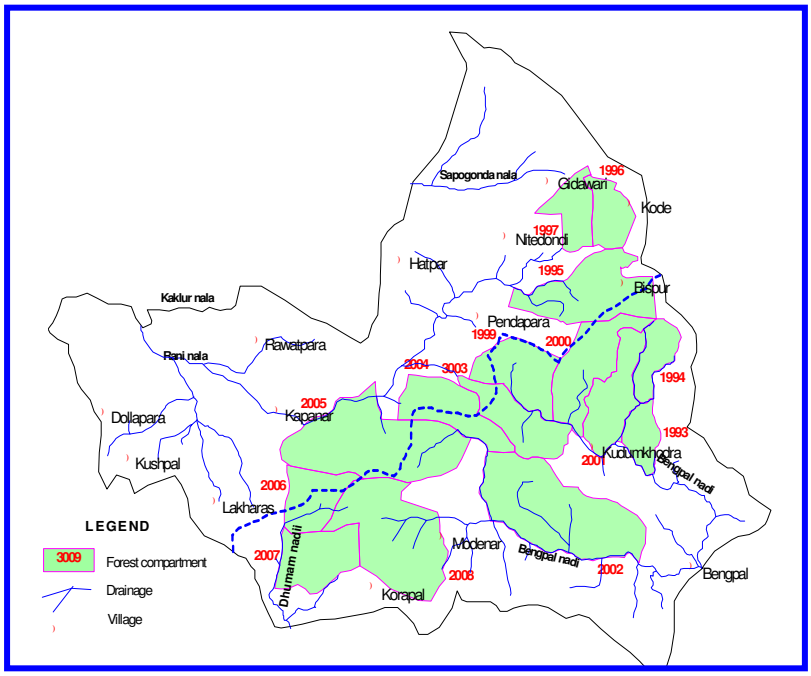
MASTER PLAN

For

ZERO DISCHARGE BASED WATERSHED MANAGEMENT

KANGER HILLY AND FORESTED AREA



FOREST RANGE: DARBHA

FOREST DIVISION: JAGDALPUR, DISTRICT- JAGDALPUR, CHHATTISGARH

TOTAL AREA – 196.3 SQ. KM.

TOTAL PROJECT COST – 1750.00 LACS

FROM,

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(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

Visit us at: http://www.lncindia.com, www.learnnature.com

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Divisional Forest Officer
Forest Division Jagdalpur

INDEX

Area at a Glance

GENERAL FEATURES	
Area in Sq.km.	196.3Sq. km.
Co-ordinates	N 18 °46'30" –18°55'39"latitude and E 81°34'15" – 81°47'46"
Population	6381
District Head Quarters	Jagdalpur
Block	Parts of Darbha and Bastanar
Villages	12 no.s
AGRICULTURE & IRRIGATION	
Net sown area (ha)	4254
Double cropped area (ha)	100
Gross cropped area (ha)	4354
Irrigated area (ha)	50
HYDROMETEROLOGY	
Annual Rainfall 2007	1400mm
Temperature Maximum	42.5° C
Temperature Minimum	13.5° C
PHYSIOGRAPHY	Structural hills & valleys, Denudational hills and valleys, plateau and Pediplain/pediment
DRAINAGE	Sabri & its tributaries of Godavari River
SOILS	Red & Sandy, Red& loamy soil
GEOLOGY	Granite Gneiss
HYDROGEOLOGY	
Depth to water level post monsoon	3.30 to5.80 mbgl
Depth to water level pre monsoon	5.00 to 9.70 mbgl
Fluctuation	1.30 to 4.50 m
Available Vadose zone for artificial recharge	472 ham
GROUNDWATER RESOURCES	
Replenisable ground water resourses	1625.92 ham
Available ground water resourses	1487.72 ham
Gross ground water draft	106.47 ham
Ground water balance	1381.25 ham
Stage of Ground water Development	7.1 %
Static ground water resources	7652 ham
Category	Safe
CHEMICAL QUALITY	Suitable for domestic and Irrigation purposes

1. INTRODUCTION

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 have also been observed in many parts of the country. To tackle the situation, 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.

1.1 Objectives and Benefits 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 as 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

The following 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, Jagdalpur
Census Data	:	Census department collected from Jagdalpur Statistics Department
Hand Pumps Details	:	Public Health Engineering Department, Jagdalpur
Water Resource information	:	Water Resource Department, Jagdalpur and Data Centre, Raipur
Groundwater Information	:	State Groundwater Survey Circle, Jagdalpur, Central Groundwater Board, Raipur
Other District Statistical information	:	Economics & Statistics Department, Jagdalpur
Geological Information	:	Geological Survey of India, Raipur

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, Geomorphologic, Land use, Soil, Hydro geological 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. Specification and tentative cost involved in constructing different artificial structures has been thoroughly worked out and presented in this report.

1.5 Location, Extent and Accessibility

Jagdalpur is one of the southerly district of Chhattisgarh state. The district extends between 18°38'42'' to 20°11'50''North latitudes and 80°40'00'' to 82°15'00'' East longitudes and is bounded on north by Kanker ,west by Maharashtra state, on south by Dantewara and east by Orissa state.

The Watershed is known as Kanger hilly and forested area occupies an area of about 196.3 sq. km. It lies between 18°46'30'' to 18°55'40''North latitudes and 81°34'15'' to 81°47'46'' East longitudes falling in Survey of India top sheet No. 65F /9 and F/13 in the part of Parts of Darbha and Bastanar blocks of the Jagdalpur 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.**

Table 2 Salient Features of Kanger illy and forested area			
1.	Area (Sq.km.)	:	196.3
2.	Annual Rainfall (mm)	:	1400
3.	Total Population	:	29562
4.	Population Density (Person / Sq. Km.)	:	32
5.	S.C. Population	:	30
6.	S.T. Population	:	6146
7.	Literacy Percentage	:	20
8.	Agriculture Land (Ha)	:	2050
9.	Forest Area (ha.)	:	13630

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 6381 the density of population is 32 person/sq. km.

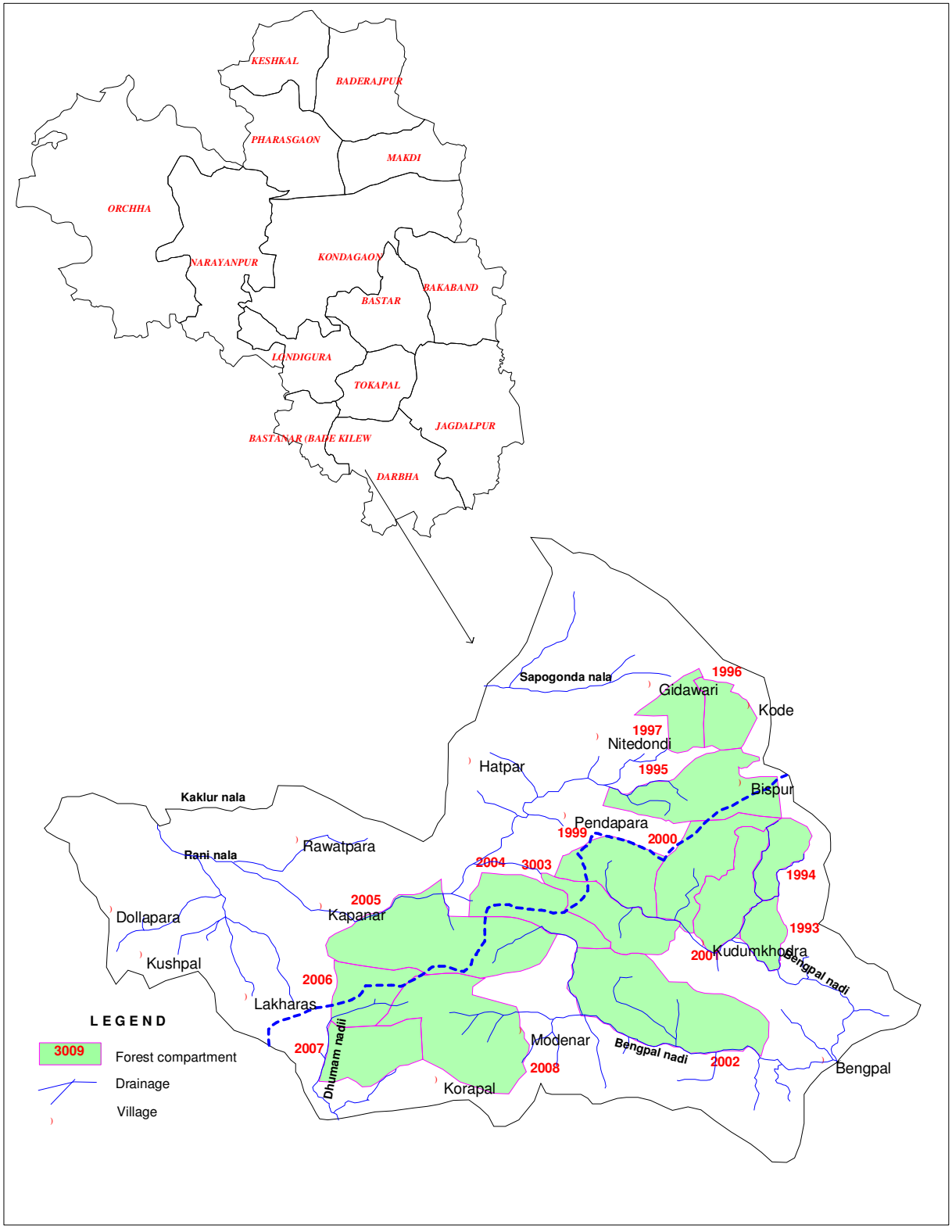
Groundwater resources in the area exclusively meet the drinking water requirement and partially meet the irrigation requirement, where the conditions are favourable for construction of bore well.

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** below.

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	Toynar	72	28	44	0	0	0	71	28	43
2	Hatpadmur	1010	508	502	0	0	0	925	458	467
3	Viranpal	690	344	346	0	0	0	674	337	337
4	Kelaur	1009	517	492	0	0	0	984	507	477
5	Gidawarli	454	228	226	0	0	0	454	228	226
6	Nilegondi Bodenar	542	253	289	0	0	0	477	227	250
7	Modenar	339	156	183	7	4	3	332	152	180
8	Klepal	514	265	249	0	0	0	514	265	249
9	Bangpal	565	295	270	18	9	9	547	286	261
10	Kudumkhodra	409	193	216	5	2	3	397	188	209
11	Bispur	470	240	230	0	0	0	466	238	228
12	Kodrichapar	307	158	149	0	0	0	305	157	148
	Total	6381	3185	3196	30	15	15	6146	3071	3075

Fig 1 Location map of the study area.



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 Jagdalpur. Besides this ordinary rain - gauges have been installed and maintained by Revenue Department at Parts of Darbha and Bastanar.

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 1950 mm and minimum ever recorded rainfall is 800 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 Darbha Rainguage station

1	1999	1175
2	2000	800
3	2001	1950
4	2002	1365
5	2003	1545
6	2004	1430
7	2005	1460
8	2006	1590
9	2007	1310
10	2008	1380
Average		1400

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

3.1 SOILS

The area has been covered by Alfisols only.

Alfisols:

This Alfisol is further divided into two categories in the area which are described below.

1. Red & sandy soil

This soil is exposed in the major part in central and eastern portion of the watershed. It covers an area of about 112.2 sq.km. It mainly consists of sand, kankar & pieces of rock fragments (sandstone) and clay.

2. Red & loamy soil

This soil is exposed in the western and northern part of watershed in patches. It covers an area of about 81.1 sq.km. It mainly consists of sand and clay.

Fig 2 is presented here for distribution of soils present in the 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	196.3	100.00
2	Forest cover	136.3	69.43
3	Agriculture - Net sown area	20.50	10.44
	Double cropped area	1.00	0.5
	Gross cropped area	21.50	11
	Irrigated area	0.5	0.25

The total geographical area of the water shed is about 196.3 Sq.km. situated in the southern portion of the Jagdalpur district covering parts of Parts of Darbha and Bastanar blocks of Jagdalpur district. Out of the total area of the watershed about 69.43 % 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 136.3 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 20.50 percentage is net sown area and about 0.25 % 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 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 **Fig3** 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	Moderate gently sloping	5-10
3.	Moderatly steep slope	10-20

Fig 2 Soil map of the study area.

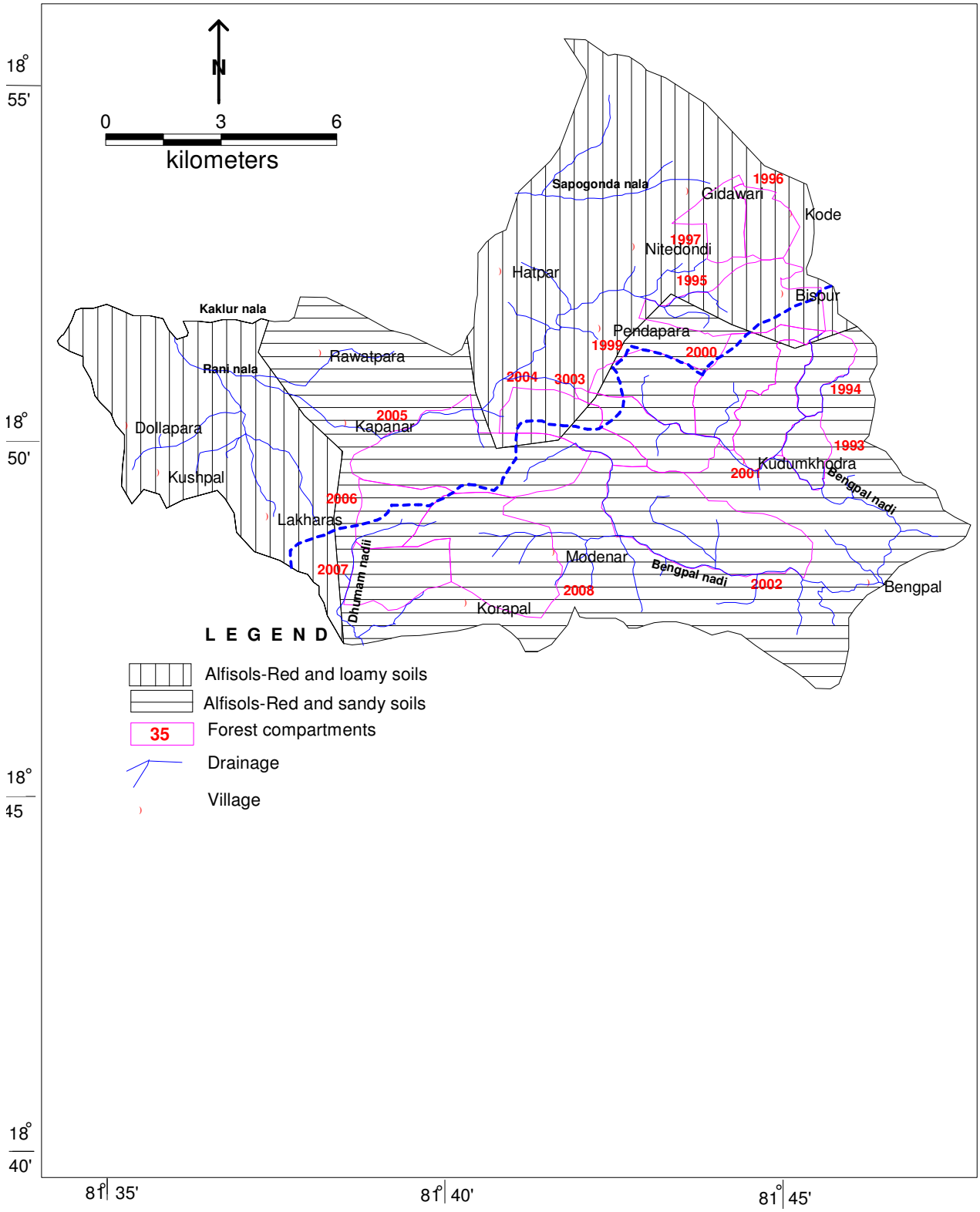
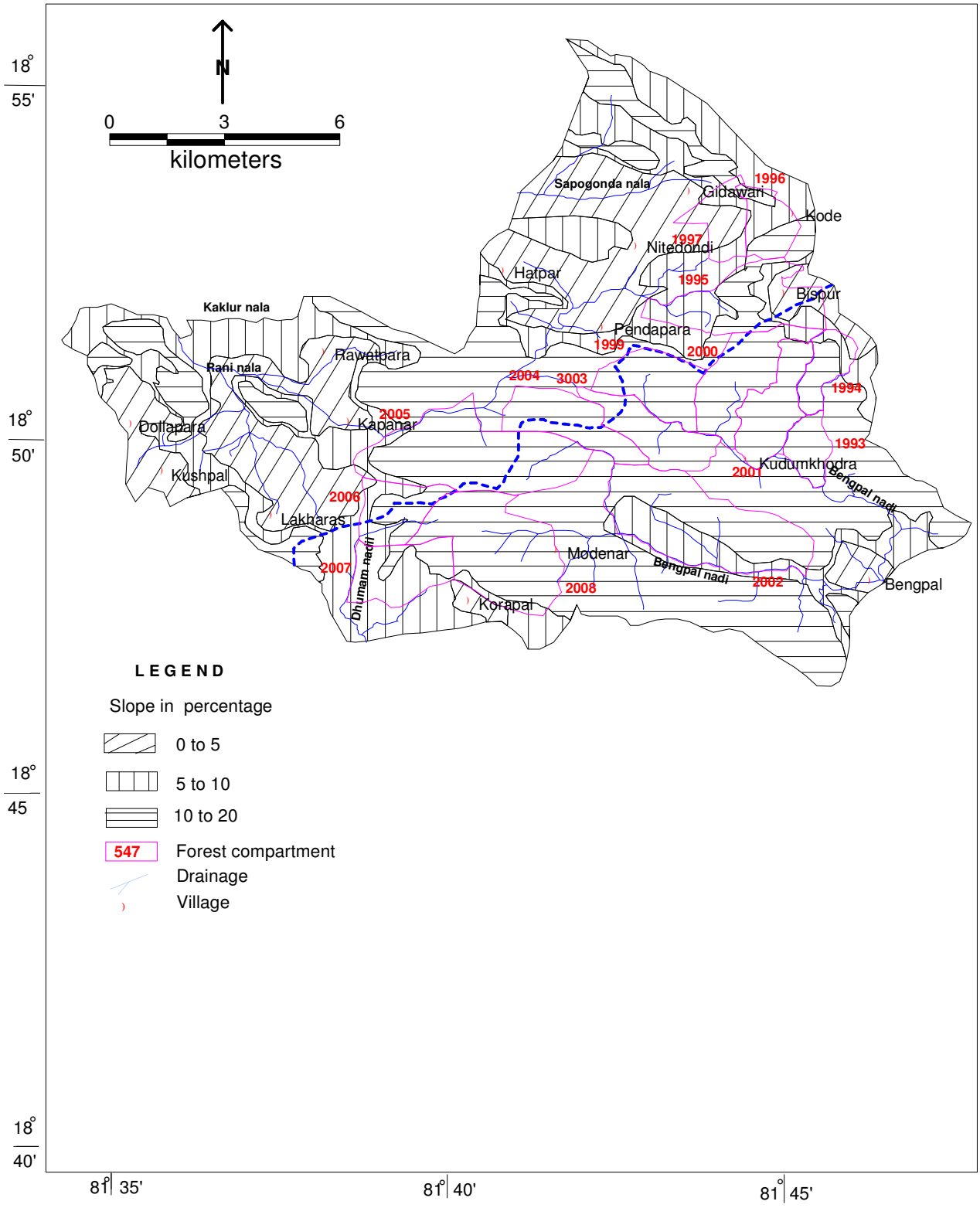


Fig 3 Slope map of the study area .



4. GEOMORPHOLOGY AND DRAINAGE

4.1 GEOMORPHOLOGY

The Study area is having somewhat elongated Catchment, the maximum length and Width of the Catchment is 15.33 Kms and 23.00 Kms respectively. The elevation of the area varies from 370 to 858 m amsl. The maximum basin elevation is 858 m amsl in the central-west part at Umadongar Pahar area while minimum elevation is present south-east of Bengpal village.

The Physiography of the basin is controlled by geological formations namely Granite Gneiss and basic volcanics.

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 hills & valleys, pediplain/pediment, Denudational hills and valleys and Plateau.

1. Plateu:

In the area it is exposed in major portion of northern part of the watershed. It is traversed by joints.It covers an area of about 79.00 sq.km. It is identified at an elevation of above 500 m amsl.

2. Structural hills & valleys

In the area it is exposed in extreme southern part of the watershed. It is traversed by faulting and folding. It covers an area of about 44.53 sq.km. It is identified at an elevation of above 600 m amsl.

3. Pediplain/Pediment:

It is resultant product of polycyclic erosional and depositional processes. It is concealed and covered under thin soil cover. About 31.11sq.km. of the area of the watershed occupying by pediplain/pediment in the western part of the area. It is identified at an elevation of between 370 –400m. above m.s.l.

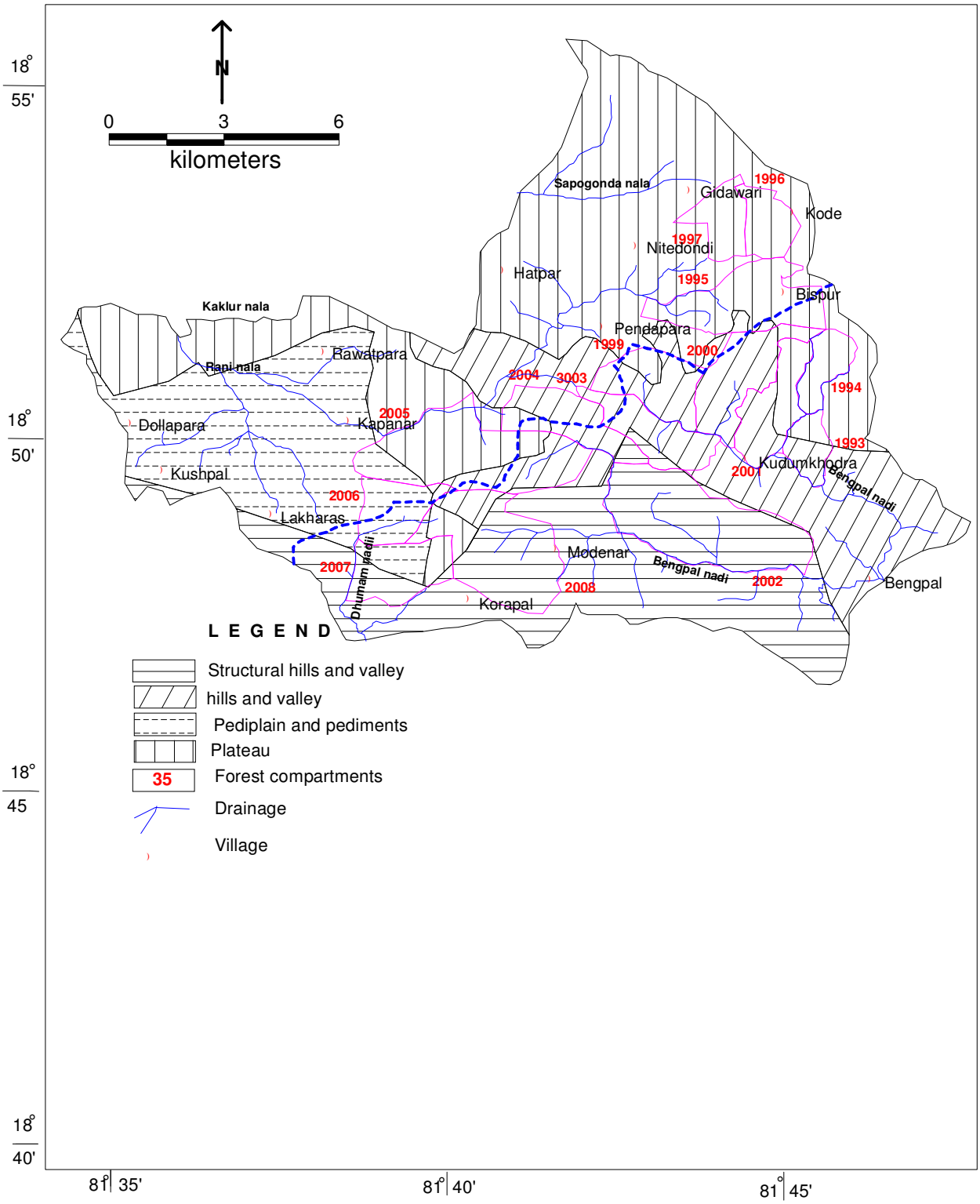
Pediment is identified at an elevation of above 400 m. above m.s.l. It is formed by combine processes of erosion dissection and pedimentation. The surface is dotted by relic very small hills rock sheet area, rocky screen deposits and other relict erosional elements. The topsoil is thin and impersistent it grey light red and brownish in colour and is mostly silty in nature with predominant rock fragments.

4. Denudational hills and valleys:

In the area it is exposed in central-east part of the watershed. It is traversed by faulting and folding. It covers an area of about 41.66sq.km. It is identified at an elevation of above 500 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 Godavari drainage system and drained by tributaries of Sabri river.

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 1.60 for IV th order stream to 5.38 for III rd order streams **(Table 7)**. As these values of bifurcation ratio ranges between 1.6 and5.38, indicating that the river flows through somewhat elevated/hilly area.

Table 7: Drainage Basin Characteristics of Hilly and Forested area of Study area 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	374.50	702	4.81	0.53	2.93
II	127.70	146	3.40	0.87	1.60
III	80.00	43	5.38	1.86	2.29
IV	34.96	8	1.60	4.37	2.48
V	14.10	5	5.00	2.82	1.41
VI	10.00	1		10.00	

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 massive thick bedded granite gneiss and basic volcanics. 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	Water shed length	Waters hed width	Drainage density	Stream Frequency	Form factor	Shape factor
Km2	Km	Km	Km	Km/ Km2	No/Km2	F=A/L 2	B=L2/A
A	P	L	W				
196.3	75.22	15.33	23	3.27	4.61	0.84	1.20

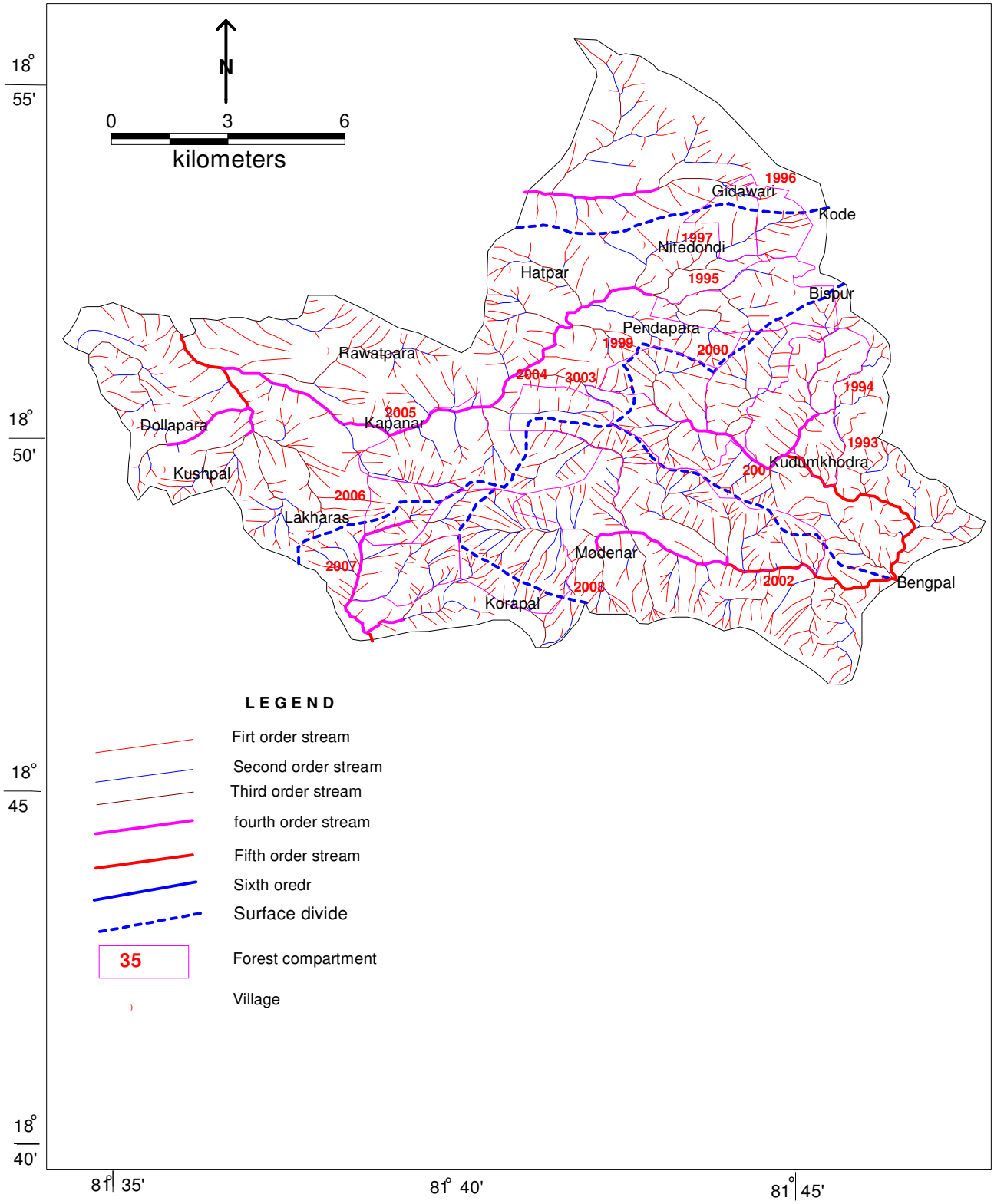
B) Relief - Longitudinal Channel Profile

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 858 metres above and it reached to minimum elevation of confluence point i.e. 370 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	
858	370	488	0.31

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 Bengpal, Dongargarh and Abujmarh groups are exposed. These are represented granite gneiss and basic volcanics etc of Proterozoic age . However, the generalized stratigraphic sequence of the study area is given in Table 5 below:

Table-5 Generalized stratigraphic sequence of study area

Age	Group	Formation	Lithology
QUATERNARY	Recent to sub-recent	Alluvium	Sand, Silt, Clay
PROTEROZOIC	Abujmarh group		Basic volcanics
	Dongargarh group		Granite gneiss
	Bengpal Group		Granite gneiss and meta sediments

Bengpal Group:

This rock type is exposed in central and southern portion of the watershed. It covers an area of about 90.84 sq.km. It mainly consist of granite gneiss and meta sediments traversed by NW-SE dolerirte dykes and quartz veins.

Dongargarh group:

This rock type is exposed in major part in northern and western portion of the watershed. It covers an area of about 104.7 sq.km. It mainly consist of granite gneiss traversed by joints and faults.

Abujmar Group;

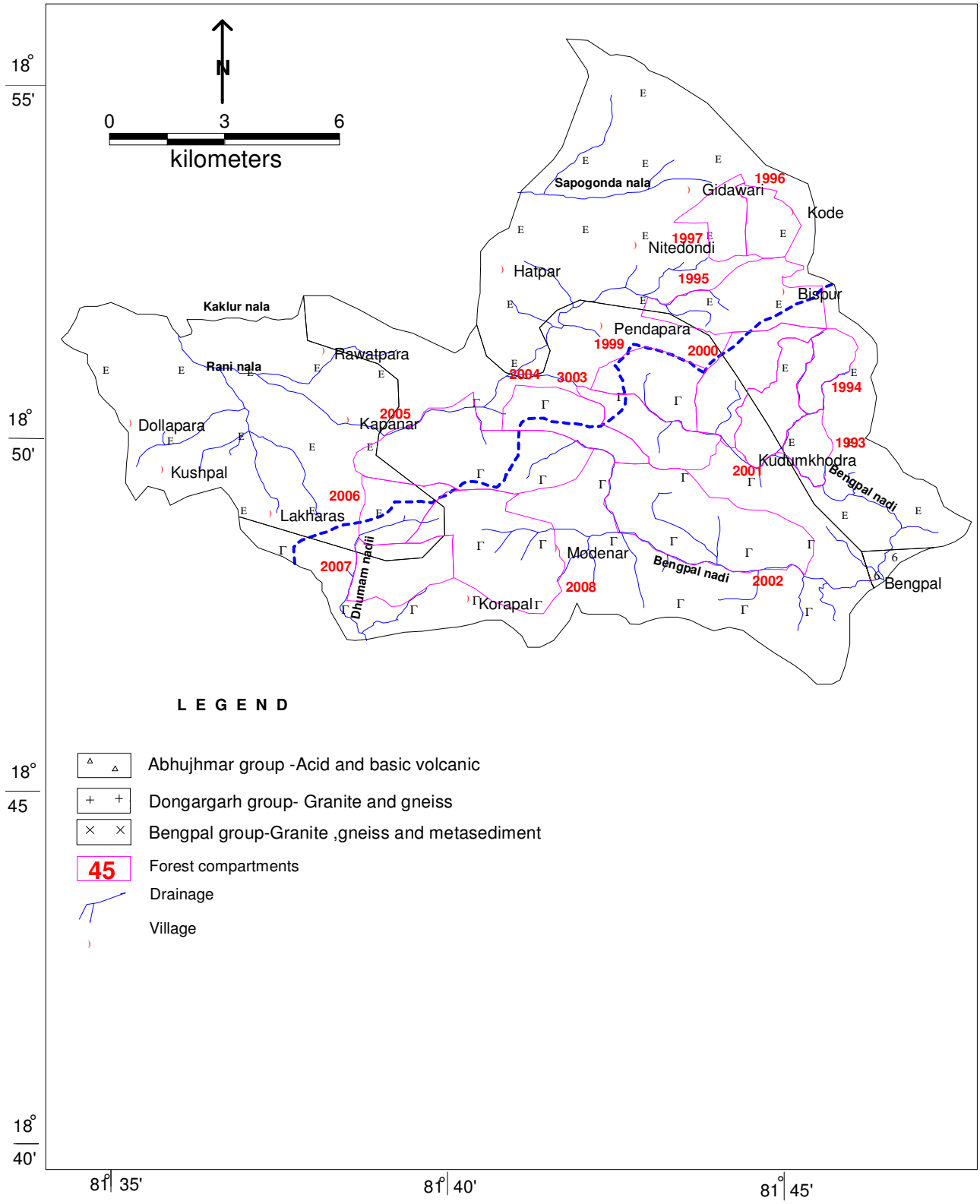
This rock type is exposed in very small patch in extreme south-eastern part in of the watershed. It covers an area of about 0.78 sq.km. It mainly consists of acid and basic volcanics.

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

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.

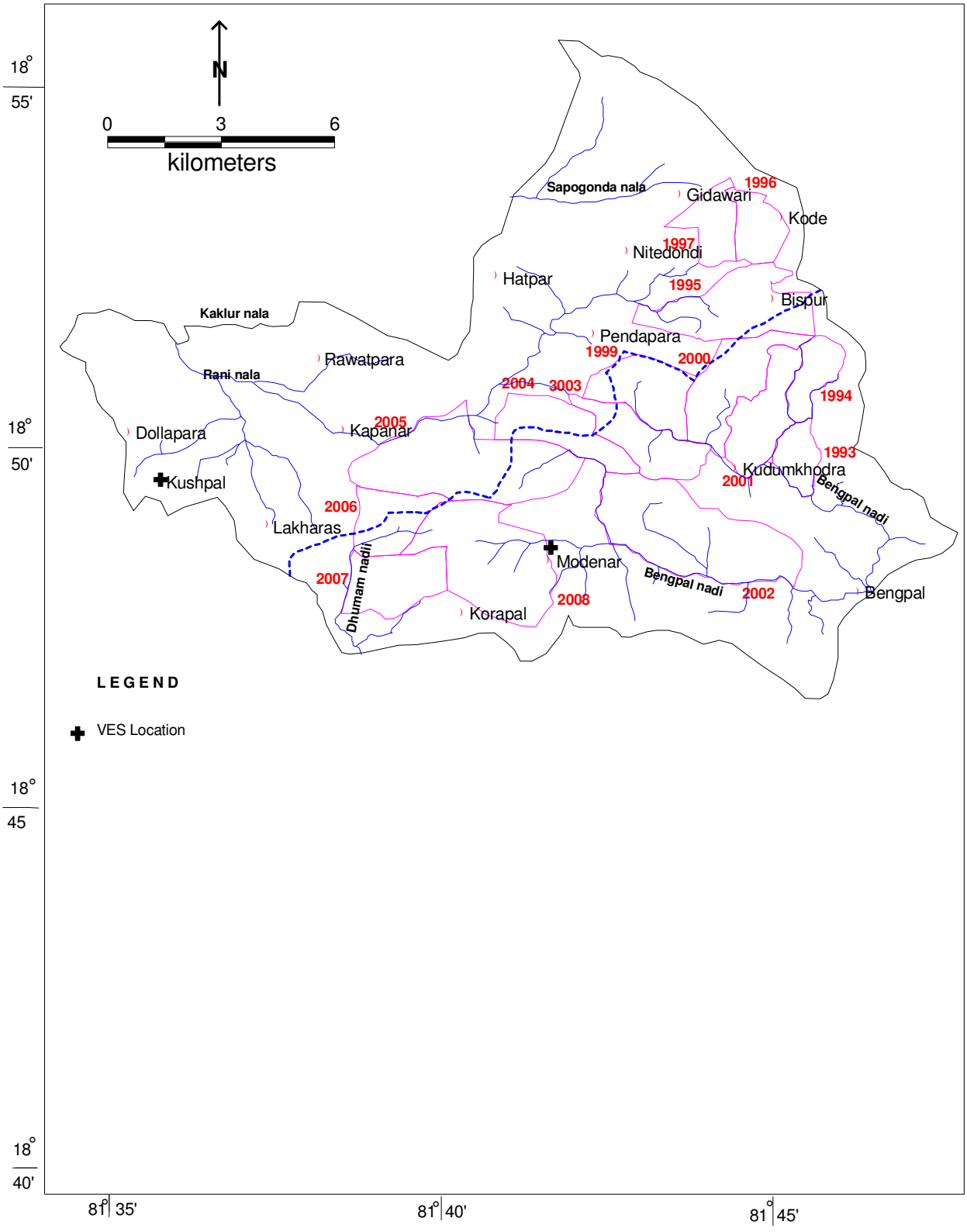
The data of resistivity soundings at three places were considered over the Study area area. The maximum current electrode separation ranged between 100 m to 110 m. The sounding results, in terms of resistivity (Ohm - meters) and thickness (h in meters) of the sub surface layers. Most of the sounding 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 11** below and location is presented in **Fig 7**.

Table 11 Summarised VES results in the study area

Name of the site	VES no.	Resistivity value (Ohm-m)			Layer depth (m)	
		ρ_1	ρ_2	ρ_3	D_1	D_2
Kushpal	1	70	65	2500	1.9	10
Modenar	2	90	75	2500	1.5	15

From the Table 11 it is seen that the first layer is soil zone ranging in thickness from 1.5 to 1.9 while the second layer is a weathered mantle of different rocks types present in the area ranging in thickness from 10 to 15 m and the last layer is a hard and compact rock like granite gneiss indicating indefinite thickness.

Fig 7 VES Location in the study area



7. HYDROGEOLOGY

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 rocks of Bengpal, Dongargarh and Abujmarh groups are exposed. These are represented granite gneiss and basic volcanics etc of Proterozoic age These formations are having moderate to 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 under confined to semi-confined conditions in deeper 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 5.00 to 9.70 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 3.30 to 5.80 mbgl. The water level fluctuation in the area varies about 1.30 to 4.50 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	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	Lakharas	81°37'25"	18°48'582"	629.63	9.00	620.63	5.70	3.30
2	Korapal	81°40'217	18°47'45"	635.80	9.50	626.30	5.20	4.30
3	Modenar	81°41'39"	18°48'28"	574.07	9.70	564.37	5.80	3.90
4	Bengpal	81°46'19"	18°48'02"	360.00	5.00	355.00	3.70	1.30
5	Bispur	81°45'02"	18°52'06"	747.00	7.00	740.00	3.50	3.50
6	Kode	81°45'10"	18°53'14"	760.00	7.10	752.90	3.30	3.80
7	Kudumkhodra	81°44'28"	18°49'45"	570.99	8.00	562.99	3.50	4.50
8	Nitedondi	81°42'50"	18°52'46"	697.53	7.90	689.63	5.00	2.90
9	Gidawari	81°43'38"	18°53'33"	694.44	7.20	687.24	5.10	2.10
10	Hatpar	81°40'52"	18°52'25"	694.44	7.10	687.34	4.80	2.30
11	Pendapara	81°42'20"	18°51'37"	672.84	7.00	665.84	4.80	2.20
12	Rawatpara	81°38'12"	18°51'16"	586.42	7.30	579.12	4.70	2.60
13	Dollapara	81°35'20"	18°50'15"	637.96	6.20	631.76	3.30	2.90
14	Kushpal	81°35'48"	18°49'35"	666.67	6.80	659.87	3.50	3.30
15	Kapanar	81°38'34"	18°50'17"	592.59	5.00	587.59	3.70	1.30

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 380 m amsl in the south-east to 700 mamsl in north. Water table more or less follows the surface topography. The northern part of the watershed shows higher altitude of water table indicate recharge area for ground water while south-eastern 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 20 to 40 m^2/day while specific capacity ranges form 25 to 40 lap/day. However for deep aquifer the transmissivity ranges from 40-70 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 Premonsoon depth to water level of the study area.

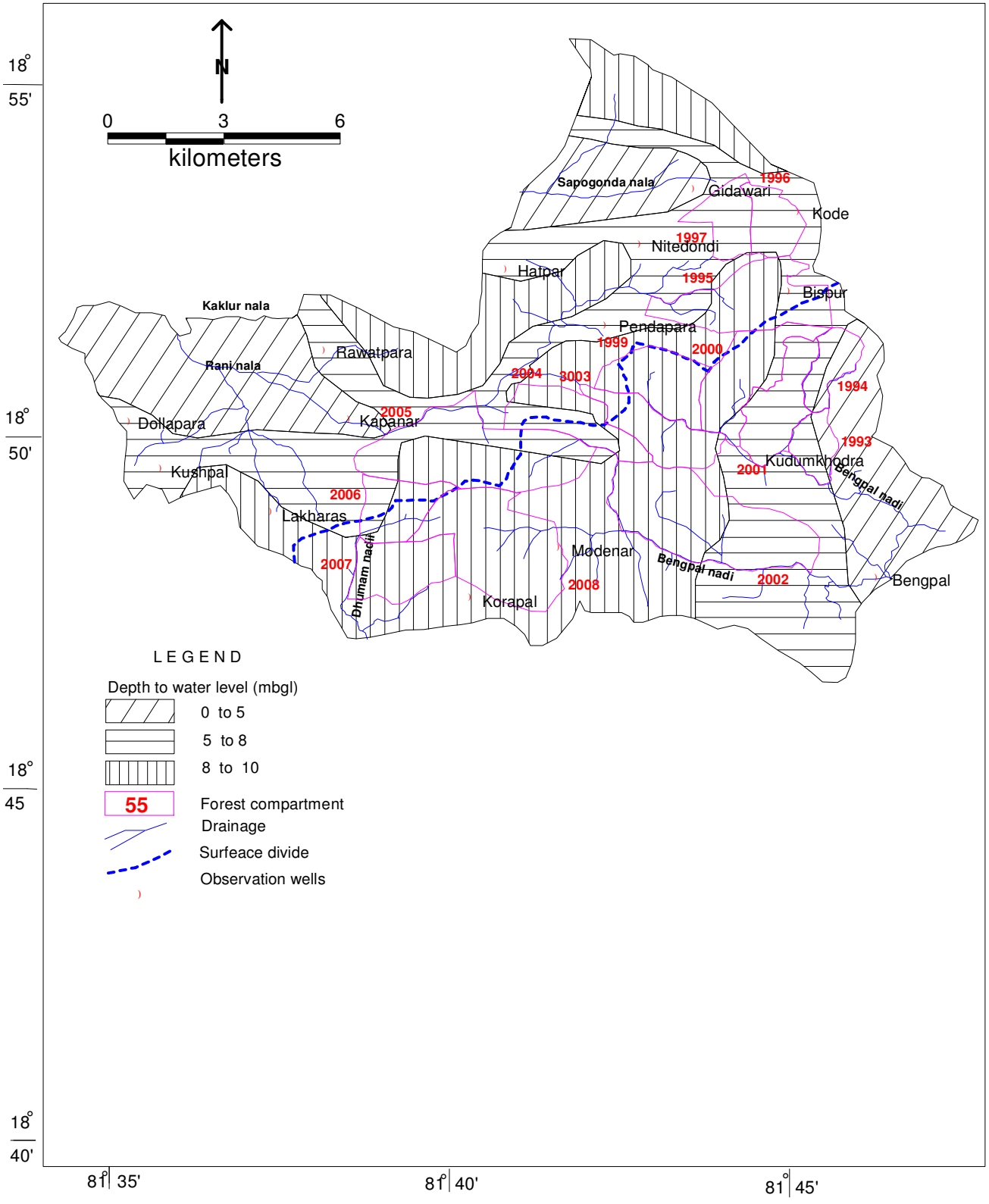


Fig 9 Post-monsoon depth to water level of the study area.

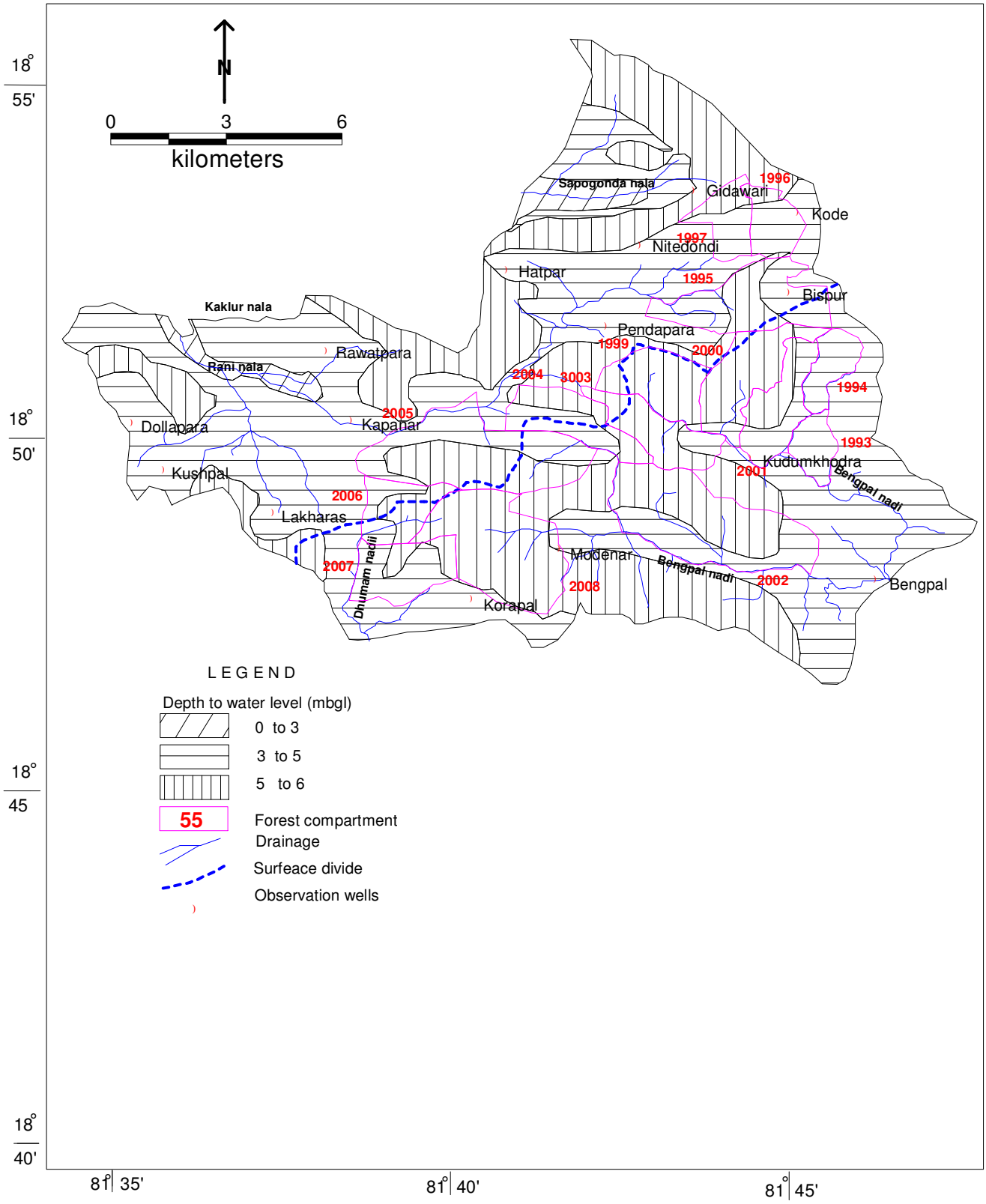


Fig 10 Seasonal ground water level fluctuation map of the study area.

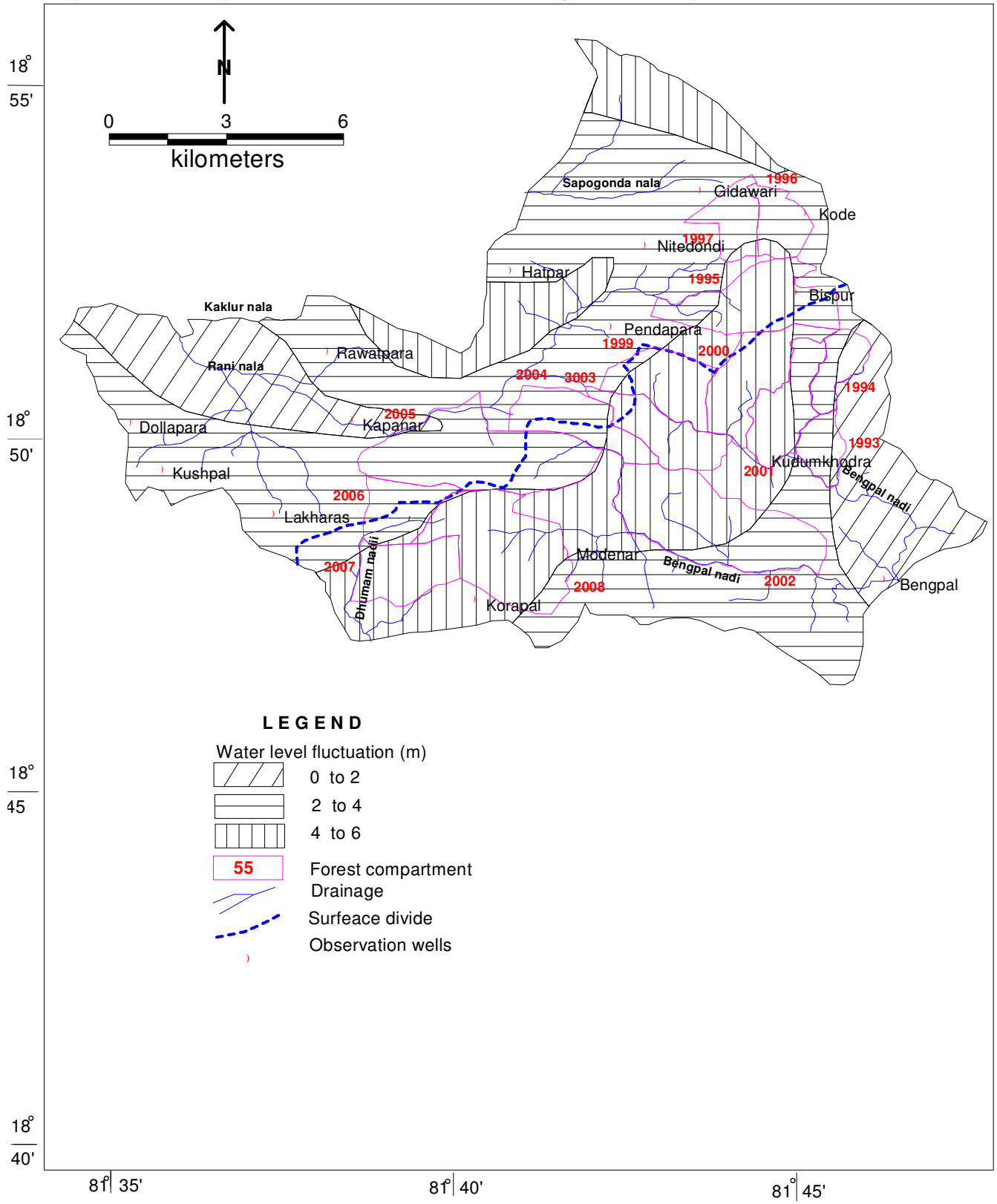
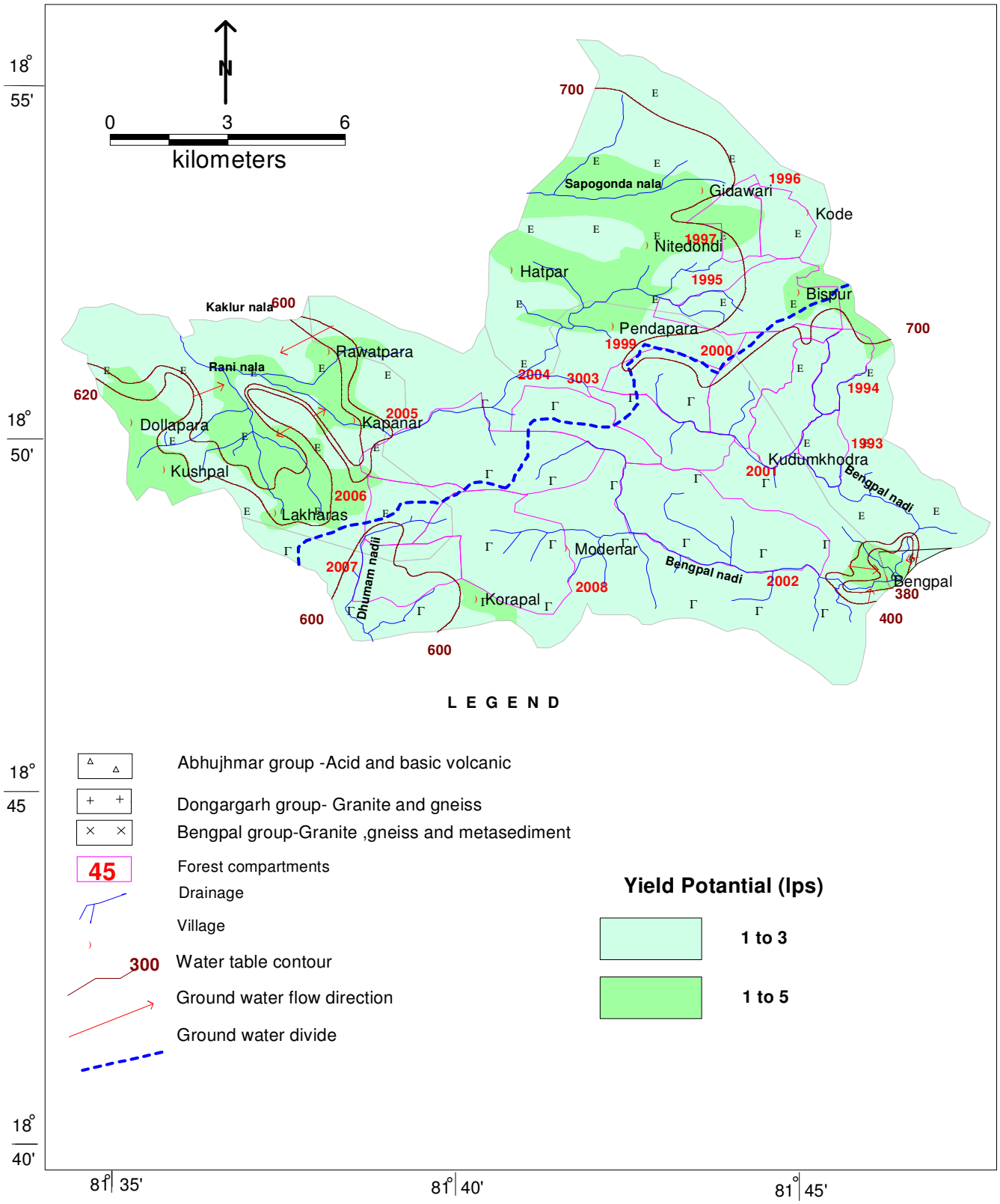


Fig 11 Hydrogeological map of the study area.



8. QUALITY OF GROUNDWATER

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 320 to 450 micro siemens/cm at 25^{o} 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^{o} C**	Concentration of ions in mg/liter				
			Ca^{++}	**Mg^{++}**	**CO_3^{--}**	**HCO_3^{-}**	**Cl^{-}**
Kushpal	7.7	450	20	15	03	155	55
Modenar	7.5	320	24	16	06	111	40

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

8. GROUNDWATER RESOURCE ESTIMATION AND DEMAND

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. = 19630

b) Area not suitable for ground recharge in ha. = 500

c) Area suitable for ground recharge in ha. =19130

d) Average water level:

Premonsoon = 6.5 mbgl.

Postmonsoon = 4.0 mbgl.

e) Normal annual rain fall = 1.4 m.

f) Normal monsoon rain fall = 1.19 m.

g) Normal non monsoon rain fall = 0.21 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 = 1.4 × 19130× 0.06

= 1606.92 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	50	0.4	20	25	0.4	10

b. Seepage from tanks/ ponds

1. No of tanks = 5
2. Total water spreaded area in ha = 15
3. Seepage factor (m/year) = 0.6
4. Total non monsoon seepage (ham) = 9

c. Total annual recharge =

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

= 1606.92 + 10+ 9

= 1625.92 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

= 1625.92 ham -138.20 ham

= 1487.72 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

= 6381 × 60 × 365 / 1000 × 10000= 13.97 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	80	1.0	80
Tube wells	5	2.5	12.5

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

= Annual utilizable GW resource – Gross ground water draft

= 1487.72 ham- 106.47ham

= 1381.25 ham

From the above it may be seen that the balance ground water resources in the area is of the order of 1381.25ham.

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

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

= 106.47*100/1487.72

= 7.1 %

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%
1347.16 ha	1776.0 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 (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,

$$\mathbf{R_s} = 19130 \times 0.02 \times 20$$

$$= 7652.0 \text{ ham}$$

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

=7976 × 60 × 365 / 1000× 10000

= 17.46 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

= 2000 × 0.694

= 1388.0 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 1405.5 ham. The water recharge to the ground water through recommended artificial recharge structure in the water shed is of the order of 472 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

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 Kanger hilly and forested area 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 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 Kanger hilly and forested area 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 13.97 ham and the ground water draft for irrigation is around 92.50ham. 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

= 11100* × 1.0 × 0.02 = 222.0ham (for DTW 3-5 mbgl)

= 5000* 2.5* 0.02 = 250.0 ham (for DTW 5-6 mbgl)

So the vadose zone of 472.00 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 627 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 catchment. The normal monsoon rainfall of the area being 1400 mm. The percentage of run-off to rainfall as per Stranger's Table is 28.1 and the depth of run-off due to rainfall is 36.55 cm. The total yield of run-off generated from watershed having 19130 ha area works out to 6992 ham and 30% of the total run-off i.e. 2098 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 area				
Sr No.	Compartment	Checkdam/nala Bund	Gabbion Structures	Percolation tank
1	2007	3	2	
2	2008	6	13	
3	2006	2	1	
4	2005	14	8	
5	2004	3	1	
6	3003	8	5	
7	1999	3	3	
8	2000	7	2	
9	1995	10	3	2
10	1997	9	2	
11	1994	8	1	
12	1993	5		
13	2001	1	2	
14	2002	12	12	
15	1996	3	1	
16				
17	Outside of the Forest Compartment	17	8	4
Total		111	64	6

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

From the table 14, it is seen that 111 no.of Nala bunds/ Check dams, 64 no.of Gabbion structures, 6 no. of Pecolation tanks and 85.56 km*4 (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 175 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	111	1.5 ham	166.5 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	6(about 15 ham capacity)	15 ham	90 ham	
4	Contour trenching and Contour bunding	85.56km x 4= 342 km	1 ham /km	342ham	
4	Gabbion structure	64	0.5 ham	32 ham	

Fig 12 Location of the praposed structures

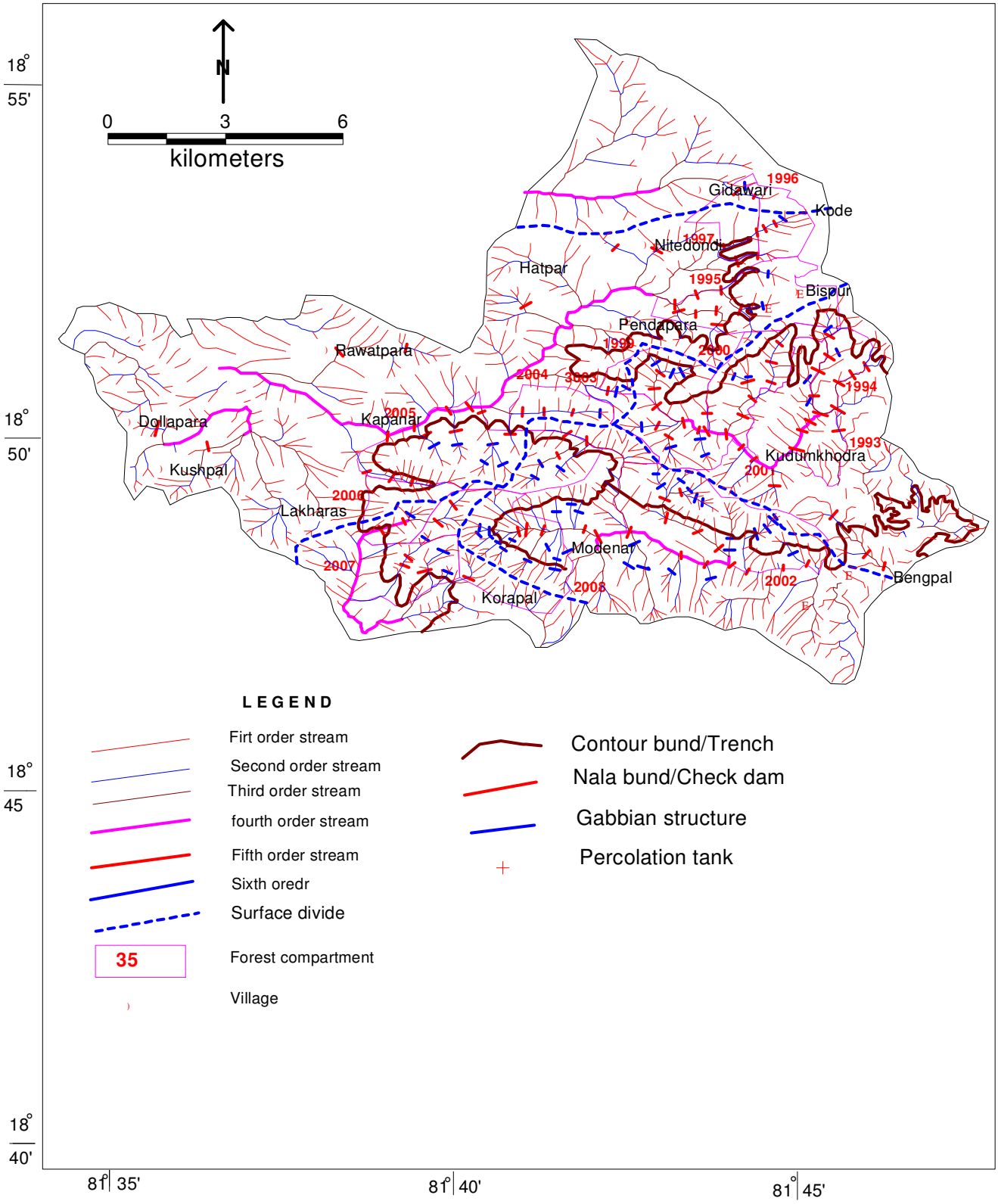
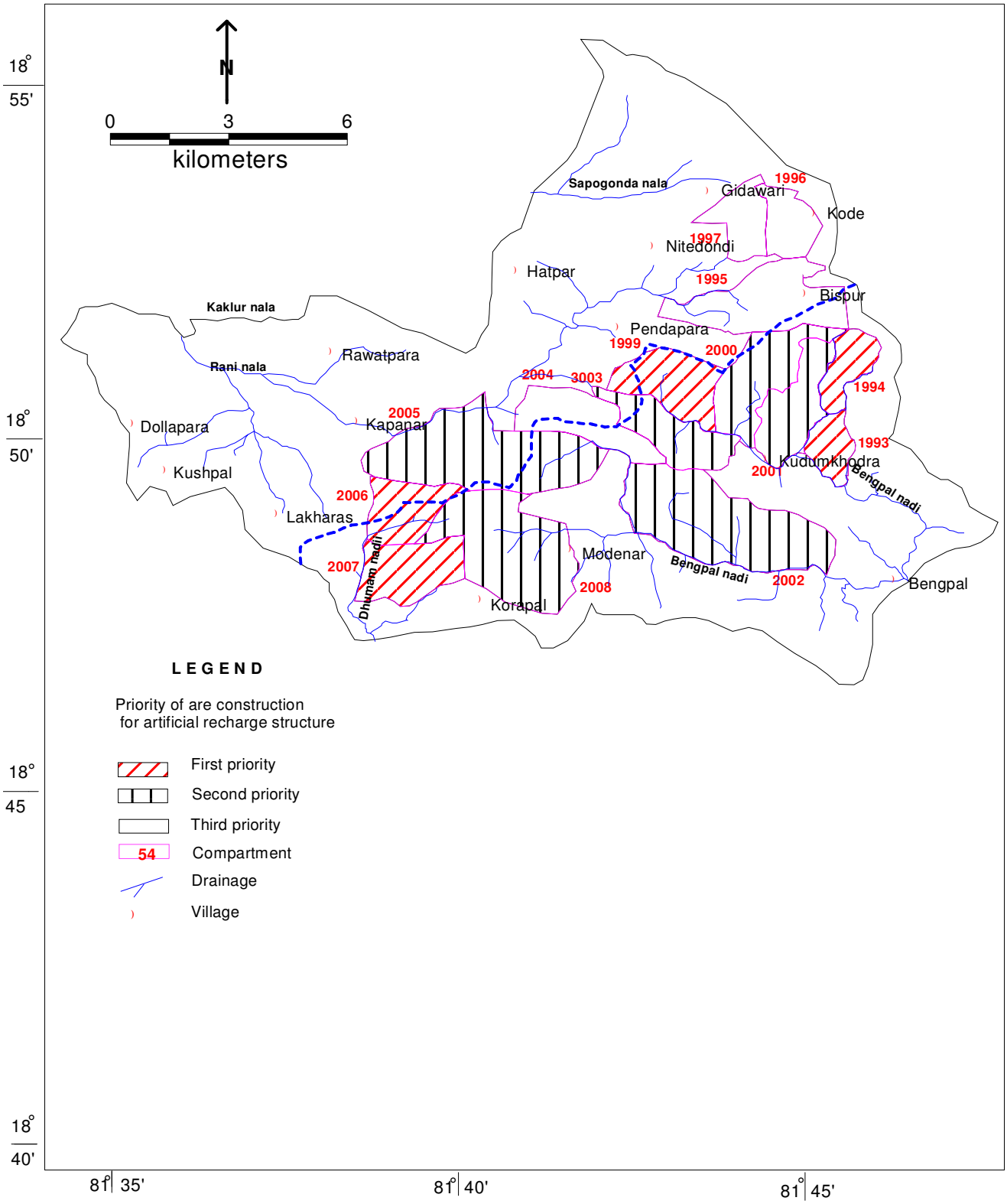
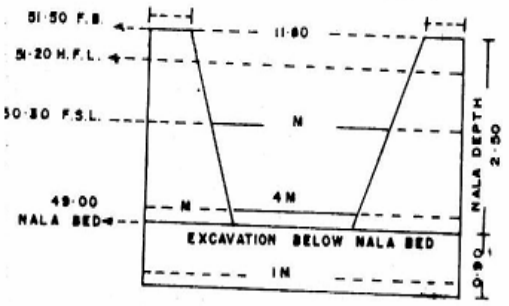
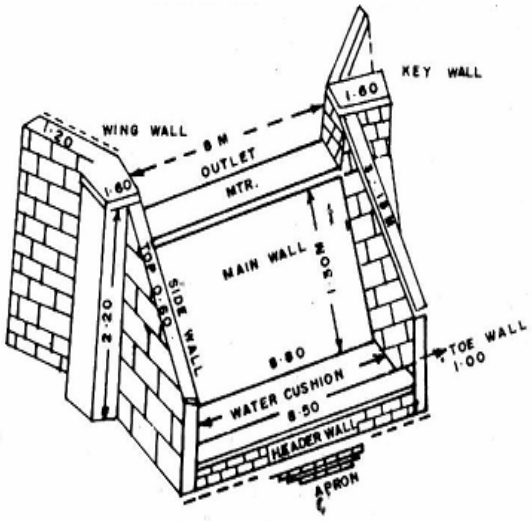


Fig 13 Area Demarcated as per Priority for Construction of Artificial Recharge Structure.



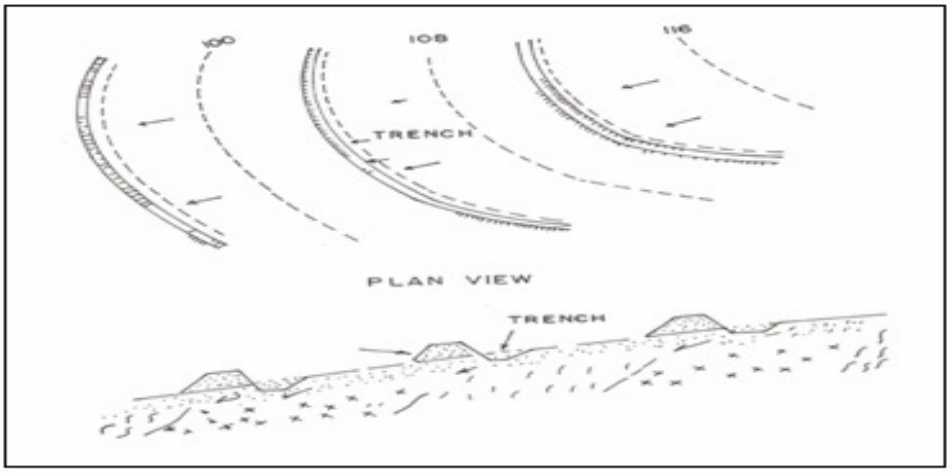
Vertical Section of Check Dam/ Nala Bund



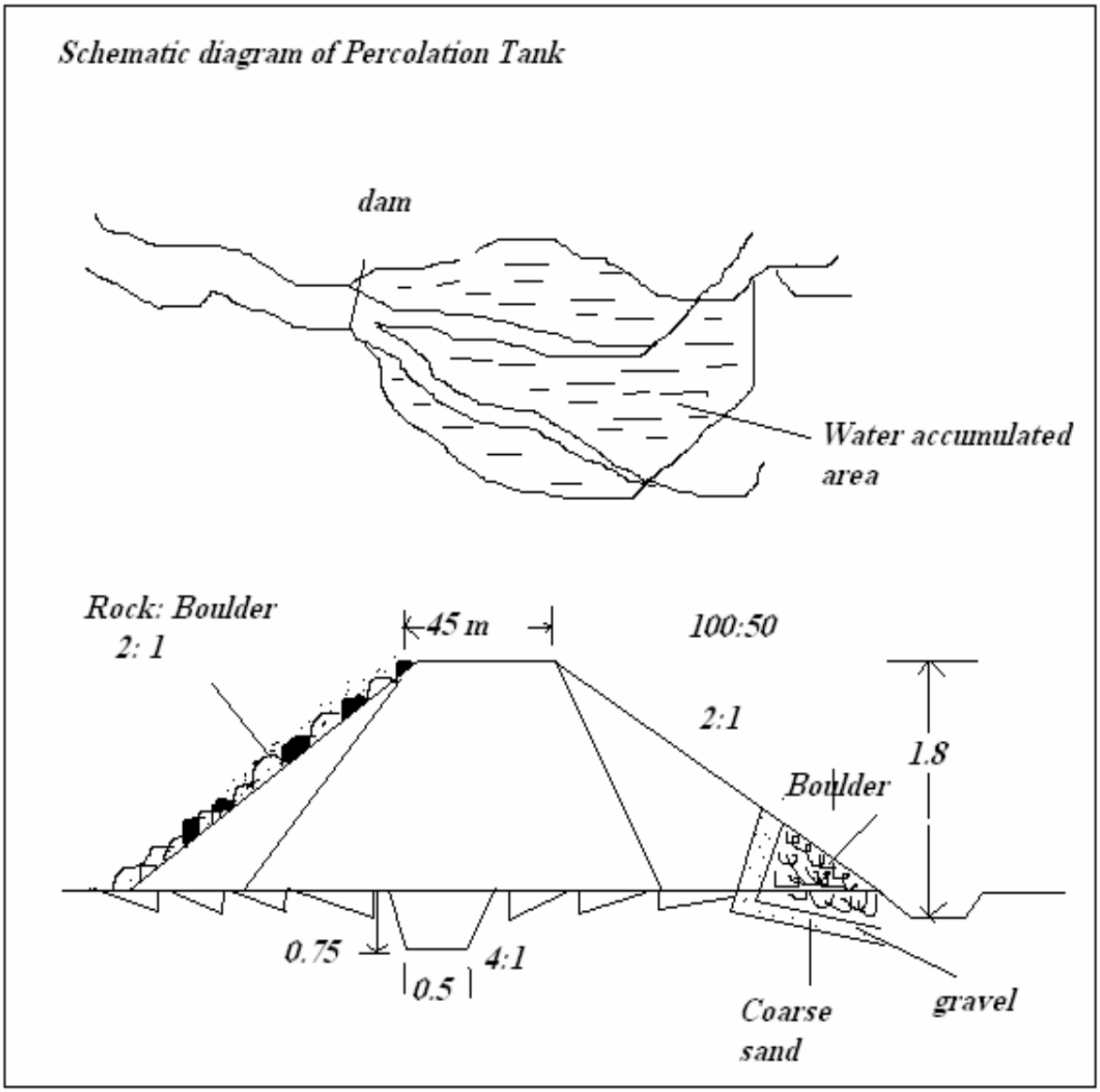


Horizontal Section of Check Dam/ Nala Bund

Sectional View of Contour Trench/ Contour Bund



Schematic diagram of Percolation Tank



11. CONCLUSIONS AND RCOMMENDATIONS

A) Conclusions:

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.

Jagdalpur is one of the southerly district of Chhattisgarh state. The district extends between 18°38'42'' to 20°11'50''North latitudes and 80°40'00'' to 82°15'00'' East longitudes and is bounded on north by Kanker ,west by Maharashtra state, on south by Dantewara and east by Orissa state.

The Watershed is known as Kanger hilly and forested area occupies an area of about 196.3 sq. km. It lies between 18°46'30'' to 18°55'40''North latitudes and 81°34'15'' to 81°47'46'' East longitudes falling in Survey of India toposheet No. 65F /9 and F/13 in the part of Parts of Darbha and Bastanar blocks of the Jagdalpur district.

The Study 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 with an average annual rainfall of 1400 mm.

Geomorphologically the area is occupied by Structurahills and valleys, pediplain/pediment, denudational hills and valleys and plateau. These landforms are formed because the rocks were exposed to renewed post depositional activities and were subjected to intensive and extensive pedimentation, peneplanation during Pre-Quaternary and Quaternary time. Hilly and Forested area of Study area is the part of Godavari drainage system.

Geologically, the Study area is occupied by mainly granite gneiss belonging to Proterozoic age. These formations are over lain uncomformably by Sub-recent to Recent Alluvium.

The depth to water level in area during pre monsoon period ranges between 5.00 to 9.70 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 3.30 to 5.80 mbgl. The water level fluctuation in the area varies about 1.30 to 4.50 m.

The ground water in the area occures in phreatic, semi-confined to confined conditions. Aquifer parameters shows that in the watershed area for different lithounits in general the transmissivity values of phreatic aquifers tapped in open well varies from 20 to 40 m^2/day while specific capacity ranges form 25 to 40 lpm/day. However for deep aquifer the transmissivity ranges from 40-75 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. 30-45, 65-70, 85-90, 90-95 mbgl and are 3 to 4 in numbers.

The chemical quality of the ground water in the watershed is suitable for domestic and irrigation purposes.

The replenisable ground water recourses in the area is 1625.92 ham, while the net available ground water resources are 1487.72 ham. The Gross ground water draft is of the order of 106.47 ham. The Ground water balance is 1381.25 ham and the stage of ground water development in the area is in the order of 7.1% falls in safe category.

B) Recommendation:

There is a scope to construct 111 no.of Nala bunds/ Check dams, 64 no.of Gabbion structures, 6 no. of Pecolation tanks and 85.56 km*4 (row) long Contour trenching/ Contour bunds in the hilly/forested area of the Study area. The tentative estimated cost to construct all these artificial recharge structures is approximately coming around 175 million. Ground water in the order of 472 ham can be recharged by constructing above no. of structures.

The design of the structures should be prepared by civil engineer may be constructed under supervision of expert .Water level may be monitored periodically before construction and after construction of structure. Implementation of ground water development should be taken up in down stream side preferably. Desiltation and maintenance of the proposed structures should be carried out periodically for long service.

TOTAL PROJECT AREA = 196.3 SQ. K.M.

PROJECT COST: RS. 1750.00 LACS

Divisional Forest Officer
Forest Division Jagdalpur