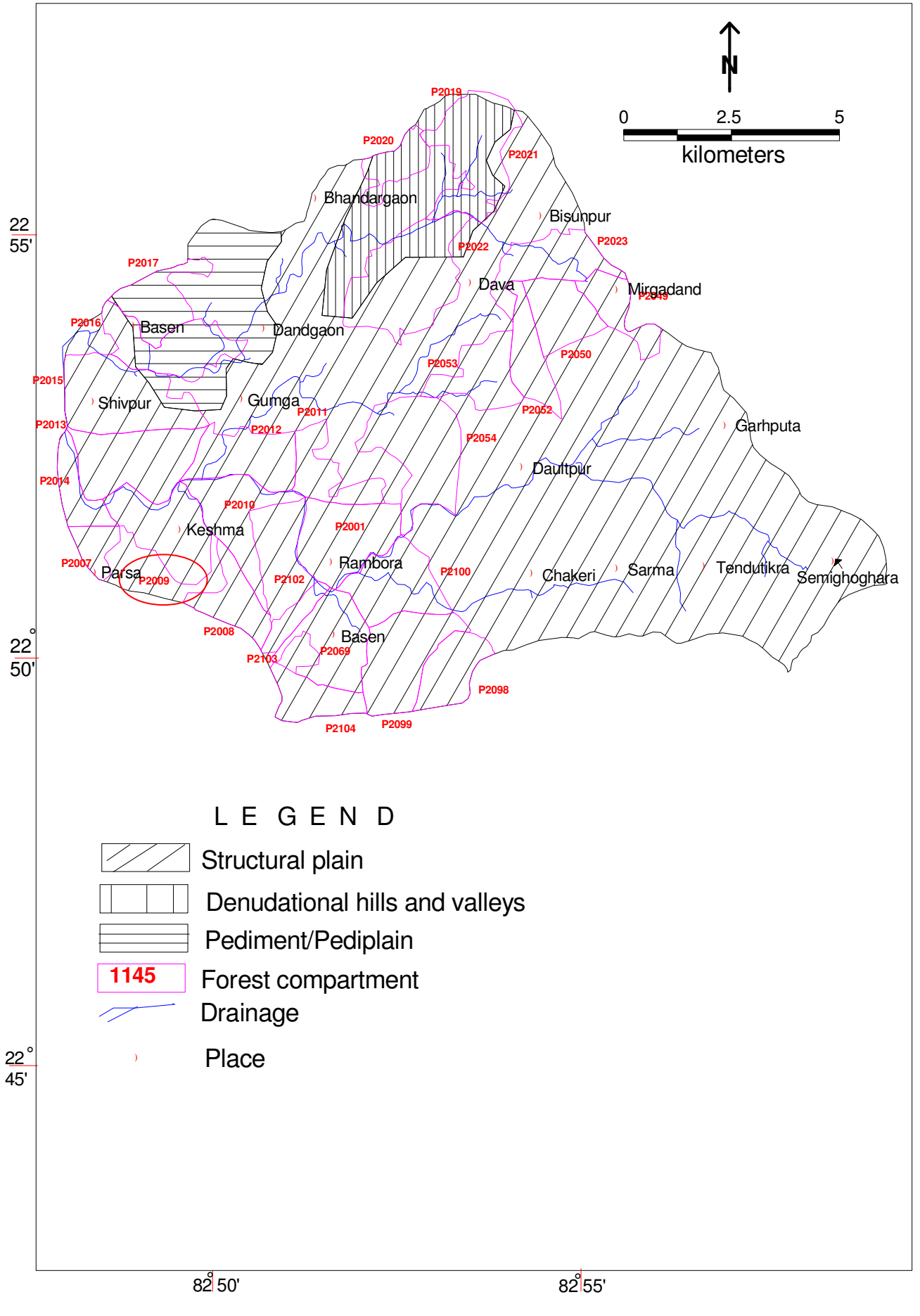
elements.The topsoil is thin and impersistent it grey light red and brownish in colour and is mostly silty in nature with predominant rock fragments.

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 northern part of the watershed. It covers an area of about 11.33 sq.km. It is identified at an elevation of above 650 m amsl.

Fig 4 is presented here to show the geomorphic features in the Study 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 Study area is the part of Atem river of Mahandi drainage system and the drainage pattern of this system is dendritic- sub-dendirtic in nature.

Morphometry:

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:-

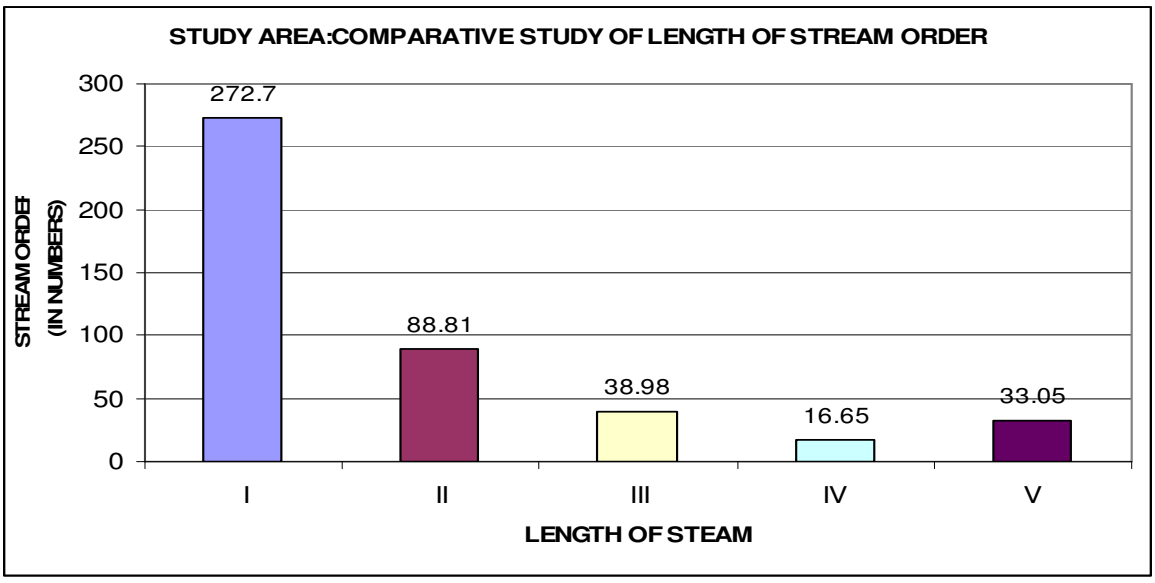
An attempt is made to analyses the various parameters of fluvial morphometry. The major geomorphic parameters of hydrologic importance have been discussed below:-

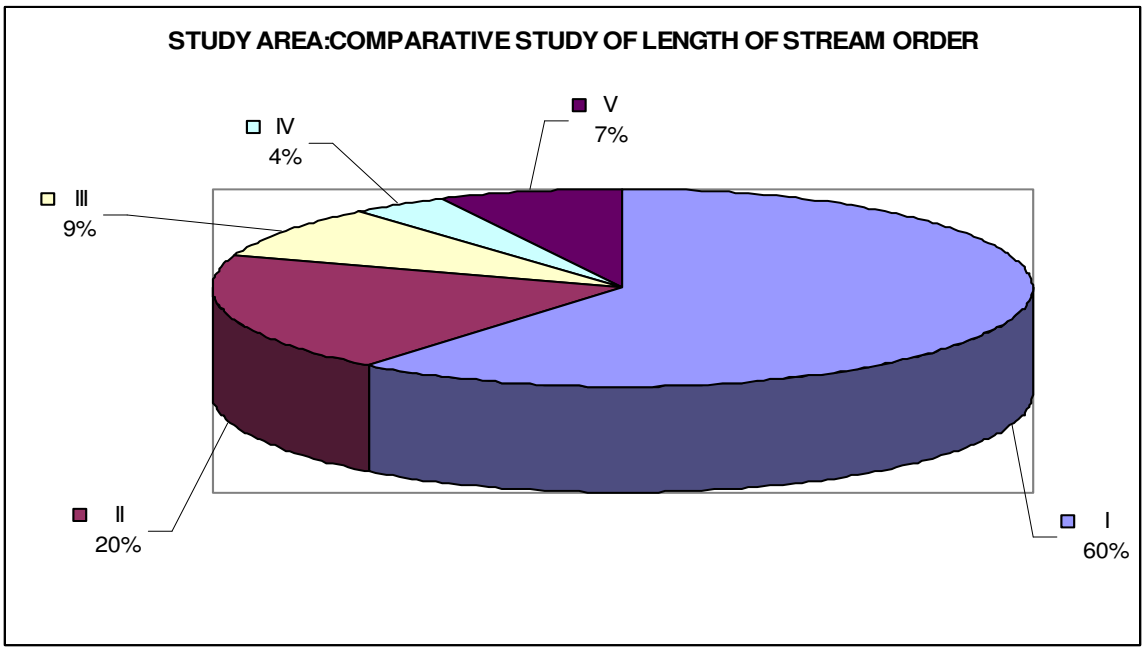
1. Linear Parameters

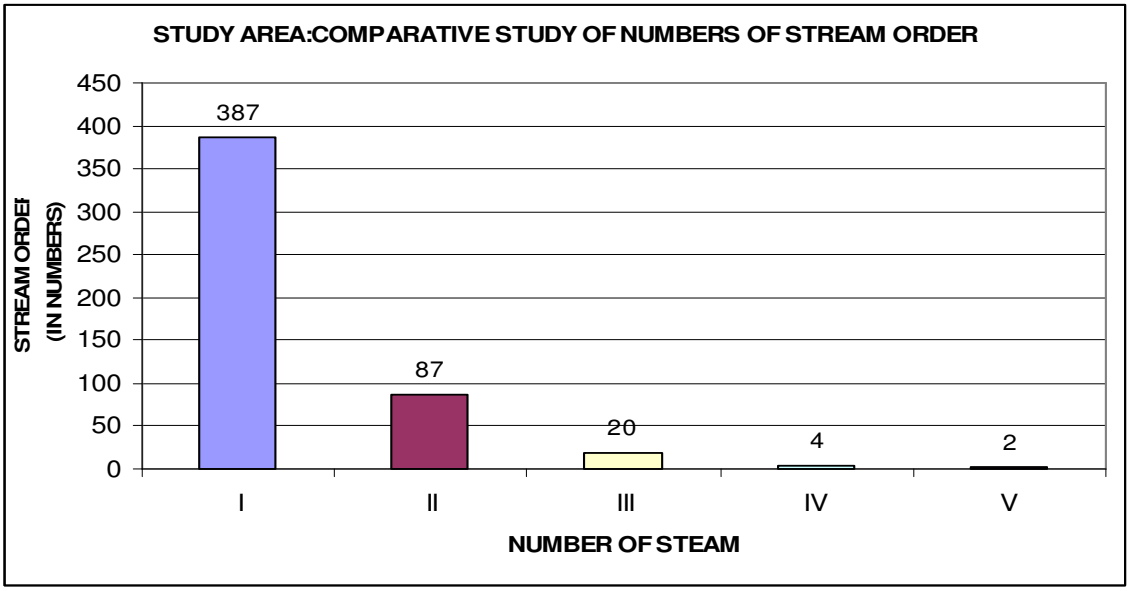
A) Bifurcation Ratio :-

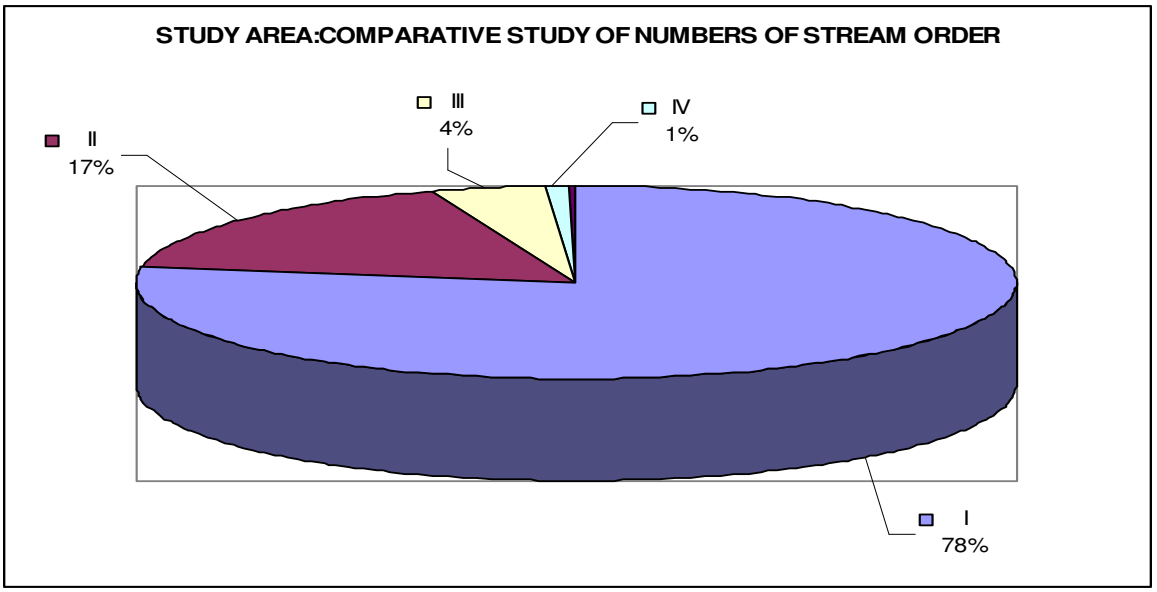
In drainage analysis, bifurcation ratio is the foremost important parameter to link the hydrological regime of a watershed under specific lithological and climatic condition is the ratio of the number of streams of one order to the number of streams of the next higher order. In the study area bifurcation ratio varies from minimum 2.0 for 4th order stream to 5.0 for 3rd order streams **(Table 7)**. As these values of bifurcation ratio ranges between 2.00 and 5.0, indicating that the river flows through hilly area.

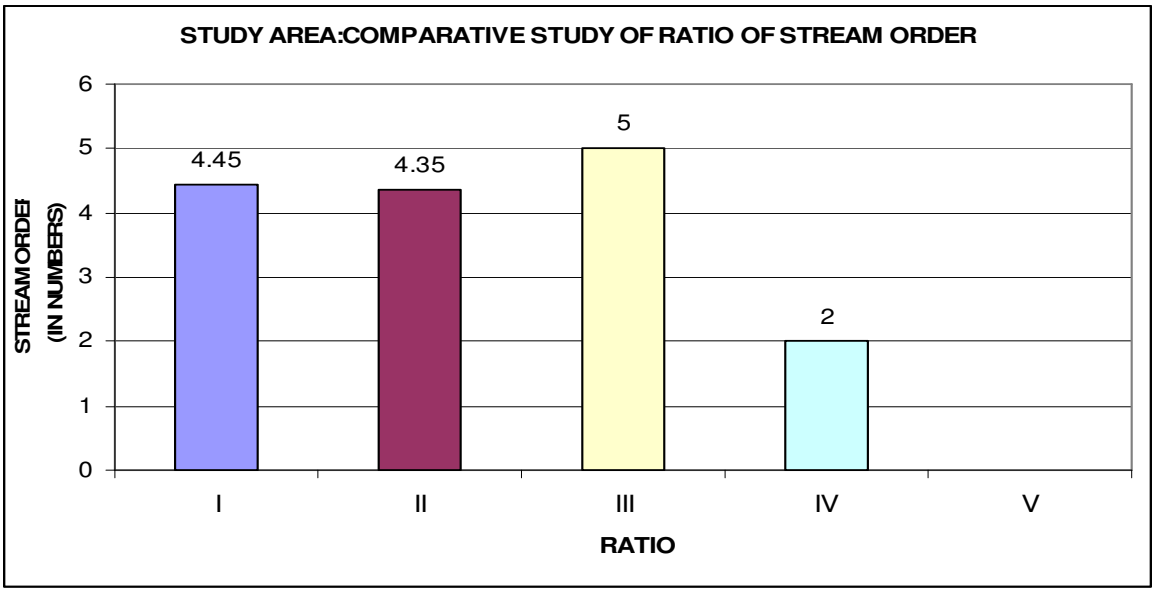
Table 7: Drainage Basin Characteristics of Hilly and Forested area					
Stream order N	Length	No of Stream	Bifurcation Ratio	Mean stream Length	stream Length Ratio
	Lw	Nw	Rb	Lw=Lw/Nw	RL=Lw/Lw-1
I	272.7	387	4.45	0.70	3.07
II	88.81	87	4.35	1.02	2.28
III	38.98	20	5.00	1.95	2.34
IV	16.65	4	2.00	4.16	0.50
V	33.05	2		16.53	

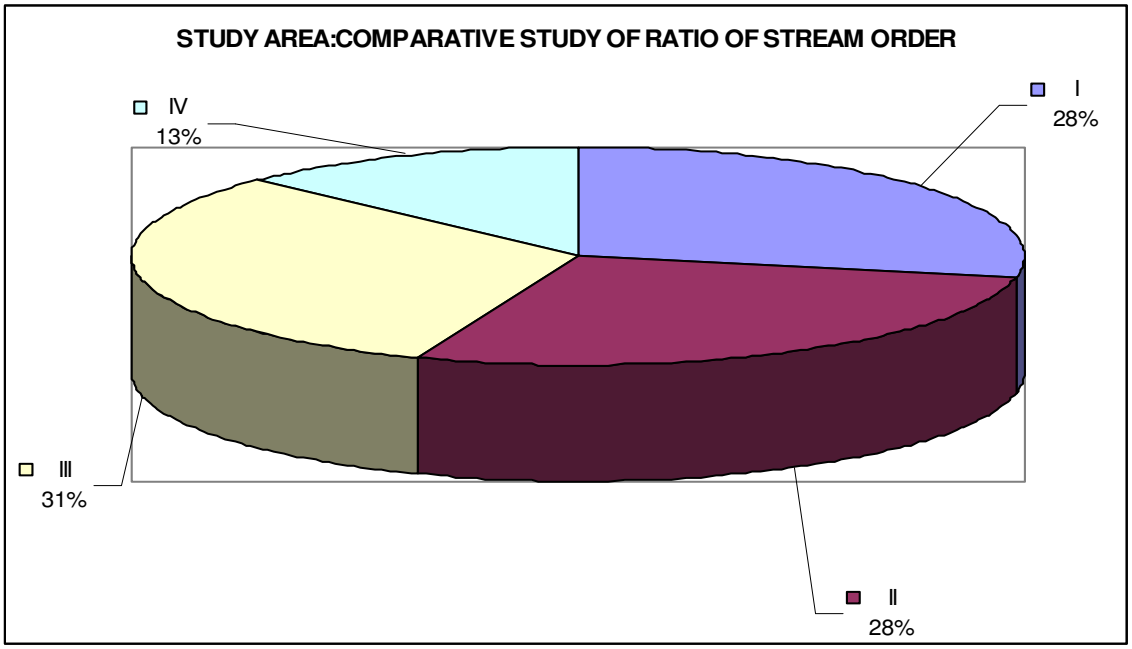





STUDY AREA:COMPARATIVE STUDY OF NUMBERS OF STREAM ORDER
450
400
350
300
250
200
150
100
50
0
387
87
20
4
2
I
II
III
IV
V
NUMBER OF STEAM


STUDY AREA:COMPARATIVE STUDY OF NUMBERS OF STREAM ORDER
II
17%
III
4%
IV
1%
I
78%


STUDY AREA:COMPARATIVE STUDY OF RATIO OF STREAM ORDER
6
5
4
3
2
1
0
4.45
4.35
5
2
I
II
III
IV
V
RATIO



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 Study area 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 granite gneisses and sandstone, shale , conglomerate and coal seams. 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 Study area watershed exhibits high drainage density and is presented in **Table 8** below.

Table 8 Morphometric details

Watershed area	Watershed perimeter	Watershed length	Watershed 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				
158.2	56.41	19.38	14.12	2.84	3.16	0.42	2.37

B) Relief - Longitudinal Channel Profile

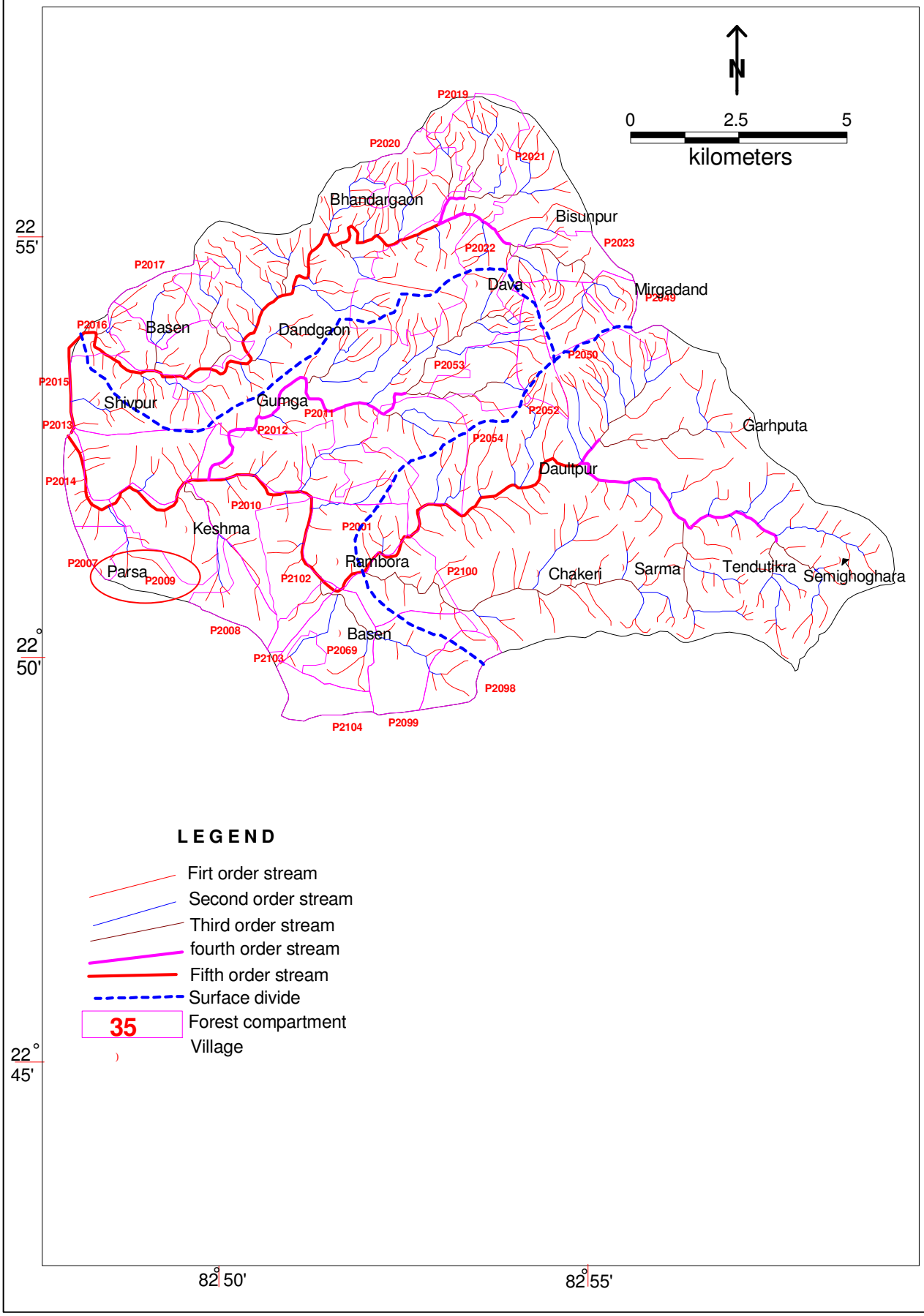
The longitudinal channel profile represents the relationship between altitude and horizontal distance. It shows relief variation from origin to mouth of river. The Hilly and Forested area of Study area attains maximum elevation of 976 metres above and it reached to minimum elevation of confluence point i.e. 490 meter above msl. The river channel profile is normally found to be gentle. The relief details is 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	
976	490	486	0.35

The nature of this gentleness is a function of the basin geology and precipitation. The profile of Hilly and Forested area of Study area 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 Study area composite profile shows that order - slope vary from 0° to >20°. It is predicted that Hilly and Forested area of Study area 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 Study area is presented in **Fig 5.**

Fig 5 Drainage map of the study area.



5. GEOLOGY

In the area rocks of Gondwana Supergroup and Unclassified Metamorphics are exposed. These rocks are of Talchir & Barakar formation of Gondwana Supergroup and Bilaspur-Raigarh-Surguja unclassified metamorphics which are represented by sandstone, siltstone, , shale, coal seams and granites, gneisses etc. However, 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		BarakarFm	Sandstone, shale & coal seams
			Talchir Fm	Sandstone, shale, tillte & conglomerate
ARCHAEAN	Bilaspur-Raigarh-Surguja unclassified metamorphics			Granites and gneisses

Bilaspur-Raigarh-Surguja Unclassified Metamorphics:

These crystalline and metamorphic rocks mainly occur along the western boundary of the study area with some patchy occurrence in Udaipur block. These are mainly composed of quartz mica schist and quartzite with granite gneiss, intruded by granite and dolerite. The rocks of unclassified metamorphic belt of Bilaspur- Raigarh-Ambikapur occurs in parts of Kharsia, block in linear patches. Equivalents of Bastar gneiss occur in Raigarh, Sarangarh and Baramkela blocks in small patches. It coveres an area of about 2.28 sq.km. in western part of the watershed.

GONDWANA SUPERGROUP:

In the area Gondwana Supergroup of rocks are represented by Talchir & barakar Formation which covers the major part of the study area.

Talchir Formation:

In the area Talchir Formation of Gondwana age are exposed in northern part of the study area covering an area of about 42.16 sq.km.. It mainly consist of sandstone, siltstone, shale, tillite and Boulder Bed.

Barakar Formation:

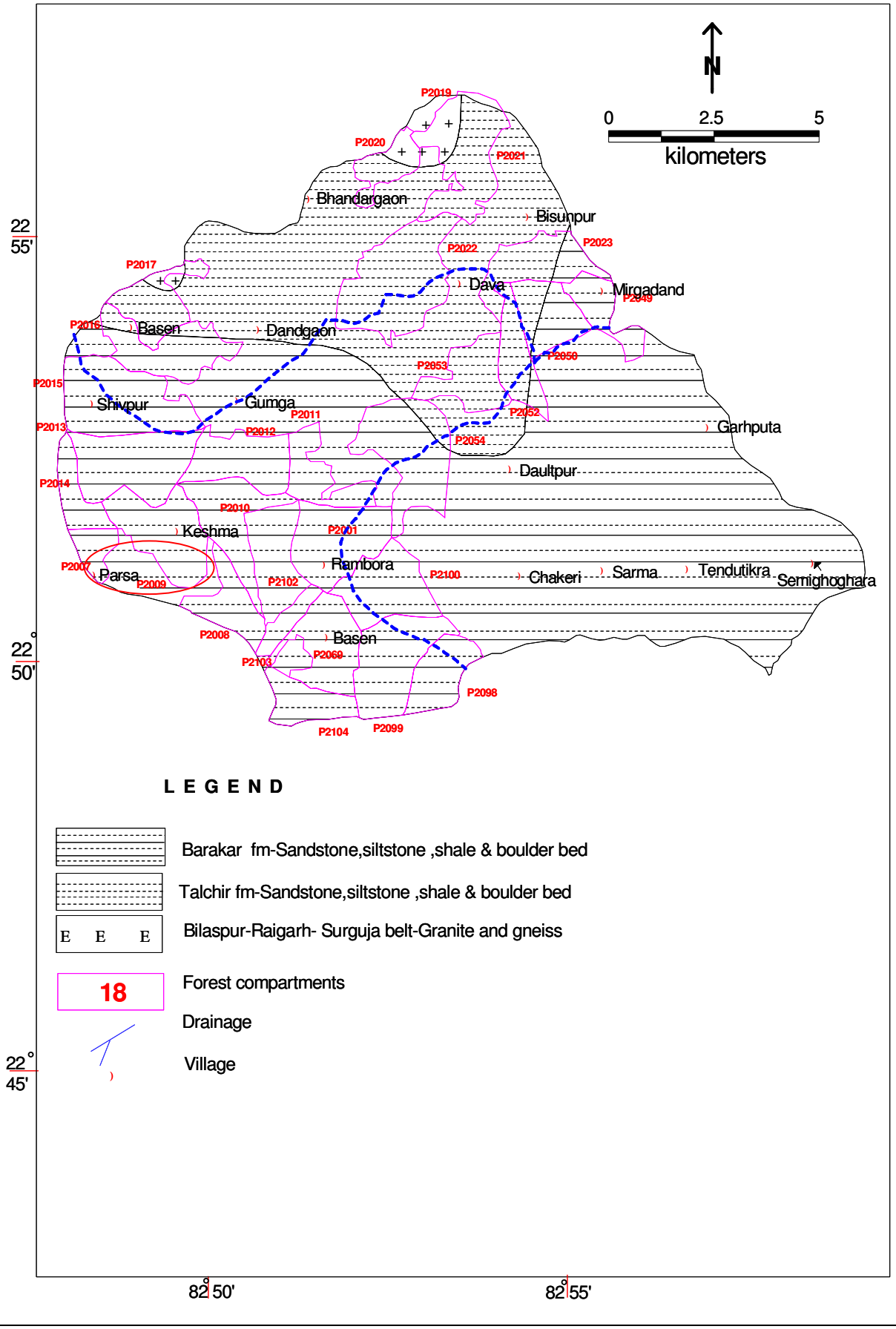
In the area Barakar Formation of Gondwana age are exposed in major part of the study area covering an area of about 113.8 sq.km.. It mainly consist of sandstone, siltstone, shale, and coal seams.

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 Study 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.

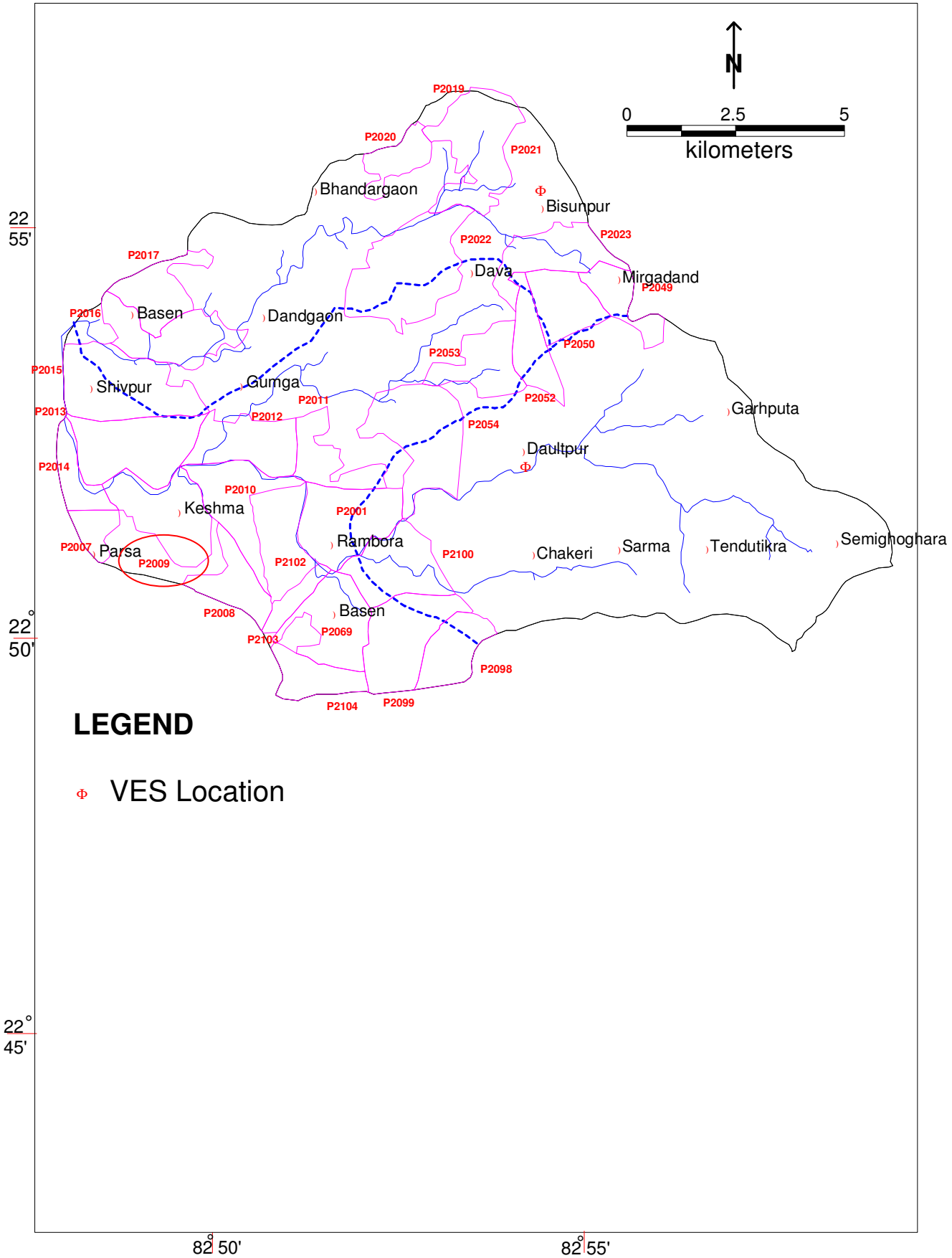
The data of resistivity soundings at three places were considered over the Study area area. The maximum current electrode separation ranged between 100 m to 110 m. The sounding results, in terms of resistivity (Ohm - meters) and thickness (h in meters) of the sub surface layers. Most of the sounding 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 10** below and location is presented in **Fig 7**.

Table 10 Summarised result of geophysical soundings

Name of the site	VES no.	Resistivity value (Ohm-m)			Layer depth (m)	
		□1	□2	□3	D_1	D_2
Dhaurpur	1	65	90	1200	1.5	25
Bisunpur	2	70	75	1300	1.6	28

From the Table 10 it is seen that the first layer is soil zone ranging in thickness from 1.5 to 1.6 while the second layer is a weathered mantle of different rocks types present in the area ranging in thickness from 25 to 28 m and the last layer is a hard and compact rock like sandstone, shale etc. indicating indefinite thickness.

Fig 7 Location of the VES 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.

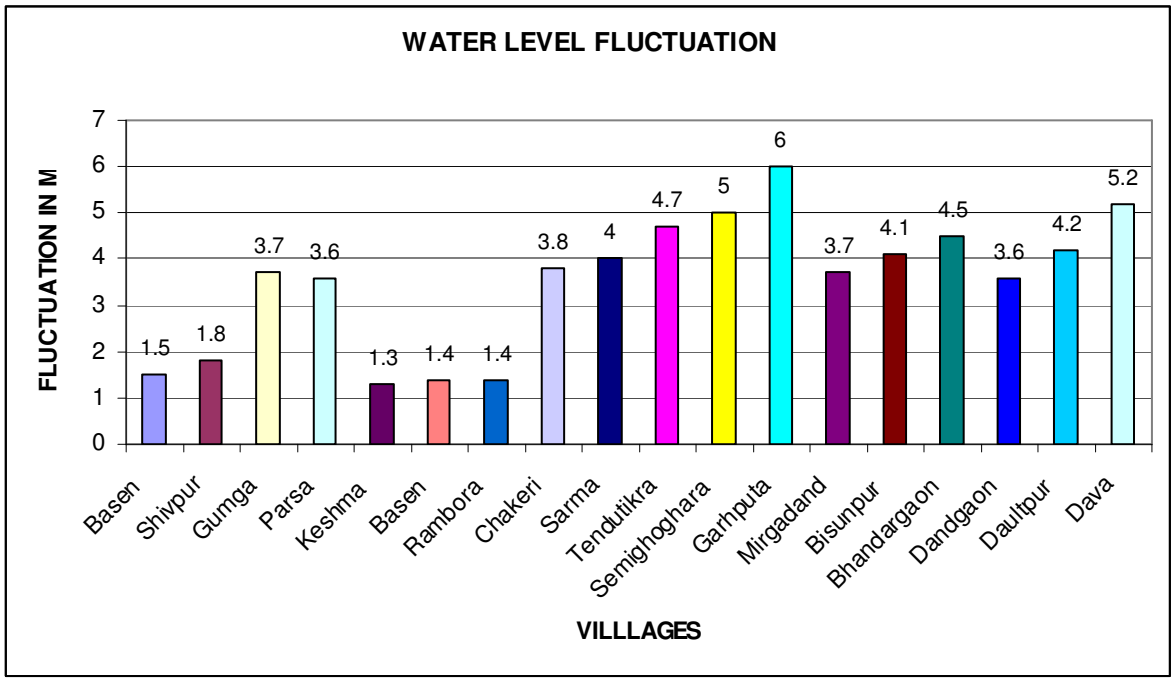
The study area is represented by, sandstone, shale, conglomerate, coal seams and granite gneiss. These formations are having low to moderate potential from ground water point of view. The thickness of the weathered zone extends down to 25 mbgl, groundwater occurs under phreatic condition in weathered zone and semi-confined to confined condition in deeper part of the aquifer.

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 4.7 to 11.2 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 2.9 to 6.8 mbgl. The water level fluctuation in the area varies about 1.3 to 6.0 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.	Name of the village	long	Lat	Spot heigth mamsl	Premonsoon depth to water level mbgl	Reduce level of premonsoon depth to water level mamsl	Post-monsoon depth to water level mbgl	Fluctuation (m)
1	Basen	82°48'58"	22°53'56"	535	5.00	530.00	3.50	1.50
2	Shivpur	82°48'25"	22°53'01"	510	4.70	505.30	2.90	1.80
3	Gumga	82°50'26"	22°53'03"	530	8.00	522.00	4.30	3.70
4	Parsa	82°48'27"	22°50'58"	530	7.50	522.50	3.90	3.60
5	Keshma	82°49'36"	22°51'29"	510	5.00	505.00	3.70	1.30
6	Basen	82°51'41"	22°50'13"	534	5.00	529.00	3.60	1.40
7	Rambora	82°51'39"	22°51'05"	525	5.00	520.00	3.60	1.40
8	Chakeri	82°54'22"	22°50'57"	545	8.20	536.80	4.40	3.80
9	Sarma	82°55'31"	22°51'01"	558	8.90	549.10	4.90	4.00
10	Tendutikra	82°56'42"	22°51'02"	590	10.50	579.50	5.80	4.70
11	Semighoghara	82°58'27"	22°51'06"	590	11.20	578.80	6.20	5.00
12	Garhputa	82°56'59"	22°52'44"	585	10.70	574.30	4.70	6.00
13	Mirgadand	82°55'31"	22°54'22"	595	10.30	584.70	6.60	3.70
14	Bisunpur	82°54'29"	22°55'15"	580	10.90	569.10	6.80	4.10
15	Bhandargaon	82°51'26"	22°55'28"	540	11.10	528.90	6.60	4.50
16	Dandgaon	82°50'44"	22°53'54"	515	8.20	506.80	4.60	3.60
17	Daultpur	82°54'14"	22°52'14"	545	8.70	536.30	4.50	4.20
18	Dava	82°53'32"	22°54'27"	575	10.10	564.90	4.90	5.20



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 Study area area. From the figure it may be seen that the water table elevation varies from 500 m amsl in the west to 560 mamsl in the north-east. Water table more or less follows the surface topography. The north-east part of the watershed shows higher altitude of water table indicate recharge area for ground water while western 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.

In the study area, the transmissivity values of phreatic aquifer tapped in open well varies from 30 to 50 m^2/day while specific capacity ranges form 35 to 60 lpm/day. However for deep aquifer the transmissivity ranges from 30-60 m^2/day and at favorable places it goes up to 100 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.

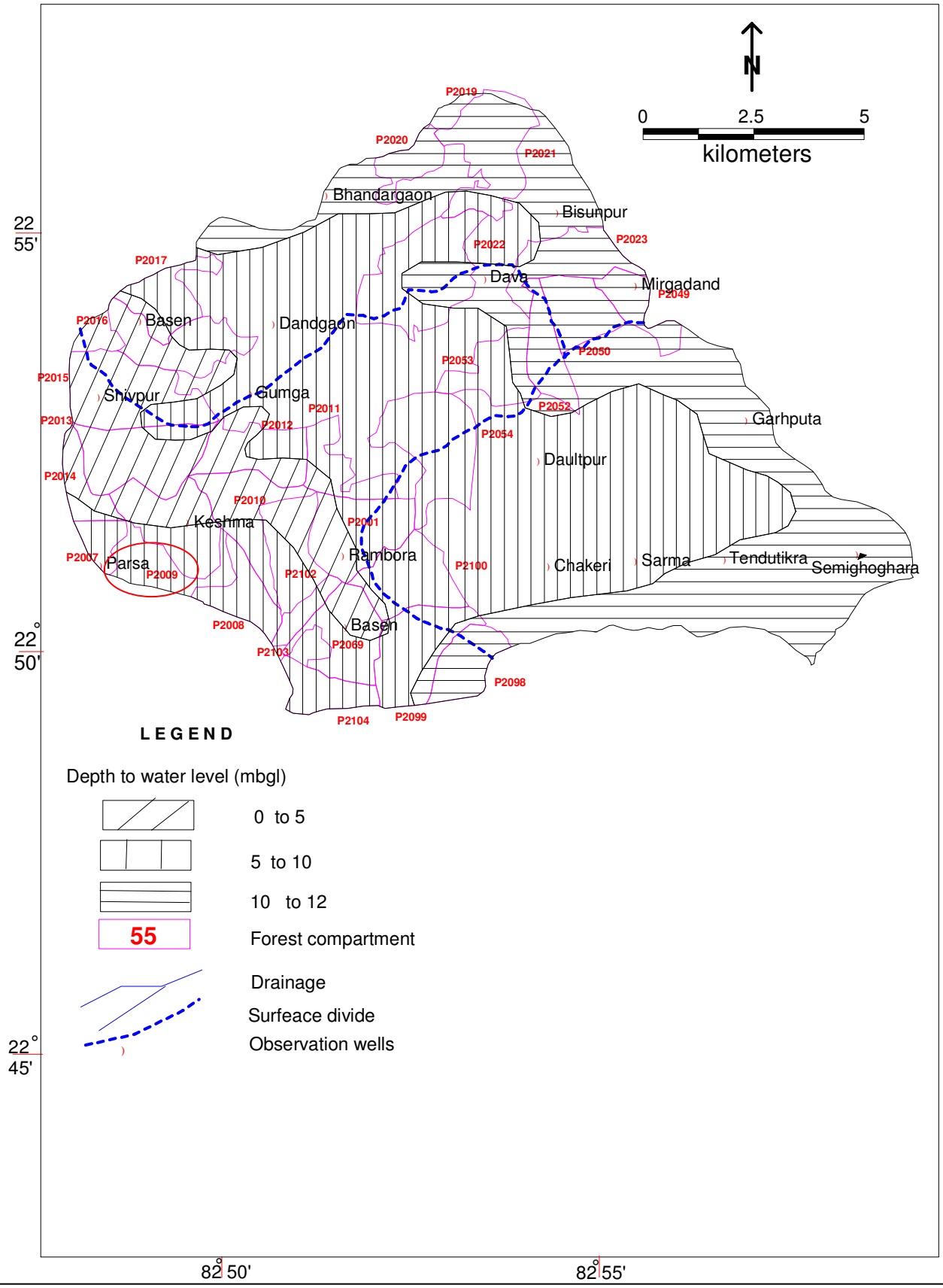


Fig 9 Post-monsoon Depth to Water Level of the study area.

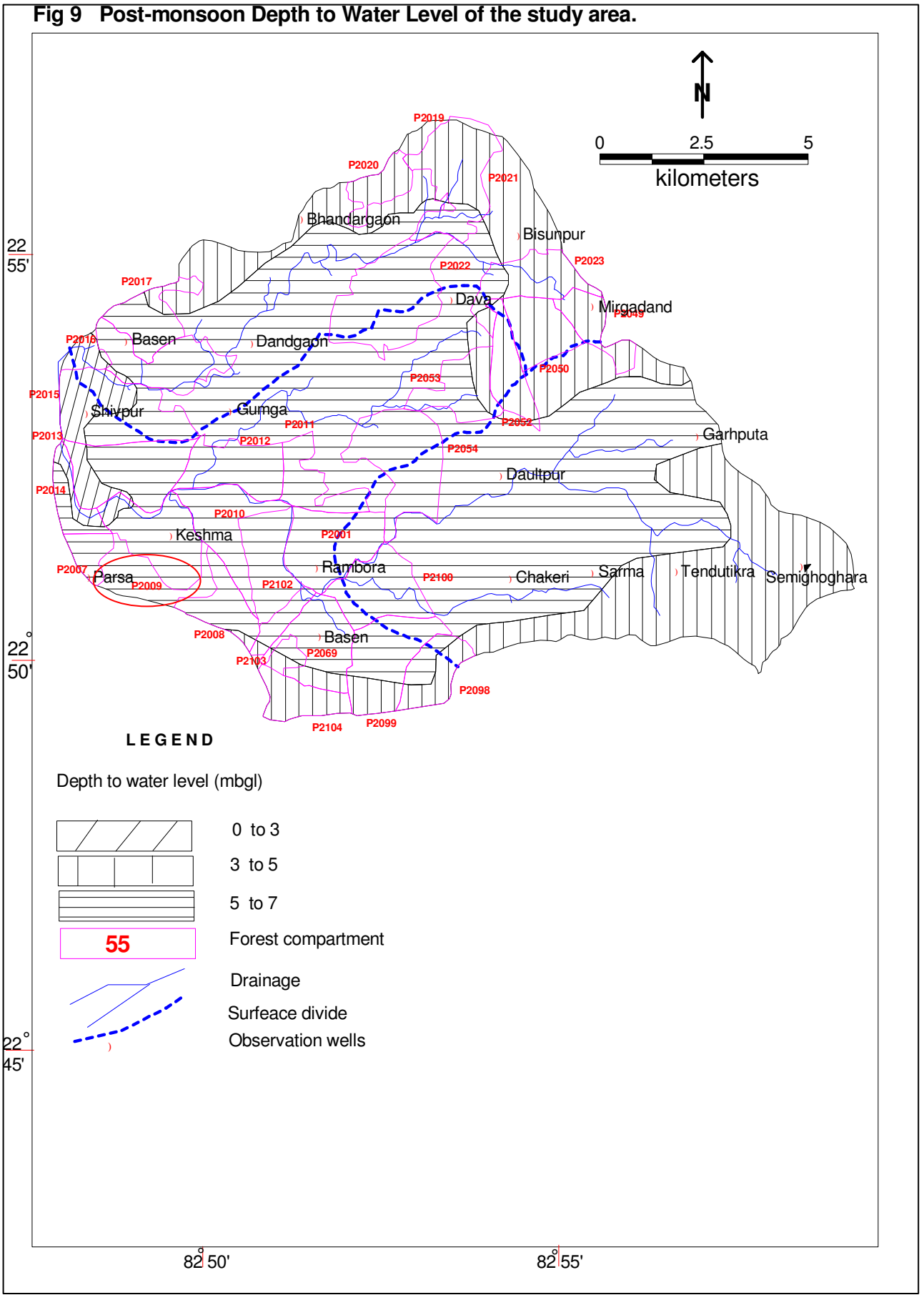


Fig 10 Seasonal ground water level fluctuation map of the study area.

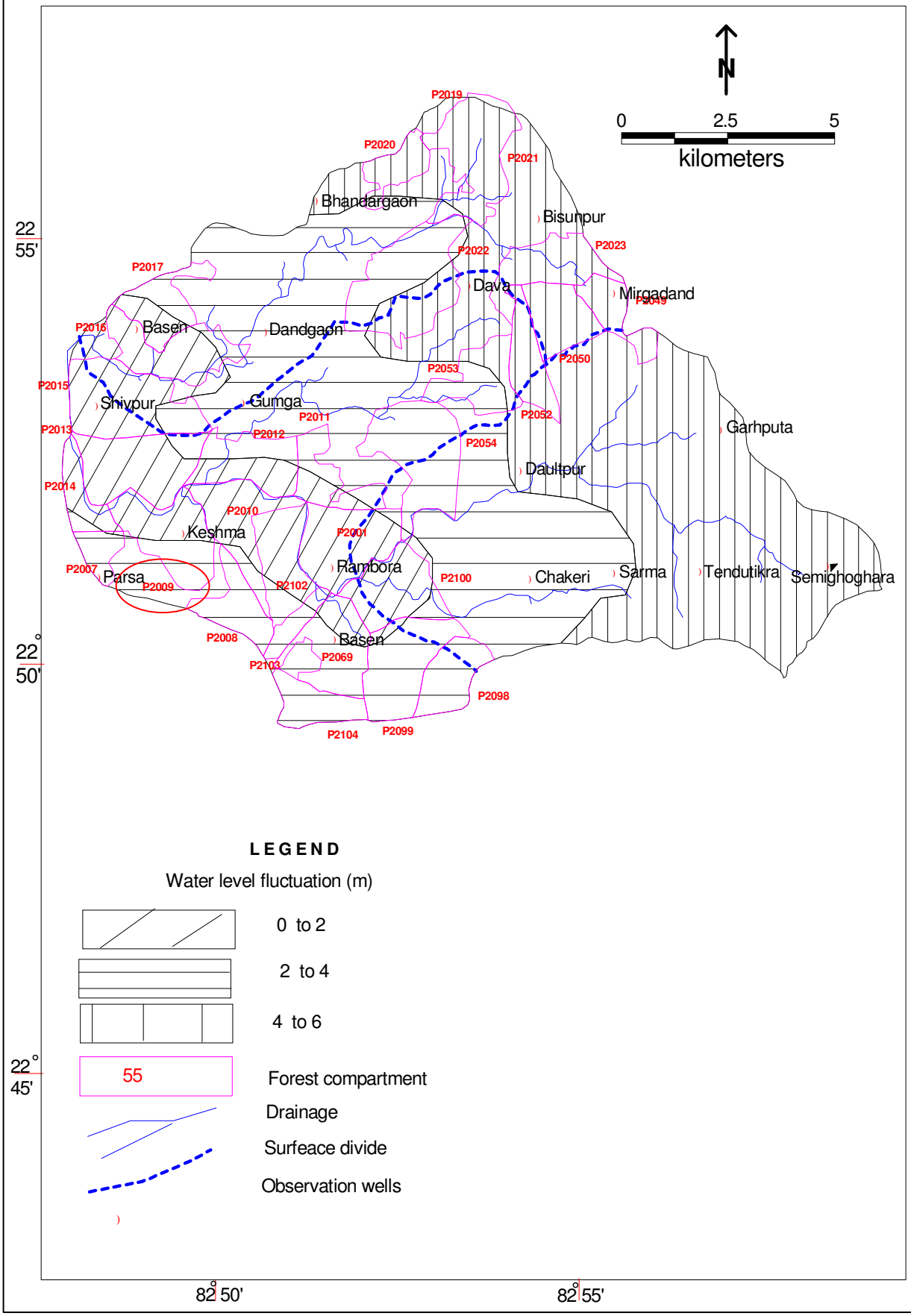
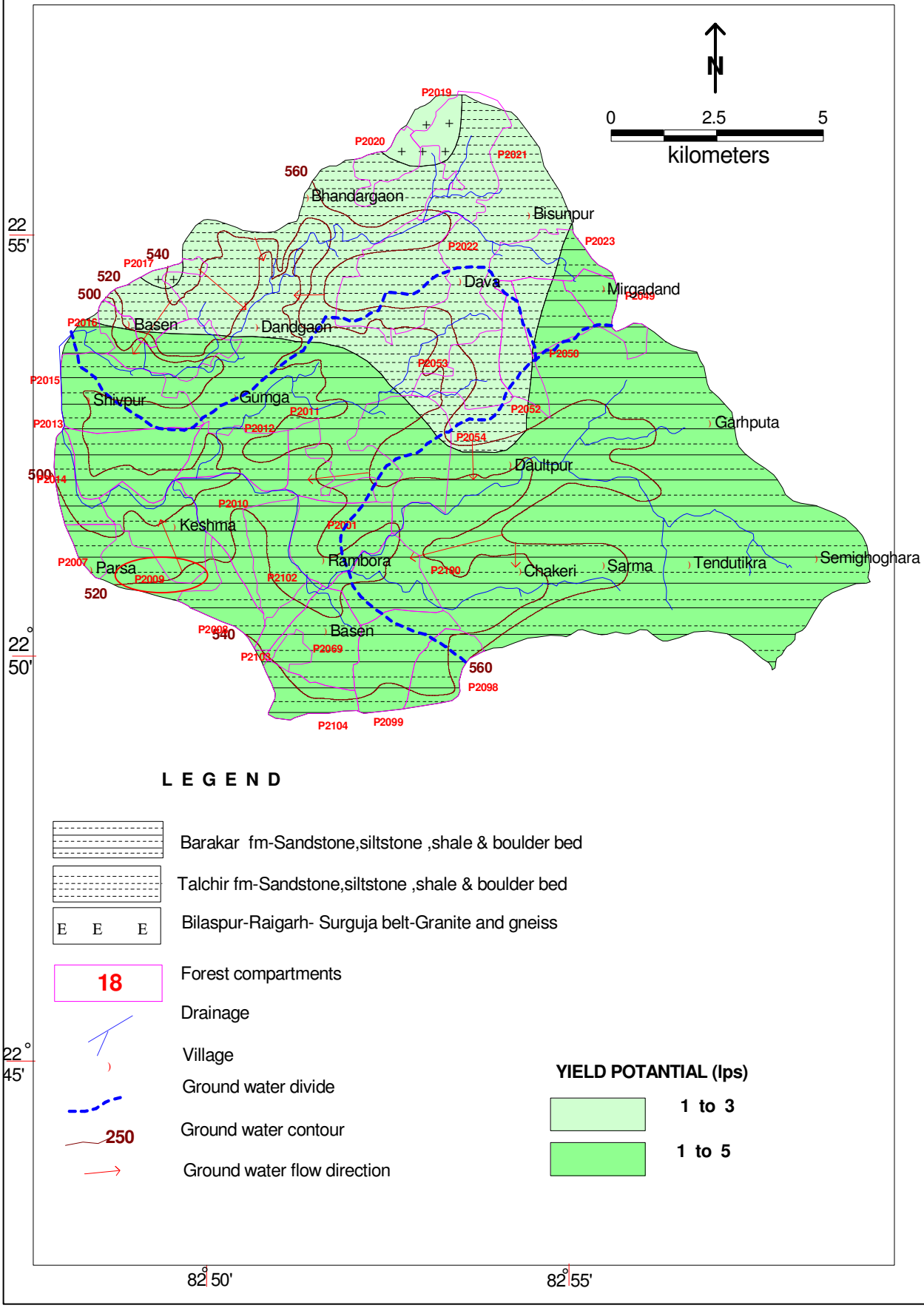


Fig 11 Hydrogeological map of the study area.



8. QUALITY OF GROUNDWATER
(OF THE STUDY AREA)

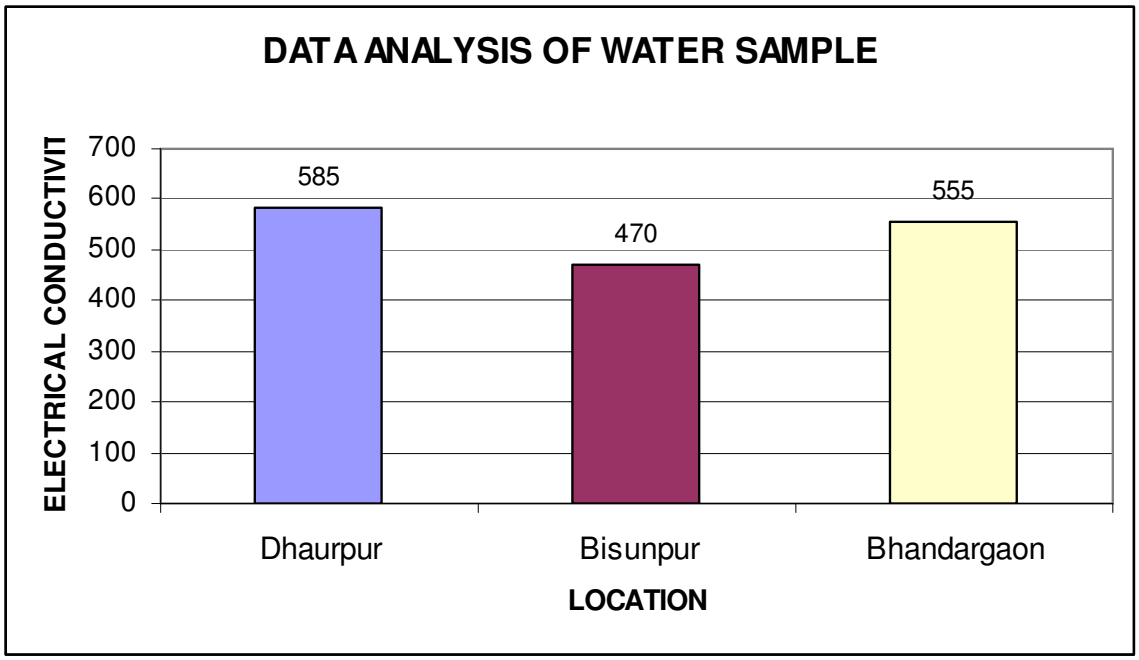
The chemical quality of ground water was evaluated from the water samples collected of selected villages from the phreatic aquifer and shallow deeper aquifer (bore wells).

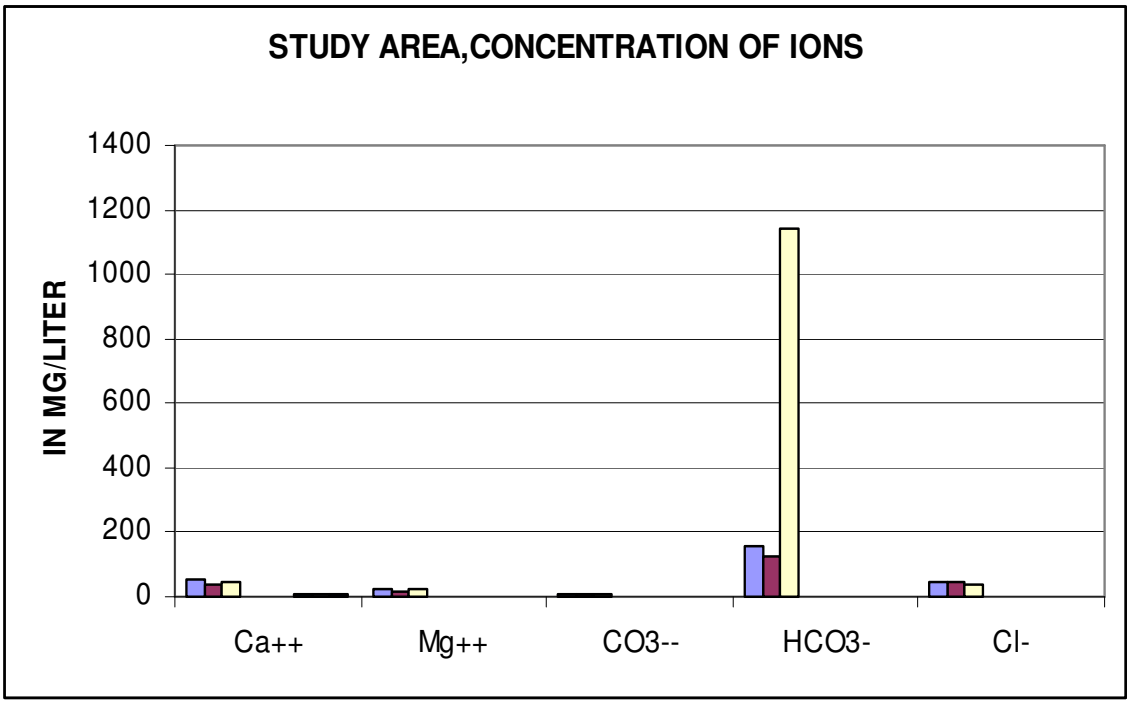
The analysis of the chemical data shows that the quality of ground water in area is generally alkaline to near neutral in nature. Electrical conductivity is a measure of total dissolved solids and ranges from 470 to 585 micro siemens/cm at 25° C. All major ions are within the limits of Bureau of Indian 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^-**
Dhaurpur	7.9	585	55	25	04	155	50
Bisunpur	7.8	470	41	15	05	125	45
Bhandargaon	7.6	555	50	20	04	1145	40

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 WATER SAMPLE
ELECTRICAL CONDUCTIVIT
700
600
500
400
300
200
100
0
585
470
555
Dhaurpur
Bisunpur
Bhandargaon
LOCATION


STUDY AREA,CONCENTRATION OF IONS
IN MG/LITER
1400
1200
1000
800
600
400
200
0
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. <u>Ground water recharge :</u>

a) Total geographical area in ha. = 15820

b) Area not suitable for ground recharge in ha. = 2000

c) Area suitable for ground recharge in ha. =13820

d) Average water level:

Premonsoon =7.0 mbgl.

Postmonsoon = 4.0 mbgl.

e) Normal annual rain fall = 1.365 m.

f) Normal monsoon rain fall = 1.16 m.

g) Normal non monsoon rain fall = 0.205 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

$R_{rf} = NAR \times A \times RFI$

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 = 1.365 × 13820 × 0.06
= 1131.85 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	500	0.4	200	250	0.4	100

b. Seepage from tanks/ ponds

1. No of tanks = 10
2. Total water spreaded area in ha = 20
3. Seepage factor (m/year) = 0.6
4. Total non monsoon seepage (ham) = 12

c. Total annual recharge =

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

= 1131.85+100+ 12
= 1243.85 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 replenishable ground water is considered to deduct from total recharge as it goes as base flow.

Net ground water availability = Total recharge- Base flow
= 1243.85 ham -105.72 ham
= 1138.13 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

= 12632 × 60 × 365 / 1000 × 10000

= 27.66 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	100	1.0	100
Tube wells	10	2.5	25

C. Ground water balance (ham) :

= Annual utilizable GW resource – Gross ground water draft

= 1138.13ham- 152.66ham

= 985.47 ham

From the above it may be seen that the balance ground water resources in the area is of the order of 985.47ham.

D. Stage of ground water development :

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

= 152.66*100/1138.13

= 13.41 %

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 (S_y) 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

$$\mathbf{R_s = A \times S_y \times T_r}$$

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

&

$$\mathbf{T_r = (Z_2 - Z_1) \times 0.02}$$

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,

$\mathbf{R_s}$ =13820 x 0.02 x 20

= 5528.00 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
=15790 × 60 × 365 / 1000× 10000
= 34.58 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

= 2500 × 0.694

= 1735.00 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 1769.58 ham. The water recharge to the ground water through recommended artificial recharge structure in the water shed is of the order of 190 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 4G2D5H1 & 4G2D5H3, Udaipur 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 Study 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 study 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 27.66 ham and the ground water draft for irrigation is around 152.66ham. The ground water draft for industrial purposes is negligible.

A. Artificial Recharge:

The plan for artificial recharge has been prepared by considering the hydro, geological 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 5-7 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

= 7029* × 1.0 × 0.02 = 140 ham (for DTW 3-5 mbgl)

= 1000* 2.5* 0.02 = 50 ham (for DTW 5-7 mbgl)

So the vadose zone of 190 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 250.00ham.

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 catchment. The normal monsoon rainfall of the area being 1365 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 54 cm. The total yield of run-off generated from watershed having 13820 ha area works out to 7462.80 ham and 30% of the total run-off i.e. 2238.8 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 is given in **Table 14** and location of proposed artificial recharge structures is presented in **Fig 12**.

Table 14 Details of Artificial recharge and Rain water harvesting structures to be constructed in Hilly/Forested part of the Study area

Sr No.	Compartment	Checkdam/nala Bund	Gabbion Structures	Percolation tank
1	2100	1		
2	2001	4		
3	2002	3		
4	2003		3	
5	2007	1	1	
6	2008	2	1	
7	2009	6	1	2
8	2010	1		
9	2011	1	1	
10	2012	3		
11	2013	2		
12	2014	2		

Sr No.	Compartment	Checkdam/nala Bund	Gabbion Structures	Percolation tank
13	2015			1
14	2016	4		
15	2017	3	2	
16	2020		3	
17	2021	5	3	
18	2022	6		
19	2023	6	3	
20	2049		2	
21	2050	2	2	
22	2052	2		
23	2053	4		
24	2054	2		
25	2069			1
26	2098	1		
27	2099	2		
28	Outside of the Forest Compartment	11	5	1
	Total	**74**	**27**	**5**

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

From the table 14, it is seen that 74 no.of Nala bunds/ Check dams, 27no.of Gabbion structures, 5 no. of Pecolation tanks and 13.7 km*5 (row) long Contour trenching/ Contour bunds to be constructed in the hilly/forested area of the Study area area. The tentative estimated cost to construct all these artificial recharge structures is approximately coming around 125 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**.

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	74	1.5 ham	111 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	5 (about 10 ham capacity)	10 ham	50 ham	
4	Contour trenching and Contour bunding	13.7 km x 5= 68.5 km	1 ham /km	68.5ham	
4	Gabbion structure	27	0.5 ham	13.5 ham	

Fig 12 Location of the praposed structures

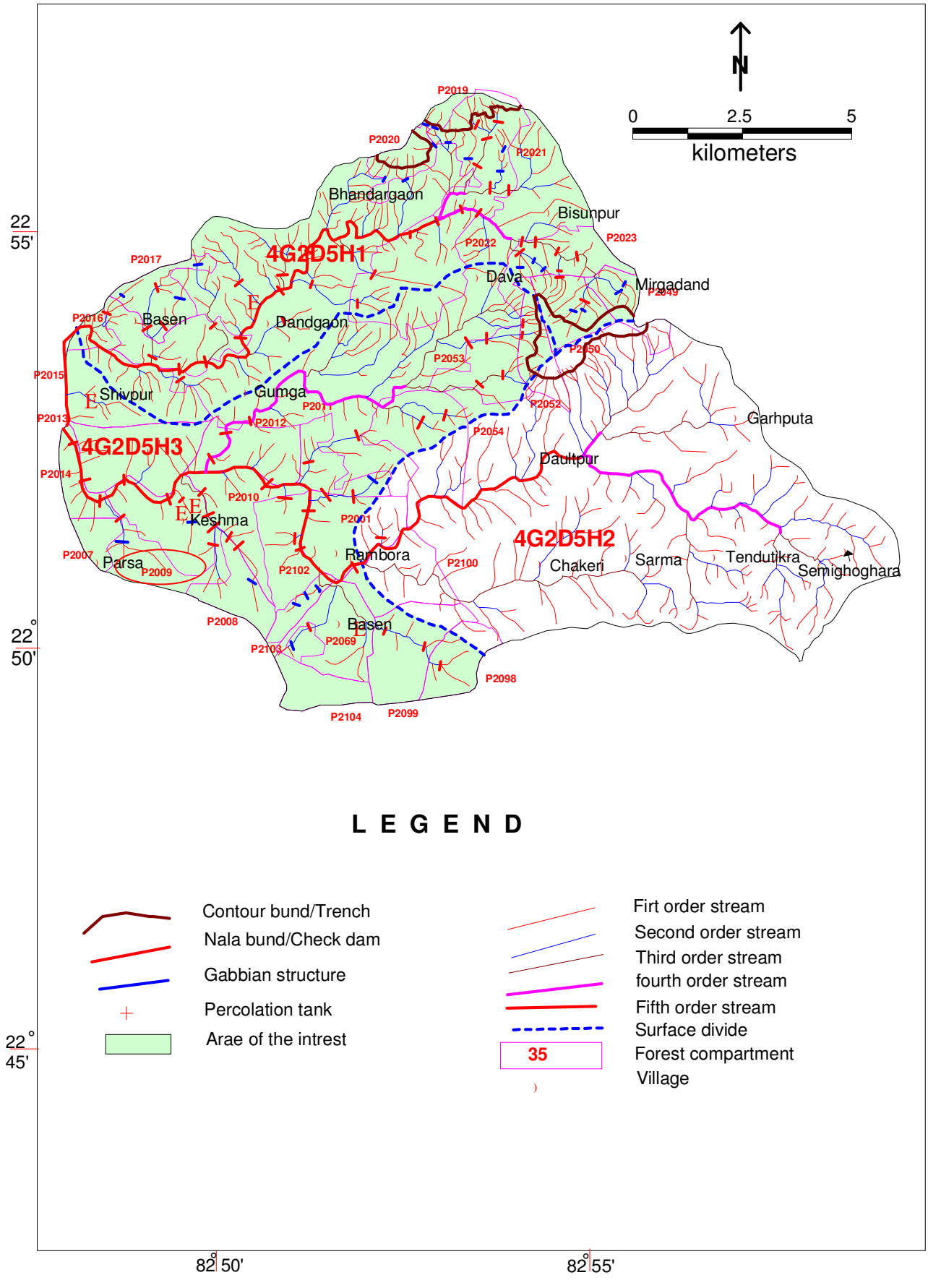
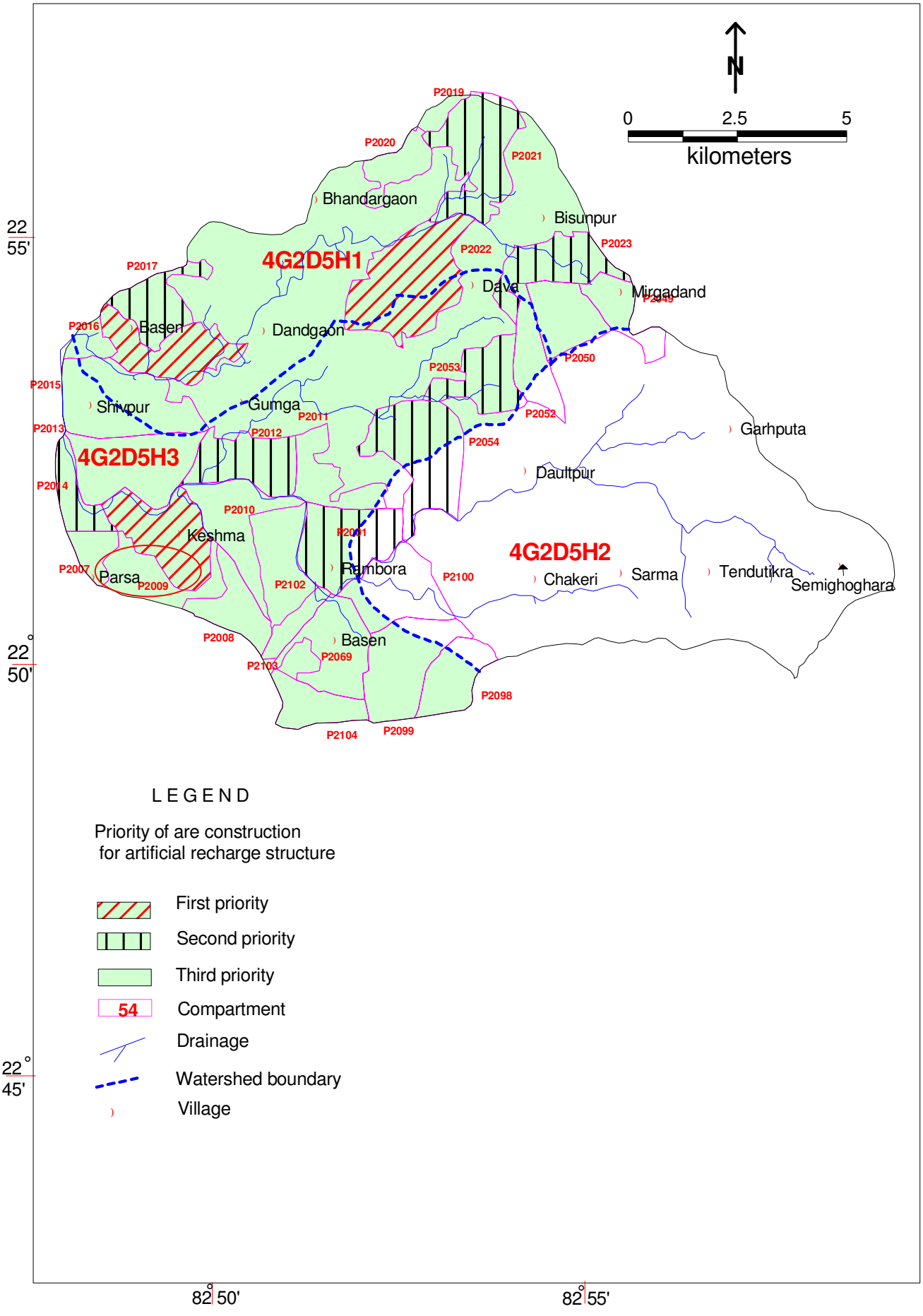
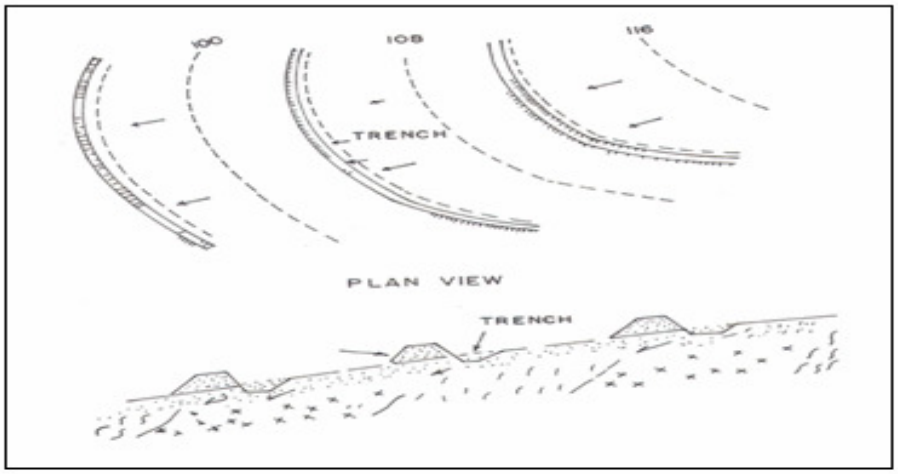


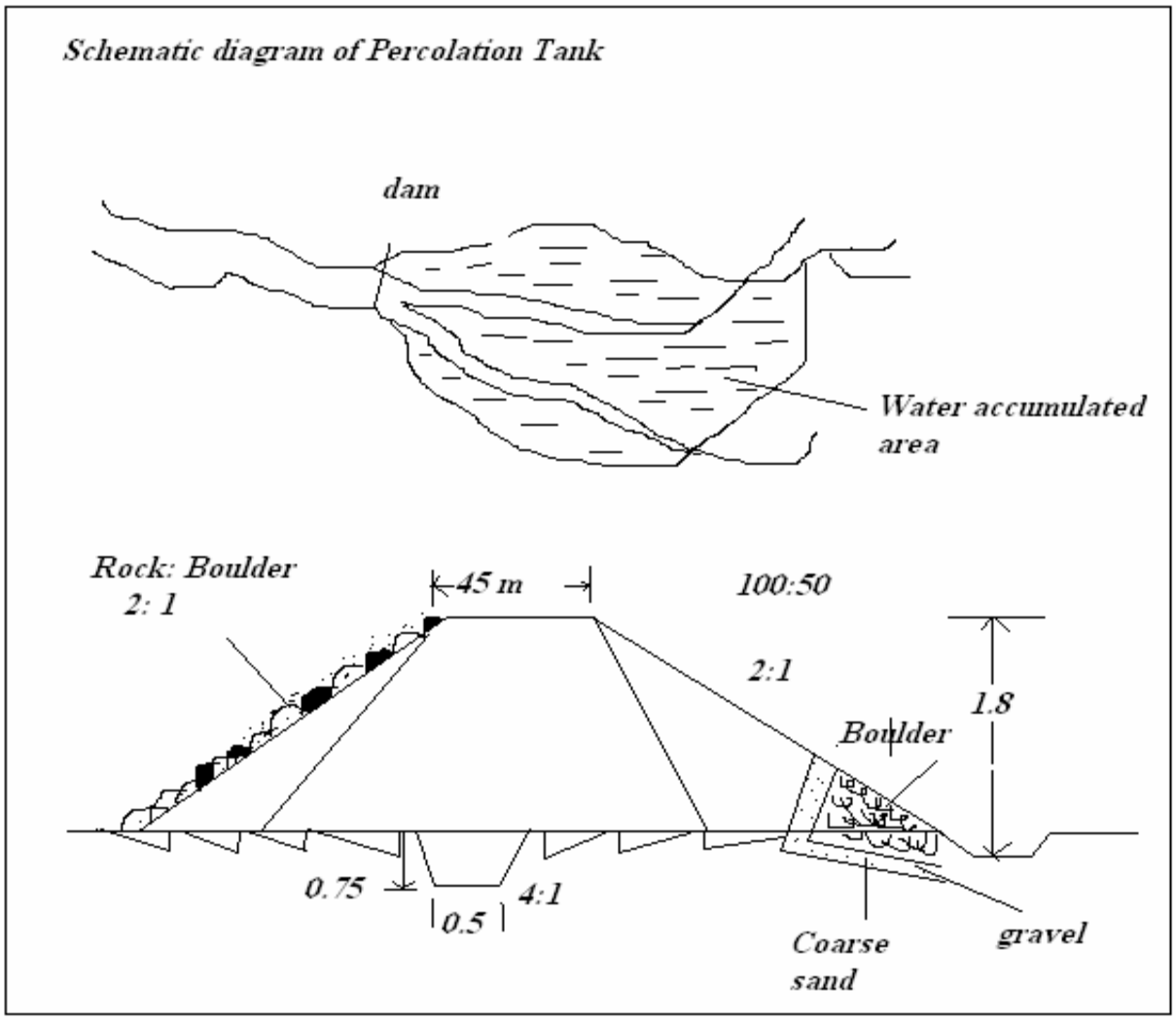
Fig 13 Area Demarcated as per Priority for Construction of Artificial Recharge Structu



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.

The **whole compartment** extents up to 322.45 ha.

The average slope at the stretch of 100 m. horizontal distance is 3061.26 m.
Ratio =3061/50 = 61.22 to I m. Say 1:61
Degree = $1^0$43’06”
Percentage = 1/61 x 100 = 1.63%

Value of C = Coefficient showing % of rainfall appearing as runoff, a watershed factor = timber plain = 0.024

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 this calculations the no. of CT, Size of CT, Spacement between the contour trench line and between the contour trench is derived. The area is divided on the basis of slope and the structures computed for the compartment no. 2001are given in the table no. 16.

Table 16 Details of Artificial recharge and Rain water harvesting structures to be constructed in compartment no. P2009

Type of structures					
C. no. P2009	**Contour trench (size 3x0.45x0.45m.) Spacement 3x550m**	**Gabbion structure**	**check dam**	**Earthen check dam**	**Bolder Check Dam**
Total Area 322.45	1954	1	6	9	9

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

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 8199 Mandays.

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 irrigate 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. P2009

AREA =322.45 HA.

GENERAL INFORMATION

1.	Work Name	: Soil & water conservation work
2.	Name of Divisional Forest Office:	South Surguja
3.	Range:	: Udaipur
5.	Block	: South Surguja
8.	Budget head	: National Rural Employment Guarantee Scheme
9.	Compartment No.	: P 2022
10.	Compartment Total Area	: 322.45
11.	Treatment area	: 322.45
12.	Rural area	: Parsa

Divisional Forest Officer Forest Division South Surguja	Sub Divisional Forest Officer Sub Division South Surguja	Range Forest Officer Forest Range Udaipur C.G.

PROJECT REPORT

Soil & water conservation work

Year 2009-10

Compartment. No. P2009

Total area 322.45 ha. Treatment area 322.45 ha.

Wage rate 100/mandays

AREA = 322.45 HA.

S.N.	Work Detail	Quantity	Unit	Rate		Unit	Cost in Rs.	Expenditure on material	Expenditure on labour
				Man days	Cost in Rs.				
1	Survey/Demarcation	322.45	ha.	0.94 MD/ha.	100	ha.	32245		32245
2	Treatment Map & preparation of project report	322.45	ha.	230/ha.	230	ha.	74163.5		74163.5
3	Cleaning of the area	322.45	ha.	4.00MD/ha.	301.88	ha.	97341.206		97341.206
4	Stacking for layout of contour trench	322.45	ha.	1.85 MD/ha.	139.61	ha.	45017.2445		45017.2445
5	Digging of contour trench in 0.6 density forest (size 3.00x0.45x200m.=0.60cmt.)	1954	No.	43.33/cmt.	25.99	Trench	50784.46		50784.46
11	Bolber Check dam	9	No.		2000	LS	18000	3600	14400
12	Check Dam	6	No.		100000	LS	600000	120000	480000
13	Earthen check dam	9	No.		2000	LS	18000		18000
9	Gabbion Structure	1	No.		2000	LS	2000		
10	Other work = Fire protection, seed sowing, maintenance of structures					LS	10000	2000	8000
Total							**947551.41**	**125600**	**819951**

Divisional Forest Officer
South Surguja Forest
Division

Sub Divisional Forest Officer
South Surguja Sub Division

Range Forest Officer
Forest Range Udaipur
C.G.