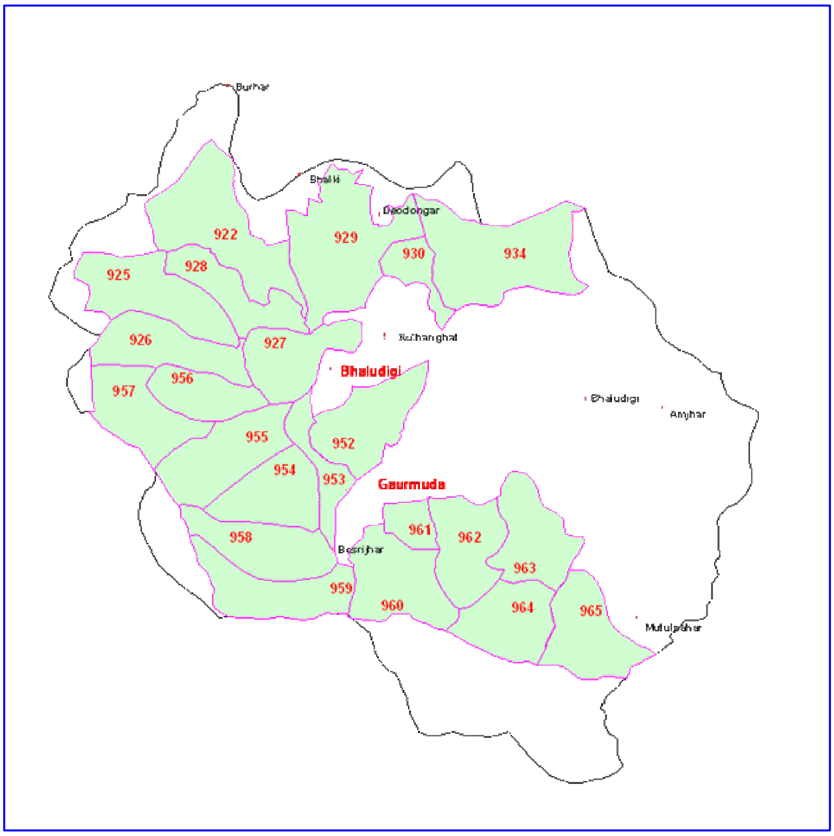
MASTER PLAN

For

ZERO DISCHARGE BASED WATERSHED MANAGEMENT

KULHARIGHAT WATERSHED



FOREST RANGE: KULHARIGHAT

FOREST DIVISION: GARIABAND, DISTRICT-GARIABAND, CHHATTISGARH

TOTAL AREA - 133.33 SQ.KM.

TOTAL PROJECT COST – 1200.00 LACS

FROM,

LEARN NATURE CONSULTANT

LNC

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Divisional Forest Officer
Forest Division Udanti

INDEX

AREA AT A GLANCE

GENERAL FEATURES	
Area in Sq.km.	133.33 Sq.km.
Co-ordinates	N 20°08' 54" – 20° 17' 04"latitude and E 82°16'38" – 82° 25'27"
Population	1377
District Head Quarters	Raipur
Block	Mainpur
Villages	08 no.s
AGRICULTURE & IRRIGATION	
Net sown area (ha)	410
Double cropped area (ha)	20
Gross cropped area (ha)	430
Irrigated area (ha)	30
HYDROMETEROLOGY	
Annual Rainfall 2007	1200 mm
Temperature Maximum	42.5° C
Temperature Minimum	13.5° C
PHYSIOGRAPHY	Pediplain/pediment, structural plains, hills & valleys
DRAINAGE	Udanti & its tributaries of Mahanadi River
SOILS	Sandy, loamy & Red/yellow soil
GEOLOGY	Alluvium, sandstone, siltstone, quartzite , shale, Limestone etc.
HYDROGEOLOGY	
Depth to water level post monsoon	3.00 to 6.00 mbgl
Depth to water level pre monsoon	6.00 -10.00 mbgl
Fluctuation	2.00-4.00 m
Available Vadose zone for artificiel recharge	345.92 ham
GROUNDWATER RESOURCES	
Replenisable ground water resources	730.26 ham
Available ground water resources	657.26 ham
Gross ground water draft	40.51 ham
Ground water balance	616.75 ham
Stage of Ground water Development	6.16 %
Static ground water resources	4388.40 ham
Category	Safe

1. INTRODUCTION

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

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

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

1.1 Aims & Objectives of Artificial Recharge and Rain Water Harvesting

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

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

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

1.2 Background

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

1.3 Data Used

Collateral Data

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

Table 1: Data collection		
Topographical maps 1:50,000 Scale& 1:2,50,000 Scale	:	Survey of India
Rainfall Data	:	Land Records & Settlement Office, Raipur
Census Data	:	Census department collected from Raipur Statistics Department
Hand Pumps Details	:	Public Health Engineering Department, Raipur
Water Resource information	:	Water Resource Department, Raipur and Data Centre, Raipur
Groundwater Information	:	State Groundwater Survey Circle, Raipur, Central Groundwater Board, Raipur
Other District Statistical information	:	Economics & Statistics Department, Raipur
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, Geomorphological, Landuse, Soil, Hydrogeological map are prepared from data gathered and available from different Government organisations. Slope map has been generated from elevation information available on topographic maps. Surface water body, drainage and watershed map and transport network, settlement location and villages are marked using collateral data.

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

1.5 Location, Extent and Accessibility

Raipur is one of the centrally located District of Chhattisgarh state. The district extends between 19° 46′00"to 21° 49' 54"North latitudes and 81°25′ 24" to 83°15′58" East longitudes and is bounded on north by Bilaspur,Janjgir-Champa on the West by Durg on the East by Mahasamund and Dhamtari.

The Watershed is known as Hilly and Forested area of Kulharighat occupies an area of about 133.33 Sq. km. It lies between N 20°08'54"to 20°17'04" and 82°16'38" to 82°25'27" falling in Survey of India toposheet No64 L/6 and 7 in the part of Mainpur blocks of the Raipur 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 Kulharighat

1.	Area (Sq.km.)	:	133.33
2.	Annual Rainfall (mm)	:	1000
3.	Total Population	:	1377
4.	Population Density (Person / Sq. Km.)	:	10.33
5.	S.C. Population	:	78
6.	S.T. Population	:	1231
7.	Literacy Percentage	:	22 %
8.	Agriculture Land (ha)	:	410
9.	Forest Area (ha.)	:	6863

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

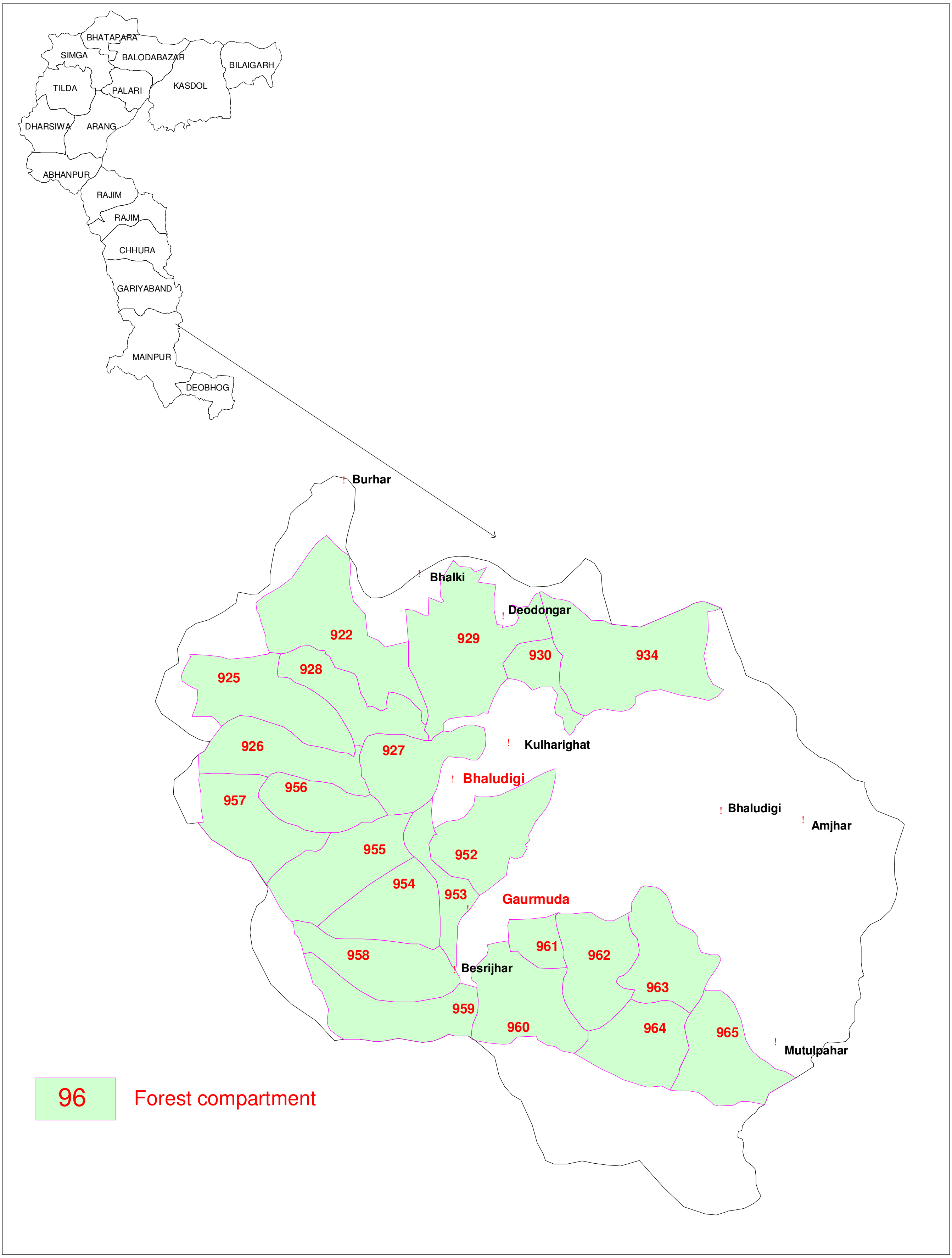
According to 2001 census the total population of the watershed is 1377 the density of population is 10.33 person/sq. km. The growth of population and intensive agricultural activities in the area followed by construction of new bore wells in the recent years.

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	Deodongar	136	67	69	0	0	0	136	67	69
2	Kathawa	90	46	44	0	0	0	90	46	44
3	Kulhadighat	415	219	196	65	32	33	338	180	158
4	Bhaludimi	102	55	47	0	0	0	102	55	47
5	Gawarmund	100	48	52	0	0	0	100	48	52
6	Besrajhar	184	97	87	0	0	0	182	95	87
7	Naripani	49	25	24	0	0	0	49	25	24
8	Konari	301	150	151	13	6	7	234	118	116
		1377	707	670	78	38	40	1231	634	597

Fig 1 Location map of the Watershed.



2. HYDROMETEROLOGY

The Kulharighat 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 Raipur. Besides this ordinary rain - gauges have been installed and maintained by Revenue Department at Mainpur.

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 1250 mm and minimum ever recorded rainfall is 810 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 Mainpur Rain guage station

1	1999	850
2	2000	1000
3	2001	825
4	2002	810
5	2003	852
6	2004	1159
7	2005	1050
8	2006	1204
9	2007	1250
Average		1000

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 divided into two soil categories namely Alfisols and Vertisols on the basis of major constituents.

Alfisols:

1 Red & Sandy soil:

This soil is covered major part (western)of the study area. It mainly consists of sand, kankar & pieces of rock fragments (granites) and clay, extended north to south of the watershed. It covers an area of about 52.88 sq.km.

2. **Red Loamy soil:**

This soil is exposed in the eatern part in in the watershed. It covers an area of about 33.59 sq.km. It mainly consists of loamy clay and little sand.

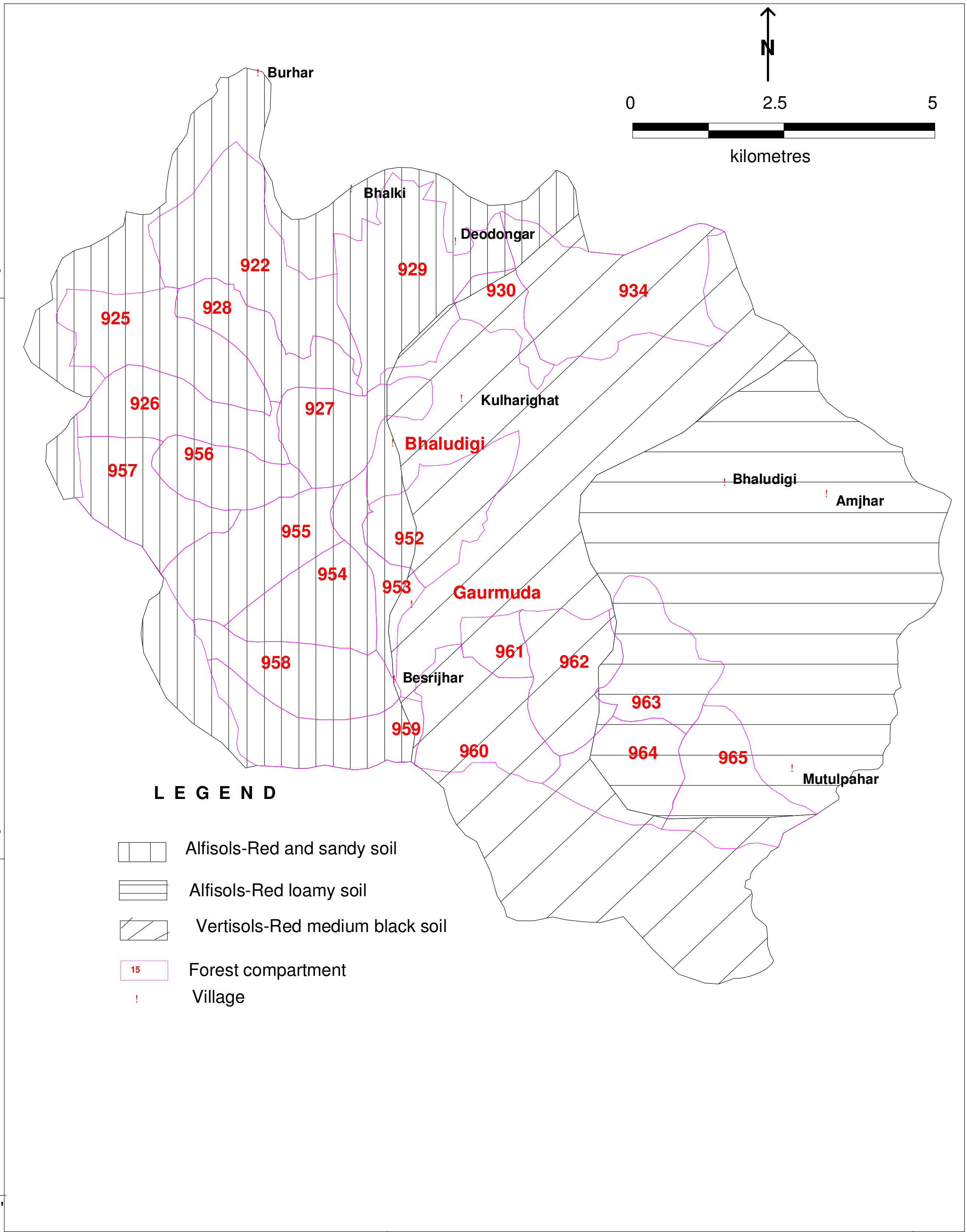
Vertisols:

1. **Medium Black soil:**

This soil is exposed in the central part of watershed. It covers an area of about 46.80 sq.km. It mainly consists of clay and silt.

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 Kulharighat

SN	Land use and land cover	Area in Sq.km.	Percentage to the total area
1	Geographical area	133.33	100.00
2	Forest cover	68.63	51.47
3	Cuturable waste	05	0.37
4	Agriculture - Net sown area	4.10	0.30
	Double cropped area	0.2	0.015
	Gross cropped area	4.30	0.32
	Irrigated area	0.3	0.022

The total geographical area of the Hilly and Forested area of Kulharighat water shed is about 133.33 Sq.km. situated in the eastern portion of the Raipur district covering parts of Mainpur block of Raipur district. Out of the total area of the watershed about 51.47% 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 68.63 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 0.30 percentage is net sown area and only 0.022 % 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 10 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 five types of slope category which is presented in fig 3 "up to 5% ,5% to 10% and 10% t0 20% slope", the lower limit of contour spacing 1.33 cm means, over a horizontal distance of 1.33 cm × 50,000 = 66500 cm = 665 meters there is vertical drop of 20 meters.

Thus the slope percentage is

(20 × 100) ÷ 665

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

4 cm × 50,000 = 200000 cm

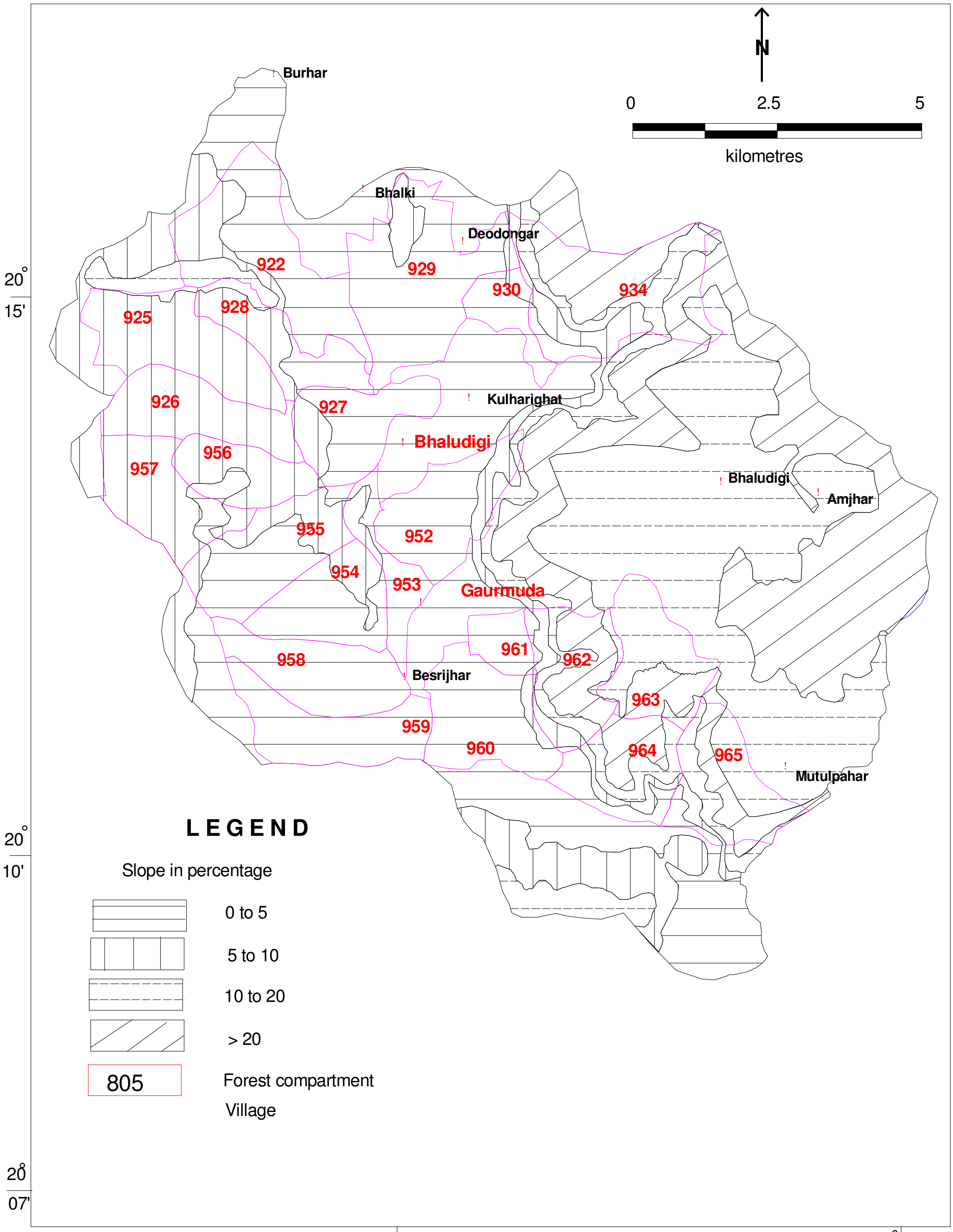
= 2000 metres, there is a vertical drop of 20 metres. Thus the slope percentage is

(20 × 100) ÷ 2000

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

Table 6: MAJOR SLOPE CATEGORY IN THE KULHARIGHAT		
S.No	**Slope Category**	**Slope (%)**
1.	Nearly level	0-5
2	Moderate gently sloping	5-10
3.	Gently sloping	10-20
4.	Moderatly Steep slope	>20

Fig 3 Slope map of the study area.



4. GEOMORPHOLOGY AND DRAINAGE

4.1 GEOMORPHOLOGY

The Kulharighat watershed is having circular Catchment, the maximum length and Width of the Catchment is 15.33 Kms and 15.31 Kms respectively. The elevation of the area varies from 390 to 967 m amsl. Eastern part of the area is hilly and forested. The maximum basin elevation is 967 m amsl in the eastern part of the watershed at south of Amjhar village area while minimum elevation is present in near Devdhar water falls in river courses of Udanti nadi.

The Physiography of the basin is controlled by geological formations namely sandstone, siltstone, limestone & Shale.

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 flood plain, Structural plain on proterozoic rocks, pediplain/pediment and structural hills and valleys.

Small and narrow flood plain surface of streams net work of micro and milli watersheds and formed by accumulation of sediments in linear valley gaps of streams particularly along the courses of Udanti River.

1. Pediplain/Pediment:

It is resultant product of polycyclic erosional and depositional processes. It is concealed and covered under thin soil cover. About 50.92 sq.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 390 –500 m. above m.s.l.

Pediment is identified at an elevation of 500-600 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 erosion 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.

2. Structural Terrace:

The Structural terrace extended in the watershed as elongated strip in the central part and cover an area of about 28.62 sq.km. It consists of sandstone & quartzite traversed by various joints and lineaments. The height of this upland is 450 to 650 m amsl.

3. Structural Plateau:

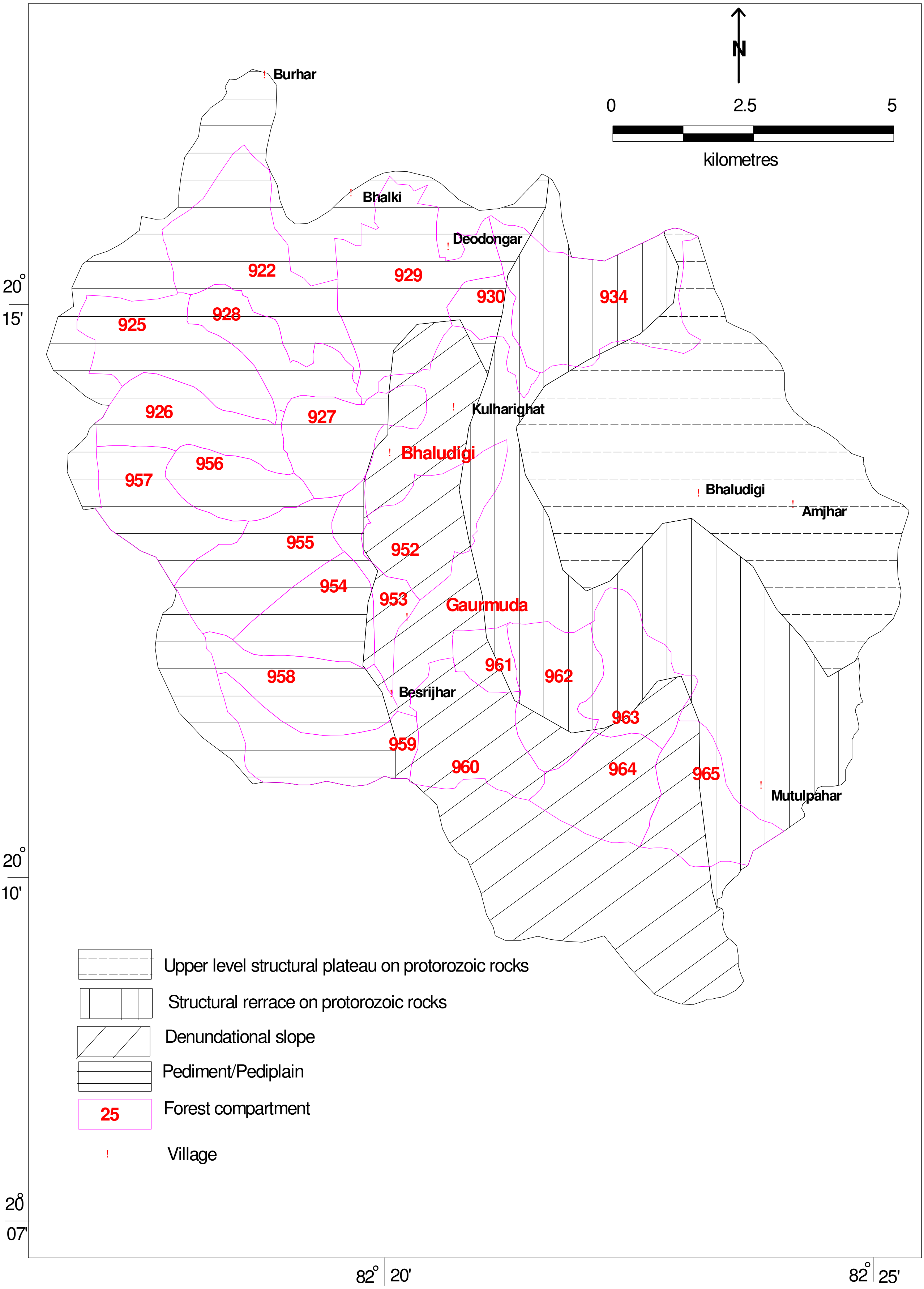
The Structural plateau is also extended in the watershed as a narrow & broad strips from central part & south parts and cover an area of about 22.98 sq.km. It consists of sandstone, quartzites and shale traversed by various joints and lineaments. The height of this upland is 700- 967 m amsl.

4. Denudational Slope:

It is exposed in the southern part and covers an area of about 30.75 sq.km. it mainly consists of sandstone and quartzite.

Fig 4 is presented here to show the Geomorphic features in the Kulharighat watershed.

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 Kulharighat is the part of Udanti river& its tributaries which is a tributary of Mahandi drainage system.

DATA BASE & METHODOLOGY:-

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

Watershed Characteristics:-

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

1. Linear Parameters

A) Bifurcation Ratio :-

In drainage analysis, bifurcation ratio is the foremost important parameter to link the hydrological regime of a watershed under specific lithological and climatic condition is the ratio of the number of streams of one order to the number of streams of the next higher order. In the study area bifurcation ratio varies from minimum 3.00 for 4^{th} order stream to 5.50 for 2nd order streams **(Table 7)**. As these values of bifurcation ratio ranges between 3.00 and 5.50, indicating that the river flows through hilly area.

Table 7: Drainage Basin Characteristics of Hilly and Forested area of Kulharighat Watershed					
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	188.7	275	3.57	0.69	2.45
II	77.17	77	5.50	1.00	2.04
III	37.83	14	4.67	2.70	4.41
IV	8.57	3	3.00	2.86	0.54
V	15.97	1		15.97	

2 Aerial Parameters:-

Drainage pattern shows marked influence of the underlying geologic structure and history of the watershed. The main drainage pattern of Hilly and Forested area of Kulharighat 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 rocks. It is observed that the stream drainage lines exhibit almost parallel appearance in upper reaches, yet the terrain has high relief. 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 Hilly and Forested area of Kulharighat watershed exhibits high drainage density and is presented in **Table 8** below.

Table 8 Morphometric details							
Watershed area	Watershed perimeter	Water shed 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				
133.33	55.01	15.33	15.31	2.462	2.775	0.567	1.763

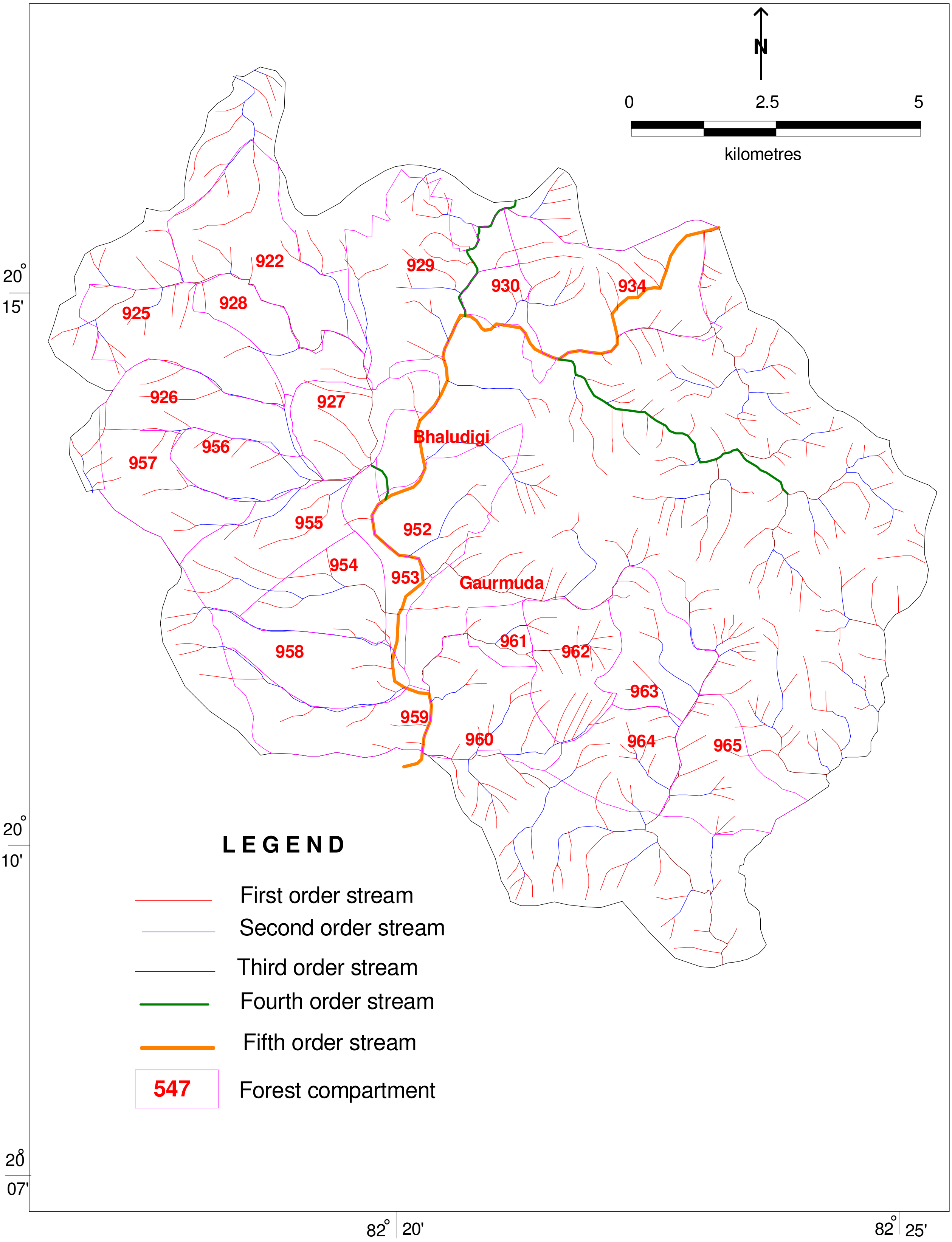
B) Relief - Longitudinal Channel Profile

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 Kulharighat attains maximum elevation of 967 metres above msl in south of Amjhar village in eastern part and it reached to minimum elevation of confluence point i.e. 390 meter above msl in lower southern portion of the watershed in Devdhar Water falls along river courses of Udanti river. The river channel profile is normally found to be concave upward. For Kulharighat profile factor b>1 (inverted parabolic outline). 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	
967	390	577	0.41

The nature of this concavity is a function of the basin geology and precipitation. The longitudinal profile of Hilly and Forested area of Kulharighat make it evident that the river is regarded as a consequent stream. Throughout its course the variation of relief are high and only humps of sedimentary structure have been observed. In Hilly and Forested area of Kulharighat composite profile shows that order - slope vary from 0° to >20°. It is predicted that Hilly and Forested area of Kulharighat 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 Kulharighat is presented in **Fig 5.**

Fig 5 Drainage map of the study area.



5. GEOLOGY

The Kulharighat area is occupied by mainly quartzitic sandstone, siltsone, conglomerate and shale of the Pairi group of rocks belonging to Proterozoic age. These formations are over lain uncomformably by Sub-recent to Recent Alluvium. The generalised litho stratigraphy of the area is given below:

Table 10 GENERALISED GEOLOGICAL SUCCESSION OF THE AREA

Age	Group			Lithology
Sub recent to recent	Alluvium			Clay, Sand, Kankar and Laterite.
Proterozoic	Chattisgarh Supergroup	Pairi Group	Devdhar Fm	Sandstone, quartzites & conglomerate
			Kulharighat Fm	Limestone, dolomite & shale
			Near Fm	Sandstone, siltstone & shale

Chhattisgarh Supergroup:

The chhattisgarh Super group are represented by Pairi Group of formations of Proterozoic age. The rocks of Chhattisgarh Super group uncomfortably overlie the basement crystallines.

Pairi group:

Devdhar Formation:

The rocks of devdhar formation are represented by Sandstone, quartzite and conglomerate. These sandstones are horizontally bedded, highly silicified, unmetamorphosed rocks. Numerous small faults have affected the sequence largely. It is exposed in western part of the study area in the form of plateau extended in north to south and covers an area of about 45.53 sq.km.

Kulharighat formation:

Kulharighat formation is mainly consists of Limestone, dolomite and shale. It is exposed in central part of the study area covering major area of about 60.42 sq.km.

Near formation:

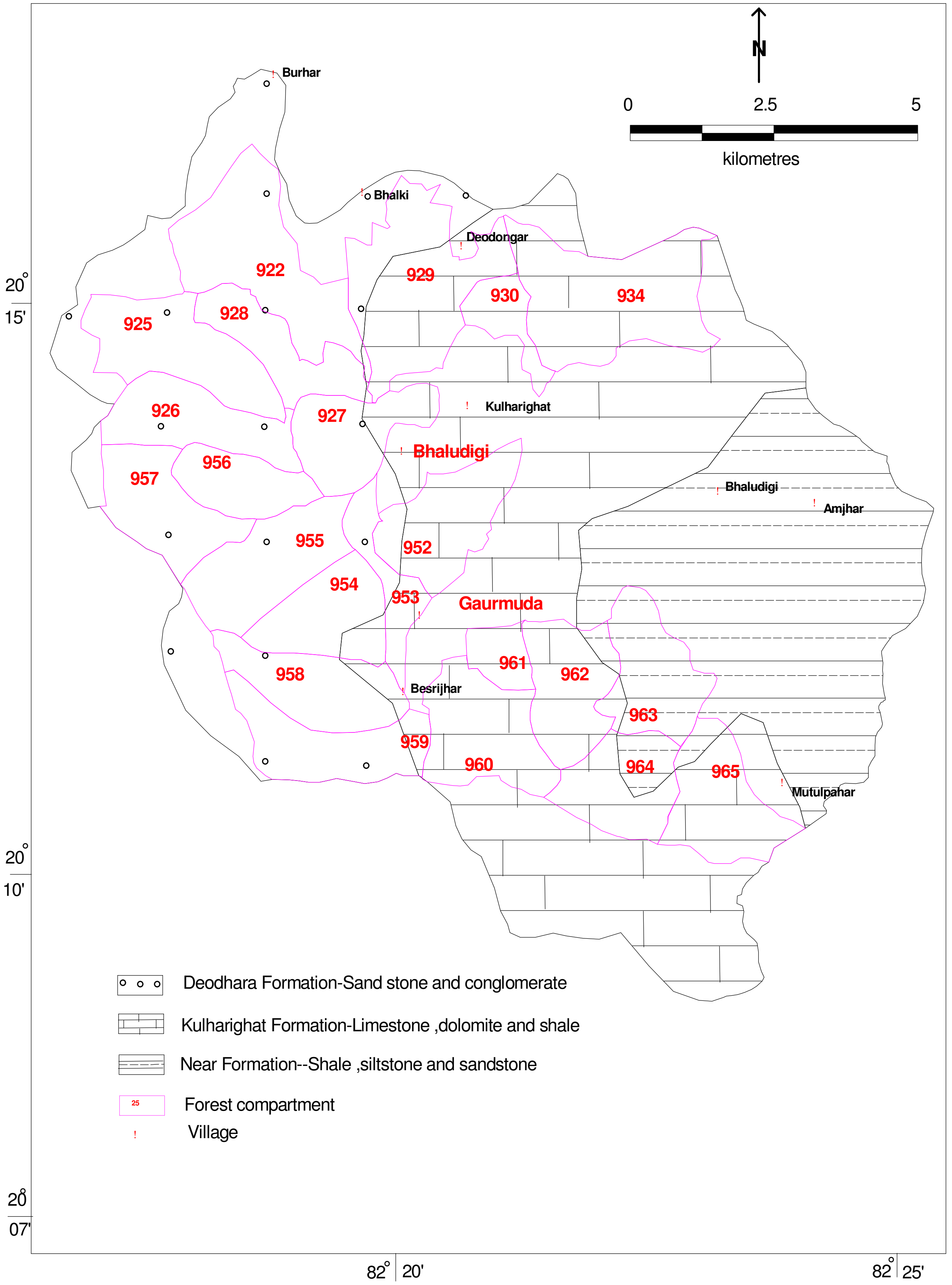
Near formation is mainly consists of sandstone, siltstone and shale . It is exposed in eastern part of the study area covering major area of about 27.38 sq.km.

Alluvium:

Alluvium occurs in the area are mainly confined along streams of Udanti river and its tributaries, 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 Kulharighat 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.

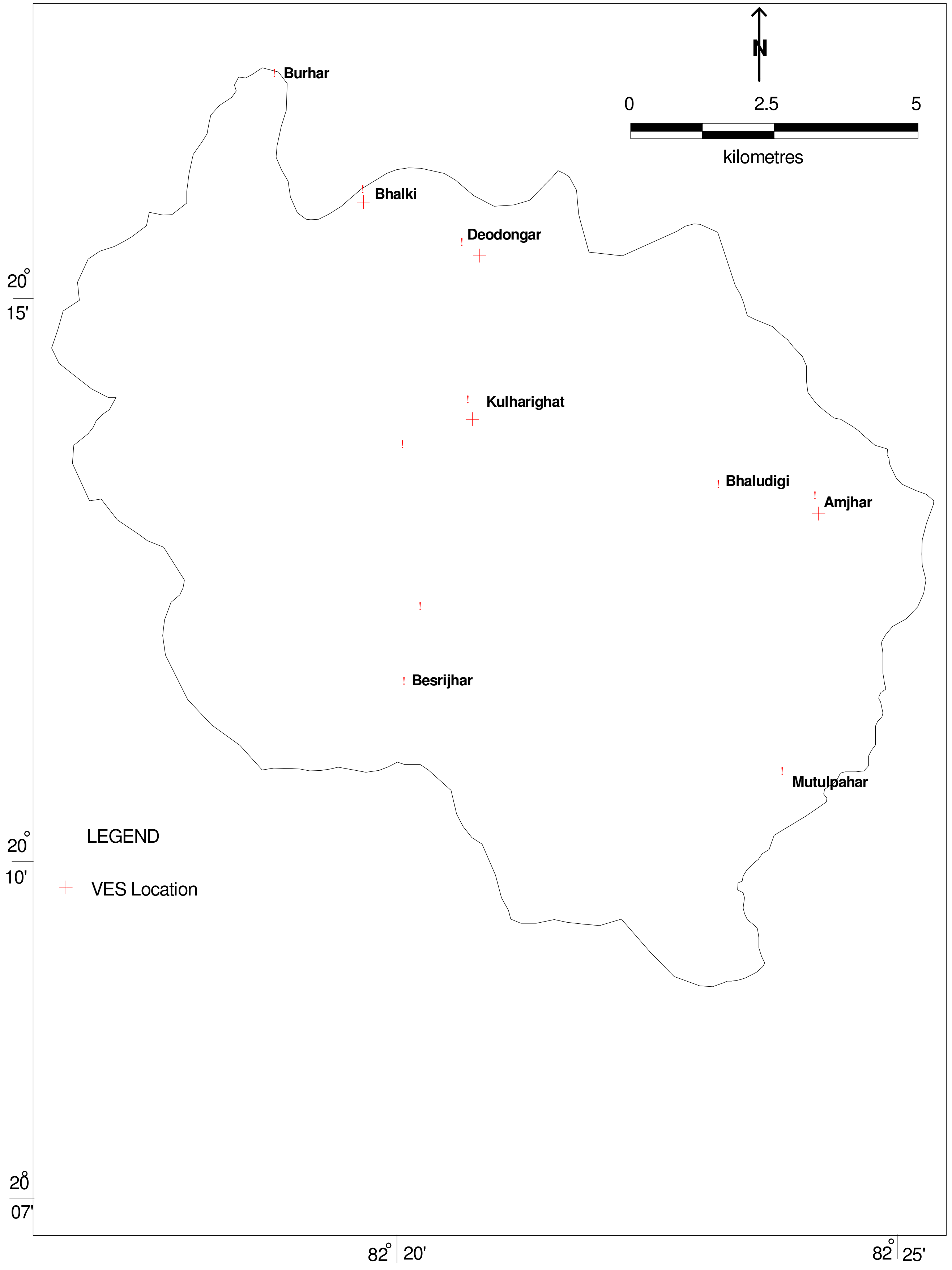
The data of resistivity soundings at six places were considered over the Kulharighat area in the middle lower reaches adjacent to hilly area. The maximum current electrode separation ranged between 100 m to 110 m. The sounding results, in terms of resistivity (Ohm - meters) and thickness (h in meters)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

Table 11 Summarised result of geophysical soundings

Name of the site	VES no.	Resistivity value (Ohm-m)			Layer depth (m)	
		$\square_1$	$\square_2$	$\square_3$	D_1	D_2
Kulharighat	1	60	25	2000	1.5	11
Devnagar	2	65	35	2000	1.8	12
Bhalki	4	85	42	2500	0.9	16
Amjhar	5	25	70	2500	1.4	13

From the Table 11 it is seen that the first layer is soil zone ranging in thickness from 0.9 to 1.8 while the second layer is a weathered mantle of different rocks types present in the area ranging in thickness from 11 to 16 m and the last layer is a hard and compact rock like granite and gneiss etc indicating indefinite thickness.

Fig 7 Location of VES 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.

Pairi group of rocks is exposed in almost entire area of the watershed covering an area of about 133.33 sq.km. Primary as well as secondary porosity are poorly developed in these rocks. Weathering resulted the formation as porous and permeable. The thickness of the weathered zone extends down to 18 mbgl, groundwater occurs under phreatic condition. The depth of the water level in dug wells in this area ranges from 6 to 10 mbgl in pre monsoon, 3 to 6 mbgl in post monsoon, and average seasonal water level fluctuation is about 4 meters, yield of bore well in this unit is 1 to 5 lps.

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 6.0 to 10.00 mbgl. However the depth to water level is deeper in upland and hilly area and shallow water level observed in low-lying area (less than 5 mbgl). For the post monsoon period water level has been reported to be ranging between 3.0 to 6.0 mbgl. The water level fluctuation in the area varies from 2.0 to 4.0 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 WATER LEVEL DATA AND WATER LEVEL FLUCTUATION

S. N.	Village	Coordinate		Spot height 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)
		Lat	long					
1	Bhalki	82.32917	20.26722	450	10.00	440.00	6.00	4.00
2	Deodongar	82.33778	20.25944	435	9.00	426.00	5.00	4.00
3	Kathawa	82.34417	20.24722	430	6.00	424.00	4.00	2.00
4	Kulhadighat	82.34889	20.23444	430	7.00	423.00	5.00	2.00
5	Bhaludimi	82.33778	20.22917	425	9.00	416.00	5.00	4.00
6	Gawarmund	82.33889	20.205	415	7.00	408.00	3.00	4.00
7	Besrajhar	82.33639	20.19389	395	6.00	389.00	3.00	3.00
8	Motupahar	82.39944	20.18028	640	10.00	630.00	6.00	4.00
9	Jhalapara	82.39472	20.155	365	7.00	358.00	3.00	4.00

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 Kulharighat. From the figure it may be seen that the water table elevation varies from 400 m amsl to 440 mamsl in the central part of the watershed. Water table more or less follows the surface topography. The extreme eastern & western part of the watershed shows higher altitude of water table indicate recharge area for ground water while central part of the watershed lower altitude indicate discharge area**.**

7.3 Aquifer parameters:

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

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

Fig 8 Premonsoon Depth to Water Level.

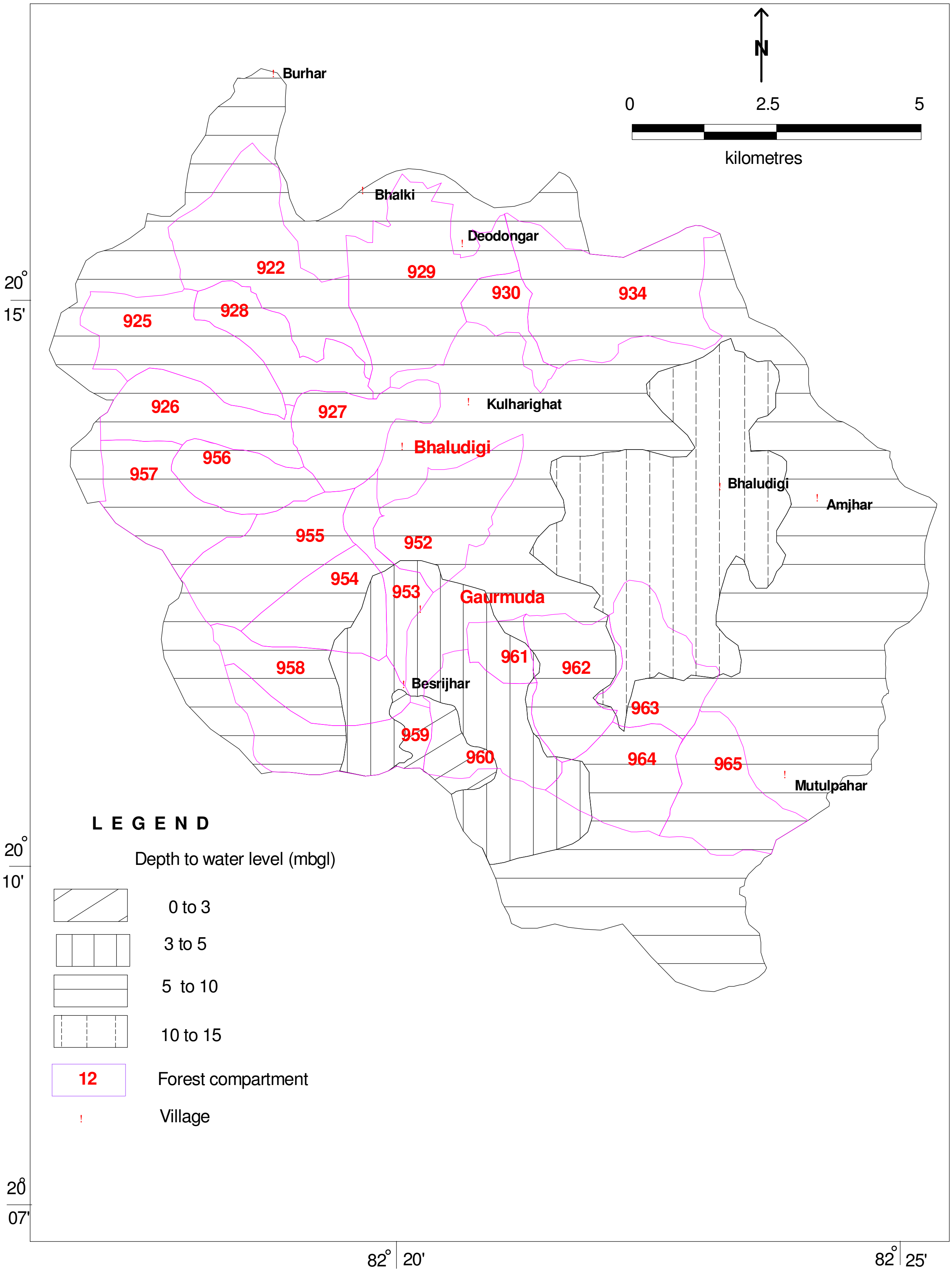


Fig 9 Post-monsoon Depth to Water Level.

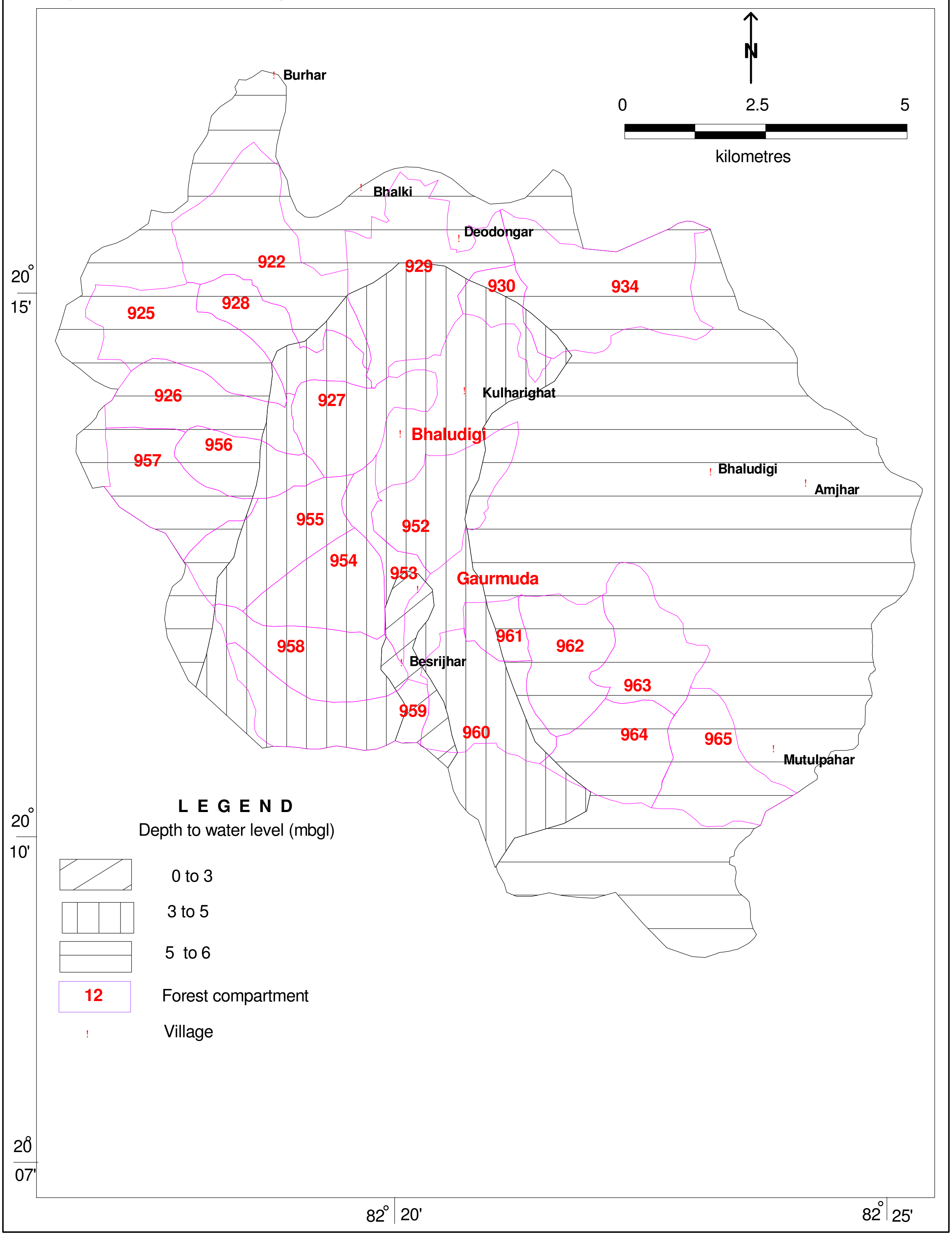


Fig 10 Seasonal Water Level Fluctuation .

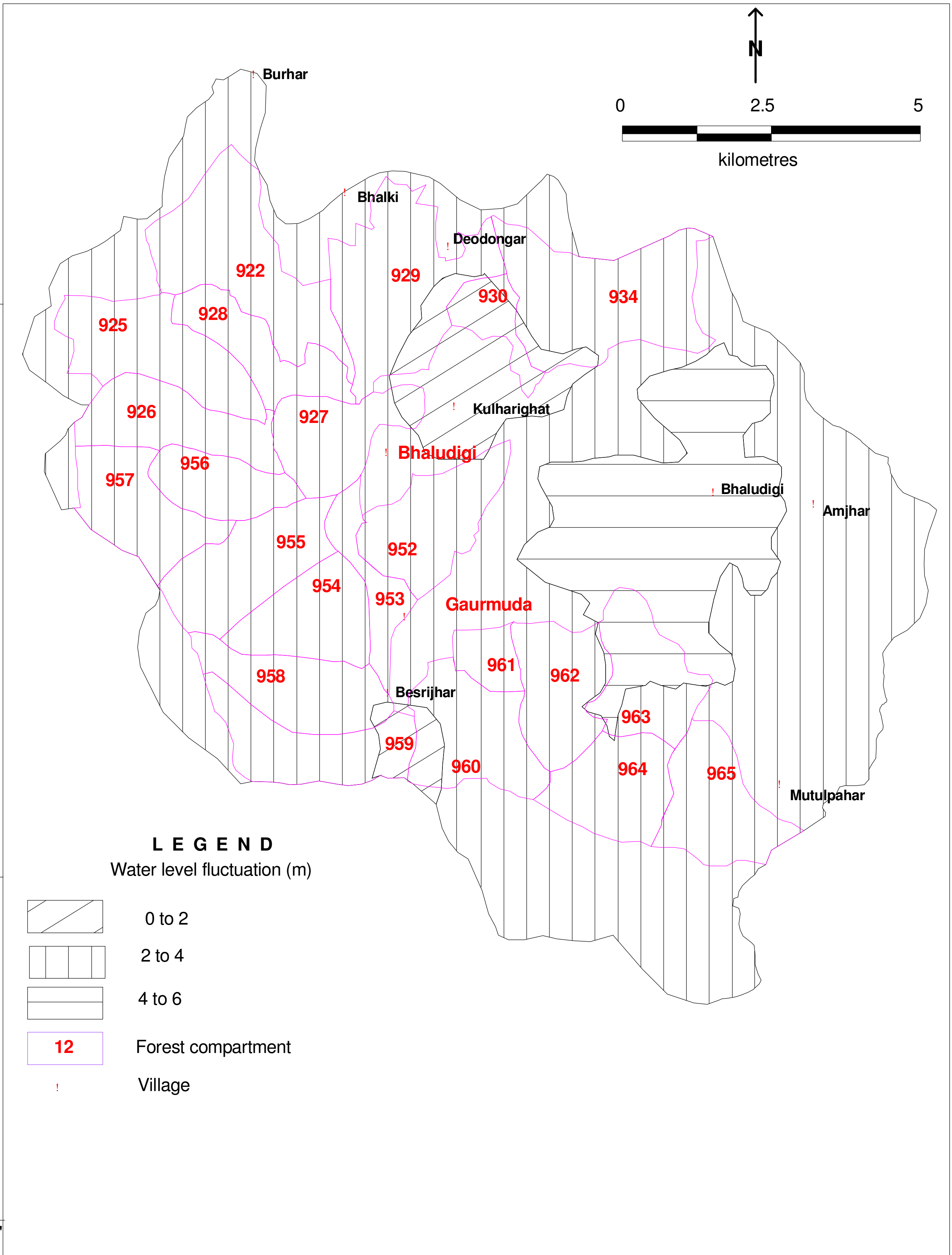
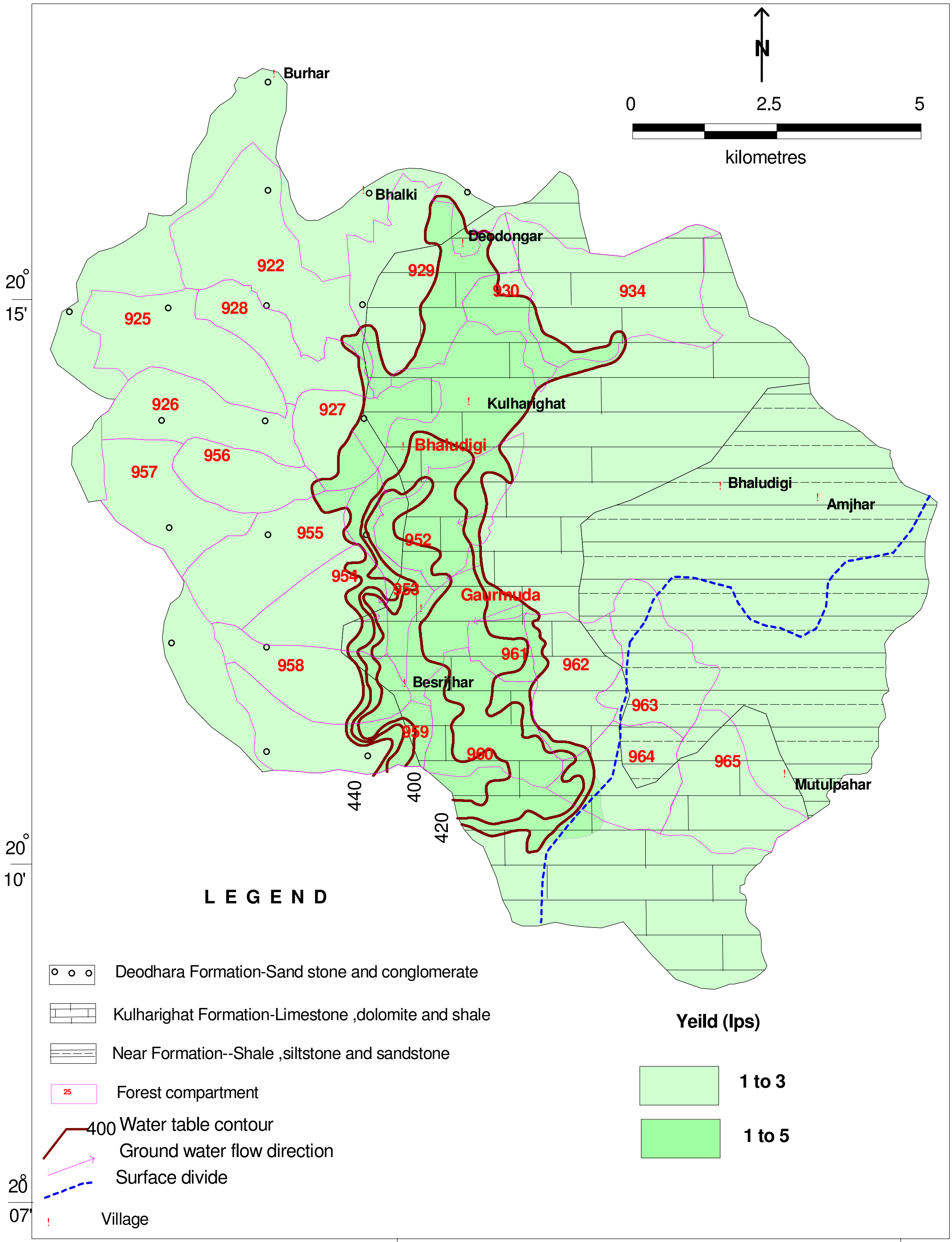


Fig 11. Hydrogeological map of the Study area.



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 350 to 550 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^{-}**
Kulharighat	7.5	440	45	35	05	100	50
Devnagar	7.6	475	55	42	05	170	42
Bhalki	7.7	550	30	21	03	280	62
Amjhar	7.4	350	25	19	04	95	35

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

9. 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. Ground water recharge :

a) **Total geographical area in ha**. = 13330

b) **Area not suitable for ground recharge in ha**. =2362

c) **Area suitable for ground recharge in ha.** = 10971

d) **Average water level:**

Premonsoon = 8.0 mbgl.

Postmonsoon = 4.0 mbgl.

e) **Normal annual rain fall** = 1.0 m.

f) **Normal monsoon rain fall** = 0.85 m.

g) **Normal non monsoon rain fall** = 0.15 m

h) **Ground Water Recharge by rain fall infiltration method** - The rain fall infiltration factors for different formations have been taken as those recommended by GEC 97 .The equation used for computation of recharge is

R_{rf} = NAR × A × RFI

Where,

R_{rf} = Recharge from rainfall

NAR = Normal annual rain fall

A = Area of the unit in ha

RIF = Rain fall infiltration factor

Recharge from rainfall = 1.0 × 10971 × 0.06

= 658.26 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	300	0.4	120	150	0.4	60

b. Seepage from tanks/ ponds

1. No of tanks = 5
2. Total water spreaded area in ha = 20
3. Seepage factor (m/year) = 0.6
4. Total non monsoon seepage (ham) = 12.00

c. Total annual recharge =

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

= 658.26 + 60 + 12
= 730.26 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 10% 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

= 730.26 ham -73.00 ham

= 657.26 ham

Annual ground water draft :

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 /10000 × 10000

= 1377 × 60 × 365 / 1000 × 10000

= 3.01 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	25	1.0	25
Tube wells	5	2.5	12.50

B. Ground water balance (ham) :

= Annual utilizable GW resource – Gross ground water draft

= 657.26 ham-40.51 ham

= 616.75 ham

From the above it may be seen that the balance ground water resources in the area is of the order of 616.75 ham.

C. Stage of ground water development :

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

= 40.51 *100/657.26

= 6.16 %

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%
604.57 ha	794.00 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,

$$\mathbf{R_s} = 10971 \times 0.02 \times 20$$

$$= 4388.40 \text{ ham}$$

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 /10000 × 10000

= 1721× 60 × 365 / 1000× 10000

= 3.76 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

= 380 × 0.694

= 263.72 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 267.48 ham. The water recharge to the ground water through recommended artificial recharge structure in the water shed is of the order of 345.92 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 hilly/forested part of Kulharighat 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 Kulharighat has been considered for various geological, hydrogeological studies which was the need to understand the area and to fulfill the present objectives, the main emphasis was given to construct various rain water harvesting and artificial recharge structures in hilly/forested part of Kulharighat. 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 17.38 ham and the ground water draft for irrigation is around 3400.60 ham. 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.
c. Area having slope > 20% is excluded.
    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

= 4421 × 1.0 × 0.02 = 88.42 ham (for DTW 3-5 mbgl)

= 5150* 2.5* 0.02 = 257.5 ham (for DTW 5-6 mbgl)

So the vadose zone of 345.92 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 460.07 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 1000 mm. The percentage of run-off to rainfall as per Stranger's Table is 27.3 and the depth of run-off due to rainfall is 27.40 cm. The total yield of run-off generated from watershed having 13333 ha area works out to 3653.24 ham and 30% of the total run-off i.e. 1095.97 ham is considered as surplus monsoon run-off available for artificial recharge.

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

The various recharge structures have suggested by keeping in view the forest compartments falling in the hilly/forested area. The suitable artificial recharge structures in the area which are proposed to construct are mainly Gully plugs, Boulder Check Dam/Gabion structures, Contour bunds/Trench in the upper reaches of the watersheds, percolation tanks, Check dams in the runoff zones and recharge shafts, gravity head wells in down stream areas. The details of artificial recharge structures along with the estimated feasible number of structures and tentative cost is given in **Table 14** and **Table 15** and location of proposed artificial recharge structures is presented in **Fig 12**.

Table 15 Details of Artificial recharge and Rain water harvesting structures to be constructed in Hilly/Forested part of the Kulharighat

Sr No.	Compartment	Checkdam/nala Bund	Gabbion Structures	Percolation tank
1	922	5	3	
2	928	1	2	
3	925		6	
4	926	3	4	
5	956	3	6	
6	955	2	3	
7	927	6		
8	952		3	
9	954	1	6	
10	958	2	4	
11	960	8		1
12	961	2		
13	964	5	2	
14	963		9	1
15	962		5	
16	Bhaludigi		3	
17	934	9	2	
18	930	4	2	
19	929	4		
	Total	55	60	2

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

From the table 14 and 15, it is seen that 55 no.of Nala bunds/ Check dams, 60 no.of Gabbion structures, 2 no. of Pecolation tanks and 54.39 km*4 (row) long Contour trenching/ Contour bunds to be constructed in the hilly/forested area of the Kulharighat. The tentative estimated cost to construct all these artificial recharge structures is approximately coming around 120 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	55	1.5 ham	82.5 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	2(about 10 ham capacity)	10 ham	20 ham	
4	Contour trenching and Contour bunding	54.39 km x 4= 217.56 km	1 ham /km	217.56 ham	
4	Gabbion structure	60	0.5 ham	30 ham	

Fig 12 Proposed Artificial Recharge Structures in study area

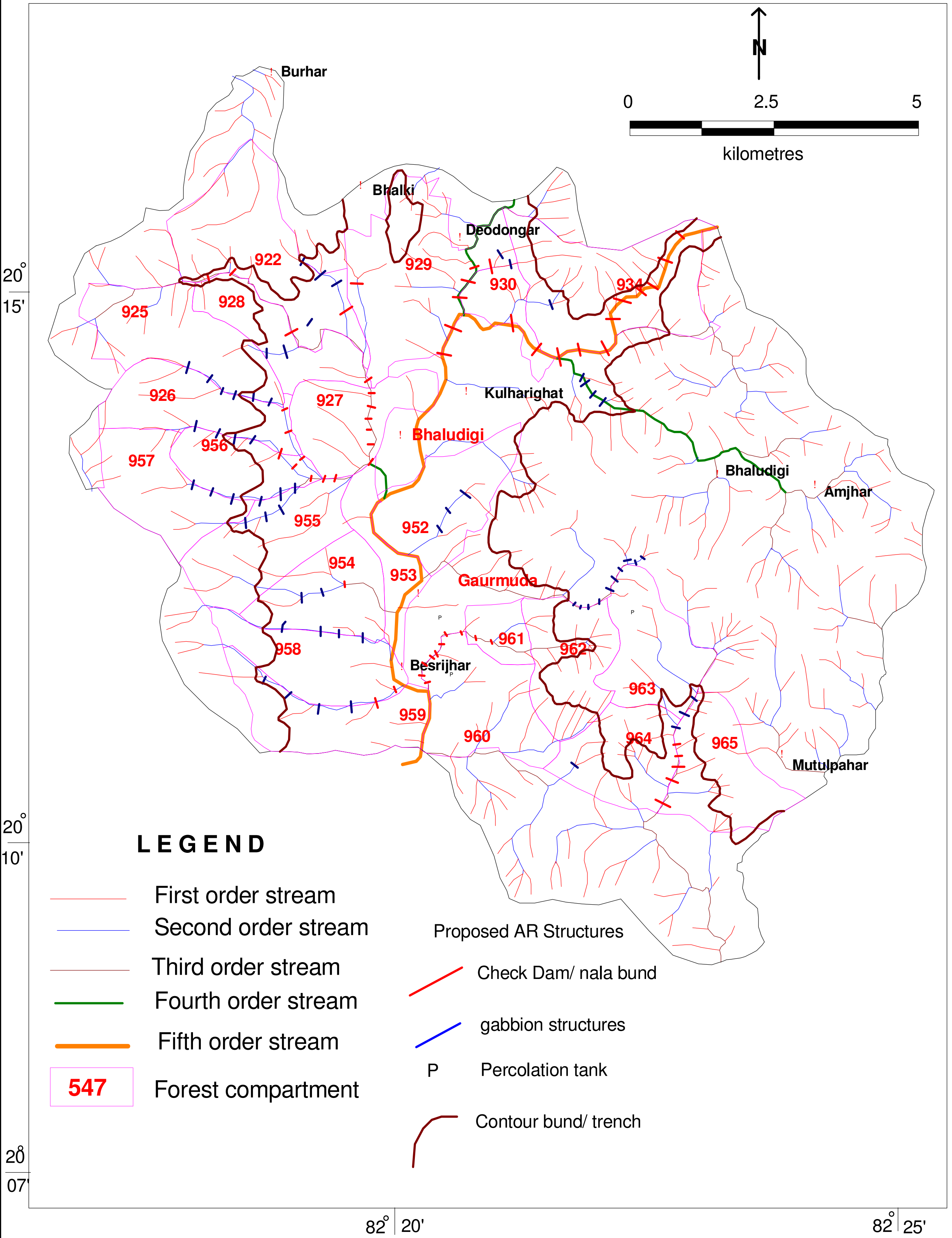
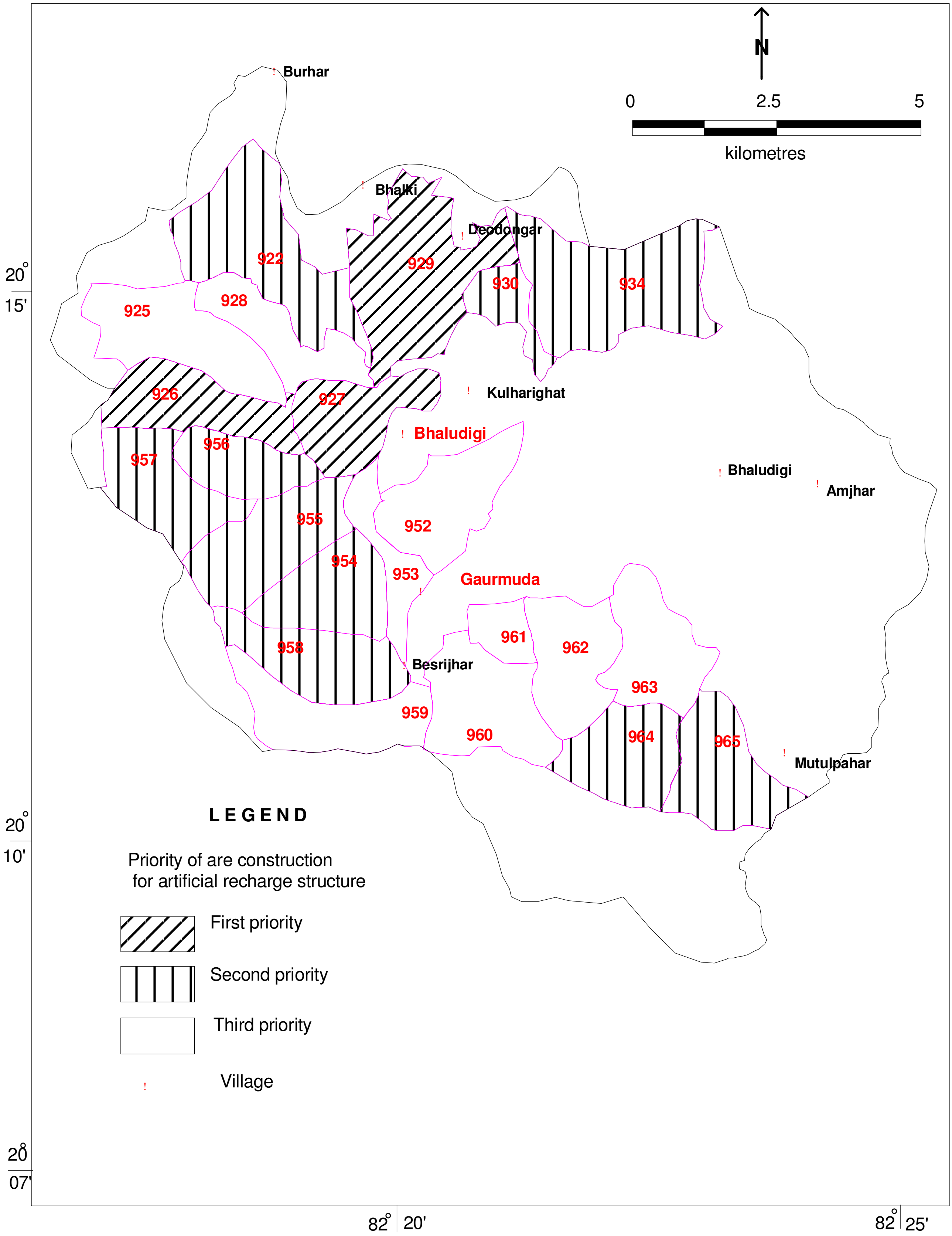
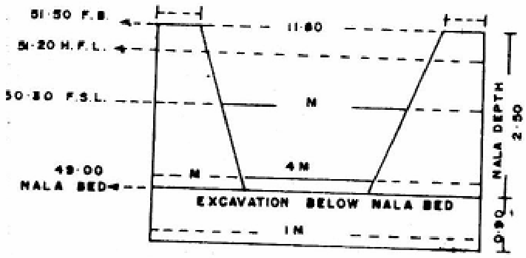
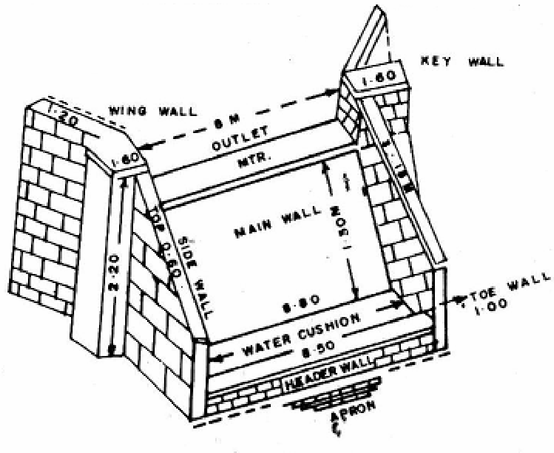


Fig 13 Area Demarcated as per Priority for Construction of Artificial Recharge Structure.



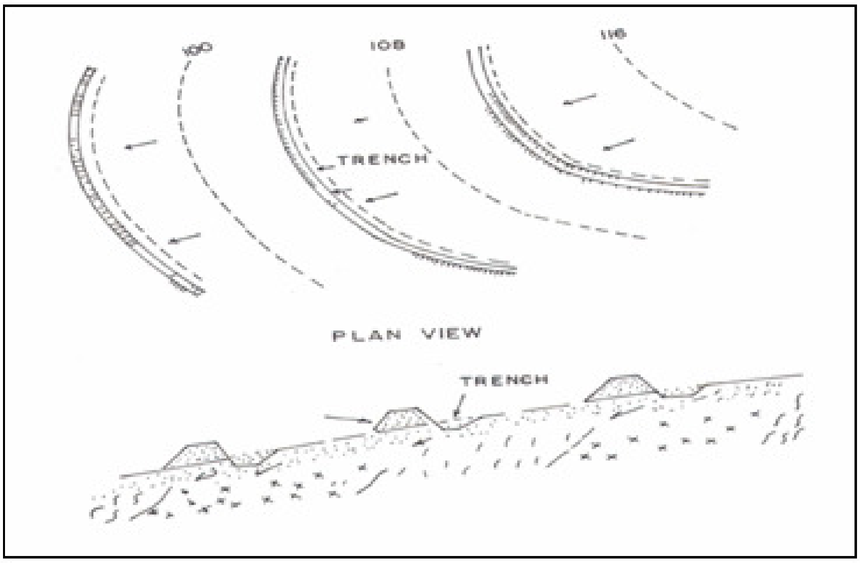
Vertical Section of Check Dam/ Nala Bund

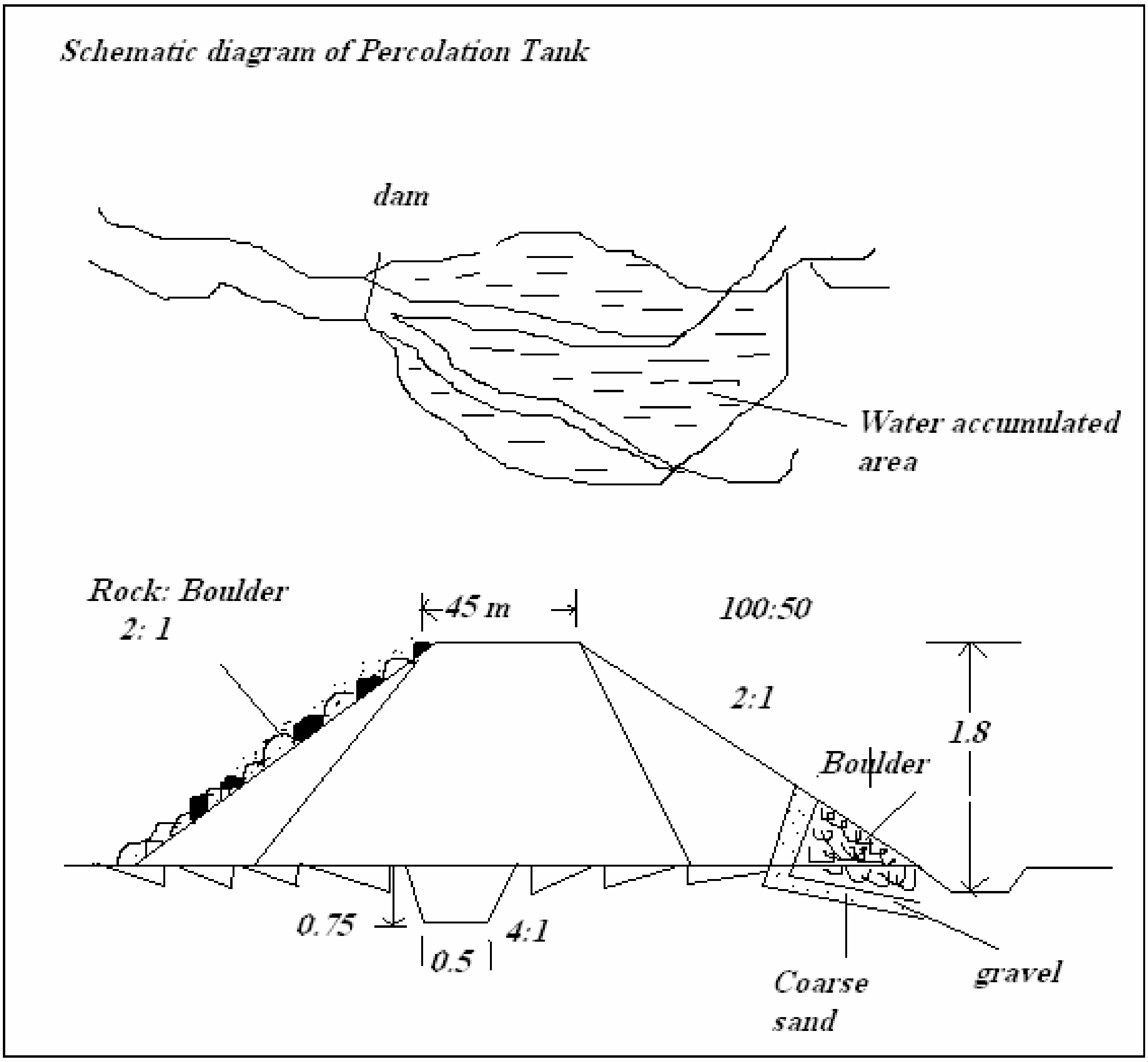




Horizontal Section of Check Dam/ Nala Bund

Sectional View of Contour Trench/ Contour Bund




Schematic diagram of Percolation Tank
dam
Water accumulated area
Rock: Boulder
2: 1
45 m
100:50
2:1
1.8
Boulder
0.75
4:1
0.5
Coarse sand
gravel

11. IMPACT OF ARTIFICIAL RECHARGE

Artificial recharge structures are constructed mostly with the objective of augmenting ground water resources and/or to improve its quality. Assessment of impacts of the artificial recharge schemes implemented is essential to assess the efficacy of structures constructed for artificial recharge and helps in identification of cost-effective recharge mechanisms for optimal recharge into the ground water system. It also helps to make necessary modifications in site selection, design and construction of structures in future.

Impact assessment may require monitoring of the recharge structure, ground water regime, changes in pattern of water supply, cropping pattern, crop productivity and/or water quality.

Impact assessment depends upon various factors such as hydrogeological set-up and ground water utilization pattern. Impact assessment of artificial recharge structures are discussed below.

a) Monitoring of Recharge Structures

Surface structures such as percolation ponds, check dams and cement plugs need to be monitored at regular intervals to assess the actual storage created in the structures, period of impounding, capacity utilization of the structure, rate of percolation and siltation problems if any. Quantification of storage in the structures may require setting up of monitoring devices within the structures. Devices such as gauges for area-capacity analysis are commonly used in surface recharge structures. Daily monitoring records are preferred for realistic assessment of storage created by multiple fillings of the structures. Evaporation and seepage losses from the structures are also to be accounted properly to evaluate the recharge efficiency of the structures.

b) Water Level Monitoring

The objective of water level monitoring is to study the effect of artificial recharge on the natural ground water system. The monitoring system should be designed judiciously to monitor impact of individual structures which can further be extended to monitor the impact of groups of such structures in the area where artificial recharge is being done. During the planning and feasibility study stage, the observation well network is generally of low well density but spread over a large area with the primary aim of defining the boundaries of the aquifer to be recharged and to know the hydraulic characteristics of the natural ground water system. After identification of the feasible artificial recharge structures, the observation well network is redefined in a smaller area with greater well density.

Demarcation of the zone of influence of the artificial recharge structure is one of the main objectives monitoring in the context of artificial recharge projects.

c) Water Quality Monitoring

A proper evaluation of potential water quality and aquifer quality problems associated with artificial recharge is also important for impact assessment.

In the present study, by constructing mentioned artificial recharge structures in the Kulharighat watershed area & by adopting above impact assessment studies following benefits can be achieved.

1. Sustainability of the aquifers.
2. Conservation of rainwater & minimize the excess runoff which is going wastes otherwise.
3. Improvement of quality of groundwater.
4. Enhancement of soil moistures which intern gives good crop yield.
5. Employment to local people.
6. Minimise the soil erosion.
7. Reduction of flood hazard.
8. balancing the natural scenario of ecosystem.

CONCLUSIONS AND RCOMMENDATIONS

A) Conclusions:

The main objectives and aims of the present study is to construct artificial recharge structures and do the rain water harvesting in the hilly/forested part of Kulharighat are 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 will enhance the sustainable yield wherever aquifers have depleted due to over exploitation. To conserve the rain water wherever it is received. To conserve and store excess run off water going waste for meeting out future requirement. To improve the quality of groundwater. To keep soil moisture content intact so that topsoil vegetation is protected.

The project area falls in Raipur district which is one of the centrally located District of Chhattisgarh state. The district extends between 19° 46′00"to 21° 49' 54"North latitudes and 81°25′ 24" to 83°15′58" East longitudes and is bounded on north by Bilaspur, Janjgir-Champa on the West by Durg on the East by Mahasamund and Dhamtari.

The Watershed is known as Hilly and Forested area of Kulharighat occupies an area of about 133.33 Sq. km. It lies between N 20°08'54"to 20°17'04" and 82°16'38" to 82°25'27'falling in Survey of India toposheet No64 L/6 & 64L/7 in the part of Mainpur blocks of the Raipur district.

The total geographical area of the Hilly and Forested area of Kulharighat water shed is about 68.63 Sq.km. situated in the Raipur district covering parts of Mainpur block of the Raipur district. Out of the total area of the watershed about 52% comes under hilly and forested area.

The Kulharighat 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 1000 mm.

Geomorphologically the area is occupied by pediplain/pediment and structural terrace & plateau & flood plain in small patch along river courses. These landforms are formed because 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. Hilly and Forested area of Kulharighat is the part of Pairi river & its tributaries which is a part of Mahanadi drainage system.

Geologically, the Kulharighat area is occupied by mainly sandstone, limestone, shale & siltstone of Chhattisgarh Supergroup 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 6.0 to 10.00 mbgl. However the depth to water level is deeper in upland and hilly area and shallow water level observed in low-lying area (less than 5 mbgl). For the post monsoon period water level has been reported to be ranging between 3.0 to 6.0 mbgl. The water level fluctuation in the area varies from 2.0 to 4.0 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 30 to 60 m^2/day while specific capacity ranges form 30 to 60 lpm/day. However for deep aquifer the transmissivity ranges from 25-60 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. 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 replenishable ground water recourses in the area is 730.26 ham, while the net available ground water resources are 657.26 ham. The Gross ground water draft is of the order of 40.51 ham. The Ground water balance is 616.75 ham and the stage of ground water development in the area is in the order of 6.16 % falls in safe category.

B) Recommendation:

There is a scope to construct 55 no. of Nala bunds/ Check dams, 60 no. of Gabbion structures, 2 no. of Percolation tanks and 54.39 km*4 (row) long Contour trenching/ Contour bunds in the hilly/forested area of the Kulharighat. The tentative estimated cost to construct all these artificial recharge structures is approximately coming around 120 million. Ground water in the order of 345.92 ham can be recharged by constructing above no. of structures.

TOTAL PROJECT AREA = 133.33 SQ. K.M.

PROJECT COST: RS. 1200.00 LACS

Divisional Forest Officer
Forest Division Udanti