PROBLEMS AND POTENTIALS OF BUNDELKHAND WITH SPECIAL REFERENCE TO WATER RESOURCE BASE

CRDT, IIT Delhi
VSK, Banda (U.P.)

Sponsored by : RGNDWM (Government of India)

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Bharatendu Prakash
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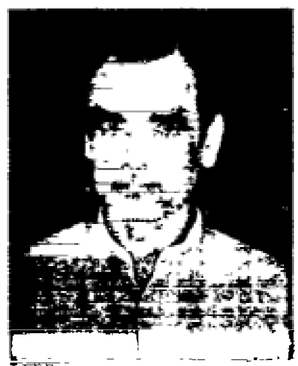

Dedicated to

DR. YASHPAL S. SATYA
an inspirer
who was supposed to co-author
this book, but untimely passed
away in [redacted] history.

—Authors

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PREFACE

The present publication is the outcome of a study under a project entitled "Documentation and Publication of Problems and Potentials of Water Resource Base in Bundelkhand Region" sponsored by Rajiv Gandhi National Drinking Water Mission (Govt. of India) during the years 1996 and 1997.

The project was conducted jointly by the Centre for Rural Development and Technology, IIT Delhi and Vigyan Shiksha Kendra, a Banda based Voluntary Organisation in U.P., with following major objectives :

1. To study the existing potential of traditional water harvesting and storage system, forest, rain pattern etc. in selected districts

   and

2. To prepare proper document on the above aspects with emphasis on traditional time-tested system for drinking water and to identify the issues requiring scientific-technical inputs for its improvements.

Methodology of study included : Collection of information by way of a field survey using a specific questionnaire, and scanning of the available literature — the Imperial Gazetteers, District Gazetteers, Census Reports, Departmental Progress reports, P.G. and doctoral theses, research papers, seminar proceedings and local newspapers.

The field survey was conducted by involving local voluntary organisations and capable individuals (mentioned in the Appendix E)

Entire data and information pertaining to Bundelkhand region were compiled and analysed at the CRDT, I.I.T. Delhi

In addition to the data thus compiled, there were other inputs. Scientific papers were gleaned and newspapers screened to get more facts and compare the figures. Besides, many villagers were interviewed and scientists and technologists consulted to arrive at solutions.

All these have been used in the preparation of the present publication.

An advisory committee was constituted in order to guide and suggest the working of the presesnt project and also the publication.

Though our purpose of study was confined to the problems and potentials of water resources (both drinking and irrigation) in the region, the collected information gives a comprehensive view pertaining to the region's geology, geography, forests, land use, agriculture, mining done to the detriment of water resources, climate etc. In a way, this may serve as a reference book for the consituent districts and could be useful to the research work planners, agencies funding the development of this area, voluntary organisations and the administration.

We are grateful for the facilities provided by the Indian Institute of Technology, Delhi and the Governing Body of the Vigyan Shiksha Kendra and particularly Prof. R.C. Maheshwari, Head, CRDT and Sh. Jagpat Singh, President of Vigyan Shiksha Kendra. Our heartfelt thanks to the members of Advisory Committee for sparing their valuable time for this task.

We are highly thankful for the care and concern and support of R.G.N.D.W.M. (Rajiv Gandhi National Drinking Water Mission, Govt. of India) and particularly, Shri P.K. Shivanandan, Dr. P. Basak, Dr. S.K. Biswas without whose help this project would not have been possible.

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We are also indebted to all friends who cooperated and helped in acquiring the field data and other information (names mentioned in the Appendix 'E').

Special thanks are due to Sh. Pankaj Chaturvedi (National Book Trust), Sh. J.K. Saxena (Govt. Library, Nagod), Sh. R.B. Nigam (Banda), Dr. S.C. Awasthi (LKO), Dr. Narmada Prasad Gupta (Chhatarpur), Shri P.V. Rajagopal (Ekta Parishad), Shri V.K. Shrivastava (Damoh), and Dr. J.P. Pathak (Datia) for providing us valuable help and access to information during preparation of this publication. The kind cooperation of Sh. M.N. Krishnamurthy of RGNDWM has been of immense help to us which we acknowledge .

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— Authors

INTRODUCTION

If the twentieth century saw wars between the nations over the command of petroleum resources, the coming century will see wars between nations and even between the regions within each nation over the use of water resources — such dire predictions are becoming common. In a fast-changing world-wide scenario of rising demands from increasingly diverse sources, increasing deterioration of quality, and in consequence, an ever-shrinking supply of usable water per capita and per sector of demand, what will be the fate of Bundelkhand, once a deeply forested region throwing up in the sky prolific rain-bearing clouds ,which had fired the poetic imagination of "Meghdoot" (clouds as messenger) of immortal fame?

To enquire into this prospect, even in relation to this specific region, we need to recognise the myriad functions of water, hitherto overlooked, because of its relative national sufficiency till a few decades back. We would also need to know the extent of damage to the substratum of resources over the centuries, the nature of demands that have come up or are likely to come up in the coming period, and the favourable or unfavourable geographic, geologic and socio-economic-cultural conditions that exist in this region. Water and air are the two key resources of life. All living things are made up of water combined with varying amounts of other materials. The bonding that water makes with other substances decides the functions and life processes of each individual species. Besides, water runs throughout the links in the food chain for each species of animal and plant through some obvious and many less obvious ways. Water also profoundly influences the climate by absorbing, storing and releasing heat, and thus making it possible for the "temperature-restricted chemistry of life" on earth to move on in its usual pattern.

Humans, cattle and terrestrial plants, however, need mostly freshwater for their direct use. Saltwater meets only a fraction of their requirements. Yet, this freshwater is only about 2.7 per cent of the total quantity of water available on this planet, the saltwater in the oceans and seas accounting for as much as 97.3 per cent. Of this 2.7 per cent, again, most is locked up in ice. In the final reckoning, less than 0.1 per cent - according to some estimate, only 0.027 per cent - of the total global quantity of water flows through rivers, lakes and underground pathways as *freshwater* and supports terrestrial life. Within that, again, the sum total of surface waters in the tanks, springs, streams, rivers and lakes is much smaller than the groundwater flows. Both the surface and subsurface bodies of freshwater keep on getting replenished by precipitation from the water flowing in a vapour state in the atmosphere. A cycle of evaporation, condensation, precipitation, variable -duration residence at sea-surface or terrestrial water-surface or as ground water, followed by re-evaporation is in operation all the time. In-built in this cycle is a process of converting the salty seawater into sweet water and donating an extra share of it to the land surface, because the scope for condensation is greater in the land-part. It is estimated that while the land surface contributes only 16% of the water vapours, it receives 23% of the total global precipitation. It looks like Nature's special benediction for life on land.

But the lion's share of this generous donation is in the form of ice particles which fall mostly in polar regions and high mountain ranges where life is sparse. This hugely uneven distribution of rain occurs because the round-shaped earth rotates about an axis, which is perpendicular to the plane of the equator and passes through the centre, terminating at the north and the south poles, thereby steering the convection forces in particular directions.

Even between the regions of human settlements, there are wide differences in rainfall intensity. And in the tropics, this phenomenon of disparity gets accentuated by the unevenness in both spatial and temporal distribution of rainfall. India particularly presents a picture of very wide divergences in rainfall distribution over both seasons and geographic locations. No other nation furnishes such contrasts spatially and temporally (even seasonally and annually) as does India, particularly North India. This points to the need for diversity of planning in both water harvesting and water use.

Despite the small percentage available as freshwater, its total volume is not small. Even though a tiny percentage - about 0.035 percent of the water outside the oceans is in the atmosphere at any given time, it is a part of a cyclical process. According to a global estimate published in 1965, "it accounts for a yearly rainfall on land thirty times as great as its own momentary burden on land". Even then, there are cries of impending water crisis not only in the West but all over the world. The reasons are to be sought in the manner of its use. If we take India as a whole,. its annual average rainfall is the world's largest in the sense that its average rainfall per unit of space is higher compared to any territory of its size. According to a 1989 report, India's projected demand of water for the year 2001 A.D. could be met by just 25 per cent of the total average rainfall on this land. But the statistical all-India average would not meet the requirements of its drought-prone regions. Even the high-rainfall areas of India face water scarcity during the non-monsoonal months. Switch-over to West-oriented production system and life-style, which is in full swing in this country now, is bound to heighten the crisis everywhere.

Bundelkhand's Peculiarities

Before we come to discuss how vast a difference can be, and is being, created by the western production system, we need to note the peculiarities of rainfall and waterflows in Bundelkhand region. The annual rainfall in Bundelkhand region in the present century has been about 95 cm. Of this, nearly 85 cm falls over just four months, June to September - that too, in about 40 effective rainy days. The remaining 10 cm falls in another 6 days distributed within the remaining eight months. Which means, some months remain completely rainless and some rainy days get heavy downpour.

This is sharply in contrast with the situation in mid-latitude countries. For example, in the U.K. the mean annual rainfall is 60 cm but it is nearly uniformly distributed over twelve months. Each month has 8-11 days of rainfall or snowfall, the total number of days of precipitation being an average of 107 days per year.

There is yet another peculiarity of the humid tropics which shows up in Bundelkhand as well. Here, it is not merely the number of rainy days that is important, the number of rainy hours is equally, perhaps more, important. Out of the total 85 cm of monsoonal rainfall in Bundelkhand, about 40 cm may fall in just 20 hours, which means an average of 2 cm per hour. On some occasions, the intensity goes up to 3-5 cm per hour, each spell lasting for 15 minutes to half an hour. Thus, the rainwater in Bundelkhand, like the rainfall in the humid tropics elsewhere, has little time to penetrate into the soil for recharging the groundwater.

On the South-western and the Southern sides, Bundelkhand is bounded by the Vindhyan mountain system which separates the region from South-west India, and the whole of North India from the Southern Peninsula. Since the Vindhyan plateau is in the southern portion of the region, flanked by a series of escarpments (high steep cliffs) of massive sandstone and limestone formations, and the plains are in the north, and because, in most parts of Bundelkhand impermeable base rocks exist at shallow depths, four consequences have followed- (i) all the rivers of this region have been flowing north - and northeastwards and some rivers after sliding downwards, have been flowing concurrently through subterranean channels and ultimately paying tribute to the river Yamuna; (ii) the rivers have carved up deep gorges with a number of waterfalls and rapids; (iii) the run-off of both rainwater and soil from the catchment areas has been very high and very quick; (iv) the recharge of groundwater in the plateau area has been the minimal. The loss of vegetal cover of the mountain range and the hills has added to the problems heightening soil erosion and siltation of the rivers, thereby causing flash floods periodically. Thus the region suffers more from over-drainage and excessive soil erosion rather than inadequate rainfall.

District	Forest Cover percentage	Rainfall (in mm)	Replenishable Ground water resource (MCM) per year	Level of ground water development (percentage in 1990.)
Jhansi	6	822	896	93
Lalitpur	13	822	669	36
Jalaun	6	794	1239	10
Hamirpur	5	794	1229	12
Banda	11	1024	1426	12
Chhatarpur	10	1083	1036	24.40
Datia	9	900	313	22.18
Damoh	36	1115	829	6 24
Panna	34	1248	812	5 80
Sagar	28	1279	1434	10.66
Tikamgarh	13	1045	818	33.67

People's lives suffer both ways. During the rains when water is available in its wasteful plenty, it ravages the land, carries off the topsoil, forms more gullies, damages the properties and often takes a heavy toll of human and cattle lives. During summer most of the tanks, streams and lakes dry up, the water level in the dug wells recede and at times fail altogether. Cultivated area in the U.P. part of Bundelkhand is about 60 per cent, and in the M.P. part about 42 per cent. Because of the uncertainty of water availability to the crops, people in the greater part of this region have to depend mostly on dry-land farming.

Redeeming Features

Yet, Bundelkhand has some redeeming features. In the northern part, the alluvial plains have great potential for groundwater recharge except where the base rocks exist at shallow depths. Much of these lowland soil is black soil, highly retentive of rain water. In the southern and south-western parts, there are considerable sandstone and limestone formations: these rocks having primary/secondary porosities are traditionally known as good absorbers of water, hence potential repositories of surface/ground water, even springs. According to the Central Groundwater Board, Union Ministry of Water Resources, out of 70008 million cubic meters that Bundelkhand receives per year from rainfall, some 15.28 percent goes for groundwater recharging, the remaining 84.72 per cent going out of the region as surface run-off. (*vide* Groundwater Statistics, March 1991)

The given rainfall figures are *per unit of space* district-wise. The replenishable groundwater resource figures are in *terms of total volume of water* district-wise. Hence from the table itself, no correlation is possible about the causes and the effect (recharge). Evidently, the variability has depended on the variation in lithology, surface topography and extent of vegetal cover. In the whole of the northern plains, the ground water recharge is naturally more.

Even in some segments of the plateau area, new hopes are rising. Some geoscientists have reported about the possibility of an alternative source of ground water of "gigantic magnitude in some of the drought-prone plateau areas." Considering that hard rocks, in many regions of the world, have been found storing considerable amounts of water in the cracks and fissures and in the weathered parts, this expectation needs to be given due weightage. (*Vide* S.C. Awasthi's paper, appendix A.1)

Seven major rivers—Chambal, Sind , Betwa, Dhansan, Ken, Tons, Yamuna, and ten relatively smaller rivers - Pahuj, Paisuni, Baghein, Sonar, Vyarma, Mahuar, Urmil, Lakheri, Jamni, Bina—flow through Bundelkhand. Each of these is joined by umpteen tributaries like arteries in a biological system. By any standard, this is an area rich in riverine resources. Some geologists have inferred that the subterranean flows of many of these rivers are more powerful. Those, who prefer to speak with subdued optimism about palaeo-channels, postulate that since the river courses were structurally controlled, their expressions of many different qualities as well as their intermingling in the geological past must have left behind numerous gravels and domains which have subsequently become effective ground water repositories. These hypotheses no doubt need to be systematically tested and the potentials for such underground flows explored.

Conservation by Minimising Run-off

But groundwater utilization is always costlier. Hence attention must primarily be directed to the conservation and augmentation of surface water resources. Conservation implies (i) minimising the runoff to the river and (ii) preventing wrong uses. By conscious and determined efforts of the people, it is possible to minimise the run-off to the river to about 25 per cent of the precipitation from its present level of 80-85 per cent. But it is not possible to reduce it to zero, nor is such targeting advisable, though many eminent people tend to suggest this. On the basis of the run-off water, the river performs some vital functions such as carrying the damaging salts and toxic substances to the sea, nurturing wildlife, resisting the salty sea water intrusions into the deltaic region by strong hydrostatic pressure, and supplying freshwater to the estuaries where the mingling of saltwater and freshwater creates a churning and causes the utmost productivity of aquatic species useful to life on land.

Conservation by Preventing Wrong Uses

In the context of the prevailing concepts of covetable life-style and "improved" farming and industrial technologies, prevention of wrong uses of water has become extremely difficult. Throughout the world, shift from organic agriculture to chemical-based agriculture has been leading to many-fold demands for irrigation water; and at the same time causing many other kinds of harm. The agro-chemicals (inorganic fertilisers and pesticides) have been destroying the soil structure, polluting both surface and ground water and creating health problems while flush irrigation has been causing waterlogging and long-term salinity. Yet ,the practice remains unabated.

Switchover from cotton fabrics to synthetic fibres would mean using up possibly one hundred times more water. Change-over from leaf plates to paper plates means the use of five to ten times more water in its manufacture. Paper manufacture and leather production on a mass scale in centralised factories have been rendering both surface and ground water unfit for human and cattle use and also ruining agriculture in the neighbourhood. Urbanization has been on the one hand leading to many times more the per capita consumption of water and on the other, turning the rivers into open sewers.

Fortunately, Bundelkhand has not made much headway in this line of "development ", possibly because of its relative isolation. But the urban and the rural elite in this region has been aspiring for the same kind of "development". Granite quarrying and other forms of stone quarrying in Bundelkhand has been flattening the hills and ruining the chances of their afforestation, which is basic to the interception of clouds and infiltration of rainwater into the soil. Quarrying of granite has, moreover, been causing large-scale deliberate destruction of precious groundwater. Since granite formations run hundreds of meters deep, the quarrying goes on becoming deeper; and the groundwater accumulations that are encountered are regarded as obstacles to the mining operation, hence thrown out to dry up on the surface area.

Elitist Blindness to Common People's Experience

Although experience all over the world has shown that construction of across-the-river dams invariably sets the river on the dying course, enthusiasm for building such dams has not waned in India. In Bundelkhand itself, such dams have already been built on rivers Pahuj, Banne, Rohani, Urmil and even on tributaries like Sahzad, Sajanam, Bila and Saprar. Most of these dams have badly affected the river flows and robbed them of their perennial character. Even then, the Rajghat dam, the biggest in Bundelkhand, is being built in Lalitpur district and some more are under contemplation. These dams will continue to weaken the flows in the river's downstream reaches, cause their siltation over time, lead to extensive salt and toxins build-up in the basins and cause strife between the people upstream and downstream over sharing of water. By spawning western-type industries on the banks, these dams are likely to be instrumental in loading the rivers with poison-laden effluents. All of these have great potential for creating water famine.

For the above reasons conservation in terms of both prevention of wasteful demands and preservation of quality, is needed. But this in turn, needs an overturning of the currently prevailing paradigm of development and concept of life-style. Much more feasible, much less expensive and far more beneficial to the people are the nature-harmonic-technology-based systems of production obeying the principle of frugality in the use of water and all other resources.

But the lure for moves in the opposite direction is very strong. A recent UN publication, after acknowledging that irrigated agriculture is a highly water-intensive activity, says that "irrigated agriculture is much more productive than rainfed agriculture" and that "increased production to satisfy the food demand of the future must essentially come from the intensification of irrigated agriculture". There can be no dispute over the importance of irrigated agriculture. But when not a word is said in warning (i) that crops, with the sole exception of paddy, requires only moisture, not flow-irrigation; (ii) that flow-irrigation is ruinous to the soil; (iii) that, according to FAO's own earlier estimate, 50 per cent of the world's irrigated lands has become infertile, it becomes a persistence in ruinousness. The Government of India also is following the same line. This is the kind of approach which is inviting water famine and inter-state and international wars over water. No region will remain immune from this scourge unless the paradigm of development and the concept of desirable life-style are changed.

Bundelkhand's geology and geography are unique : so is its history.

As the legends have it, back in the 11th century, a Rajput prince offered his own life to a mountain goddess to whom human sacrifices used to be made earlier. When he brandished his sword on himself, drops of blood fell on the ground. Impressed by his valour, the goddess blessed him with the name of Bundela (meaning one who offers blood) and held out to him the promise of a kingdom that will know plenty and prosperity. People believe that her blessing saw the flowering of prosperity for generations. The network of rerservoirs, tanks, ponds and dugwells contributed to a thriving agriculture. The Bundela kings are no more. But Bundelkhand remains. It can once again reach the peak of prosperity by being true to its potential and avoiding imitation of false models.

The present study is directed towards the initiation of this process. It aims at making the people conscious about the region's potential and inherent disadvantages. It studies the region basin-wise and political division-wise. In the former, it gives the physical features, geology and hydrogeology, the types of soil and the climatic condition of each basin. The political division-wise studies split into district-wise studies covering all the districts under the Chitrakut, Jhansi and Sagar divisions and the one district under Gwalior division which falls into the Bundelkhand heartland region. The specifics of each district's hydrometeorology and climate, topography, geology, soil types, natural drainage systems, the characteristics of rivers, lakes, streams and canals systems, situation in respect of drinking water and irrigation facilities are given here on the basis of data obtainable from government sources and the scanning of available published literature including Imperial Gazetteer / District Gazetteers, Census Reports, and other publications and scientific papers collected from many sources and above all, the data collected during the survey and field studies conducted jointly by IIT, Delhi and Vigyan Shiksha Kendra, Banda. It also gives (i) people's perceptions about their problems, (ii) solutions suggested by scientists from many disciplines and the people themselves, and the conclusions that finally emerge from the dialogues.

CHAPTER TWO

BUNDELKHAND — A GENERAL SURVEY

The present region of Bundelkhand lies between approximately 23° 10' and 26° 27' (north) Latitude and 78° 4' and 81° 34' (east) Longitude, and comprises four districts of Chitrakut Division, three districts of Jhansi Division, five districts of Sagar division and one district of Gwalior division. The cultural Bundelkhand, however, spreads beyond this region and touches partially several of the adjacent districts, namely Bhind, Gwalior, Morena, Shivpuri, Guna, Narasinghpur, Hoshangabad, Jabalpur, and Satna etc.

The present account is concerned with the heartland of geo-physical and historical Bundelkhand and comprises the following districts :

U.P.

1. Chitrakut Division :	Banda, Chhatrapati Shahuji Maharaj Nagar, (Chitrakut), Hamirpur and Mahoba
2. Jhansi Division :	Jalaun, Jhansi, and Lalitpur

M.P.

1. Sagar Division:	Chhatarpur, Damoh, Panna, Sagar and Tikamgarh.
2. Gwalior Division:	Datia

In ancient days dating back to ca. 600 B.C., this area was included in the extensive Chedi-Kingdom of north-central India. The region was also known as Dasharna-Pradesh, so named because of the ten principal rivers flowing in this region[1]. Possibly the centrally located river Dhasan has got its name from DASHARNA. Famous Chinese traveller Huen Tsang (641-2 AD) has referred this area as *Chichito* having its capital at Khujarahu. During the Chandela - Kingship lasting nearly four centuries, this region was termed Jejakabhukti or Jajhauti with its capital fort at Kalinjer. A.R. Al-Biruni mentions the country of *Jajhoti* as containing the cities of Kalinjar and Gwalior, towards the end of tenth century[2].

Later the great Bundela king Chhatrasaal, during his rule over this region (1691-1731), carved out Bundelkhand. This was bounded by river Yamuna in the north, Narmada in the south, Chambal in the west and Tons in the east*. The history of this region, however, has been so chequered that it never remained united. The largest measure of unity was during Chhatrasaal's regime.

Archaeological reports of General Cunningham[3] defined Bundelkhand as the land lying between south of Yamuna, east of Betwa, west of temple of Vindhyavasini Devi, and north of Narmada river.[3]

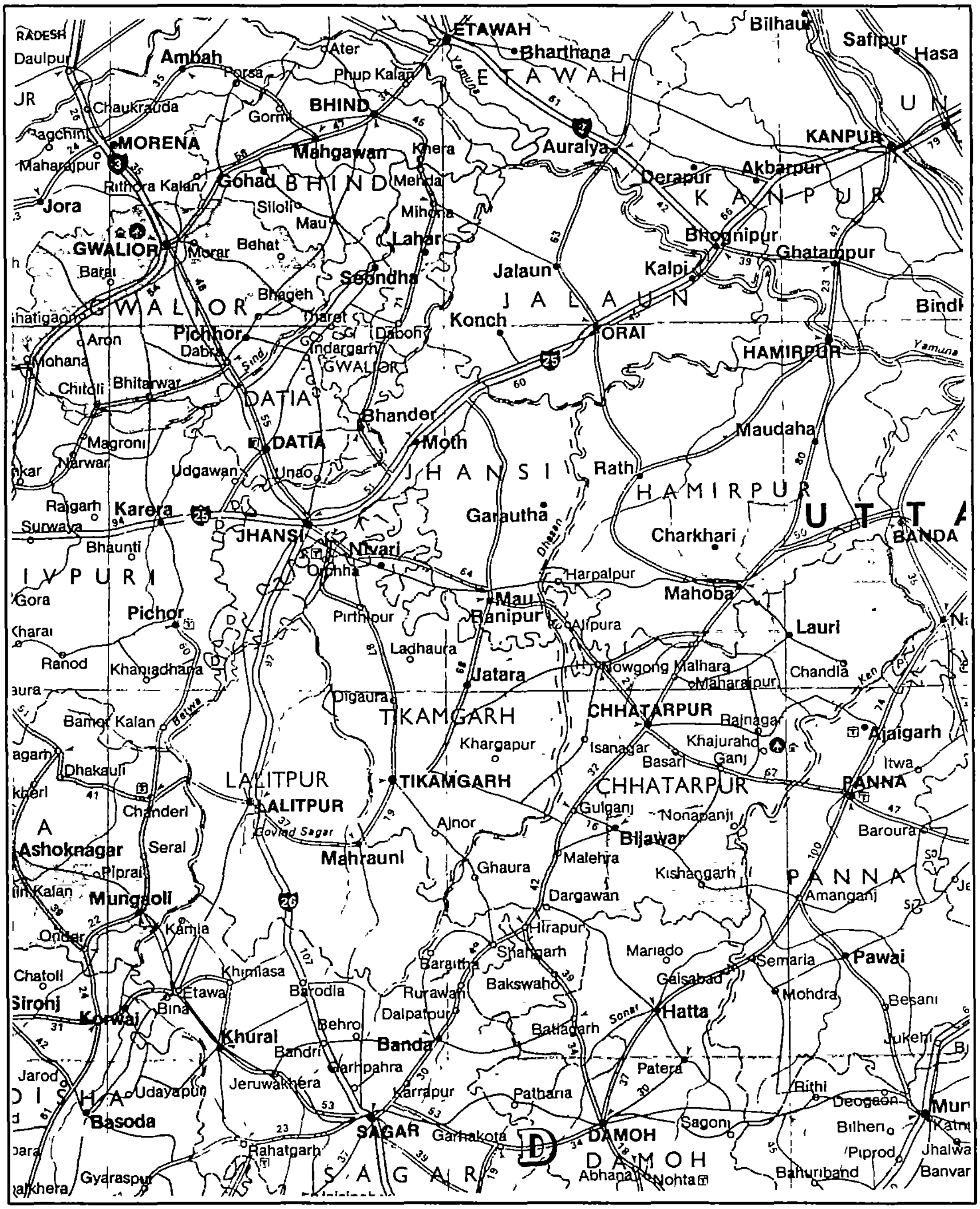
**It Jamuna Ut Narbada, It Chambal Ut Tauns. Chhatrasal Se laran Ki, Rahi Na Kahu Hauns*

Important Statistics of Bundelkhand

S.No.	Particulars	DISTRICTS										
		Banda (CS Nagar)	Hamirpur (Mahoba)	Jalaun	Jhansi	Lalitpur	Chhatarpur	Damoh	Panna	Sagar	Tikamgarh	Datia
1.	Area (Km^2)	7,624	7,166	4,565	5,024	5,039	8,687	7,306	7,135	10,252	5,048	2,038
2.	Population (1991)	18,62,139	14,65,401	12,17,021	14,26,751	7,48,997	11,58,853	8,97,544	6,84,721	16,46,148	9,40,609	3,97,743
3.	Rural Population (%)	87.14	82.70	78.06	60 51	86.31	80 64	81.91	87.39	70 85	83.12	77.27
4	Gender Ratio	848	838	822	851	858	854	907	901	883	867	840
5	Population Density	243	205	267	284	149	133	123	96	161	186	195
6.	Population Growth rate 1961-71 1971-81 1981-91	 23 96 29 76 20 67	 22.39 20.48 22.71	 32 67 21 24 23.40	 21.79 30 67 32.21	 17.14 32.21 29.66	 21.48 24.46 30 70	 30 78 25 85 24 41	 29 53 25.85 26.31	 33.36 24 55 24.42	 24.85 29 55 27 63	 27.34 22.18 27.53
7.	Inhabited Villages	1,203	926	942	760	689	1079	1193	939	1808	836	402
8.	Nyay Panchyat	118	98	81	65	48	—	—	—	—	—	—
9.	Dev. Blocks	13	11	09	08	06	06	07	05	11	06	02
10.	Tehsils	06	06	04	04	03	06	06	05	07	05	02

Source
- Distt. Census Hanbooks 1981 and Census data 1991
- Ashish Bose, Demographic Diversity of India - 1991, Census
- Tables Prepared by People's Science Instt., Dehradun 1997

MAP OF BUNDELKHAND



While Atkinson's account[4] defined Bundelkhand as the tract lying between the river Jamna (Yamuna) on the north; the Chambal on the north-west; the Jabalpur and Sagar Divisions of the central provinces on the south; and Rewa, or Baghelkhand, and the Mirzapur hills on the south and east.

2.A. PHYSICAL FEATURES

TOPOGRAPHY:

Bundelkhand has been endowed by Nature, with beautiful mountains, good perennial rivers, fast flowing seasonal rivulets, large forest areas with traditional timber, tendu and herbal plants and rich fertile alluvial plains. To the south of this region, Vindhyachal range is all along stretched while some part of the south and the northern part is plain with comprehensive agricultural activities. Geographically, the present Bundelkhand is a part of the central zone of India with a group of north-bound perennial rivers flowing and paying tribute to river Yamuna. From west to east these are Sind, Pahuj, Betwa, Dhasan, Ken, Baghein, Paisuni, and Tons, along with their numerous tributaries which drain water from a very large area of the constituent districts.

The region of Bundelkhand is homogeneous dissected upland, presenting an old eroded surface, carved out of granite, with northern alluvial plains merging imperceptibly into the granitic uplands. The frequent constriction of drainage by the dykes has resulted in the multiplicity of small tanks, practically in all parts of the region.

To the south of the region's upland, stand out three massive sandstones with quite distinctive features. These are known as Kaimur Sandstone, Rewa Sandstone, and Bhander sandstone. [5]

GEOLOGY:

The Bundelkhand region consists of 13 districts, namely Sagar, Damoh, Chhataarpur, Panna, Tikamgarh, Datia, Banda, C.S. Nagar, Jhansi, Lalitpur, Hamirpur, Mahoba and Jalaun. For the general geological succession of this region see Box A.

The metasediments and metabasites, which occur as enclaves within the granitic rocks, form good exposures in Mahroni tehsil of Lalitpur district. The meta-sedimentaries mainly comprise quartzite, quartzose-schist and quartz sericite schist. The meta-basites are represented by peridotite, serpentinite, pyroxinite and amphibolite rocks. The scattered small exposures of these rocks are also found at many other places. These rocks occur in Jhansi, Lalitpur, Datia, Sagar, Chhatarpur, Tikamgarh, Panna and Banda Districts of Bundelkhand region.

The granite gneisses and migmatite are closely associated with schistose rocks and exhibit minor folding. Medium-grained granite gneiss which is porphyroblastic at places form low

Box A

Recent	Alluvium	laterite, sand, silt, clay, etc.
	Unconformity	
Upper Cretacioes to Ecocen	Deccan Trap	Basalts
	Unconformity	
Middle cretacious	Lametas	limestone, clay
	Unconformity	
Pre-Cambrian	Vindhyan Super Group	
	Unconformity	
	Bijawar Group	
	Unconformity	
Archaean	Bundelkhand Granitod complex and Meta Sediments and Metabasites	

mounds in the area. The leucocratic fine to medium grained granite represents intrusive phase and forms bold hills. The granite gneisses which are porphyroblastic at places exhibiting effects of metasomatism, are well exposed in north of Jhansi. The diorite represents hot phase intrusive in the above rocks and is widely exposed in the vicinity of Jhansi town. The leucocratic granite (intrusive of cold phase) generally forms rounded hillocks and is followed by various intrusive dykes of porphyry, aplite, pegmatite, quartz, dolerite and lamprophyre. The granitic rocks carry enclaves of various dimensions of metasedimentaries such as quartzite, quartzose - schists, quartz amphibolite, sillimanite hornfels, banded hematites quartzite, impure marble, etc., and metabasites such as amphibolite and pyroxinite. The metasediments and metabasites exhibit various grades of metamorphism ranging from low temperature gneiss schist facies to high temperature K-fields-par-cordierite-hornfels facies. Foliation is generally developed in the granitoid rocks and trends in ENE-WSW directions with steep to vertical dips.

Major shear planes in the area trend in N60°E-S60°W to N30°E - S30°W to N30°E - S30°W directions and are generally occupied by quartz reefs which are conspicuous features in the form of linear ridges, and often crossed at right angles by dolerite dykes. These rocks occur in Jhansi, Lalitpur, Datia, Sagar, Chhatarpur, Tikamgarh, Panna and Banda Districts of Bundelkhand region.

The granitic activities were followed by intrusions of aplite, pegmatite, diorite, granite porphyry, quartz reefs, dolerite and secondary veins of quartz and epidote. Aplite and pegmatite seen as minor veins are present in all the granitic rocks. The porphyries are particularly common in the northern part of the district (near Jamalpur-Talbhat etc.) generally trends in ENE-WSW direction. These are cut by reefs of quartz which are trending in NE-SW direction. The dolerites are trending NW-SE direction.

Bijawars consisting of limestone, dolomite, quartzite, shale, sand-stone, banded hematite quartzite, basic dykes and lavas belonging to Bijawar Group are exposed in a narrow zone in the south of granitoid complex. The Bijawars are folded to form a large W-S-W plunging synclinorium, the southern limb of which is concealed below the Vindhyan rocks. The northern limb is traversed by several strike and oblique faults. These rocks occur in Sagar, Chhatarpur, and Panna districts of Bundelkhand region:

Vindhyans comprising sandstone, Limestone and quartzite are exposed at the southern fringe of the region and forms great Vindhyan scarps. These rocks occur in Sagar, Damoh Panna and Banda districts of Bundelkhand region.

Deccan Trap consisting of basalt with intra-trappean beds occur in Sagar, Damoh and Panna districts in the form of flat topped hills, plateaus, and conical hills.

Lametas consisting of limestone, granite, clays, etc. are found in Sagar and Damoh districts of Bundelkhand region. These are fossiliferous and overlain by Deccan Trap rocks.

Alluvium occurs along the banks of the river of the Bundelkhand region. Mostly it occurs in Datia, Jalaun, Mahoba, Jhansi and Banda districts of Bundelkhand region. It consists of sand, silt, gravel, clay etc.

The geological formations are shown in fig.2.1

Joints in Rocks

Joints are the openings in rocks which play a very important role in the movement of groundwater. These are primary and secondary joints. Primary joints are those which formed during the formation of rocks whereas secondary joints are formed after the formation of the rocks. Generally in the hard rock, the joints are of secondary type. These are formed when the rocks are subjected to deformation which goes under stress and strain. The path of groundwater flow is controlled by the joints. Therefore, the measurement of attitudes of joints is made in the field in different types of rocks. The amount of dip and the average direc-

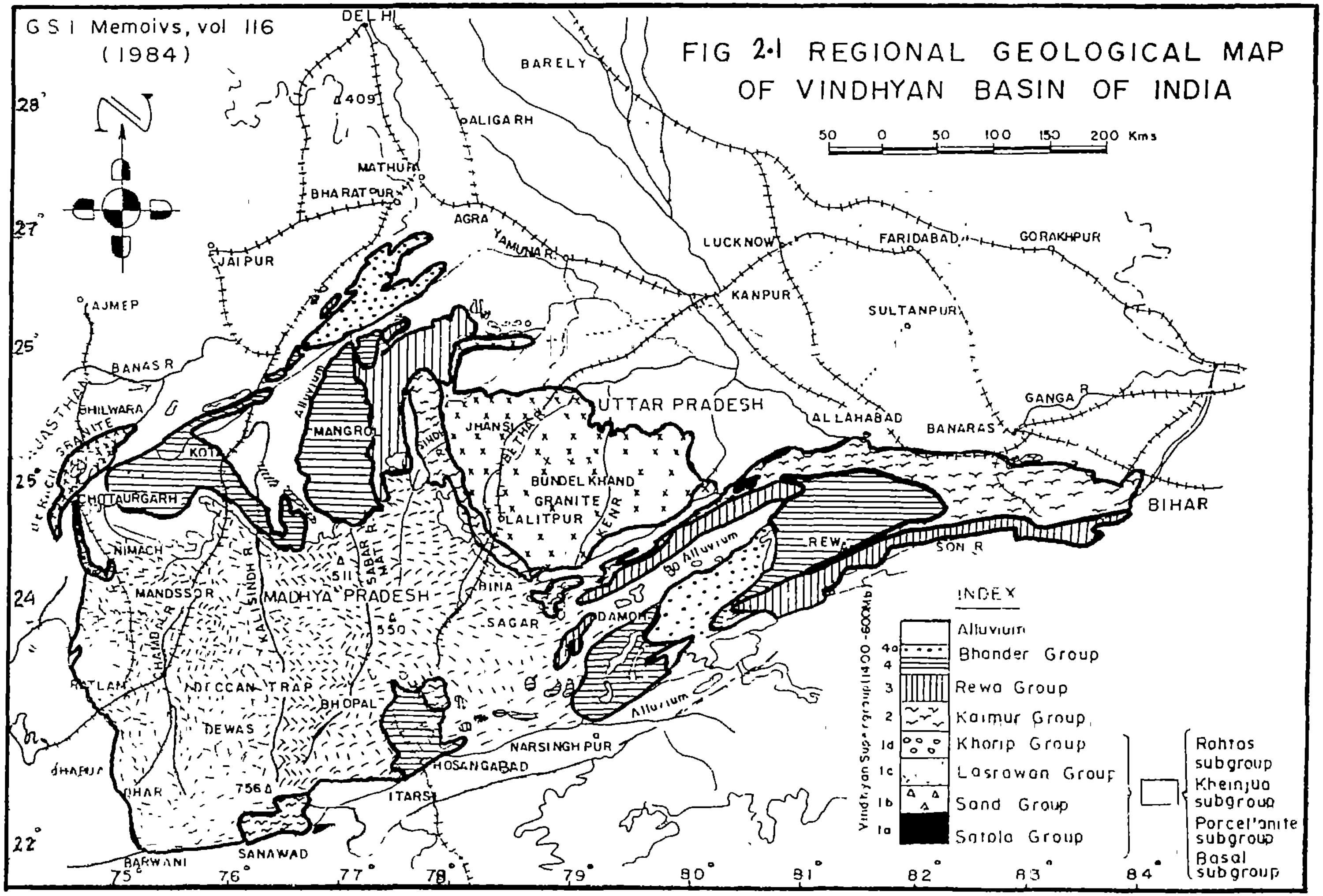


FIG 2·1 REGIONAL GEOLOGICAL MAP OF VINDHYAN BASIN OF INDIA tion of the different rocks is shown in Fig 2.2. A glance at this diagram shows that the average direction of joints in Bundelkhand granite is nearly towards south; in Bijawar rocks, it is towards S-W and in Vindhyan, it is nearly in south direction. These directions show that the ground water flow takes place in these directions.

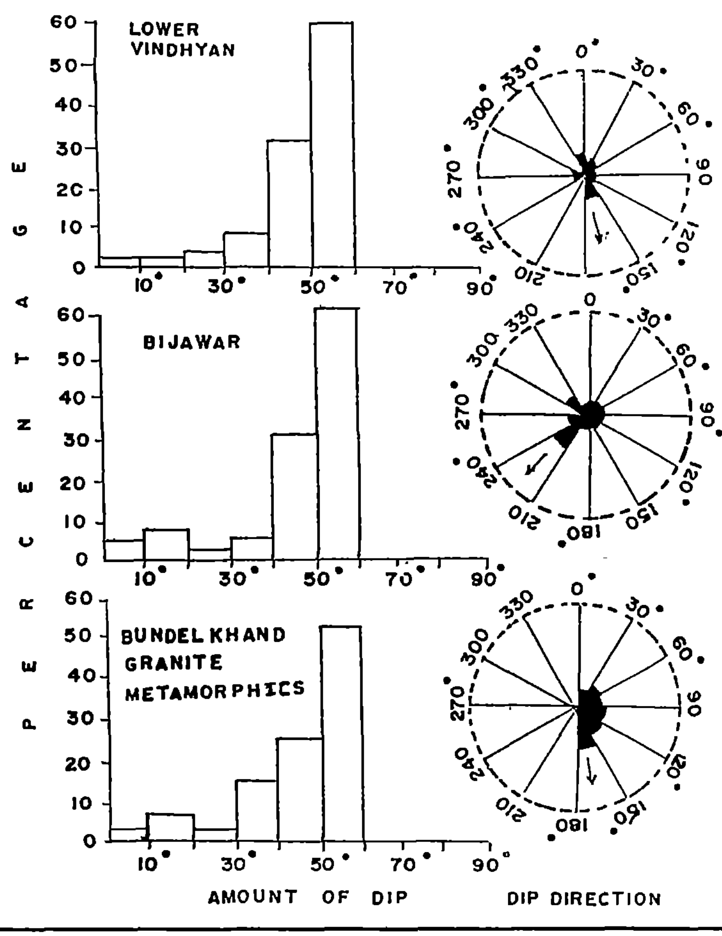
SOILS

The soils in the Bundelkhand region have developed from Vindhyan rocks abounding in gneiss and granites of the Deccan trap with highly ferruginous beds and often soft lime stone. The soils can be divided into two broad groups, (1) red and (2) black soils. Four soil associations have been recognized in the area which include (i) Bundelkhand-coarse grained-reddish brown soils, (ii) Bundelkhand-coarse grained-grey to greyish brown soils, (iii) Bundelkhand-clay loam-black soils and (iv) Bundelkhand-fine clayey black soils. Locally these soils are termed as *rakar, parua, kabar* and *mar*, respectively. The red soils *rakar* and *parua*, belong to the order Ultisols, Alfisols, and Inceptisols and the black soils are grouped under the great groups, Pellusterts, Chrousterts and Ustochrepts.

The *rakar* soils are residual, slightly acidic, coarse grained, shallow and excessively permeable soils occupying higher elevations. The *parua* soils are alluvial, mildly alkaline, very deep soils with free $CaCO_3$ accumulation at lower depths.

The black soils, *mar* and *kabar*, are very deep soils confined to low lying landscapes having fine texture and the remarkable property of shrinkage and swelling on drying and wetting. These soils are normally deficient in organic matter and difficult to work.[5]

FIG. 2.2 ATTITUDES OF JOINTS



MINERALS :

Diamond is extensively found around Panna. Other than Diamond, **Coal** is the most valuable deposit in the vicinity of Bundelkhand. **Copper** was at one time extensively worked in Shahnagar Pargana of the Panna State. **Lead** in the form of galena was found at Bargoa village near Bardi (Rewa State), and exists in rich veins in the hills near Seondha and Datia, in the Par Sandstones and in the Quartzites of the Bijawars.

Iron is met with throughout the Vindhyan rocks, to which it gives its characteristic red and brown colours. The richest and most easily worked ores occur at Hirapur village (24° 42' N-79° 39' E) in the Bijawar State, once a famous centre of iron smelting industry. Iron smelting has been very popular in the whole of Bundelkhand and one can see the iron slag still spread out at many places in the thick of jungles and around forts like Kalinjer etc. The local *adivasis* especially Kols were the main iron smelters. In addition to the above, **Agate** and **Jasper** also are found in several localities [6].

Bauxite is found in many places but the quantity is not economic. Building materials like lime is found in many places and the sandstones in the form of boulders and stone slabs are still mined and marketed.

The stone-gravels made of granites are an extremely popular product these days for RCC work and is exported throughout north India. The sand of the rivers of Bundelkhand form extremely valuable building material for masonry and RCC work. Now-a-days the Bundelkhand granite stones are mined and tiles manufactured for exporting these even to foreign countries, especially from the districts of Lalitpur and Jhansi.

2.B. DRAINAGE AND WATER RESOURCES

Major drainage of the Bundelkhand region is through its numerous perennial rivers and their tributary rivulets and seasonal *Nallahs* which carry all the water including the rain-water off to river Yamuna in the north. The main slope of entire region is towards north and north-east. The situation is that the drainage of Sagar district which is just 9 km from Narmada river at one point, is towards river Yamuna which is several hundred km from this district.

The main water resources of the Bundelkhand region have been the same perennial rivers and rivulets, the numerous lakes formed through embanking the lower side of the valleys and the ponds almost in each village as a tradition. This region has also been getting on an average about 1000 mm rains annually, almost 90% of it within two months of August and September. Yet, it was sufficient to fill all the lakes, ponds and reservoirs of Bundelkhand.

Even upto the forties, this region was full of deep forests which allowed good recharge of underground water except at a few places in the plateaus of Banda and Panna districts. The rivers and rivulets invariably were charged with water streams from the foot of the hill forests. Even some of the hilltops were also seen giving good streams of water as in Chitrakut and Kalinjer and Jatashankar. In Banda, Datia, and Jalaun there are numerous artesian flows (*jhirnas*). Such wells are even source of water for certain rivers like Paisuni and Pahuj and rivulets like Gadra, Banganga, and Bisahil etc. A stream named NIMNI south of Banda city was an active *Jhirna* just a few decades ago.

THE RIVERS

The rivers form the boundaries of Bundelkhand. There are numerous north-bound perennial rivers (all paying tribute to Yamuna river) like Sind, Pahuj, Betwa, Dhasan, Ken, Baghein, Paisuni, Tons, and their tributaries named Chandrawal. Bardaha, Banganga, Birma, Padwah, Saprar, Shahzad, Sajnam, Jamuni, Mahuar, Angoori, Kathne, Beela, Urmil, Banne, Sonar, Vyarma, and Bamner and many perennial and seasonal rivulets and *Nallahs* etc. The details about these rivers are given in the following pages where we dwell on the information about the districts separately.

The Human Endeavour For "Managing" the Water-Resources

As described earlier, major reservoirs and ponds belong to the period of *Chandela* kings who ruled over this part of country from the 10th to the 13th century A.D. and/or the *Bundelas* who governed this region from the 16th to the 18th century A.D. The major technology those days used to be embanking of the lower part of the valley formed by any river, rivulet or a seasonal *Nallah* surrounded by hills on three sides or a pond embanked on three sides leaving open the fourth i.e. upper side for intake of rain-water. Such structures are seen today even in the deep of the forests and were not necessarily meant for irrigation. These reservoirs, however, contributed to enriching the underground water resources raising the level of water in wells and increasing soil moisture to allow healthy growth of vegetation. The hills looked greener and there were numerous streams from the foothills to add to the perennial rivers and rivulets. The forests with water reservoirs provided congenial atmosphere to the wild animals and whenever necessary shelter to native armies fighting with imperial forces adopting guerilla-war tactics.

The British acquired authority of this region in 1803, but could not hold any substantial power until 1860 because people here opposed the British occupation through a treaty with the Marathas[7]. After 1860, British Administration of India did undertake surveys and construction of several weirs associated with canals. Canals were dug and even joined to the earlier reservoirs in order to *sell water to farmers* as opposed to the peoples' previous culture of using wells and tanks/ponds for limited irrigation. During British administration the forests were acquired and in the name of scientific management, largescale commercial exploitation of the these forests started taking place.

The frequent famines and epidemics during the last quarter of the 19th century and the first few years of the twentieth century produced reserves of cheap labour which was employed in *making weirs* over the rivers of Bundelkhand such as *Parichha* over *Betwa* (1881-85), *Bariarpur* over *Ken* (1900-04), *Dhukuwa* over *Betwa* (1905-09), *Lahchura* over *Dhasan* (1906-10), *Pahadi* over *Dhasan* (1909-12), and *Gangau* over *Ken* (1915). The complete *damming* of the rivers was not initiated till then. It started with the newer technologies introduced in the 1950's.

These unnatural policies towards the rivers and the forests, however, were unchanged during the post-independence period and that disturbed the entire balance of nature by affecting the forests and rivers perhaps in a greater measure than in other parts of India. The industrial policy never bothered about the environment; and the forests and hills were seen as generators of revenue only. The forests were first exploited through the contractors and later through forest corporations, which were even less concerned about regeneration of the forests or the environmental equilibrium.

The blame for the destruction of the forests was unnecessarily placed over the poor communities which were employed by the contractors and the corporations in denuding the forests. These communities were almost displaced from their habitats, deprived of their right to forest-mangement and even of minor forest produce and starved for want of any other occupation. The so-called scientific management of the forests theorised by the British administration was never followed by either the British or the new incumbents of the Indian administration after 1947. Talking about the environment was more seen and termed as backwardness and laughed at by politicians, bureaucrats and commercial interests. The nexus of the three is even now involved in destroying the forests, crushing the hills and mining the granites, gneiss, basalt, sandstones etc. for exportation and profits.

Impact of Mining Activities

Besides the decimation of forests and the induced decay of locally controlled water resources like lakes, reservoirs, tanks, ponds, *bavdis*, *chohnras*, dugwells by the switch of emphasis on centrally controlled canal system, there is another kind of human activity which has been drastically reducing the availability of water for the common people and also degrading its quality. This is mining.

Varieties of minerals like limestones, granites, gneisses, basalt, sandstones, limestones, diamond, pyrophylite and diaspore and different kinds of ochres, river sands, silica sands are the major materials being mined in Bundelkhand. Mining consumes huge amounts of water and deplete the water table. The lure of commercial profits includes foreign exchange earnings and ruins the chances of agriculture. The present mining operations in Bundelkhand are so indiscriminate that the entire environment has been endangered. Mining starts with deforestation and leads to groundwater wastage, soil erosion, silting and pollution of rivers and streams. The prominent areas which have been destroyed in this way are Narsinghgarh (Damoh district), and quite a few blocks in each of the districts of Lalitpur, Jhansi, Panna, Mahoba, Banda and Chhatrapati Sahuji Majaraj Nagar. Mining generally benefits a few individuals (company proprietors and contractors) but damages the environment irreversibly, depleting groundwater, ruining people's health, defoliating vegetation and flattening the hills.

As a result of all the above factors the climate of the entire region has been seriously disturbed. The rainfall, surface water storage, groundwater recharge have all been affected. The summers have become hotter, the dusty storms and hot winds (*Loo*) have become more severe, increasing the chances of conflagration in the villages and dehydration deaths during summers. In the summer of 1995, day temperature during May-June shot up to 52°C in Banda district, resulting in hundreds of deaths within 24 hours of 14-15 June. Chitrakut, the most popular centre of pilgrimage of this region records several events of deaths due to heat and dehydration during summer season.

People are firm in their conviction that deforestation has caused gradual decrease as well as erratic behaviour of the annual rainfall. During rainy season the flash floods have become common which result in loss of houses, properties and people's lives, in addition to the run-off of the top-soils and the loss of traditional local seeds.

The deforestation has also caused diminishing availability of herbs, medicinal plants and the minor forest produce which used to give support to the forest dwellers economically.

Thus, such human activists have not only ruined agriculture but have made life vulnerable in all respects. The poorer people have become the most vulnerable. Bundelkhand, once a prosperous region, has now become dependent on the mercy of rulers sitting somewhere at a great distance in Lucknow, Bhopal or Delhi.

2.C. VEGETATION

The ancient literature like RAMAYANA of Valmiki mentions Chitrakut, the *Vindhyatavi* (Vindhyan forests), the river Mandakini (Paisuni) etc. and the dense forest around it. Bundelkhand was extremely rich in the resource of forests even upto the last century. Useful timber-trees, fruit trees, and the medicinal plants were in abundance. Appendix D gives common flora which used to be found in Bundelkhand region. The rich forests and the plentiful rains had rendered this region rich and supportive of humans as well as of wild life.

As in other parts of India the forests, before appropriation by the British imperial power, were the common property resources in Bundelkhand and were generated and protected by people. The total acquisition of forests by the British administration has been termed as the most painful event of the nineteenth century which turned entire common property resource into Govt. property and the people around forests were, by one stroke of pen, termed outsiders. This led to several events of people's revolt in this region. It was unfortunate that even after 1947, the Govt.'s view towards forests remained the same and these were never integrated with the interests of the people. This seemed the most important reason behind the denudation of forests. No doubt there was the growth of population and of the common people's need for forest produce including timber. But the displacement of people form the single most important factor, preventing forest regeneration.

In Madhya Pradesh seven out of 21 forest circles namely Bhopal, Jabalpur, Sagar, Seoni, Hoshangabad, Shivpuri and Gwalior are in the vicinity of Bundelkhand region and had similar mixed forest comprising the valuable timber, fruit-trees, medicinal plants and herbs including widespread herbs. In addition quite a large part of these forests has been rich in bamboos. Similar situation was also in the southern portion of the Lalitpur district. The situation today, however, is very precarious and most jungles lie only on paper.

The wild life in this tract has been so rich that during the times of Moghul-rule at Delhi, the forests around Panna were used for hunting elephants. Like the vegetational diversity, the wildlife here also was quite diverse and rich. Tiger, panther, leopard, wild dog, hyaena, wild boar, bear, Kotri, antelopes of several types, *Nilgai*, ravine deer, spotted deer, shambhar, fox and jackals etc. used to be found all over the forests of Bundelkhand. The rivers, particularly Ken and Dhasan, used to be full of crocodiles. River Yamuna, just fifty years back, was full of alligators, porpoises and tortoises. All the common game birds such as duck, geese, teal, snipe, partridge, quail and plover etc. The florien and the great bustard were also seen in the plains of central and western Bundelkhand[4]. The present situation is, however, very alarming; the forest as well as the wild life including that in the rivers, is on the verge of extinction.

2.D. HYDROMETEOROLOGICAL STUDIES :

The hydrometeorological subzone 1(c) includes the basins of the Sind, Betwa and Ken rivers and the free catchment areas of other Southern tributaries of the river Yamuna. The subzone is located between Latitudes 23° 0' and 26° 52' (North) and Longitudes 77° 20' and 81° 30' (East). This subzone consists of the *entire Bundelkhand* — i.e. the five (now seven) districts of U.P. and six districts of M.P. plus 10 other non-Bundelkhandi districts of M.P.

This hydrometeorological subzone 1(c) is bounded by :

Subzone 1(e) (Upper Indo-Ganga Plains) to the north

Subzone 3(c) (Narmada Basin) to the South;

Subzone 1(b) (Chambal Basin) to the West;

Subzone 1(d) (Sone Basin) to the east (9).

The *basin-wise details* have been given in the following pages.

1. THE SIND BASIN

The Sind Basin lies between the north latitude 24°00' and 26°45' of east longitude 77°15' and 79°10'. The maximum length of the basin from North to South is 300 km and the width from East to West is 170 km. The total catchment area of the basin is 27,742 km^2 of which 26,050 km^2 lies in M.P. and the rest 1,692 km^2 in U.P., covering the areas of Bundelkhand uplands.

PHYSICAL FEATURES

The Sind river flows through Vindhyans and Bundelkhand granites in the form of narrow stream in the upper stretches and the gradient is steep. In the lower reaches, it passes through undulating ravines with gradual slope. The general elevations of the basin vary from 198 m to 203 m. above the mean sea level. The three distinct regions are apparent :

1. Medium land
2. Plains
3. Deep Ravines

Geology and Hydrogeology

The basin is covered initially by Deccan Traps followed by granites and gneisses and later by Vindhyan sand stones, then passing on to the alluvial plains.

The ground water occurs in granite and gneisses in the fractures, fissures, joints and weathered zone. In the Vindhyans also it occurs in jointed and fractured sandstones and cavernous lime stones. In the Deccan traps, weathered, fractured, and vesicular basalts form the aquifers. Alluvium with sand forms good ground water reservoir.

The Soil :

The soils of this region consist of mainly hilly fine loamy to coarse loamy in texture and shallow in depth. These are low in organic and possess poor water retention capacity.

a. Hilly Soils

These soils are fine loamy to coarse loamy in texture and shallow in depth. They are prone to severe erosion. Hilly soils are low in organic matter content and have poor water retention capacity.

b. Plateau Soils

These are mixed red black soils, and are coarse to medium in texture and low in nutrient status. These are shallow to deep, moderately eroded and the water retention capacity varies with the texture and organic matter content.

c. Pediment Soil

These are also like plateau soils, coarse to medium in texture and moderately eroded.

d. Alluvial Soil

These are deep to very deep, fine loamy and well to moderately drained. These are low in organic matter content, but are fairly rich in nutrient status.

Climate

The Sind Basin is characterized by tropical climate. Normally there are four distinct seasons. Summer from March to June, rainy season from mid-June to September, the post monsoon transition season between October and November while winter extends from November to February.

This is a medium rainfall zone varying from 867 to 1220 mm. The normal temperatures have been recorded at the Gwalior station as varying from 7.2^0 (min) to 42.6^{0}C (max). The wind velocity has been found to be ranging from 2.8 km/hr to 13.0 km/hr recorded at Gwalior and Guna, respectively.

2. THE BETWA BASIN

The Betwa Basin lies between the north latitudes 22^{0}51' and 26^{0}0' and east longitudes 77^{0}10' and 80^{0}20'. The maximum lengths from South to North is ca. 431km. While the maximum width from West to East is ca. 155 km. It consists of a number of distts. of Bundelkhand region like Sagar, Tikamgarh, Chhatarpur, Lalitpur, Jhansi, Jalaun and Hamirpur. The catchment area of the basin is 43,895 km^2 of which 30,217 km^2 lies in M.P. and the rest 13,678 km^2 in U.P. state.

PHYSICAL FEATURES

Physiography

Bundelkhand granites, Vindhyan Sandstone and Deccan Trap lava flows form the basic physiography of the region. The alluvium deposits also have been important in developing the present central valley plains of the basin. The elevation of the basin ranges from 106 m to 680 m. above mean sea level

Physiographically, the basin can be divided into three main units :

1) Uplands 2) Medium land 3) River banks

The overall drainage pattern is Sub-dentritic and the drainage segments are controlled by Joints.

Geology and Hydrogeology

The Betwa Basin is occupied by Bundelkhand granites, upper Vindhyan Sandstone, Deccan Traps and alluvium and laterites. The

Bundelkhand granites in the northern parts are traversed by numerous quartz reefs and basic dykes. They have water bearing zones within joints, fissures and fractures and along the contacts with quartz reefs and dykes. The weathered zones also form shallow aquifers within the granites.

Major central parts are overlain by basaltic lava flows with isolated outcrops of sandstone forming inliers. Isolated Deccan Trap exposures can also be seen in Vindhyan valleys in the southern parts of the basin. Shallow ground water occurs in the weathered vasicular jointed and fractured basalts. The sandy and gravelley alluvium in the north also forms good aquifers.

The Soils

Based on the studies of National Bureau of Soil-Surveys and Land use Planning, Nagpur and the State Soil Survey deptt. (MP), the soils of Betwa Basin could be classified into five broad groups as follows:

a. Soils on Hills and Ridges

These are fine loamy to coarse in texture, prone to severe erosion, and low in organic matter contents, having very poor water-retention capacity.

b. Plateau Soils

These are coarse to medium in texture and low in nutrient status. They are shallow to deep and are moderately eroded and possess water-retention capacity varying with soil texture and organic matter content.

c. Pediment Soils

These are shallow to very deep, coarse to medium in texture and poor in nutrient status.

d. Soils on Basalt Landscapes

These soils are deep to very deep, fine in texture, rich in base and nutrient status with swelling and shrinking properties.

e. Alluvial Soil

These are deep to very deep, fine to fine loamy and well to moderately drained. They are neutral to slightly alkaline, low in organic content, fairly rich in nutrient status and are moderately eroded.

Climate

This is also a region with hot summers to moderately cold winters, like in Sind Basin and exhibits four distinct seasons. The rainfall varies within the basin from 870 mm to 1394 mm. The maximum and minimum temperature in this region have been reported to be ranging from 39.9°C to 42.6° C and 5.3° C to 10.6°C respectively. The hottest month is June while the coldest month is January. The wind velocity of the region under the present study has been found to vary from 3.5 km/hr at Bina to 11.0 km/hr at Sagar.

3. THE KEN BASIN

This river basin lies between north latitudes 23°20' and 25°20' and east longitudes 78°30' and 80°36'. The Ken basin covers the areas of Jabalpur, Sagar, Damoh, Panna, Satna, Chhatarpur and Raisen districts of M.P. and Hamirpur and Banda districts of U.P. It is bounded by Vindhyan ranges in south, Betwa basin in the west, free catchment area of Yamuna in east and the river Yamuna towards the north.

PHYSICAL FEATURES

Topography and Physiography

In the upper reaches, the Ken basin is characterized by very undulating terrain with isolated steeply sloping hills and ridges. Except for a large patch on the right bank, the basin is occupied by dissected plateau in the central part. The gently undulating terrain next to the plateau can roughly be marked up to Banda associated with the preponderance of surface boulders. The flat plain which, with imperfect sub-surface drainage extended to the southern banks of Yamuna, is also characterized by ravines. Besides a few locally radial and annular drainage, a coarse dendtritic drainage dominates the area.

Geology and Hydrogeology

The rock formations encountered in the southern part of the basin is comprised of Deccan Traps, Lameta bed and Vindhyans. A few outcrops of dark grey porphyritic basalts are also found in the region. The inter-trappean beds are met with between the flows of basalts and consist of limestones, cherts and clays. The rocks of Vindhyan system consist of a succession of sandstones and shales with horizons of limestones and cover a large part of Sonar Sub basin. In the North, the basin is mainly occupied by Bundelkhand granite and alluvium. Some Palaeochannels have also been demarcated around Banda. While the Vindhyans form poor aquifers, ground water occurs in vesicular, jointed, fractured and weathered basalts. Weathered and fractured granites also form water bearing zones. The palaeo-channels and sandy zones within alluvium yield copious supplies of ground-water.

The Soils

Based on the preliminary studies by the National Bureau of Soil-Survey and Land-use Planning, ICAR, Nagpur, the soils of this region can be classified as follows :

a. Soils on hills and ridges

These are fine to coarse loamy, greyish brown to dark reddish brown, highly eroded, well drained, slightly acidic to neutral, stony and gravelly shallow soils, with low organic matter and poor water retention capacity.

b. Plateau Soils

These soils occupy eroded levels to gently undulating terrains. These are locally known as *Parua* and could be sub divided into three types:

Sub Group 1
* Loamy to fine
* Shallow to moderately deep
* Yellowish to reddish brown
* Slightly acidic to neutral with somewhat high base status.

Sub Group 2
* Fine loamy to fine
* Moderately eroded, moderately deep to deep
* Yellowish brown to reddish brown
* Base rich; slightly acidic to neutral
* With low organic matter
* Low water retention capacity

Group 3
* Occur in gently undulating landscape.
* Fine loamy to fine deep
* Brown to greyish brown
* Slight acidic to neutral
* Low in organic matter
* Moderate water retention capacity

c. Pediment Soils

These soils are shallow to deep, coarse to medium in texture and poor in nutrient status.

d. Soils of Inter-Plateau Basin

These are deep to very deep, fine loamy to fine, brown to dark brown, well drained to moderately well drained, Neutral to slightly alkaline, base rich, having low organic matter. High bulk density, and possess poor and somewhat high water retention capacity

e. Piedmont Plain Soils

These are very deep, moderately well drained, normally calcareous, yellowish brown, brownish to dark, greyish brown, fine loamy to clayey soils. They are base rich, neutrally to moderately alkaline, of low organic matter content, high bulk-density and possess high water retention capacity. These soils are locally known as *kabar* and *mar*.

f. Soils of alluvial plains and undulating old flood plains

These are deep to very deep, undulating, fine to fine loamy, well to moderately well drained, yellow brown to dark yellowish–greyish brown calcareous soils.

They are neutral to slightly alkaline, base rich and low in organic matter and have moderately high water retention capacity.

g. Soils of dissected flood plain

These are fine loamy yellowish, dark brown soils, with low organic matter, possess moderate water retention capacity and are susceptible to erosion.

Climate

The climate of the basin area is mainly semi-arid to dry sub-humid with hot summer and fairly cold winter.

The Rainfall

From the IMD-records (1931-60), about 91.5% of the total annual rainfall occurs from June to October. The maximum annual rainfall has been recorded for Sagar and the lowest for Hamirpur district. The Temperature recorded for (1931-60) in this basin at Nowgong and Banda give the maximum and minimum as 43.0°C at Banda and 7.5°C at Nowgong in the Month of May and December respectively.

The Wind Velocity

The data yielded by the observatories at Nowgong and Banda give the maximum 8.2 km/hr in June at Nowgong and 0.7 km/hr, in December at Banda.

4. FREE CATCHMENT AREA

Besides the three main basins of the Sind, the Betwa and the Ken forming the hydrometeorological sub zone : 1-c, there are three free catchments of Yamuna, (i) between Sind and Betwa basins, (ii) between Betwa and Ken Basins and (iii) east of Ken basin and North of Tons Sub basin.

These catchments comprise mainly *parts* of Jhansi, Jalaun, Hamirpur and Banda districts and are overlain by alluvium. These areas are similar to adjoining basins and therefore not separately discussed.

II

DIVISION - AND DISTRICT-WISE DATA

Since the region is politically split into two states, U.P. and M.P., it will be useful to present here the account division - and district-wise:

2.1.CHITRAKUT DIVISION:

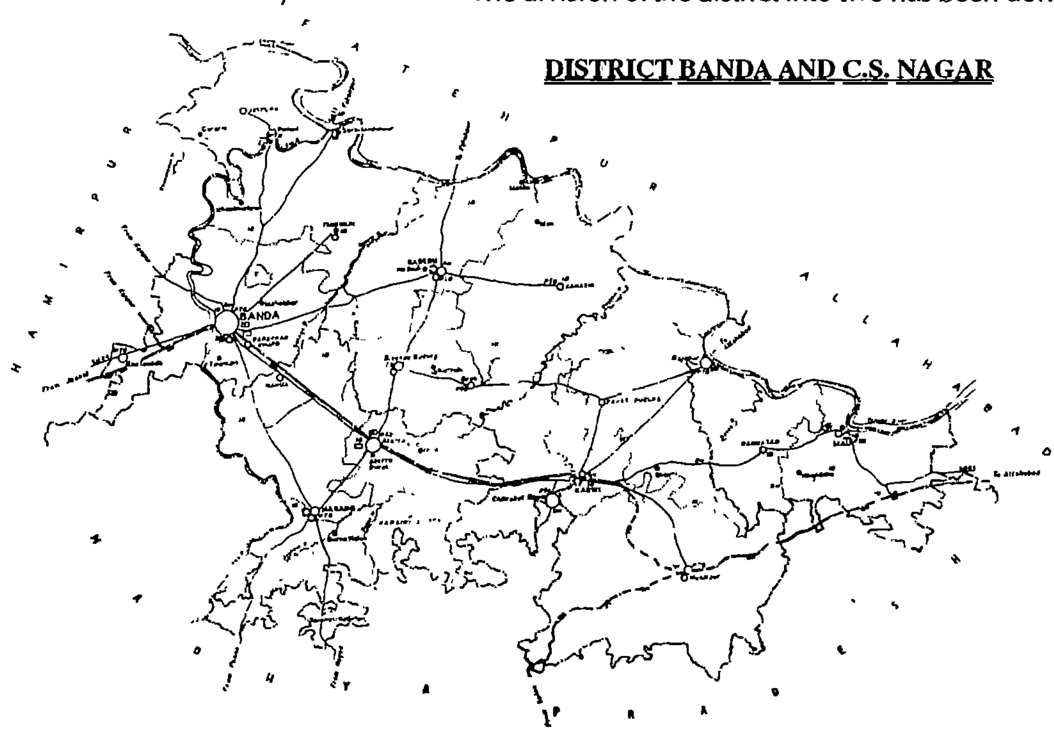
This comprises four districts namely Banda, C. Shahuji Maharaj Nagar, Hamirpur and Mahoba. Since this is a recently formed division separated from Jhansi division and also because the two districts Hamirpur and Banda have been split, recently into the present four districts, the statistics and information available officially deals with the parent districts only. We have the District Gazetteers published by the Govt. of U.P. for Banda (1981) and Hamirpur (1988) which give combined information about these districts.

District wise information is presented as follows:

2.1.1. BANDA district and the Recently Carved Out

C. Shahuji Maharaj Nagar:

This is the easternmost district of Bundelkhand. The division of the district into two has been done



by splitting Banda district, tehsil and block-wise. Karwi and Mau Tehsils lying in the eastern and south-eastern direction comprising the Manikpur, Mau, Pahadi, Chitrakut and Ramnagar blocks form the present C. Shahuji Maharaj Nagar district while the four Tehsils namely Banda, Naraini, Baberoo, and Atarra comprising eight blocks of Badokhar-Khurd, Jaspura, Tindwari, Naraini, Mahua, Baberoo, Bisanda, and Kamasin form the present district of Banda.

The erstwhile district of Banda lies between latitude 24° 53' and 24° 55' (north) and longitude 80° 27 and 81° 34' (east) with an area of 7,624 sq.km. The southern and south-eastern boundary of the district is made up of the plateau and the mountain of Vindhyas bordering on the districts of Rewa, Satna, and Panna. The northern boundary is entirely made up by Yamuna river which flows for nearly 215 km, separating it from Fatehpur and Allahabad districts. The western boundary of Banda touches Chhatarpur and Hamirpur districts separated by river Ken for certain distance.

A. PHYSICAL FEATURES:

TOPOGRAPHY:

The district largely consists of irregular uplands with outcrops of rocks intermingling with mostly lowlands, frequently under water during rainy season. The Baghein river traverses the district from south-west to north-east. The tract lying to the right of the river is intersected by numerous smaller rivers and rivulets (*Nallas*), but to its left is a flat expanse, for the most part made up of *Mar* and *Kabar* soils, eroded and converted into ravines along the banks of the Ken and the Yamuna and to a lesser extent, the Baghein river and the Gadara Nala (a perennial stream)[10].

The general slope of the district is from south-west to north-east, along with the course of Baghein river as mentioned earlier. The district falls into two sharply defined portions—one is upland called PATHA, situated on the Vindhyan plateau in the south of Mau and Karwi tehsils (presently known as C. Shahuji M.Nagar district), the other is lowlands of alluvium (presently known as Banda district.)

(i) THE UPLAND (*PATHA*)

Patha lying south and east of the first range of the Vindhyan hills covers about 10% of the total area of the combined Banda District. The soil is entirely disintegrated sandstone overlying a sub-stratum of rock and is never very deep. This tract has been largely under forests, which now stand almost denuded. Water is scarce, and unless it has been conserved in tanks, the inhabitants have often to go over long distances for their supplies. The productivity of the soil is less here and the life is difficult[1].

(ii) THE LOWLANDS;

This itself has three distinct zones:

a: The tract east of Baghein river:

This consists of lowlands of Mau and Karwi tehsils and south-eastern portion of Naraini tehsil. The general feature of this tract is succession of narrow doabs formed by numerous deep channelled streams that carry off the drainage of the hills to the Yamuna river and further west to river Baghein. Each Doab generally contains a complete section of Bundelkhand-soils. Between the streams lies a central plateau of *Mar* and *Kabar*. As this slopes down on either side, it changes to *Parua* (or *Singua*) and ultimately to *Rakar*. The main stream in this tract is Paisuni which along with the Baghein as well as the Yamuna, is flanked with unsightly ravines due to erosive action. The tract between the Paisuni-Yamuna confluence and the Baghein-Yamuna junction is very flood-prone, the whole region being uneven one, from which the surface soil is being constantly washed off except where it is held up by embankments.

b: Ken-Baghein Tract:

This is roughly triangular in shape, and is a gently sloping plain fringed along the river bank by ravines. The southern portion from Naraini to Atarra towards Yamuna river in Baberu tehsil is mostly *Kabar* soil or *Kabar-parua* mixed. To the north-west, this is succeeded by *Kabar* and then by *Mar*. The best soil is found in a level expanse of *Mar* to the north of Banda town; the quality deteriorates as it approaches Yamuna river. Usrah the most important drainage channel in the tract, has isolated the black soil of the Baberu sub-division where fairly extensive and numerous patches of *Mar* are found. The lighter soils in this tract are mostly due to excessive erosion.

The whole of this portion of the lowland is the most important part of the district, and owes its superiority to the course of Baghein which by flowing across the district from south-west to north-east has arrested all the drainage from the south and prevented the country to the north being cut up by the numerous streams found in the tract between that river and the Vindhyan scarp.

c. Trans-Ken Portion:

The trans-Ken portion of Banda tehsil lies on a generally higher level than the Cis-Ken portion. It has a slope from west to east and south to north. The soil is generally undulating and cut up by streams which flow into the Ken river from south-west to the north -east . Major streams are the Chandrawal, the Shiam, The Bichui and the Gawain. The part to the west of Mataundh is more level and contains some good black soil, but the whole is a precarious tract of country, heavily drained and poor in availability of water.

The villages along Yamuna river generally possess good alluvial soil. In the tract between Ken and Yamuna, lighter to rich fertile soils are found, but the bulk of the area is *Parua*, and much of this approaches closely the loam of the *doab*.

Hills:

The hills of the district consists of the part of the Vindhyan plateau which lies in the extreme southern portion of the tehsils Mau and Karwi (now known as the district C. Shahuji Maharaj Nagar).

The northern flank of the Vindhyas known as Vindhyachal range, starts near the Yamuna in the extreme east of tehsil Mau. It recedes from the Yamuna in a south-westerly direction-gradually rising in elevation, although nowhere above 450 metre from the mean sea level. It leaves the district near the sacred hills of Anusuiya to reappear at Godhrampur in the south-eastern part of Naraini tehsil. From this point westward to Kalinjer the hills form the border of the district.

The Panna range of the Vindhyas also touches Karwi tehsil's southern point. The difference between the Vindhyachal and Panna ranges lies in the nature of rock system. While Vindhyachal range consists of Kaimur sandstone, the Panna range consists of overlying upper Rewah sandstone. Both these sandstones are massive rocks of great thickness.

Sometimes as at Kalinjer hill, the Kaimur sandstone rests directly on Archaean genesis, but elsewhere, as near southern Karwi, there intervenes a group of sandstones, shales and limestones known as the lower Vindhyan series.

The most northerly of these hills in the district is situated at the village Pawaiyya in Baberu. Besides Kalinjer and Madfa, which are the detached portions of the main plateau, the best known of them are the Bambeswar hill at Banda town the Khattri Pahar near Seohnda, and the hill at Rasin, and the Chitrakut hill[1].

GEOLOGY;

The district forms part of the northern fringe of the peninsular India coming in contact with the Gangetic alluvium. It has an important place in the geology of the country owing to the presence of all precambrian rocks, probably right from the oldest ones in the Indian subcontinent, in a compact linear east-west stretch.

The major mineral wealth of Banda district consists of pyrophyllite and diaspore, glass sand, dolomite (the Tirohan limestone), clay and ochres, bauxite and agate etc.[1].

Pyrophyllite and Diaspore is a moderately soft mineral which is light in colour (pink,greyish-white, brownish black etc.) and is used in paints as filler, in paper industry, cosmetics ceramics and as pot-stone. It is also used in slate-pencil making and is called the pencil-stone. In this district this often is associated with diaspore occurring in the form of geode like bodies as shining crystals upto 30-35 mm in length used in high alumina refractory bricks alone or banded with flint plastic clay.

Glass-Sand: The deposits of this mineral near Bargarh in tehsil Mau and adjacent Shankargarh (Allahabad Distt.) are the best sources of glass-sands in India.

Dolomite: The deposits were investigated by surface and sub-surface means. The tirohan limestone forms extensive deposits located in the hill ranges 6.4 km to 8 km south-east of the rail-head at Karwi, extending from Gohra Nullahon the south-west to village Khoh (now a rail-station itself) on the north-east over a distance of about 13.5 km. The material is of a grade suitable for use in blast furnaces.

Clay and Ochres: The whiteware clays for which Banda is famous, are fine textured and are generally used as mixtures to increase the plasticity and strength. The material (clay) has been reported to possess pozzolanic character. Clay (lithomarge) with patches of red ochreous clay occurs associated with Rewah sand-stone. The Banda clay is tentatively considered to have resulted from the alteration of Vindhyan shales and other elastic materials. Red and yellow varieties of ochre are found in the area.

The largest clay deposit is located in Majhpura hills about 3.2 km South of Kusmi which is 6.4 km from Tikakria railway station. Clay occurs at a height of about 122 m from the base of the hill. The material is exceptionally reactive and is well suited for lime and cement industries. There are some other deposits also close by where deposits of china clay have also been found.

Bauxite: Deposits of Bauxite were found in Rajahavan area of the district.

Agate: Agate pebbles are found associated with gravels in the Ken river. The material is largely brought from the place of origin of the river and is used in making beautiful artistic items in the lapidary industry.

THE SOIL-EROSION IN THE DISTRICT:

The large number of rivers and streams in the district shows that the region suffers from over-drainage. The streams here have erosive tendency and therefore, large tract of ravines is apparent in this district. There are seven major watersheds in the district; each has a large catchment area which has been eroded. The figures of catchment areas and of the area affected by soil-erosion of each river in the district are given below.

S.NO.	NAME OF RIVER/ *Nallah*	CATCHMENT area (hect)	ERODED AREA (hect)
1.	Ken	2,30,000	1,47,000
2.	Baghein	3,60,000	2,65,000
3.	Paisuni	2,75,000	2,00,000
4.	Yamuna	5,17,000	4,08,000
5.	Gunta	1,95,000	1,20,000
6.	Bardaha	1,10,000	30,000
7.	Manda	35,000	30,000
	Total:	17,22,000	12,00,000

B. DRAINAGE AND WATER RESOURCES:

Entire drainage of Banda district is from south/ south-west to north/north-east. The rivers of the district belong to the Yamuna system, and consist of the Ken, Baghein, and Paisuni and their numerous tributaries. The central tract of Banda is also drained seasonally by the USRAH and GADARA *Nallahs.*

Although Banda and newly created C. Shahuji Maharaj Nagar (Chitrakut) districts have ponds in each village and town, there is no lake of any significance in this district. Banda city however, has had several ponds of repute like Nawab Tank built during Nawab's rule during early nineteenth century, Pragi Talab, Diggi Talab, Chhabi Talab, Kandhardas Tal and Parashuram Talab etc. The ponds have been integral to the culture of Bundelkhand and places like Rasin, Kalinjer, Karwi, Manikpur, and Baaberu etc. have large ponds along with temples which attract people of the area during festivals like KAJALIA, JAL VIHAR or DASHARA. The landscape of the district is such that ample water is stored in various places. Most ponds have been used for irrigation in the past but after the introduction of commercial fish culture in the ponds, these are rarely used for irrigation. The tanks of the towns like Atarra, Karwi, or Banda are slowly becoming the sewage-ponds and in many of them water hyacinth is on the increase depicting the polluting situation. Due importance to the tanks/ponds is not given by either the Government or the people.

Karwi, and Chitrakut have picturesque *BAVDIS* (step-wells), built during past centuries for the travellers and pilgrims, The wells have been the source of drinking water and sometimes for irrigating garden-crops, vegetables and sugarcanes. The wells also had religious importance like famous BHARAT-KUP, situated west of Chitrakut.

Some details of the rivers of this district are as follows:[1]

THE RIVERS:

Yamuna flowing north of the district, is the principal river attracting all the drainage of the district. For long this river had a general tendency of cutting the southern bank : this rendered many villages displaced and destructed. A famous village Shadipur near Chilla-ghat the head quarters of Pargana Pailani during Moghul time, is said to have been entirely swallowed by it. Flowing circuitously towards north, south and south-east directions Yamuna is joined by Ken at Chilla-ghat, Baghein near Bilas, and Paisuni near Kankota villages. Total length of this river in this tract is 215 km. of this 130 km lies with, Banda while the rest 85 km with C.S. Nagar district.

Ken rising in district Damoh, touches Banda near village Bilaharka in Naraini tehsil for about two km and then turns towards Chhatarpur district appearing again in the same tehsil. Then entering Banda tehsil near Utarandi village it flows north-east bordering distt. Hamirpur and then turns eastward to meet Yamuna at Chillaghat. On the whole it flows in a deep and well defined channel scoured out by the action of flood-waters which occasionally come down in enormous volumes. The right bank is generally high and steep, scarred with innumerable ravines, but the left bank slopes somewhat more gently, and is subject to a certain amount of fluvial action. From Pailani to its junction with Yamuna, the Ken is much affected by the stream of the larger river, which blocks occasionally its flow resulting in the swell of river water, submergence of even high-level villages and deposition of valuable silt in elevations which are normally above the flood-plains.

Chandrawal: This stream rises near a lake called Chandanwas in district Hamirpur and flows through the west of the trans-Ken portion of Tehsil Banda. It joins the Ken near Pailani-khas village.

Other tributaries of Ken are the Shiam, the Kel, the Bichhui, and the Gawain with a large number of smaller rainy-seasonal drainage channels including the *Turi Nallah.*

Baghein: This is the second important river of this district. Emanating from a hill near Kohari of

Panna district, it enters Banda district at Masauni Bharatpur village (teh: Naraini). It flows north-east-ward and at a point separates Banda from the newly created C.S. Nagar district forming boundaries between Atarra, Baberu and Karwi tehsils. Continuing north-east it joins Yamuna near Bilas village. It, being most capricious in its action, deposits comparatively little alluvial soil, and often deposits quantities of sand or *kankar* shingles, but near its junction with Yamuna it tends to flood a large area of low lying land, if the stream in the Yamuna is sufficient to block its outlet.

The chief tributary of Baghein, the Ranj, joins it at Gurha Kalan (tehsil:Naraini) but further east, there are several smaller tributaries from south namely the Madrar, the Barar, the Karehli, the Banganga and the Barua, each of which in turn has tributaries of its own. The Barua has been dammed to provide some irrigation through canals.

Paisuni: Rising in the adjacent district of Satna in M.P., Paisuni touches this district at Itawan Dundaila village and flows due north separating the district from the state of M.P. for some 25 km. At the village of Mangawan it falls from the Vindhyan plateau in two fine cascades, separated by a deep pool about 50 m long. The lower pool which is always filled with clear, translucent water, is said to be very deep. This is associated with the legendary demon VIRADH associated with *Ramayan*. There is another remarkable cavity in the rock, 1.5 km from this river in the village of Tikariya-Jamanhai known as Viradh-kund associated with the same legend. The water has excavated some remarkable pot holes in the rock, but the falls are spectacular only during the rains. From this point it enters the famous pilgrim centre Chitrakut associated with Lord Rama's exile. It flows north-east almost parallel to Baghein for some distance, then takes a turn to join Yamuna near village Kankota. On the left bank a *Nallah* named Kuthar joins Paisuni near Sitapur while on the right bank this river is met with the Sarbhang, the Karibarar, and the Hira Kotra streams and the river Chan.

Chan: This stream rises in the upland below the Patha proper, on which villages Rukma and Dadari are situated. It flows in shallow bed, srewn with boulders, as far as the village of Semardaha, and continues between steep banks lined with the usual ravines to its junction with the Paisuni at Sagwara (Tehsil: Karwi). With the denudation of the forest, this stream has become mostly seasonal these days.

Bardaha: This stream flows from the highlands of Rewah in the south-east corner of Karwi tehsil and after a short course in this district flows out eastwards towards Rewah district again. It is chiefly noticeable for the falls of Bedhak above the village of Nihi and at Abarkan and Dharkund above Kalyanpur. This river has been dammed in *Patha* to provide irrigation to some area through canals. The denudation of the forests has influenced this river as well as the dam. The problem of loss due to seepage has also been reported.

Garara: This is almost a perennial stream draining off the central tract of Banda district. Rising at two places—one near the village Jamrehi and the other at Adhrauri, the two streams join near Murwal (Baberu Tehsil) and then flow due north to join Yamuna near Jalalpur. It consists of deep pools alternating with shallow rapids. *Underground water resource* also helps this stream to flow. Before joining Yamuna this is met with two tributary *Nallahs* —USRAH from the west and MATIYARA from the east.

In addition to these larger streams, there are the Gunta with its tributary Jeevanti, the Satetha, the Khursaha with its tributary the Aunjha, the Bangawa and the Bareri with its tributary the Hagni, all in tehsil Mau and numerous Nallahs joining one or the other of these larger streams, which have scoured the face of the district on all sides. The ohan river has already been dammed for irrigating some area while the Gunta is in the process of damming.

B.1. SITUATION OF DRINKING WATER :

Almost in all villages, the traditional wells have been the major source of drinking water except for few places where ponds/tanks were used for the purpose. The rivers of this district have been the least polluted because of the continuance of traditional i.e. chemical avoiding agriculture and the lack of polluting industries.

A major Govt. project in this district was initiated as Patha Drinking water scheme. Inaugurated in 1973 by the then Prime Minister, Smt. Gandhi it was purported to reach water to the most problematic villages of Patha area in Karwi and Mau tehsils. This ambitious scheme in spite of big budget, has failed to accomplish its goals even upto this day, because of several factors including lack of will.

The drinking water schemes — whether for the piped supply from borewells/tubewells through overhead tanks or for putting the India Mark II handpumps — were planned without consulting the people and taking them into confidence.

For the past twenty years tube-wells have been bored all over the district without control which has affected the normal drinking water wells of the villages. Necessity for the installation of the deep tube-well associated handpumps had been created by the indiscriminate exploitation of ground water for irrigation.

THE INFORMATION PROVIDED BY JAL-NIGAM (1996) IS AS FOLLOWS:

1. Drinking water situation and Sewage Disposal system in urban area:

a. Urban Drinking Water Situation (already operating)

S.NO.	PLACE	DESIGN YEAR (POPULATION)	MAIN SOURCE	HANDPUMPS	SCHEME/CONTROL
1.	Banda*	2010(1,36,000)	TW-09/Ken river	272	Several/JS
2.	Karwi	2000(23,000)	Paisuni river	51	PATHA/JS
3.	Atarra	2007(26,570)	TW-03	38	/JS
4.	Baberu	2009(14,000)	TW-02	30	/JS
5.	Oran	2008	TW-02	16	VDWS/JS
6.	Naraini	1995(7,500)	TW-01	26	/JS
7.	Manikpur	2000(7,335)	TW-01/Paisuni /Ohan	46	PATHA/JS
8.	Rajapur	1985(8,000)	TW-04	29	VDWS/JS
9.	Bisanda	2016(16,000)	TW-01	32	
10.	Mataundh	-	Ken-river	22	/IS
11.	Tindwari	2009(6,675)	TW-01	34	VDWS/IS

* The discharge from the tubewells is decreasing gradually; another scheme of tapping Ken river- water is under construction.

$ One more tubewell bored at Tindwari has not been operated so far.

#PATHA DRINKING WATER SUPPLY SCHEME: This scheme was planned for a population of 1,84,096 covering two towns and 250 villages (including hamlets) with an initial cost of nearly Rs.197 lakh. It was modified twice with additional cost of nearly Rs.130 lakh installing also 97 handpumps in town and 673 handpumps in villages; yet officially the benefit has gone to only two towns and 169 villages (including hamlets) only.

b. Urban water supply (under review or construction)

S.NO.	PLACE	DESIGN YEAR/ POPULATION	SOURCE TW/R	O/H TANKS	H.P.	REMARKS
1a.	Banda	2010/1,36,000	TW-14	04+3 CWR	272	
b.	Banda(II)	2022	-do-	-do-	-do-	10 med treatment plant to be added
2.	Mataundh	2021/13,600	TW-2+ Ken river	01	22	
3	Naraini	2021/18,625	TW-2	01	26	yet to complete
4.	Rajapur	2006/17000	TW-2	01	29	
5	Oran	2021/11,600	TW-2	01	16	

2. Rural Drinking Water Supply Schemes

a. *Under Operation:*

S.NO.	NAME OF SCHEME	VILLAGES	SOURCE	O/H TANKS	H.P.	REMARKS
1	PATHA-area Drinking Water Scheme	103 villages+ 2 towns	Paisuni river+ Ohan *Nallah*	86+ 12CWR	770	insufficient
2.	Bargarh	38	TW-1	13+ 02CWR	199	
3.	Mau A	04	TW-3	04	40	
	B	11	TW-2	07	49	TW'S have failed
	C	07	TW-1	05	22	
4	Mau D	16	TW-1	12	56	
5.	Oran	05	TW-2	05	103	
6	Berraon	12	TW-2	10	66	
7.	Kamasin	07	TW-2	07	86	
8.	Pahadi	07	Paisuni river	04	52	
9	Sursen	02	TW-1	02	15	
10	Rajapur	09	TW-4	01	75	insufficient
11	Tindwari	20	TW-2	14	202	insufficient for villages
12.	Barethi-Kalan	17	TW-2	12	110	
13	Nivaich	09	TW-2	01	60	

b. *Under Construction/almost Complete:*

S.NO.	NAME OF SCHEME	VILLAGES COVERED	DESIGN YEAR/ POPULATION	SOURCE TW/R	H.P NO.	REMARKS AS REPORTED
1	Kanakheda	17+3 hamlets	2000/29,850	TW-1	96	TW diminishing discharge
2	Jaspura	12	2011/34,900	TW-2	109	almost complete
3	Khandeh*	14	2010/52,600	Ken river	56	the scheme still not complete
4	Murwal	29	2011/43,280	TW-2	117	almost complete
5	Bilgaon	18	2011/	TW-2	120	- do -
6	Patwan	13	2011/27,620	TW-2	127	yet to complete
7	Bhabhua	14	2016	TW-2	103	almost complete
8	Augasi	08	2011/17640	TW-2	144	- do -
9.	Khaptiha-kalan	23	2011/48,500	TW-2	157	- do -
10	Sanda Sani	16	2011/26,500	TW-3	111	- do -
11	Karaundi-kalan	08	2000/7,240	TW-2	22	- do -
12	Turra-Badausa	05 +3 hamlets	2005/21,300	TW-2	168	yet to complete
13	Vindhyavasini	04	2010/5,273	TW-2	30	- do -
14	Kalinjer	02	2010/3,652	TW-2	11	- do -

3. Blockwise distribution of Hand-Pumps

S.N.	BLOCK	VILLAGES	INSTALLED H.P.
1.	Badokhar	76	781
2.	Baberu	79	936
3	Bisanda	57	859
4	Jaspura	45	433
5	Kamasin	75	775
6	Mahua	118	1106
7.	Naraini	128	1444
8	Tindwari	75	623
9.	Chitrakut	128	766
10.	Manikpur	108	709
11.	Mau	100	515
12	Pahadi	123	864
13.	Ramnagar	73	424
	Total in villages:		10,235
	Total in towns:		504
	Grand total		10,739

B.2. SITUATION OF IRRIGATION IN THE DISTRICT :

As reported, the traditional irrigation in this district was through the ponds and wells especially made for the purpose, particularly for the crops of vegetables, sugarcane, and horticulture. The water was lifted by the bullock-power using the leather bag and rope system. A report of 1902 gives the number of wells as being 1133 masonry as well as 259 semi-masonry and 131 *Katchcha* dugwells. The maximum wells were recorded in Girvan area, numbering 394 while the minimum around Mau numbering 57 only. The construction of bigger embankments (bandhan) and individual field embankment (bandhi) has been the traditional system in Banda for water for Kharif and moisture for especially the winter crops. The indigenous mode of lifting water from a lower level through swing baskets, locally named *Beri, Banka, dugla,* or *dauri* has been very common.

Existence of numerous rivers and rivulets in the district attracted attention of the Govt. for initiating several projects which could provide irrigation facility to farmers. The different sources of irrigation developed during these years have been summarized in the following pages.

The present situation of the Irrigation-Resources:

a. The information regarding the resources (1993-94)

S.NO.	RESOURCE/MEANS	LENGTH	NUMBER	AREA
1	Canals	1804 km	-	-
2.	Tubewells (Govt.)	-	397	-
3	Masonry wells	-	6,768	-
4	Persian wheels	-	3,225	-
5.	Pumping-set (surface water)	4,447	-	
	pumping set (on boarings):	8,994	-	
6	Tubewells (pvt)		2,074	-
7	Embankments (pvt)*	-	-	45,493

*figures for 1992-93 available

b. Resource wise irrigated area (1992-93) are as follows:

S.NO.	PARTICULARS	AREA (HECTARE)
1	Net sown area:	6,02,112
2	Total irrigated area:	1,87,851
3	Net Irrigated area:	1,39,675
	Area according to irrigation sources.	
	Canals.	96,701
	Tubewells (Govt)	9,135
	Tubewell (Pvt)	11,386
	Wells	9,004
	Ponds	1,890
	Other sources	11,559

Source: Sankhyikiya Patrika, Distt Banda, State planning Inst. U P (1994)

c. The Total Availability of Surface Water in the district:*

The study of the past twenty years discharge figures at the Banda gauge and discharge site and taking 75% of its base has given a figure of 0.195 million cubic metre per sq km. of the available surface water in this district. The total surface water thus available in the district is 1,487 million cubic metre. The total available ground water has been calculated block-wise by the Ground Water department which comes out to be 950 million cubic metre while the present draft is nearly 168 million cubic metre.

The need of water if one thinks of 100% irrigation in the district is 3,385.47 million cubic metre which is much beyond present availability of all water from all sources.

*based on information provided by the Irrigation Deptt., Banda District

d. THE CANALS:

Ken canal system for Banda was envisaged in 1870-75 which was taken up sometime in 1900 by initiating construction of a weir at Bariarpur (Panna district) over river Ken. The canal system to provide irrigation to the central tract of Banda district was organised by constructing canals connected to this weir. Another weir with large capacity was again built at Gangau in Chhatarpur district in 1915 in order to feed the Ken-canal system. Later in 1950 a dam was constructed at Rangawa on Banne river, a tributary of Ken, in order to meet the needs of the Ken canal system.

Some more reservoirs/water bodies were developed in this district at Kanwara, Panchampur, Murwal, Lama, Paprenda, Atrahat, Deoratha, Ohan, Barua, Bagehta, and Bahadurpur etc.

A few pump-canals were also planned and erected after 1968-69 around the rivers for the areas where irrigation was otherwise impossible. These are detailed further in this chapter.

The capacities of the above mentioned canals and pump-canals are as follows:

1. Working Systems:

S.NO.	NAME OF THE PROJECT	CATCHMENT AREA (SQ.KM)	TOTAL CAPACITY (M CM)	AVAILABLE CAPACITY (M CM)	PROPOSED IRRIGATED AREA (HECTARE)
1.	Ganga	18,637	56.43	56.43	-
2	Rangawan	828	164.14	155.08	1,11,800
3	Bariyarpur	20,760	12.59	12.59	-
4	Ohan	141.09	10.02	9.45	6,613
5	Barua	113.91	24 9	23 26	5,463
6.	Tanks/Embankments.	213.82	79.88	75 19	20,418
7.	Pump canals	-	16.63 cm/sec	-	35,726

2. The Projects under Construction or Proposed:

S.NO.	NAME OF THE PROJECT	CATCHMENT AREA AREA (SQ.KM)	TOTAL CAPACITY (M CM)	AVAILABLE CAPACITY (M CM)	PROPOSED IRRIGATED AREA (HECTARE)
1	Gunta-dam	168.5	28.8	24 5	3,880
2.	Bardaha-dam	44 55	7.84	7.375	974
3	Masauni pump canal	0 71cm/sec.	-	-	510
4	Rasin Dam	14,051	15 67	13.13	3,030
5	Baghein	1,533 3	127.35	86,37	11,420
6.	Greater-Gangau	18,637	724 48	724.48	1,49,.737
7.,	Paisuni canal	288	-	-	3,302
8 ,	Chillimal P.C. Extension	8.49 cm/s	-	-	13,712
9	Rajapur P.C Extension	2 25 c.m./s	-	-	6,207

3. The state of the Reservoirs used for irrigation purpose in the district:

S.NO.	NAME	D.S.L. (FT)	CREST LEVEL (FT)	P.S.L (FT)	MAX. AVAILABLE CAPACITY (M C.M.)
1.	Gangau	690	733	741	1,994
2	Rangawa	721	750	765	5,480
3.	Bariarpur	596	607	615	445
4.	Ohan	515 5	551	561	1,334
5	Barua	452	466	481	822

4. The status of the Canals:

S.NO.	NAME OF THE CANAL	DISCHARGE (CUSEC)
1	Main Ken canal	2,100
2.	Banda Branch	670
3	Atarra Branch	1,545
4	Baberu Disty	381
5.	Ohan canal	135
6.	Barua canal	180

*source of information: Deptt. of Irrigation, Banda Director.

5. The Pump Canals:

S.NO	PLACE	YEAR OF COMMEN-CEMENT	SOURCE	CAPACITY (CUSEC)	PROPOSED IRRIGATION (HECT)	ACTUAL IRRIGATI-ON (HECT)
1	Sonepur	1972	Paisuni R	5.0	324	246
2	Tiiveni	1979	Ken R	7.5	534	236
3,	Chillimal	1976	Yamuna R	120.0	8,939	1,349
4	Oia	1979	Baghein	25 0	2,135	424
5	Rajapui	1969	Yamuna	50 0	4,455	848
6	Sirawal-Maufi	1976	Yamuna	30.0	2,072	443
7	Guihakalan	1975	Baghein	30.0	2,116	728
8	Kanwara	1968	ken	15.0	1,090	375
9	Alona	1976	Ken	15,0	3,505	424
10	Pashchim Patai	1985	Yamuna	5.0	284	113
11	Madanpur	1969	Yamuna	20.0	1,223	464
12	Daulatpur	1990	Ken	20.0	932	305
13	Jauharpur	1971	Yamuna	40.0	3,239	283
14	Augasi	1981	Yamuna	150 0	12,692	3,116
15	Bankat	1969	Paisuni	10.0	778	717
16	Lamiyari	1990	Baghein	5.0	526	236
17	Lohda	1988	Paisuni	5 0	286	476

e. THE MINOR IRRIGATION;

The responsibility of building check-dams and boring deep tubewells has been entrusted to the Deptt. of Minor Irrigation in Uttar Pradesh.

Following are some information pertaining to these as supplied by this department :

a. The Dev-Block-wise irrigation capacity of the Check-dams:

S.NO.	BLOCK	CHECK-DAMS (NO.)	IRRIGATION CAPACITY (HECTARE)				TOTAL (HA)
			90-91	91-92	92-93	93-94	
1	Badokhar	09	75	110	135	30	350
2	Baberu	-	-	-	-	-	-
3.	Bisanda	-	-	-	-	-	-
4	Jaspura	02	-	40	-	50	90
5.	Kamasin	-	-	-	-	-	-
6	Mahua	01	-	30	-	-	30
7	Naraini	06	80	100	40	50	270
8	Tindwari	03	45	-	-	45	90
9	Chitrakut	08	35	115	160	50	360
10	Manikpur	13	-	225	240	150	615
11	Mau	08	-	265	-	125	390
12	Pahadi	01	-	-	-	50	50
13	Ramnagar	01	-	-	-	45	45
	total	52	235	885	575	595	2,290

b. The Check-dams constructed after 1995

S NO	BLOCK	PLACE	IRRIGATION CAPACITY
1	Badokhai	Mohanpurwa	40 acre
2.	Baberu	Aliha	40 hectare
3	Jaspura	Amara	45 acre
4	Kamasin	Bankat	40 acre
5.	Naraini	Gahbara	40 acre
6	Tindwari	Khaunda	40 acre
7	Chitrakut	Khutha	40 acre
8	Manikpur	Vamila	40 hectare
9	Mau	Bhanakwar	40 hectare
10	Pahadi	Dadiya	40 hectare
11	Ramnagar	Rampuriya	40 acre

c. The Govt. Tubewells:

YEAR	WORKING TUBEWELLS (NO.)		TOTAL AGRICULTURAL IRRIGABLE AREA (HECT)		ACTUAL IRRIGATED AREA (HECT)	
	KHARIF	RABI	KHARIF	RABI	KHARIF	RABI
1990-91	317	319	31,700	31,900	487	13,448
1991-92	331	385	33,100	38,500	527	17,981
1992-93	390	395	39,000	39,500	620	9,506
1993-94	395	395	39,500	39,500	1,270	12,086
1994-95	397	397	39,700	39,700	773	15,470

d. Deep Tubewells of Farmers (pvt) installed by the Deptt. after 1982:

S NO.	DEV-BLOCK	VILLAGE	IRRIGATING CAPACITY	COST (RS.)
1	Badokhar	Tindwara	12 hectare	1.00 lakh
2	Baberu	Bhabhua	-do-	1.25 lakh
3	Bisanda	Bisanda	-do-	1 00 lakh
4	Kamasin	Pannah	-do-	1 25 lakh
5	Mahua	Ajitpur	-do-	1.00 lakh
6	Tindwari	Moongus	-do-	1.10 lakh
7	Chitrakut	Ranipur Bhatt	-do-	1 10 lakh

The minor irrigation data available upto March 1996 for Banda district is as follows:

a.	Total Area :	7,78,170 ha
b.	Cultivated area :	4,98,047 ha
c.	Irrigated by M.I. works	1,43,260 ha
d.	Minor Irrigation Works (no.)	
1.	Wells	10,128
2.	Persian wheels	3,225
3.	Surface-pumpsets	8,699
4.	Pumpsets on borings	9,422
5.	Deep tubewells	702
6.	Artesian wells	-
7.	Free borings	5,888
8	Private tube wells	1,399

Source . Progress report of Minor-Irrigation Programme (Jhansi divison) oct. 1996

C. THE VEGETATION:

THE FORESTS:

The south-eastern Banda which is now under new name of the district C. Shahuji Maharaj Nagar as well as the southern Banda had been a dense forest along the Vindhyachal range of hills. Half a century back, it was full of diverse variety of trees, bushes and herbs.

Except for the Marraiyan forest block with a small SAL-belt and Riparian fringing forest, the flora of the district has been characterised by northern tropical dry deciduous vegetative growth and the species were capable of sustaining on low rainfall. The forest area of the district under the Govt. Forest Department is about 76,997 hectares. The Forest department claims to have scientifically well managed the forest during the last 100 years but these were the years when entire forest has been cut, and sold out. The regeneration has been poor; and even the reserved forests had been denuded systematically. The condition of Ranipur sanctuary falling in this area is also far from satisfactory.

In the forest tract of Mau and Karwi tehsils, the thinness of the top-soil has not been conductive to allow regeneration of trees either of great height or large girth. The chief trees found abundantly were then Babul, Karaunda, Kareel, Rian, Charail, Mahua, Hingota, Sahjana and Palash around ravines, and Mahua, Z, Saj, Tendu, Khair, Achar, Haldu, Tinsa ,Bamboo and Sal in the Patha tract. The availability of these trees in the same area is difficult now. Entire Baberu Tehsil which was abundant in the growth of Palash is now barren so far as trees are concerned. What one sees for miles, is either plain land or Babul trees which the farmers have grown for making their agricultural implements or burning the bricks. Kalinjer and Marfa were famous for their pasture grounds over the hills extensively used by the farmers of this district.

The Kans as weed has been very common on the black soils. Markundi range has been a good fodder-growing tract, yielding *Musel*, a sweet scented species of anthisteria (Iseilema laxum). On light soils Jharber (Zyzyphus nummularia) grows in great profusion. *Mahua* has been an important tree of this tract which was not cut because of the value of its flowers and fruits capable of sustaining villagers' life. *Aonla* and herbs of many kinds were grown in the forests near Chitrakut, Marfa, Kolhua, and Kalinjer.

This forest has been quite rich in minor forest produce, but the policy of handing over the forest to the contractors and then to the State Forest Corporation for its commercial exploitation has taken this common property resource out of reach of the common man and thus the natural protection and regeneration which the villagers and the tribals used to give a century ago was totally lost, resulting in the denudation of the forest. The policies framed by the British administration towards economic exploitation of the forests was continued even after 1947 setting aside the guideline of maintaining ecological balance by preserving a minimum of 33% forest cover over the land.

Atkinson[4] in his report has given an extensive list of the indigenous medicinal plants, crops and vegetables grown and used in Banda district. The District Gazetteer of Banda (1981) also details about 95 types of trees, 32 kinds of herbs and shrubs, 18 kinds of climbers and 20 types of grasses found in Banda district. (See Appendix D).

AGRICULTURE:

The economy of Banda district is based mainly on agriculture. The soils here are mostly fertile and inspite of many projects of irrigation as seen in the previous pages, the uncertainty of irrigation and its dependence on rains has made this tract adopt mostly the traditional farming,. This is one area where despite the Govt's push for hybrid seeds and commercial agriculture and despite several droughts and floods which affect the seeds most, the farmers have been able to save some of their traditional seeds.

There are two main crops: *Kharif* and *Rabi*; the one between July and October and the other between November and March. The old records in the imperial gazetteer or the district gazetteer mentions cotton as one of the major crops here. But that has vanished now. The main crops grown presently are as follows:

Kharif: Paddy, Jowar, Bajra, Til, Moong, Urd, Arhar, and Sanai are the main crops taken these days. Paddy is normally taken as mono crop while others are mixed sown. 100 years ago cotton was taken as a mixed crop along with other crops in Kharif. Presently Government is pushing Soyabean replacing all other Kharif crops. *This tendency ultimately will starve this district.*

Rabi : Wheat, barley along with gram, linseed, mustard, Masoor and Peas are the major crops. There is a tendency for mixed cropping. and regional variation in choices of the crops depending upon the geographical situation and the availability of irrigation.

The **Zaid**-crops i.e. the third crops are usually taken in the river beds; that includes *Kakri, Tarbooj* (water melon), *Kharbooja* and some vegetables.

The figure regarding the area under different crops and the agricultural production is given as follows:

a. Area under different crops, Irrigation Situation and Average Yields (1992-93)

S.NO.	CROP	AREA COVERED (HEC)	IRRIGATED AREA (HEC)	AVERAGE YIELD (QUINTAL/HECT)
KHARIF				
1	Paddy	74,888	62,131	10 63
2.	Juwar	76,166	-	7.50
3	Bajra	12,451	-	7.32
4	Urd	2,040	27	4 09
5.	Moong	1,312	09	2 80
6	Arhar	29,371	-	13 08
7	Til	1,161	-	1.39
8	Sanai	1,269	-	5.05
9	Soyabean	1,614	205	6 54
RABI				
1	Wheat	1,85,936	1,19,765	13.24
2	Barley	8,839	290	14.12
3	Masoor	36,945	29	8.27
4.	Chana (gram)	1,46,884	2,253	7.39
5	Matar (peas)	533	45	12 24
6.	Mustard	4,163	374	5 29
7.	Linseed	6,958	19	3.37
OTHERS				
1	Ground-nut	171	05	9 74
2	Sugar-cane	829	799	362.55
3	Potato	309	292	147.08

Many crops like maize, Sawa, Kodo, Kakun, Kutki,Moth, castor and tobacco etc., being less popular have not been included in the list

b. Total production of major crops in 1990-91 to 1992-93

S.NO	CROPS	Production in (m. tonne)		
		1990-91	1991-92	1992-93
KHARIF				
1	Paddy	81,335	53,530	79,603
2	Juwar	64,964	41,851	57,131
3.	Bajra	10,432	7,896	9,115
4.	Urd	247	340	834
5.	Moong	179	204	369
6	Arhar	47,968	25,283	38,422
7	Til	178	86	161
RABI				
1.	Wheat	2,20,656	2,06,408	2,46,213
2.	Barley	13,557	131,624	12,483
3	Gram	1,25,199	80,003	1,16,541
4	Peas	854	953	652
5	Masoor	25,281	20,134	30,554
6	Linseed	4,534	2,108	2,414
7.	Mustard	2,188	2,031	2,205
OTHERS				
1	Ground-nut	223	188	167
2.	Sugar cane	22,749	29,780	30,055
3.	Potato	6,165	5,455	4,545
4	Sanai (hemp)	580	522	641
5	Soyabean	318	382	1,055

Information on agri production has been taken from District Statistics booklet published by *Artha Evam Sankhyadhikari*, Banda (1994)

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY:

The climate of the district is characterised by hot summer, pleasant monsoon and cold seasons. Although there are mainly three seasons, namely summer (March-June), rains (July to September) and winter (October -February), yet the months October and November are essentially transitional months with moderate temperature[10].

A century ago, the situation which was remarkably different from the present day are pointed below: (Atkinson 1874)

* The hot winds during summer-season were distinguished by two peculiarities:
  a. The absence — or extreme rareness — of dust-storms
  b. The exceeding purity and transparency of the atmosphere during a greater part of that season, especially in the afternoons.
* The cold was less intense in the cold season, frost being rare except in the moist land adjoining the rivers.

The above situation is quite different now. That may be attributed to the environmental disbalance which has taken place in the past few decades.

Temperature:

Meteorological observations are taken only at one place at Banda, in whole of the district. The detailed account of the temperature recorded at Banda between 1950 and 1974 are summarized below:

Month	Mean daily max.temp. °C	Mean daily min.temp. °C	Highest max. temp./date	Lowest min temp./date
January	23.7	9.6	32.4 (10/1/64)	0 6 (18/1/62)
February	27 9	11 8	35.6 (28/2/56)	3.3 (12/2/50)
March	34 1	17 3	41.1 (25/3/53)	9 6 (12/3/64)
April	39.5	22.8	45 0 (30/4/61)	13 1 (9/4/63)
May	43.0	28.0	47 8 (9/5/50)	17.2 (13/5/64)
June	40 8	29.4	48.6 (8/6/66)	21.0 (14/6/62)
July	34 0	26.4	44.5 (12/7/65)	20.6 (18/7/63)
August	32.1	25 6	40.1 (17/8/65)	20.1 (30/9/63)
September	33.1	24.8	37 8 (25/9/51)	18 0 (30/9/63)
October	32.8	20 4	38.7 (7/10/65)	13 2 (28/10/57)
November	29.2	12.9	36.0 (4/11/65)	6.1 (30/11/50)
December	25.2	9.6	31.1 (15/12/59)	0.8 (27/12/61)

1. The maximum and minimum temperature for 1991-92 were reported as 47.8°C and 4.6°C respectively. *This huge differential between the maximum and the minimum was unimaginable earlier.*

2. The recorded data of the last twenty years could not be available, but the day temperature on 14, 15th June 1995 certainly crossed 52°C. The day recorded maximum no. of sun-stroke deaths as reported in newspapers.

Rainfall

Records of rainfall are available from 9 raingauge stations namely Banda, Pailani, Girwan, Baberu, Badausa, Kamasin, Karwi, Mau, and Manikpur for period ranging from 44 to 97 years. The summarised average data of the rainfall for Banda district between 1901 and 1950 as reported in the Distt. Gazetteer (10) are given below:

Annual Average : **Maximum rainfall:** **Minimum rainfall:**	**946.2 mm :**	**Day of Rains: 44.4** **140% in 1919** **52% in 1918**
Month	**Rainfall (mm)**	**Average days rains > 2.5 mm**
January	14.7	1 3
February	15.7	1.3
March	6.7	0.7
April	4.6	0.4
May	6.9	0.7
June	73 3	3.7
July	300.7	12 9
August	309.0	15.6
September	168.3	7.4
October	32.8	1.4
November	7.5	0 5
December	6.0	0.5

The Winds:

Winds generally start being felt around the month of February with the advent of *Vasant* (spring) season, which go on increasing till June when there is rain from the south-west monsoon. From April to June the winds go on getting hotter and drier, till it rains. May and June are very dangerous months so far as the temperature of winds is concerned. Many deaths occur due to sun-stroke during these months. Incidentally these are the months when there is harvesting as well as marriage season and most village people generally are out in the field, or roads. The wind during summers is generally from western direction but any moment of eastern wind called PURWAI brings humidity in the atmosphere and is not liked by the farmers when they are busy harvesting foodgrains.

The annual month-wise and wind-speed in km/hr for the district is given in a table shown ahead.

The Humidity:

The relative humidity is higher during south-west monsoon season, generally exceeding 70%. Thereafter, the humidity decreases progressively and by summers the atmosphere is hot and dry. In the table the relative humidity is shown month-wise:

MONTH	MEAN WIND SPEED KM/HR	RELATIVE HUMIDITY (%) 8.30 AM	5.30 PM
January	1 6	76	57
February	2.1	62	41
March	3.0	48	31
April	3.5	35	23
May	4.2	35	25
June	4.7	54	44
July	2.9	83	76
August	2.4	88	82
September	2.0	80	74
October	1.7	69	59
November	0.7	61	49
December	0.7	73	58
Annual		64	52

The Cloudiness:

During the monsoon season, the skies are heavily clouded or overcast. Cloudy skies also prevail for a few days in association with western disturbances in the cold season. The disbalance in the environment for several factors cause clouds or even most untimely rains these days.

Special Weather Phenomena:

Storms and depressions during the early part of the south-west monsoon, originating at the Bay of Bengal move across the country affecting this tract and also cause wide-spread rains. Similar disturbances are also felt in the cold season. Occasional dust-storms occur during the summer season. Rains are generally associated with thunder. During the winter season, the occurence of fog sometimes continues for days together.

2.1.2 HAMIRPUR along with MAHOBA

Hamirpur alongwith Mahoba, the district newly formed out of Hamirpur, lies between latitude 25°7' and 26°7' (north) and longitude 79°17' and 80°21' (east). Yamuna river forms its northern border while it is bounded by chhatarpur and Tikamgarh districts in south, Banda district in the east and Jhansi and Jalaun districts in the west. Combined Hamirpur district has an area of 7,165 sq.km.

A. PHYSICAL FEATURES:

TOPOGRAPHY;

The district has all the distinct features of the Bundelkhand region. In the south numerous outcrops of gneiss rocks, tending to cluster into low ranges, surrounded by uneven broken tracts and covered for the most part with stunted jungles, are succeeded by a more level tract in which the hills grow sparser. At the base of these hills lie the villages which they have partly helped to form and in many places, large and artificially formed lakes[11].

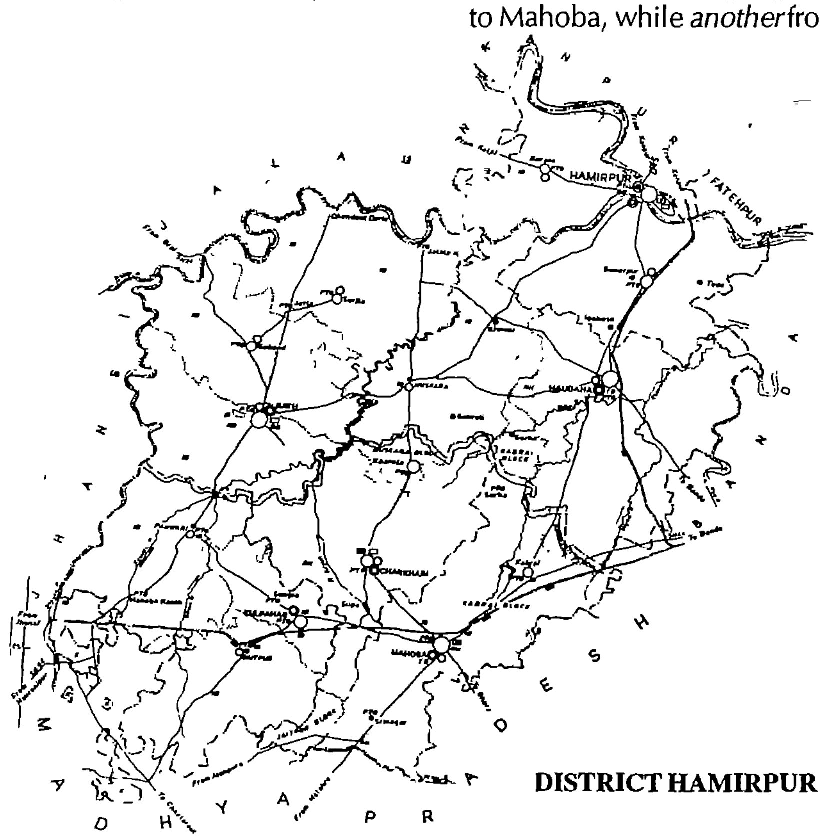
From them stretches northward the alluvial plain as far as the Yamuna river, differing from the familiar *doab* aspect only in its treelessness, paucity of villages and predominance of waste land. The three southern tehsils — Charkhari, Kulpahar, and Mahoba (this is the area which has been separated as Mahoba district in 1995) may fairly be described as hilly tracts though the rocky outcrops seldom exceed 100 or 130m above the land at their base.

To the north of town of Rath, no hills are found and there is nothing to relieve the monotonous stretch of black-cotton soil which breaks up into barren ravines as it approaches the banks of the large rivers and into less infertile, though no less unsighly *Rakar*-hillocks along the smaller streams.

Hills:

There are two distinct chains of hills—somewhere dipping beneath the soil and reappearing a few kilometers away.

One runs from Nowgong (District: Chhatarpur) to Mahoba, while *another* from Ajnar to Kulpahar.



DISTRICT HAMIRPUR AND MAHOBA

The most conspicuous peak amongst them being the high hills rising over Salat in tehsil Charkhari[11]. The summits of the higher rocks often contain a large admixture of felspar and exhibit a great variety of grain and colour, ranging from bluish, grey to whitish pink. In the lower strata felspar is less conspicuous and hornblende predominates, giving the rock a dull green colour often almost black, from which it derives its well known name TELIYA (greenstone).

The rivers and streams constituting the natural drainage line of the district play an important role in forming the topography of the district. Their course except for URMIL AND YAMUNA which form south (to some extent) and north boundary respectively, is from south to north-east. Owing to steep slope, they carry off the surplus water quickly but as they advance they cut deeper beds and in every case cause considerable scouring.

The Birma river practically divides the district

TEHSIL*	AREA AFFECTED BY SOIL-EROSIN (HEC)	% OF THE TOTAL AREA
Rath	68,797	40.79
Hamirpur	68,797	63.71
Maudaha	78,914	50.39
Charkhari	74,867	53.01
Mahoba	72,843	40.09
Total :	3,64,218	50.56
*Kulpahar Tehsil was created after 1971		

into two equal parts; the western part is drained by the *Parwaha* and is much less broken than in the east. East of the Birma, the watershed lies close to that river and there is generally a steeper gradient which is reflected in the more easterly trend of the streams.

Because of heavy rains and quick draining off, these channels are destructive and spread-prone. By denuding the surface-soil in the hilly tracts and by carrying off the organic matter and other soil constituents from the level plains, they are constantly and steadily impoverishing the soil, except where the land is protected by embankments.

Soil erosion is an important feature of the physical characteristic of this region. Areas along the rivers Yamuna, Ken, Dhasan and Betwa in especially Rath, Kulpahar, and Charkhari tehsils are scoured by deep ravines. The table gives the situation of the ravinous area of the district in 1971.

GEOLOGY

Hamirpur also has very important place in the geology of the country owing to the presence of pre-cambrian rocks, probably the oldest ones in the Indian subcontinent to be found in a compact, linear east-west stretch.

Geological Survey of India (GSI) has done extensive work towards identification of mineral wealth and ground water resources etc. The major mineral wealth of Hamirpur-Mahoba combined district are described below[11].

Pyrophyllite and Diaspore:

It is a moderately soft mineral light pink, greyish, white or brownish black in colour, and generally used in paints as filler, in paper industry, cosmetics, ceramics, in making pots as pot-stone, and the slate-pencil etc. Here it is usually associated with diaspore as in Banda district described earlier.The villages Gorahri, Basela, and Girwar are the locations for this mineral

Granite mining and crushing: Presently Kabrai is the centre of granite mining and stone crushing. This is so serious that the surrounding areas are under threat of environmental pollution and if care is not taken, this will destroy all agriculture and human health around this town.

Gorahri has been the source of soap-stone for ages which was turned into vessels, dishes and a variety of artistic articles.

THE SOILS

The district has two distinct parts on the basis of which it has already been bifurcated into two separate districts, Hamirpur and Mahoba. The northern portion is a flat plain consisting mainly of black soils, except where the land has suffered erosion. This tract is the present Hamirpur district. Towards the south, i.e.. the Mahoba district, the surface rises, the soils becoming lighter in character. The soils consist of the well-known Bundelkhand varieties, *mar, kabar, parua,* and *rakar,* the former two known as black and the latter as light soils.

The characteristics of the two north-eastern tehsils, Hamirpur and Maudaha, is an upland plain of black soil, the highest portions being generally *mar.* This slopes away and passes into lighter soils along the edge of the ravines which fringe the rivers, *parua* and alluvial soils lying between the ravines and the stream. In the central tract of these tehsils, are found specimens of the best black soil, while in the triangle between Hamirpur town and the junction of Betwa and Yamuna rivers lies a good example of a semi-alluvial tract.

In Rath and Jalalpur, west of the Birma river similar soils are found. To the south of Rath tehsil, the land rises considerably and appears to be above the black deposits. In the extreme south-west of Rath tehsil is a tract of good *parua* varied by light *kabar.* This passes northward into heavier *kabar* and gradually merges into the northern black soil plains.

In the southern tehsils of Charkhari, Kulpahar, and Mahoba, conditions are somewhat more varied owing to the occurrence of hills. The prevailing soil is *parua* of an inferior quality, deteriorating into poor *rakar* along the foot of the hills. It is interspersed here and there with patches of shallow mar and *kabar,* and is improved in the vicinity of habitation-sites by irrigation and manure, where it is known as *kachhiyana, goind,* and *kherwa (khero).*

B. DRAINAGE AND WATER RESOURCES:

All the rivers and rivulets flowing in the district north or north-eastward tend towards river Yamuna. The rivers and rivulets, all of them have a tendency of forming ravines. The main rivers of the district are the Yamuna, the Betwa, the Dhasan, and the Ken alongwith their numerous tributaries. The minor streams get swollen to considerable dimension during the rains, at other times they flow with very small discharge. In the upper portion of their courses the smaller channels have low but abrupt sides occasionally covered with small scrub jungle, but as they advance they cut deeper beds much below the level of the surrounding country, the land in the immediate vicinity becoming more and more scoured and uneven. Their course is often tortuous and frequently brings considerable areas within the reach of its destructive action and as they approach the rivers they occasionally create varying strips of rich alluvial land along their beds.

THE RIVERS:

Yamuna : The river first touches the district at the village Haraulipur in Hamirpur tehsil, where it forms a sudden loop. This then follows a north-eastern path, curving at places, and flows approximately 56 km by the border of this district. The stream is well below the level of the southern bank which, with few exceptions, forms an abrupt cliff in marked contrast to the shelving northern bank. Stretching inland from the cliff for varying distances are ravines carved out by the force of rain; only at Jamrehi Tir and below the town of Hamirpur there are good alluvial tracts. The bed between Misripur and Jamrehi Tir is occupied by large stretches of sand.

BETWA : This river flows along the north-western border of the district from the point where the Dhaasan joins it to the village of Kupra separating tehsil Rath from Jalaun district. It enters the district near Beri village and flows separating tehsils Rath and Maudaha from tehsil Hamirpur which it enters near the village Parasani, and traversing through this tehsil it joins the Yamuna some 10 km east of Hamirpur. The total direct distance from the point of its toruching the district to the point of confluence with Yamuna is not more than 65 km but the course of the river is so tortuous that it flows almost double this distance. In most part of this river the bed is sandy. The banks except in the last few kilometers are usually scoured with ravines. Like other rivers this also brings enormous water during rains, which quickly subsides after the rains and the rivers shrinks to a narrow stream for the rest of the year.

Dhasan : The river first touches the district at Lahchura Ghat and runs northward in a tortuous course separating this district from district Jhansi as far as its junction with the Betwa near village Chandwari. In the initial part this river passes through a rocky bed but later, it flows on a sandy bed till it meets Betwa. The banks of Dhasan are also eroded by ravines but these are less extensive in Hamirpur district.

Birma : Barma or Birma a perennial stream, and tributary of the Betwa, rises in the hilly tract west of Jaitpur in tehsil Kulpahar (now district Mahoba). It gradually gathers volume and becomes broader. Turning north-east at Kaitha, it is joined by a considerable affluent, the *Arjun* 13 km south-east of Rath, and continues in the same direction to join Betwa near Kupra village. The upper reaches are rocky and lie deep below the level of the surrounding tracts, but the watersheds terminate a few kilometres from the stream and little land suffers from the erosive action of its tributaries. Later its tributaries become more frequent and form extensive ravines that invade the fertile plains of Muskara and Rath and hardly compensate for the deterioration they cause by depositing patches of alluvial silt. Throughout its course, this stream is extremely tortuous.

KEN; touches the district at Khair village and flowing 29 km north eastward forms the boundary of Maudaha tehsil with Banda district. There are no ravines along its bank, but it exercises important influence through its tributaries.

The major tributaries of Ken in this district include the *Chandrawal* and the *Urmil. Chandrawal* rises north-west of Mahoba flowing north-eastward across the tehsils of Charkhari and Maudaha, finally enters tehsil Banda before joining Ken near Pailani village. Together with its winding affluents the *Sihu* and the *Karoran* on the left and the *Shiam* on the right bank, it causes considerable erosion along its course.

Urmil gets drainage from the south of Mahoba tehsil and after passing through picturesque rocky tract with low bank covered with jungle trees, from west to east forms the southern boundary with district Chhattarpur finally paying tribute to Ken river. Recently this stream has been dammed by U.P. and M.P. states jointly for irrigation in both the districts, Mahoba and Chhatarpur.

Parwaha is another small seasonal torrent which flows through the tracts of Jalalpur and Rath. It joins Betwa some 8 km west of Jalalpur after creating enough destruction to the tract it flows through.

THE LAKES :

In the southern tract of combined Hamirpur district which is now termed as Mahoba district the position of the hills and the course of streams draining between two rocky outcrops has been used to form several artificial lakes for which this district has been famous., The common feature of all more than forty such lakes is a massive embankment built of huge square blocks of stone thrown across the line of drainage between the two hills. The famous lakes are *Bela-Taal* near Jaitpur and *Vijaisagar, Madan Sagar,* and *Kirat Sagar* around Mahoba, all of them belonging to Chandela-kings who ruled this tract during 9th-12th century A.D.

The purpose of these lakes was not necessarily irrigation during critical days but later on, the canals were built to take water from these Lakes to the fields.

B. 1 SITUATION OF DRINKING WATER :

Traditionally masonry wells have been the major source of drinking water in this district. In some villages the nearby river or the pond or lakes are also used for this purpose. Seasonal *Nallahs* or perennial rivulets have also been tapped in some towns and villages.

The piped water supply from the overhead tanks fed by tubewell has been taken up in some villages along with towns while India Mark-II handpumps are also slowly becoming the ready source of drinking water. The following table gives some relevant information :

a. Urban drinking water situation (upto March 1997)

S.NO.	PLACE	POPULATION (1991)	SOURCE	OHT/CWR	H/P	SCHEME/ CONTROL
Hamirpur District						
1.	Hamirpur	26,835	TW-04	OHT-02	121	/J.S.
2.	Maudaha	26,250	TW-02	OHT-02	80	/J.S.
3.	Rath	42,696	TW-05	OHT-02	73	/J S.
4	Gohand*	6,478	TW-02	OHT-01	33	/J.S.
5	Kurara*	8,661	TW-02	OHT-01	40	/J S
6.	Sarila	7,413	TW-03	-	38	/J.S.
7	Sumerpur	18,354	TW-03	OHT-01	57	/J S
Mahoba District						
8.	Charkhari					
9.	Kabrai					
10	Kharaila	Information could				
11	Kulpahar	not be available.				
12	Mahoba					

*Gohand and Kurara - drinking water schemes also include 6 and 9 villages respectively
J S.- Jal Sansthan TW = Tubewell OHT = overhead tank CWR = Clear Water Reservoir

b. Rural Water Supply Schemes:

S.NO.	SCHEME	VILLAGE COVERED	SOURCE TW/R	OHT NO.	H/P NO.	REMARKS
Hamirpur District						
1	Muskara	01	TW-02	n.s.	29	maintained by Jal Sansthan
2	Imilia	05	TW-02	OHT-02	45	-do-
3.	Shekhupur	14	TW-02	OHT-01	92	-do-
4.	Mishripur	05	TW-02	OHT-08	91	-do-
5.	Biwar	08	TW-04	OHT-03	90	-do-
6.	Umri	11	TW-02	OHT-03	n.s.	-do-
7	Puraini	02	TW-02	OHT-02	n.s.	-do-
8.	Mamana	07	TW-02	OhT-03, CWR-01	41	-do-
9.	Parchha	06	TW-02	OHT-04	35	-do-
10.	Atrauli	06	TW-02	OHT-05	46	-do-
Mahoba District						
11.	Charkhari					
12	Kabrai	Information could				
13	Kharaila	not be available				
14.	Kulpahar					
15	Mahoba					

c. The Schemes under Construction Proposed

S.NO.	SCHEME NAME	VILLAGES COVERED	POPULATION	SOURCE	H/P NO.	REMARKS
Hamirpur District						
1.	Majhgawa	12	18,509	TW-02	143	
2	Itailia Baja	09	12,886	TW-03	102	
3.	Pahadi-Bhitari	04	12,809	TW-03	28	
4	Jigni-Bagra	14	14,079	TW-02	146	
5.	Jalalpur	05	5,557	TW-02	39	
6.	Sayar	06	8,194	TW-02	n.s.	
7	Khanna	04	7,751	TW-02	n.s.	
Mahoba District						
8.	Charkhari					
9	Kabrai	Information could				
10.	Kharaila	not be avilable.				
11	Kulpahar					
12.	Mahoba					

d. Development Block-wise installation of hand-pumps

S.NO.	DEV. BLOCK	VILLAGES	INSTALLED H/P
Hamirpur District			
1.	Gohand	87	645
2.	Kurara	84	525
3.	Maudaha	123	1,011
4.	Muskara	62	512
5	Rath	85	593
6.	Sarila	83	511
7.	Sumerpur	107	967
Mahoba District.			
1.	Charkhari		
2.	Jaitpur	Information	
3.	Kabrai	could not	
4	Panwari	be available	
Source: Jal Nigam, Hamirpur (UP) report upto March 1997			

B.2 IRRIGATION SITUATION IN DISTRICT HAMIRPUR-MAHOBA

The masonry wells had been the old means of irrigation in this district. The drawing out of the water was traditionally done through leather bucket attached with a rope (*tarsa* or *purwahi*) or persian wheel (*rahat*) moved by bullocks. Irrigation was confined to garden crops, vegetables, or horticulture. Like in other Bundelkhand districts, big *bandhan*-system was prevalent in this district which gave support to one good crop. Agriculture in this district has almost been traditional.

Means of Irrigation:

The above table are the reported means of irrigation (1990 to 1993):

Year	Length of canals	Govt. TW	Masonry wells	Persian wheel	Pumpsets surface	Pumpsets boring	Pvt. TW	Bandhi no.
90-91	908 km	418	13,304	-	6,287	3,936	914	95,022
91-92	908 km	440	13,715	-	7,224	4,608	1,064	95,022
92-93	975 km	472	6,709	-	6,536	13,184	772	95,022

The irrigated area of the district resource/means-wise are given in the following table :

Year	Canals	Govt TW	Pvt TW	Wells	Ponds	others	Total
90-91	80,057	11,020	7,181	18,748	1,440	8,966	1,27,412
91-92	77,655	13,885	13,837	27,808	2,185	12,463	1,47,833

source: State Planning Institute, distt. Hamirpur1993-94

IRRIGATION-PROJECTS;

The district does not have any major irrigation projects. The utilisation of the lakes and tanks existing in the district was taken up in 1855 and a beginning was made with *Vijaisagar* and *Bela-Taal* and subsequently the *Dasrapur, Thana, Madansagar, Kirat Sagar, Kalyan Sagar, Naigaon* and *Tikamau* lakes providing them with sluices.

The construction of artificial embankments (*bandhan* and *bandhi*) for storage of the water for the crops has been a special feature of these areas since times immemorial. This system was promoted early this century and nearly 215 embankments were made in the district by 1916.

The situation of the irrigation oriented dams is as given in the box below :

S.NO.	PROJECT	SOURCE	SANCTION YEAR	IRRIGATION CAPACITY (HECT)	PROPOSED COST (LAKH RS)	REMARKS
1.	Maudaha	Birma	1975	27,700	3,744.00	under construction
2.	Urmel	Urmel	1978	4,770	2,945.15	-do-
3.	Lahchura (renewal)	Dhasan	1955-56	10,760	2,877.00	already working
4.	Chandrawal	Chandrawal	1962	43,100	90.00	-do-

THE CANALS:

The river canal system is prevalent in Kurara, Panwari, Rath, and Sarila development blocks; and the canals fed by the dams and embankments, tanks and lakes cover Muskara, Jaitpur, Maudaha, Panwari, Kabrai and Charkhari Dev. blocks of the district[11].

1. The canal-systems working in this district are as follows :

S.NO.	NAME OF THE SYSTEM	SOURCE DAM/TANK	YEAR STARTING	LENGTH KM	AREAS IRRIGATED (TEHSIL)
1.	Betwa	Parichha (Jhansi)	1887-88	58	Hamirpur
2.	Dhasan	Lahchura	1912	632	Charkhari and Rath
3.	Majhgawa	Tank	1914	52	
4.	Kulpahar	Tank	1924	08	
5.	Bela-Sagar	Tank	)		
6.	Raipura		)	110	
7.	Kamalpura		)		
8.	Arjun	dam			Charkhari and Hamirpur
9.	Kabrai	)	till		Mahoba and Maudaha
10.	Keolari	)	1973-74	426	
11.	Chandrawal	dam			

source : Samajarthik Sameeksha (State Planning Inst.) dist. Hamirpur 1993-94

2. The Pump-Canals operating in the district :

S.no.	Project	Source	Dev.Block	Irrigating capacity (hect)	Water availability cusec	Present state
1	Bilauta	Yamuna	Kurara	923	22.5	working
2.	Baijemau (south)	Ken	Maudaha	1,600	20 0	-do-
3.	Baijemau	Ken	-do-	1,884	30.0	-do-
4.	Bhauli	Yamuna	Kurara	1,275	35.0	-do-
5.	Ramedi (chain)	Betwa	-do-	376	7.5	-do-
6	Merapur (chain)	Yamuna	-do-	397	10.0	-do-
7.	Patyora	-do-	Sumerpur	2,400	60.0	-do-
8.	Sarauli	-do-	-do-	80	2.5	-do-
9.	Sohrapur	Betwa	-do-	2,500	80.0	-do-
10	Kaimaha	Urmel	Kabrai	2,437	-	-do-
11	Chhani	Ken	Maudaha	3,825	100.0	-do-
12.	Bardaha-Sahjana	Betwa	Sumerpur	1,262	30.0	-do-

source : Samajarthik Sameeksha (State Planning Inst.) Dist. Hamirpur 1993-94

3. The Dams under Construction :

Virath Sagar, New Pahadi, Rewai, Arjun, and Charkhari - dams are reported under construction The Lahchura dam is an old construction which needs de-silting.

4. The status of the Reservoirs used for Irrigation :

S.NO.	NAME	DSL (FT)	CREST-LEVEL (FT)	FSL (FT)	MAX. AVAILABLE CAPACITY (M.C.M)
1.	Arjun	550	568	578	2,064.0
2	Chandrawal	482	484	500	1,090.0
3	Kabrai	489	499	506	421.8
4.	Majhgawa	712	735	736	915.5

5. The status of the canals :

S.NO.	NAME OF THE CANAL SYSTEM	DISCHARGE (CUSEC)
1.	Arjun (Mahoba)	310.00
2.	Kamalkheda Dy. (Hamirpur)	65.00
3.	Pindari Dy. (Hamirpur)	15.00
4	Kabrai (Mahoba)	70.00
5.	Shurut (Mahoba)	68.70
6.	Barkhera (Mahoba)	18.70
source : Deptt. of Irrigation, U.P.		

MINOR IRRIGATION

The minor irrigation data available upto March 1996 for Hamirpur (alongwith Mahoba) district is as follows :

a	Total area :	7,11,631 ha
b.	Cultivated area ·	5,08,890 ha
c.	Irrigated by MI works ·	1,47,833 ha
d	Minor Irrigation works (no)*	
1.	Wells	14,333
2.	Persian Wheel	-
3.	Surface-Pumpsets	15,408
4	Pumpsets on boring	7,245
5.	Deep Tubewell	517
6.	Artesian well	-
7.	Free borings	2,527
8.	Private Tube wells	1,118

**Note* : The figure of minor irrigation sources for Mahoba separately could not be available

Source : Progress report of minor irrigation programme (Jhansi Division) Oct. 1996

C. THE VEGETATION:

THE FORESTS:

The flora of the district is characterised by northern tropical, dry, deciduous vegetative growth. The northern half (almost the present Hamirpur district) is highly deficient in vegetation. On black soils the hardy babul grows spontaneously and is liked by people for its use in making the agricultural-implements. In the riverine tracts generally the mixed vegetation are found. The common plants available here are *khair, hingol, karaunda*, and *karil* etc.

In the southern portion, which is now known as the district Mahoba, the hills as well as considerable "level stretches" have been covered with forests. The common trees available here were *tendu, mahua, semal, dudhi, dhawa, gurja, dhak, rioni, khair* and *kardhai* etc. Towards the end of the last (i.e. ninteenth) century, more than one third of the district was covered with dense forests including in the northern tract. Rapid clearing operation of the forests was taken up by the British during their rule in early nineteenth century. Later conservators were appointed but the emphasis was on commercial exploitation rather than conservation. The area of the forests till 1931 remained nearly 5,000 hectare which dwindled to 1,895 hectare by 1941 owing to reclamation of the land for agricultural purpose. In 1951 after the merger of the erstwhile states, the area under forest increased to 3,786 hectare which by 1961, it increased further to 4,226 hectare.

Unfortunately, the policy towards forest was never of conservation. In spite of the declared adoption of 'scientific management' of forests, the one-point programme of clearing and selling out the forests, initially the flora and then the granite base has continued till this day and the situation of the forests has become extremely precarious. The road-sides which were meant for growing the fruit bearing and shade giving trees like mango, *mahua, jamun, sissoo, siris, pipal, arjuna, bargad,* and *neem* ., were ultimately planted with the thorny prosopis juliflora which is helpful to the neither living beings nor to the tyred vehicles passing through these roads.

AGRICULTURE:

Agriculture in this district resembles other parts of Bundelkhand. This has been largely a single-crop area, *Rabi* crops being the most important. The individual or the bigger embankments improve the water retention and soil-quality. Application of organic manure is essential in *parua* soils for better yield. But in the post-independence era, the improved irrigation facilities and availability of water-lifting machines and power has changed scenario of the district.

Only a small tract of the district can claim to harvest all the three types of crops — Kharif, Rabi and Zaid. A large part of the district has been traditionally one-crop area, i.e. of the winter crop. But after provision of irrigation, the two crops *Rabi* and *Kharif* have become common in many parts. *Zaid* crop consists of vegetable, spices, tobacco, and legumes etc and is not very common.

Principal crops:

As reported earlier, the two crops i.e. the KHARIF and RABI are the main crops. Locally these are also called *siyari* and *unhari* respectively. The KHARIF crops are harvested between June-July and October-December while the RABI crops are taken usually betweeen November-December and March-April.

KHARIF: Jowar, mostly combined with *arhar*, is grown on black soils, but in lighter soils this is also mixed with Moong and Urad. In recent years hybrid *jowar* has been introduced but the traditional variety named *dugru* is quite popular.

The next popular Kharif crop is paddy whose traditional varieties named *anokhi, dudhi, manki, gardhan,* and *ajan*, are now being slowly replaced by the hybrid varieties.

Bajra is another notable crop during this season. Locally known as *lihdra*, this is a favoured crop in the sandy soils or in the undulating tracts near the streams. This is also mixed with *arhar.*

Other minor Kharif crops like *kodon, sawan,* and *kakun* flourish in the *rakar* and light *parua* soils. The *kodon* is also usually mixed with *jowar.*

RABI: Gram has been the most popular crops of this season. This is grown in most of the soils from the finest *mar* to the better *rakar* fields. Wheat takes second place. The general tendency is to grow wheat mixed with gram, barley, pea. and /or mustard. In the recent cultivation of wheat with hybrid seeds the mixed cropping has not been promoted. This is a disturbing trend.

Of the pulse crops in RABI, *masoor* is the most important; *arhar* is a long-duration crop which covers both the seasons.

The following table gives the area-coverage of different crops during 1972-73 and later in 1991-92.

S.NO.	CROPS	AREA COVERED (HECT) 1972-73	1991-92	TOTAL YIELD (M.TONNE) 1972-73	1991-92
KHARIF					
1.	Jowar	89,046	30,396	60,875	45,802
2.	Bajra	2,961	523	1,249	390
3	Arhar	30,549	20,446	59,511	21,297
4.	Moong/Urad/Moth:	2,818	9,593	984	3,071
5.	Sawan*	1,292	nil	542	-
6	Kodon*	4,106	nil	1,893	-
7.	Rice	9,425	2,123	4,602	1,404
8.	Soyabean	-	754	-	517
9.	Til	-	6,236	-	611
10.	Sanai	-	1,313	-	673
*the figures pertain to 1971-72					
RABI					
1	Gram	1,98,280	1,39,225	1,54,265	70,872
2.	Wheat	1,41,919	1,52,288	1,68,805	2,30,567
3.	Barley	4,261	4,510	3,517	7,846
4.	Pea	2,013	39,611	1,097	44,879
5.	Masoor	5,973	53,508	6,085	38,205
6	Mustard	-	7,015	-	3,969
7.	Linseed	-	22,742	-	8,619

source : U P District Gazetteer (Hamirpur) 1988
Samajathik Sameeksha, (State Planning Inst.) Dist. Hamirpur (U.P.) 1993-94

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of this district is characterised by an intensely hot summer, a pleasant cold season and general dryness (in northern portion) except during the monsoon season. Like in other districts, four seasonal variations are distinct in this part also. The summer extends from March to half June, the rains last upto September followed by a transitional period of one and half months; thereafter winter starts which lasts for over three months from November-half to February.

Temperature :

As there is no meteorological observatory in this district, the temperature has been calculated on the basis of the figures for the adjacent districts. Normally the temperature starts rising in the month of March, leading to the highest temperature sometime in May-June, the mean daily temperature during May is about 43° C and the mean daily minimum is about 28°C. The heat during the summers is intense, the maximum temperature now crosses 47° C and is severely felt in the treeless tract of the northern district. By middle of June, the temperature falls, only if the rains have started. For about a month the atmosphere remains humid-hot until it rains heavily. In September, due to breaks in the south-west monsoon, day temperature increases slightly. With the advent of October, it falls slowly when the nights become colder. In later months the temperature falls steadily and January becomes the coldest. With the western disturbances the cold waves affect the district and the minimum temperature sometimes goes down to 2-3°C.

Rainfall :

There are 10 rain-gauge stations within this district. These are: Hamirpur, Rath, Maudaha, Sarila (in Hamirpur part) and Kulpahar, Mahoba, Khannah, Charkhari, Belataal and Bijanagar (in Mahoba part). The records are available from 54 years to 97 years. The normal (average annual) rainfall of the district is 850.7 mm. Of the total rainfall nearly 90% falls during June to September July and August are the rainiest months. On an average there are 42 rainy days (days with rainfall above 2.5 mm); the rain days also differ from place to place.

Following is a table which gives average rainfall and the rain-days monthwise, based on the data available upto 1970.[II]

Annual Average : 850.7 mm		**Days of rains : 42.4**
Maximum rainfall :		**158% (1919)**
Minimum rainfall :		**36% (1918)**
Month	**Rainfall (mm)**	**Rain-days (rains > 2.5 mm)**
Januray	13 5	1.2
February	12 8	1.1
March	7.1	0.7
April	4 3	0.4
May	6.1	0 7
June	69.6	4.1
July	275.8	12.5
August	277.7	12.5
September	145.1	6.9
October	23.5	1.2
November	8.3	0.5
December	6 6	0 6

Humidity :

During the monsoon season relative humidity crosses over 70%. Thereafter humidity decreases progressively and by summer, which is the driest part of the year goes down to less than 25%.

Cloudiness :

During the monsoon season and for spells of a few days during the cold wave, skies are generally heavily clouded or overcast. With the overall environmental disbalance caused by heavy pollution or the disturbance over Himalayas, the clouds and the rains have become erratic. These can now appear in any part of the year. This has definite influence over the productivity of agriculture and people's health.

The Winds :

The winds are generally light during winter months. Slowly it increases and becomes hotter during summer season. The wind speed increases also with the advent of south-west monsoon. During winter generally the direction of the wind is from the west or north-east. By May easterlies and north-easterlies also appear. During the south-west monsoon, winds are either from the south-west and west or from the north-east and east.

Special Weather Phenomena :

Storms and depressions from the Bay of Bengal during the monsoon months moving in westerly direction approach the neighbourhood of the district and cause wide-spread heavy rain and gusty winds. In the cold season western disturbances affect the weather of the district causing thunder-storms. Such disturbances also occur during summer season. Rain is often associated with thunder. Fog occurs continuously for a few days during the cold-waves.

2.2 JHANSI DIVISION

Jhansi Division has three districts, namely Jalaun, Jhansi, and Lalitpur. Lalitpur used to be a part of Jhansi upto 1974 and the District Gazetteer (Govt. of U.P.) 1965 has combined information of these two districts. Jalaun has been a separate unit and an independent District-Gazetteer published in 1989 is available for references.

The district-wise information is presented as follows:

2.2.1 JALAUN DISTRICT :

Jalaun forms the northern boundary of Bundelkhand and lies in between latitude 25° 46' and 26° 27' (north) and longitude 78° 56' and 79°52' (east) and has an area of 4,565 sq.km.

Jalaun is bounded by river Yamuna in north and north-east separating this district from Etawah and Kanpur (rural) districts of U.P., by district Jhansi in the south-west, by Betwa river and Hamirpur district in the south-east and by Bhind and Gwalior districts and Pahuj river in the west.

A. PHYSICAL FEATURES :

TOPOGRAPHY

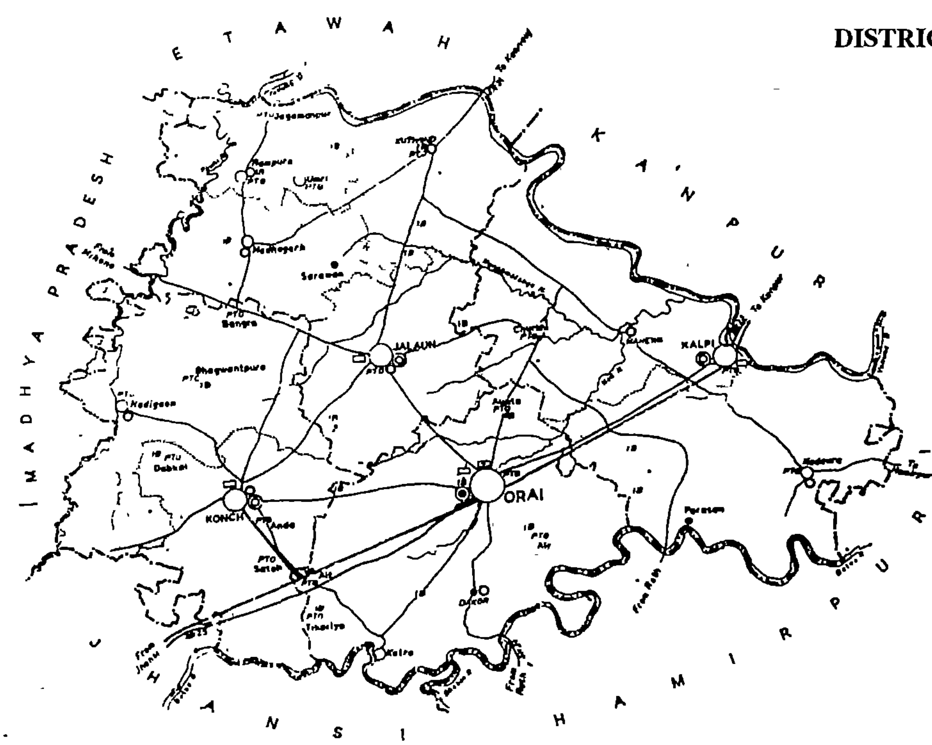
Jalaun is the northernmost district of the Bundelkhand region and though its general landscape exhibits large similarity with the adjoining tract in the south and the east, it is devoid of any rocky outcrops due probably to its being situated farthest from the Vindhyan ranges running east-west in the southern districts[12].

The three rivers Yamuna, Betwa and Pahuj determine the physical features of this district. The rivers are beset with an unending series of ravines. Due to the high velocity of the run-off of water over the denuded soils, the ravines have been forming even at a distance of 1-3 km from the river beds.

Jalaun district has a special feature that is not found in other districts.

The high lands border on the *khadir* valleys of Betwa and Pahuj, while the low lands occupy the central tract. The latter is thus a wide flat

DISTRICT JALAUN



basin encircled by a narrow rim of higher ground which break up into a network of ravines along the river banks, stretching for some kilometres inland from the streams.

The levels of the district are clearly indicated from the situation and direction of the branches of the Betwa canal which follows the watersheds closely. The drainage of the central tract is supplied by two minor streams, the Non and the Melunga which flowing north-eastwards unite some 12 km from the Yamuna bank and join that river at an equal distance to the north of the town of Kalpi. Like the larger rivers they too have carved deep ravines which increase in extent the nearer the Yamuna is approached and as a consequence of their action, the Kalpi tehsil is cut up by a tracery of ravines which have scoured the greatest portion of the soil and having more barren and sterile land than in any other part of the district.

The natural divisions into which this district falls are clearly marked. Along the outer edge, is the ravine belt—fringed, here and there, by rich alluvial soil, but for the most part consisting of low hummocks thickly strewn with *kankar.* The upland which succeeds the ravines is poor in quality. To the north there is a tract of loam, the characteristics of which resemble those of *doab*, but practically the whole of the south in tehsil Kalpi affected by Non and Melunga is occupied by the dark *kabar* and the black cotton soil *mar.* With the exception of two rocky outcrops near Saiyid Nagar in tehsil Orai, there are no hills in the district; and the red soil which is found in the hilly tracts of Jhansi is also absent. But in other respects the district is a typical part of Bundelkhand.

GEOLOGY:

Geological formation of the district consists more or less entirely of alluvium which consists of *kankar* sand ballast, *maurang*, and brick-earth. *Kankar* is available in significant quantity in Konch, Orai, and Kalpi tehsils of the district. It was used for metalling the roads and making lime. Large deposits of sand and *maurang* are found on the bank of the Yamuna. The ballast is found in Orai tehsil.

The Soils:

The soils are of the same nature and nomenclature as in other part of Bundelkhand region. These are the *mar*, the *kabar*, the *parua*, and the *rakar* however. On account of the wide variations in colour, depth and texture, they are differentiated from one another in almost all the locally known soil-regions.

Right in the centre of the district, the heaviest soil known as the *mar* occurs which is very special in its characteristics as a good fertile stuff but has a danger of growth of the *kans*-grass. The soil in the central tract is deep and clayee and locally known as the *kabar.* It has two kinds : one is darker in colour and resembles the *mar* and another is lighter being an admixture of the *parua.*

On the upland portion along the rivers, adjoining the ravine belt and extending far into the levelled plain are found areas with very gentle slopes and their soil material is texturally superior to that of the belt. In this tract soils are generally deep and are light loamy. The *parua* in its pure form is confined to the northern part of the district. On the slopy ground or in the ravines, the soils are mostly the *rakar.* In the beds of the streams and the rivers the soil which is found is called *kachhar* or *tari* which is alluvial and its quality depends upon the normal floods.

B. DRAINAGE AND WATER RESOURCES :

The chief rivers of the district are the Yamuna, the Betwa, and the Pahuj along with several streams, of which *non* and *melunga* are notable. The slope of the district is towards the north and north-east, a characteristics of Bundelkhand tract; and therefore the drainage is towards the same direction, all the rivers and streams terminating in river Yamuna.

The excessive drainage of the soil is observed in this district. The tract of the land in Konch gets watered by a considerable annual rain-flood called the *pou*. Entering by three channals, at Kishanpura and Sunau from the Samthar highlands and at Khukul on the west from the Datia district, it spreads over about 30 villages in all. The flooding takes place twice or thrice during the rainy season lasting from three days to a week each time. The entire area is submerged and gets fertile silt-deposit which enhances the value of the land.

The water resources mainly consist of the traditional masonry wells, beautifully constructed *bavdis* (step wells) and ponds to store the rainharvest. Since the water table was quite low, the construction of wells has been costly. Yet before the spread of Betwa canals, wells had been the major source of irrigation. Irrigation from the ponds was not very popular. The local black soil was always felt not favouring irrigation and therefore, the efforts of building irrigation projects were always seen useless.

Later when flow-irrigation became fashionable due to Betwa canals, other projects were also envisaged and encouraged. There were efforts of various departments and agencies in this direction. Deptt. of minor irrigation concentrated on building wells and fitting them with lifting device, persian wheels and later pumping sets or motor-pumps. Lift canals were also constructed and operated.

Detailed information follows:

THE RIVERS AND STREAMS:

Yamuna: This river forms the northern boundary of Jalaun district. It first touches the district near village Siddoura in Jalaun tehsil at a point where it is joined by Sind river. Flowing with a gently curving course towards the east, south-east, and north-east direction it leaves the district some 16 km south-east of Kalpi town on the border of Baoni near village Ikauna. Yamuna traverses about 83 km within this district.

Betwa: The Betwa forms boundary of this district with Jhansi district along the southern border from a point a few kilometres east of Erich town to its junction with Dhasan river. Its course is tortuous like a serpent moving in the eastern or slight north-eastern direction and goes further to Hamirpur district near village Bhendi in Kalpi tehsil after travelling within this district for 96 km.

Pahuj: From Jhansi side, Pahuj enters this district in the south-western corner of tehsil Konch near village Salaiya Buzurg and forms the western boundary of the district, except at few points where the district projects beyond the stream. This is a small river, flowing in deep channel. Added by numerous artesian wells around Salaiya Buzurg, this river flows in tortuous course with high banks and joins Sind river near Jaigha village. As usual, on both the sides of this river the banks are cut up into ravines and *Nallahs*.

Non and Melunga: These are the important tributaries to Yamuna river. Non rises in the tehsil of Orai and drains the southern tract of the district, while Melunga rising near Konch flows due north as far as Hadrukh and turning near the town abruptly east, holds a course parallel to Yamuna till it unites with Non at Mahewa in Kalpi tehsil. Both the streams are, for the most part, deep-bedded and carry off the drainage of the central black soil tract, during the rainy season and then dry up. Approaching the main river the streams have a tendency of forming ravines. Near the junction with Yamuna, almost 13 km north of Kalpi town, they are responsible for more extensive erosion and deterioration.

Other Streams:

In the extreme south flows a small but deep-bedded stream called Manmesari *nullah* which also causes certain amount of deterioration of the villages it passes through. To the south of Kalpi tehsil, flow two small streams the *Rayar* and *Jondhar*, which join Yamuna near Kalpi. Starting in uneven and undulating but not actually uncultivable land, these two are flanked by ravines before reaching their destination. Dhumna is a tributary to the Pahuj, rising at Kailia and joining it near Maheshpur.

B.1 SITUATION OF DRINKING WATER :

Traditionally masonry wells had been the major source of drinking water since time immemorial. Like in other districts of Bundelkhand, the tradition of *bavdis* (step-wells) and ponds is common here also. Total 9,358 masonry wells have been reported in rural areas, block-wise distribution being as follows:

S.NO.	BLOCK	VILLAGES	WELLS
1	Dakor	124	1,300
2.	Jalaun	100	1,336
3.	Kadaura	98	710
4	Konch	101	1,593
5	Kuthaund	117	543
6	Madhogarh	84	1,395
7	Mahewa	97	684
8.	Nadigaon	145	1,249
9.	Rampura	73	548
	Total	939	9,358

With the advent of technologies and tendency of urbanisation, projects were formulated for piped water supply and still later the deep bore-India Mark-II handpumps were introduced to serve as sources of drinking water.

The problems faced in this district are as follows:

- In some places the ground water is brackish and unpotable
- There are places where deep tubewell boring is extremely difficult.
- The water yield from some of these tubewells is not consistent.

The situation of urban and rural water supply in the district is summarised in the box below:

a. Urban Drinking Water Supply:

S.NO.	PLACE	DESIGN YEAR/ (POPULATION)	MAIN SOURCE	H/P	SCHEME/CONTROL
1.	Jalaun	1990 (20000)	TW-04	15	/JS
2.	Kadaura	2010 (13000)	TW-01	13	/JS
3	Kalpi	2010 (45000)	TW-05	32	/JS
4.	Konch	2010 (54000)	TW-04	15	/JS
5.	Madhogarh	2008 (16307)	TW-03	15	/JS
6.	Nadigaon	(8600)	TW-02	16	-
7.	Orai	2010 (118000)	TW-11	51	/JS

b. Rural Water Supply Schemes :

S.NO	SCHEME	VILLAGES COVERED	SOURCE TW/R	O/H TANK NO.	H/P NO.	SCHEME
1.	Arjunpura	09	ns	ns	22	non-IDA
2	Ata	04	TW-02	03	10	-do-
3	Aurekhi	05	TW-01	03	15	-do-
4	Baheena	09	TW-02	ns	17	IDA
5.	Bahadurpur-Bavali	44	TW-02	01	78	RDWS
6	Bhendi	04			07	twarit
7.	Gohan	30	TW-04	04	70	RDWS
8	Harauli	37	TW-04	02	132	IDA
9	Kapasi*	01	-	01	02	IDA
10	Kotra	05	TW-02	01	08	non-IDA
11	Kuthaund	48	TW-05	03	77	RDWS
12.	Madanpur	55	TW-05	03	102	non-IDA
13.	Ninavali	08	TW-03	01	20	IDA
14	Rampura	21	TW-02	01	46	IDA
15	Kadaura	07	TW-02	02	-	-do-

*water from irrigation deptt tubewell was proposed which could not work out
ns=non-specified H/P=handpump TW=tubewell

C. The projects under Construction

1. Under minimum need programme

S.NO.	SCHEME	VILLAGES	TW	OHT	REMAKRS
1.	Girthan	08	02	01	six of eight villages have been provided handpumps.
2.	Babai		02	01	paratially done
3.	Usar Gaon	03	02	01	one village has been benefited.
4.	Pahad Gaon	01	01	01	partially done
5.	Akbarpur itaura	02	02	01	partially done
6	Khaksis	39	04	02	partially done but lacks electric connection; budget-modification proposed 75 handpumps installed.
7.	Rangeda	04	-	-	only one village is getting water from irrigation-deptt. tubewell. The rest are equipped with 9 handpumps.
8	Musmaria	03	02	01	partially done

2. under other programmes

S.NO.	SCHEME	VILLAGES	TW	OHT	REMAKRS
1.	Saidnagar	ns	02	01	two borings failed one another found OK; needs modification
2	Ghurat		02	01	borings have failed
3.	Bhadawa	02	01	01	partially done

d. Total installed handpumps

S.NO.	DEVELOPMENT BLOCK (VILLAGES)	INSTALLED HANDPUMPS
1.	Dakor (124)	936
2.	Jalaun (100)	755
3.	Kadaura (98)	902
4	Konch (101)	685
5	Kuthaund (117)	567
6	Madhogarh (84)	483
7.	Mahewa (97)	738
8.	Nadigaon (145)	742
9.	Rampura (73)	302
	Total in villages	6,110
	Total in urban area :	335
	Grand Total :	6,445 handpumps

Source : Water supply and Sewage Disposal, report of U.P. Jal Nigam. Distt. Jalaun; published by Executive Engineer, J.N., Orai (March 1996)

B.2 SITUATION OF IRRIGATION IN THE DISTRICT :

Normally, the presence of soils *mar* and *kabar*, both being fertile and water retentive, need no artificial fertilisation or extra irrigation, in normal rainfall situation. Till the beginning of the present century it was a common belief that extra irrigation of these soils does more harm than good. This prevented the efforts of initiating irrigation projects. The second cause, as already mentioned, was the great cost of sinking a well in this tract because of deeper level of groundwater. Construction of embankments on the fields, being popular as in other parts of Bundelkhand, was adopted here also. This gave sufficient moisture for the winter crops.

With the spread of Betwa canals from Parichha weir, the era of extra-irrigation began in this tract sometime around 1885, although it was not very popular then. Presently the Betwa canal and several other pump-canals give this district a good coverage of the means of irrigation.

BETWA CANAL:

Betwa canal in this district has two branches bifurcated near village Pulia: 1. Kuthaund branch, and 2. Hamirpur branch:

1. Kuthaund Branch: This is the western branch of Betwa canal which runs for about 80 km on a water-shed between the Pahuj river and the main drainage system of Jalaun district. The canal enters the district near village Pipri Kalan in Konch tehsil and moves almost northwards west of Madhogarh to Rampura. At this point this turns sharply to the east along a minor watershed parallel to Yamuna and after a course of ca. 194 km tails into some ravines leading to the river near village Randhirpur in Jalaun tehsil.

2. Hamirpur Branch: This is the eastern branch of the Betwa canal, touching Jalaun distt. near village Ingui in tehsil Konch. It follows the watershed between the Betwa and the central drainage system, and after a course of ca. 135 km discharges its surplus water into Yamuna through some ravines approximately 8 km west of Hamirpur town.

THE PUMP-CANALS

Following is a table which gives information about some of the pump canals made active in sixties:

S.NO.	SYSTEM	TEHSIL	SOURCE	LENGTH (KM)
1.	Mainpur	Kalpi	Yamuna	6 00
2	Makrechha	Orai	Betwa	1 78
3	Bara	Kalpi	-do-	2.01
4.	Amraurh	Orai	-do-	2.40
5.	Chandarsi	Kalpi	-do-	9.40
6.	Gauraha-Semaria			7 10

BLOCK-WISE DISTRIBUTION OF IRRIGATION RESOURCES (1992-93)

Dev.Block	Length of canals	TW*		Masonry wells	Persian wheel	Pumpset	
		Govt.	Pvt.			surface	bore
Dakor	-	66	59	261	26	151	734
Jalaun	-	41	93	275	139	111	680
Kadaura	-	69	43	187	147	85	658
Konch	-	42	73	220	78	94	810
Kuthaund	-	44	114	179	15	67	540
Madhogarh	-	09	173	219	301	96	706
Mahewa	-	129	42	229	362	80	554
Nadigaon	-	30	79	264	115	90	692
Rampura	-	23	131	179	42	126	648
Total	1916 km	453	807	2013	1225	900	6022

Source : sankhyikeeya patrika (Dist Jalaun) 1993
*the numbers of Govt. and private tubewells in 1995 were reported to be 480 and 955 respectively.
The state tubewells have capacity of irrigating 24,000 hectare.

MINOR IRRIGATION :

The minor irrigation data available upto March 1996 for Jalaun district are as follows:

a	Total area ·	3,88,234 ha
b.	Cultivated area :	3,41,818 ha
c.	Irrigated by MI works	1,13,776 ha
d	minor irrigation works (No)	
1.	Wells	9,604
2.	Persian wheel	339
3.	Surface-pumpsets	224
4	Pumpsets on borings	2,629
5	Deep tubewell	215
6	Artesian wells	78
7.	Free Borings	2,763
8.	Private tubewells	1,601

Source: Progress Report of minor irrigation programme (Jhansi division) at 1996.

C. VEGETATION :

THE FORESTS:

There is no forest-belt in this district. However, small patches of flora could be seen along the rivers Yamuna, Betwa and Pahuj. The total forest-area reported in the Distt. Gazetteer (1989) is 26,502 hectares, which presently is in denuded state. The 314 km PWD roadsides are under Forest Deptt.'s management. There are two botanical divisions in the district namely Dry Deciduous Scrub and Ravine Thorn Forest described as follows:[12]

Dry Deciduous Scrub Forest :

This type has been mostly confined to ravinous areas of the district. The important species found there were *siari, dhawai, hingot,* and *karil* etc. This is reported to have been covering 14,919 ha.

Ravine-Thorn Forest:

It can also be called northern acacia shrub forest consisting of a mixture of small thorny trees like *khair, reonjha,* and *ghont.* The area of this type has been reported to be 11,585 ha.

The undergrowth varied in nature and composition. The main shrubs found were *karaunda, jharberi,* and *katai* and the climbers included *dudhi, gunghchi,* and *makoh.* The common grasses found in the district were *parwa, ehikua, guner, bhanjura* and *kans.*

AGRICULTURE:

Like other Bundelkhand districts, Jalaun also is predominantly dependent on agriculture for its economy. It is a district with highly mechanised agriculture, the number of tractors and other machineries being largest in Bundelkhand. All major crops are grown here, but the recent shift has been towards growing *masoor* and soyabean. Of the three seasonal crops, *Rabi*-crops are more important, and the area it covers far exceeds other crops.

The table below gives an account of main crops taken here in the year of 1991-92:

S.NO.	CROPS	AREA COVERED (HA)	IRRIGATED AREA (HA)	AVERAGE YIELD QTL/HA.
KHARIF				
1.	Bajra	15,004	24	7.46
2.	Urd	6,205	16	2.41
3	Moong	358	08	2.33
4	Til	1,015	nil	0 67
5	Paddy	1,489	802	6.61
6.	Soyabean	2,000	204	5.86
RABI				
1	Wheat	80,596	72,916	22 06
2	Gram	76,924	4,958	9 10
3	Masoor	75,347	1,136	10.21
4.	Mustard	10,215	3,135	7.25
5.	Linseed	5,992	196	3.53
6.	Pea	45,398	25,643	14 87

Crop-Rotation:

Due to the soil condition and lack of adequate irrigation facilities, the general tendency in this district has been towards taking a single crop in the year with Kharif and Rabi alternating. Leaving the land fallow for one season has also been a tradition here.

Crop-Mixture:

The main mixed crops of the district have been: *arhar-urd, arhar-jowar, moong-soyabean, surajmukhi*-mustard, wheat-gram, wheat-barley, barley-gram, and gram-linseed. This practice has been an assurance of gain from agriculture which never happens with mono-cropping practice.

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of the district is, as a rule, drier and hotter than the area north of Yamuna river. Like in other Bundelkhand districts, the four seasons are quite apparent— March to middle of June being the summer months, June half to September being rainy months, October and November being the transition period followed by cold season upto February. The south-west monsoon is what causes rains here during the rainy-season.

The lack of forests affects the environment which also causes soil erosion and adds to dryness.

Temperature

There is one meteorological observatory in the district i.e. in Orai. The records here can be taken as the average for the whole district. From February onwards the temperature rises rapidly; the hottest months are May and early June. The heat in summer is intense and the hot and dry dust-laden winds which blow in this season add very much to the discomfort. On individual days the temperature sometimes goes beyond 47°C.

The box below gives the record of average and maximum and minimum temperature of the district from 1950 to 1974: (12)

Month	Mean daily max.temp. °C	Mean daily min.temp. °C	Highest max. temp./date	Lowest min temp./date
January	23.0	8.4	39.1 (10/1/64)	1.4 (23/1/73)
February	27.1	11.9	34.4 (29/2/60)	2.2 (3/2/61)
March	33 5	16.7	41.1 (31/3/55)	8 9 (7/3/65)
April	38.9	21 8	44.1 (27/4/58)	14 4 (2/4/55)
May	42.6	27.1	47.2 (9/5/73)	19.0 (13/5/64)
June	40.4	28.5	47.7 (10/6/66)	15.6 (7/6/57)
July	34.0	25.5	43.9 (12/7/51)	17 8 (24/7/62)
August	32.0	24 5	39.1 (5/8/64)	20.0 (20/8/50)
September	33.0	24.1	37.8 (25/9/51)	17.8 (28/9/50)
October	32 8	19.9	38.3 (17/10/51)	11.1 (28/10/57)
November	29.1	12.5	35.5 (2/11/63)	4.4 (24/11/50)
December	24.8	8.9	30.6 (2/12/54)	1.7 (26/12/61)
Annual average	32 6	19.1		

Rainfall:

The heaviest rainfall recorded as reported in the Distt. Gazetteer (1989) for Jalaun Distt,. is 264.2 mm on 6th August 1899 and at Orai it is 368.3 mm on 29th July 1881.

The average annual rainfall in the district is 782.6 mm of which almost 90% falls between June and September — that too within a few days. The rainfall data for 1901 to 1950 is summarised below in a table which gives remarkable variation during the fifty year period:

Annual Average : 782.6 mm		Days of rains :42.1
Maximum rainfall : 163% (1919)		
Minimum rainfall : 36% (1905)		
Month	**Rainfall (mm)**	**Rain-days (rains > 2.5 mm)**
Januray	13.7	1.2
February	12.8	1 2
March	. 7.3	0.7
April	5.5	0 6
May	7 4	0.8
June	64 5	3 9
July	241.7	12.1
August	254 3	12.1
September	139.1	7.0
October	20.3	1.1
November	5.3	0.4
December	5 5	0 5

The Winds:

Winds are generally light. During non-monsoon months they blow predominantly from the north and the north-west. From May onwards easterlies appear and during the monsoon season, the winds between north-east and south-east are as common as the winds between south-west and north-west.

The table which follows gives mean wind-speed within this district.

The Humidity

In the south-west monsoon period humidity exceeds even 70% while during summer season, it is nearly 30%. Details of the normal and extremes are given in the table which follows:

Month	Mean wind-speed km/hr	Relative humidity 8-30 AM	Relative humidity 5-30 PM
Januray	5.6	73	54
February	5.8	58	38
March	7.6	49	32
April	8.0	37	28
May	9 3	36	27
June	10.8	53	42
July	10.2	80	72
August	8.8	88	81
September	7.5	77	68
October	6.3	64	50
November	4 4	51	39
December	n a	63	48
Annual		61	48

Cloudiness:

During the monsoon season and for brief spells of a week or so in association with the western disturbances in the cold season, cloudiness increases. The cloudiness these days is really unpredictable because of immense environmental disturbances in our country and abroad. The atmosphere is influenced by many factors.

Special Weather Phenomena:

Depressions from the Bay of Bengal during the monsoon season which move in western and north-western directions across the country sometimes affect the weather over the district causing wide-spread heavy rains and dusty-winds. In the cold season western disturbances affect the weather and thunderstorms occur in association with them.

2.2.2. JHANSI DISTRICT:

One of the heart-districts of Bundelkhand, Jhansi lies between latitude 25°30' and 25° 57' (North) and longitude 78°40' and 79°52' (East) and has an area of 5,024 sq.km. Jhansi is bounded by Jalaun district in north, Lalitpur and Tikamgarh districts in south, Hamirpur district and river Dhasan in east and Shivpuri and Datia districts in west.

A. PHYSICAL FEATURES :

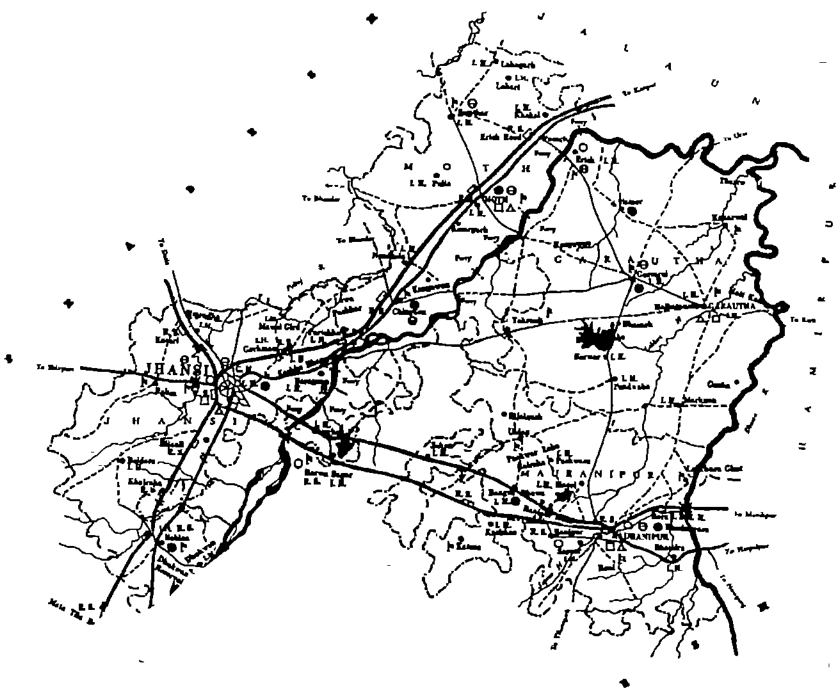
TOPOGRAPHY

Jhansi is comparatively level; a low lying and fertile tract. It has the general appearance of a plain dotted with isolated low and rocky hills and comprises the northern part of tehsils Jhansi, moth, Garautha, and the north-eastern part of Mauranipur.

This district has two physically distinct portions[13]:

1. NORTH-EASTERN PLAINS

This vast plain is adorned with spread-up hillocks here and there . The main river is Dhasan, which is joined by Lakheri and Chainch rivers along with its tributaries draining totally the Mau-



DISTRICT JHANSI

Ranipur and Garautha tehsils. River Betwa also attracts some drainage particularly of Moth tehsil.

Two distinct hill-ranges are also seen in this portion of the district.

a. a range starting near Barwa-Sagar going to north-east towards Jhansi and Moth tehsils,

b. another starting near Katera south of Mauranipur, going towards north passing by Kachneo and Magarwara lakes.

In the north the land towards Betwa is ravinous and undulating. The ravines are more widely spread near Dhasan and Betwa rivers. The country has a slope towards the north-east.

2. THE SOUTH-WESTERN PLATEAU

The country forms a plateau in the south-western direction and is also adorned with tall/big hills here and there. It forms the southern portion of Jhansi tehsil and south-western part of Mauranipur tehsil. The land is undulating and also marked with severe ravines. The general slope is towards the north.

GEOLOGY

Jhansi is well-known for its unique assemblage of granite rocks known as Bundelkhand-Granitic Complex[14]. Geologically, the northern boundary of Jhansi is partially Gangetic alluvium. Bundelkhand granite and gneiss are in plenty. Like in other parts of Bundelkhand, quartz reefs are visible along the granites and is also adorned with igneous rocks at many places.

The general geological succession in the area is as follows:

Recent ----------------	Soil and alluvium
	Secondary veins of quartz and epidote/lamprophyre
	Dolerite
Bundelkhand Granitoid Complex:	Quartz Reef
	Porphyries
	Aplite and pegmatite
	Leucocratic fine to medium grained-granite
	Diorite
	Granite Gneiss
	Metabasites
	Meta-sedimentaries

The granite gneisses which are porphyroblastic at places exhibits effects of metasomatism, are well exposed in north of Jhansi. The diorite represents hot phase intrusive in the above rocks and is widely exposed in the vicinity of Jhansi town. The leucocratic granite (intrusive of cold phase) generally forms rounded hillocks and is followed by various intrusive dykes of porphyry, aplite, pegmatite, quartz, dolerite and lamprophyre. The granitic rocks carry enclaves of various dimensions of meta-sedimentaries such as quartzite, quartzose-schists, quartz amphibolite, sillimanite hornfels banded hematites, quartzite, impure marble etc. and metabasites such as amphibolite and pyroxenite. The metasediments and metabasites exhibit various grade of metamorphism ranging from low temperature gneiss schist facies to high temperature K-feldspar-cordierite-hornfels facies.

Foliation is generally developed in the granitoid rocks and trends in SNE-WSW directions with steep to vertical dips. Major shear planes in the area trend in N60° E-S60° W to N30° E-S30° W directions and are generally occupied by quartz reefs which are conspicuous features in the form of linear ridges, and often crossed at right angles by dolerite dykes[14].

The available mineral in this district is as follows:

1. Building stone and road-material
2. Ceramic Pegmatite
3. Pyrophyllite and Diaspore

The Soils:

All representative soils of Bundelkhand are found in Jhansi district. It can be roughly divided into three kinds:

1. Bundkelkhand type I :
   a. Red soil in the north
   b. *Rakar* soil in south
2. Bundelkhand type II:
   a) Brown Fertile *Domat, Parua* somewhere mixed with *kankars* and clay; *Matiyar* (13-45%) is also found which has less lime-stone on the surface but increases as one goes lower.
3. Bundelkhand type III :
   a) *Kabar*-coarse grain; *Domat* fertile soil of brown to black colour mixed with *Matiyar* upto 25%
   b) Mar (it is fertile soil with capacity of greater moisture retention; scantly available in Jhansi district).

B. DRAINAGE AND WATER-RESOURCES :

The slope of the district is towards north and north-east which is apparent from the direction of the rivers and streams flowing and touching this district. Betwa, Dhasan, Pahuj and Saprar are the major perennial streams along with their numerous tributaries drain off entire district well. All of them have been tapped in this district to construct weirs or the dams. Canals have been taken out to irrigate the agricultural land of this district.

Jhansi district is famous for its numerous huge water-reservoirs built during the rule of *Chandela*- and later *Bundela*-Kings. There are good numbers of such structures which have utilised the slope of the land, the plateau and existing hillocks by obstructing the lower side to give them good shape of artificial lakes. These lakes were later used as irrigation resources by channelising water through canals.

THE RIVERS AND STREAMS :

Rivers and streams are the natural resources of water of which a brief account is given below :

THE BETWA :

Rising near Bhopal this river flowing from south-west touches this district at Badora village. It flows along the boundary of Jhansi district for nearly 14 km and leaves it towards Tikamgarh returing to Jhansi tehsil at Banguan village. It flows in north-easterly direction till Erich where it turns east and flowing slightly south-easterly, leaves this district near village Deori where it is also met by river Dhasan flowing from the south.

Betwa river in its upper reaches, is generally confined between high banks and flows in a deep and rocky channel, forming a series of deep pools and picturesque cataracts. In the later part of the flow it widens and also forms ravines along the banks. In Jhansi district, Betwa has been dammed at two points, first at Dhukuwan and then at Parichha both by way of constructing weirs.

The Tributaries of Betwa: In addition to Dhasan which is described later, some minor streams flowing from the hills of tehsils Moth, Jhansi, and Mauranipur form its tributaries. On the left bank of the river the most important is the Ghurari which flows through the southern part of tehsil Jhansi while the Gairao, Barwa, and Garrukha *nallahs* drain the western half of tehsil Moth. The affluents of the river on its right flank are not of any importance except the Barwa which has been dammed to form Barwa-Sagar lake in this district.

The Dhasan : Also rising in Madhya Pradesh this river enters Jhansi district from the south at Khakaura village of Mauranipur tehsil and forms throughout its boundary with Mahoba and Hamirpur districts of Bundelkhand. The river has a rocky bed and its course is flanked by ravines, which grow highly complex as it approaches Betwa.

The river has been dammed at Lahchura and at Pahari opposite to Deori (in Mauranipur tehsil) by way of weirs, the water from which has been channelised for irrigation through canals.

The tributaries of Dhasan: The larger and more important tributaries of this river are the Ur, the Sukhnai, the Lakheri and the Chainch. All of them cut deep channels and carry a considerable volume of water during the rains causing floods, erosion, and wide-spread destruction over large areas but become more or less dry after the winter.

The Pahuj : Rising in Gwalior region, this river enters Jhansi district near village Raunija (Jhansi Tehsil) and forms its boundary with the district of Datia, leaving at Shahpur in Moth Tehsil towards Gwalior, it retouches Jhansi at Budhera Kalan in Moth tehsil to leave it finally at Sajauni village. The Pahuj river, although flowing mostly through rugged country, does not have a deep bed.

Pahuj has been dammed near village Simartha some 8 km north-west of Jhansi; the reservoir, although planned for irrigation purpose, supplies drinking water mainly to Jhansi town. There are canals taken out from this reservoir to irrigate land in a few villages but the supply is insufficient. Pahuj in this district does not have any appreciable tributary.

The Saprar : This river flows north-east from Tikamgarh district, has been dammed at about 6 km south of Mauranipur to make *Kamla Sagar* reservoir. This river meets Sukhnai, another seasonal stream near Mauranipur.

The Lakes of Jhansi :

Jhansi has numerous lakes which have been formed by embanking the lower portion of the streams surrounded by hillocks on other sides and some of these constructions date back to thousand years i.e. during *Chandela* rule over this tract. *Bundela* Rajputs also were fond of building ponds and lakes in this region.

Some major lakes are described below:

1. *Kachneo* Lake: This is an old construction of *Chandela* period which was repaired and rebuilt by the famous ruler of Orchha, Bir Singh Deo around 1600 AD. Canals were taken out during the past century. Its capacity is ca. 44.7 million cubic metre.

2. *Arjar* Lake: Situated ca. 27 km south-east of Jhansi near Nivari this lake was built by Orchha ruler Surjan Singh around 1671 A.D. Its capacity is 17.4 million cubic metre although very much silted these days. Canals have been taken out from this lake.

3. *Barwar* Lake: Situated ca. 29 km north of Mauranipur on Gursarai-road this lake is used for drinking water supply as well as irrigation. It has a capacity of holding 33.4 million cubic metres water.

4. *Barwasagar* Lake: Situated nearly 15 km east of Jhansi and dammed by a 1.21 km strong embankment, this lake dated the *Chandela*-period, was rebuilt by Orchha ruler Udit Singh in the eighteenth century to hold ca. 10.332 million cubic metre water. Canals were taken out from this lake sometime before 1862 A.D.

5. *Magarpur* Lake: Situated 5 km south-east of Nivari station this small lake is an ancient construction with water storage capacity of nearly 2.44 million cubic metre. Canals have been taken out from here for irrigation.

6. *Siaori lake*: Situated at about 8 km north-west of Mauranipur at village Siaori on Lakheri river, this lake was improved in 1906 and opened for irrigation. This also receives water from *Kamla Sagar* which has increased its irrigation capacity.

7. *Magarwara* Lake: Built during the famine-relief work in 1868-69, this lake has a storage capacity of 1.65 million cubic metres of water and used for irrigation.

8. *Pachwara* Lake: This lake was also built in 1868 and has water storage capacity of ca.5.88 million cubic metre; used for irrigation.

Important Dams in Jhansi District:

Jhansi Distt. has dams built at various locations on the Betwa, the Dhasan, the Pahuj, and the Saprar rivers. Some information about these dams is given below:

1. PAHUJ DAM; This dam is situated about 8 km north-west of Jhansi. Presently it is used to supply drinking water to Jhansi town and also some irrigation.

2. DONGRI DAM: Built to supplement the Pahuj dam, in the years 1979-86 this also serves the purpose of providing drinking water to Jhansi and irrigation canals taken out from Pahuj dam.

3. PARICHHA DAM: Situated about 21 km north-east of Jhansi this weir was constructed during 1881-1886 on river Betwa to provide irrigation facility to Jhansi, Jalaun and Hamirpur districts.

4. DHUKUWAN DAM: Built around 1905-1909, this weir on Betwa serves to enhancement of the irrigation capacity through Betwa canals.

5. PAHARI DAM; Situated about 18 km east of Mauranipur on Dhasan river this weir was built in the years 1909-12 and repaired in the years 1918-19 and 1926-28. This also serves the purpose of irrigation through Lahchura dam mainly in Hamirpur district.

6. SAPRAR DAM: The reservoir is known as Kamla Sagar. Built during the first five-year plan, this consists of ca. 3.9 km long earthen dam; 16.8 metre high at the main river section having 152.05 metre masonry spillway with 38 gates. This stores water in an area of 24.6 sq km with a capacity of nearly 76.29 million cubic metre. The reservoir irrigates Jhansi district through Ranipur canals and enhances the capacity of Siaori lake.

7. LAHCHURA DAM; Built on Dhasan at about 11 km north of Harpalpur station in the years 1906-10 this dam consists of a masonry weir and earthen bunds on each side. The useful capacity of this dam is nearly 10.6 million cubic metre.

8. KHAPRAR DAM: This dam has been built on river Khaprar, a tributary to Pahuj with a small water storage capacity of 3.5 million cubic metre. It is an earthen dam with masonry flank escape and the length of the dam is ca. 276 metre.

Technical details of the above dams are presented in the following table:

Salient Features of dams in Jhansi district:

DAM	Source river	Catchment area (sq.km)	Storage gross (Mcm)	Depth (m)	Spillway length (m)	Gates/shutters no./size
Pahuj	Pahuj	310.50	18.27	ns	183.8	ns
Dongri	-do-	141 50	9.92	13.75	26.0	ns
Parichha	Betwa	26 60	78.22*	16.77	871.3	6' high
Dhukuwan	-do-	21341.60	57.79	11EB	1196.34	383/8' high
Pahari	Dhasan	7839.00	47 76	15.24	563.41	165/10x8 sq ft
Saprar	Saprar	363.52	76 20	16.76	152.40	38/10x10 sq ft
Lahchura	Betwa	8755.00	10.57*	14.94	54 33	ns
Khaprar	Khaprar	27.70	3.51	11.19	130.03	ns

*effective live storage

Other than the above, there are many smaller reservoirs/tanks and embankments built as irrigation projects which serve well as water bodies within this district. Some of these are Garhmau reservoir, *Kharkhari* Bund, *Urwan Tal*, *Bachera* Tank, *Jamalpur* Tank, *Tindol* Tank, *Palra* Tank, and *Shekhradhawa* Tank, etc.[15].

B.1 THE DRINKING WATER SITUATION :

As mentioned, Jhansi district has been traditionally using masonry wells for meeting its major drinking water needs. The villages near the rivers have been using water which, in the absence of any polluting big industry in the region, has been potable for ages. The urbanisation process and Jhansi becoming major railway and cantonment centre, needed a break-through in arranging its drinking water needs and that brought the transfer of huge water from the reservoirs of Matatila and Pahuj dam in picture.

The rural water needs have been supplemented by planning some piped water supply-projects and expanding the installation of India Mark II-hand -pumps in the region.

Detailed information follows :

1. DRINKING WATER SITUATION IN URBAN AREA:

a. Urban Drinking Water Supply (already operating)

S.no.	Place (year)	Covered population 1991	Sources	Available capacity	Relevant information
1.	Jhansi 1916 1960	4,13,951	Matatila dam Pahuj Dam H/P· 744 open wells TW-12 Baratha-basin TW-06	10,000 cmd 12,000 cmd 7,440 cmd 2,000 cmd 4,200 cmd 9,000 cmd	all these sources are not enough Two World Bank assisted schemes are under operation.
2	Samthar 1960	16,894	TW-02 H/P : 36	n.s.	J.S. Jhansi is maintaining
3.	Barwasagar	18,786	RDWS H/P : 55	n.s.	-do-
4.	Chirgaon	13,900*	TW-02 H/P - 25	n.s.	-do-
5.	Ranipur 1978	15,957	Saprar dam H/P : 52	n.s.	-do-
6	Moth	10,519	TW-01 H/P :25	n.s.	-do-
7	Erich	7,400	TW-02 H/P :28	n.s.	-do-
8.	Gursarai	17,913	Barwar-lake H/P : 47	-	-do-

9	Mauranipur	43,820	Saprar dam H/P · 71	-	-do-
10	Badagaon	6,577	TWH/P . 26	-	-do-
11.	Todi-Fatehpur	9,771	TW-04 H/P : 21	-	-do-
12.	Jhansi Cantt	27,800	Jhansi-Babeena DW-scheme	-	maintained by Jhansi Cantt.
13.	Babeena cantt	—	-do-	-	maintained by Babeena cantt
14	Jhansi Rly. Settlement	15,780	-do- H/P : 02	-	Railway Deptt.

b. Urban Drinking Water supply (under Construction)

S.NO.	PLACE	POPULATION	PLAN OF ACTION AND REMARKS
1.	Jhansi D.W. Extension scheme	4,40,850	Raw water has be to brought from Matatila dam (48 km) to Babeena based settling and purification system from where it is to be distributed to Jhansi city. The status of the work is as follows · a *Pen- stock to CP Tank* 1. pen stock tapping work at Matalilla dam has been completed 2. pipe-laying upto wing-wall has been competed. 3. 1400 mm dia. pipeline from wingwall to CP tank has been fully constructed. 4. CP tank has been fully constructed. 5. The electric motors and raw-water pumping plant etc have been acquired. 6. electric transmission line is being laid. 7 raw water pump-house and generator room have been completed, generator installed. b. *Matatilla to Babeena RawWater Main* 20.140 km pipeline (1400 mm dia) has been laid between CP tank and Matatila to Babeena and tested, awaits supply c. *110 mld Water Purification Plant* this has been completed; power connection obtained and dry-running of back-wash pump and air-blower etc. has been done. d. *Clear Water-Main from Babeena to Jhansi* In the 27.660 km distance, pipeline (1300 mm/1200 mm dia) for transfer of clean water from Babeena to Jhansi is being laid. The formalities and necessary construction of culverts involving crossing over the rail line, Rajghat canal (at three locations) and highway are in progress, all the bridges completed.
2.	Jhansi-DW scheme (quick relief) Baratha-basin	-do-	a All the six tubewells have been commissioned b. 8.425 km rising main has been laid from the tubewell to Badagaon pumping station c 800 kilo-litre capacity water reservoirs and the zonal pumping station have been completed at Badagaon. d. In the 14.320 km pipeline from Badagaon to Talpura, three bulk water metres have been installed for calculation of supplied water e. At Badagaon pumping station three pumping plants of 4000 lpm capacity and 96 m head have been installed. f. Necessary O/H tanks have been constructed, and the intra-city connections between O/H tank and distribution line has been commissioned
4.	Samthar source enhancement scheme		On U.P Governor's promise one extra tubewell is being installed
5.	Barwasagar source-enhancement of D.W scheme :	-	Six pumping plants and feeder main of 6.1 km are being set up.

2. RURAL DRINKING WATER SUPPLY SCHEMES:

a. Under Operation:

S.NO.	SCHEME VDWS	VILLAGE COVERED	SOURCE	OHT/CWR	H/P NO.	REMARKS
1.	Barwasagar (1968)	10	Betwa R	OHT-1 CWR-2	n.s.	JS is maintaining
2	Hansari-Gird (1975)	14	Jhansi-Babeena pipe-line	-	n s	-do-
3.	Mauranipur (1972)	52	Saprar dam	OHT-18	n.s.	-do-
4.	Bamhrauli					
	1st stage	14	TW-02	OHT-01	n.s.	-do-
	2nd stage 1975	09	TW-02	OHT-02		
5.	Bharosa (1977)	06	TW-02	OHT-01	n.s.	-do-
6	Ranipur (1978)	03	Saprar dam	OHT-01	n.s	-do-
7	Talaur					
	1st zone	02	TW-02	OHT-01	n.s.	-do-
	2nd zone	08	TW-02	OHT-01	n s	
8	Gursarai	34	Barwar lake	OHT-07 CWR-04	n s.	-do-
9	Kochha Bhawar					
	Digara	07	TW-02	OHT-01	n.s.	-do-
10	Ram nagar	01	well-01	OHT-01	n.s.	work in progress
11.	Mauranipur Gursarai- (modification)	13	TW-02	-	n.s.	one TW failed

VDWS=village group Drinking water Scheme CWR=Clear Water Reservoir TW=tubewell
R=river OHT=Overhead tank JS=Jal Sansthan H/P=Handpump (India mk.II)
In addition to the above, there are certain rural drinking water schemes which are under construction. These are.

1 Khisni Khurd 2. Raksha-Sijwaha 3. Magarpur
4. Kuan Gaon 5. Bamhrauli (Extn) 6. Sakrar

The installation of India Mark II hand-pumps have also helped the people to meet drinking water needs; their blockwise distribution is as follows:

S.no.	Dev. Block	Villages	Handpumps (no.)
1	Babeena	73	676
2	Badagaon	82	594
3	Bamaur	100	662
4	Bangra	82	720
5	Chirgaon	102	691
6	Gursarai	106	558
7.	Mauranipur	83	570
8.	Moth	123	724
	Total	751	5,215
	Total handpumps in urban area :		1,210
	Total handpumps in Jhansi distt.		6,425

source . U P. Jal Nigam Report District: Jhansi, (March 1996)

B.2 SITUATION OF IRRIGATION IN THE DISTRICT

Irrigation plays a role of varying importance in different parts of the district depending on the nature of the soil. In the regions of black soils in tehsil Moth, Garautha, and Mauranipur artificial irrigation has not been absolutely necessary because of the water retaining capacity of the soil. In the red soils, however, irrigation was necessary because the soils were incapable of retaining moisture.

The low water table and the hilly topography of the district have always been an obstacle to the expansion of irrigation. This district was abundant in masonry wells which were employed for irrigating the fields before canals were introduced in the same area for revenue-benefits. As shown earlier, this district has many lakes, *ponds, and reservoirs from where canals have been taken out for irrigation. Embankments* (Bandhan-system) were also popular here as in other districts of Bundelkhand.

The present situation of irrigation is as follows:

a) Different Irrigation Resources in the district (1991-92):

S no.	Resources	Length	Number	Hectare
1	Canals	1196 km	-	-
2	Tubewells (Govt.)	-	58	-
3	masonry wells	-	12,261	-
4	Persian wheels		10,267	
5	Pumping sets			
	on surface	-	4,859	-
	on borings	-	11,350	-
6.	Private tubewells	-	1,920	-
7	Embankments	-	-	n a.

Source . Sankhyikiya Patrika Distt. Jhansi (State Planning Instt) 1992

b) Resourcewise Irrigated Area in the District (1990-91)

S no.	Particulars		Area (ha.)
1.	total area sown .		3,60,668
2	total irrigated area ·		1,11,962
3	net irrigated area		1,10,098
Area according to Irrigation sources :			
	(i)	canals :	66,612
	(ii)	tubewell (Govt)	1,192
	(iii)	-do- (Pvt.)	1,687
	(iv)	masonry wells :	37,284
	(v)	ponds/Lakes etc.	706
	(vi)	others .	2,617

source . Sankhykiya Patrika Distt. Jhansi (1992) State Planning Instt. U P.

CANAL SYSTEMS:

Several storage reservoirs have been constructed on different rivers in this district as already described, to provide water for irrigation during winter season — or if necessary for the rainy-season crop. These reservoirs also provide drinking water to various towns and some villages through piped water supply. During summers the canals are run to fill the village ponds for cattle and the inhabitants.

Following canal-systems are operating in Jhansi district:

1. Betwa canal system
2. Gursarai canal system
3. Ranipur canal system
4. Pahuj canal system
5. Garhmau canal system

1. Betwa Canal System: This is the largest system of canals in Bundelkhand region providing irrigation to Jhansi, Jalaun, Hamirpur and Datia districts. Starting from Parichha dam on left side, the main canal goes 30.9 km on the land of Jhansi district where it bifurcates into Kuthaund and Hamirpur-branches. The initial 24 km of Kuthaund branch irrigates Jhansi district; then it enters into Jalaun district.

2. Gursarai canal system: Taking off on the right side of the Parichha dam, this system is a contour channel alligned along a ridge and provides irrigation to the area between the ridge and Betwa river. All the outlet channels from this canal are from left of the canal. It consists of a network of 43 canals, all irrigating the district of Jhansi. Total length of the canal is 307 km, while its discharge is 503 cusec.

3. Ranipur canal system: The system takes off from Saprar reservoir, provides irrigation facility to the area between river Dhasan and Lakheri rivers in block Bangra, Mauranipur , and Gursarai of Distt. Jhansi., This is also a contour channel aligned along the ridge and all the off-taking channels are towards its left bank except Girha minor. This canal crosses river Skukhnai through a siphon and has small distributaries and minors, the total length being 116 km.

4. Pahuj canal system: Taking off from Pahuj reservoir, this is an old system planned to irrigate the area between Pahuj river and Betwa main canal. Water is also supplied to Garhmau tank when necessary. The total length of this system is 40.6 km and the head discharge is 75 cusec.

5. Garhmau canal system: Taking off from Garhmau tank, this is a U shaped canal system. This also is supplemented through Badagaon pump-canal. The system is planned to discharge 57 cusecs of water and irrigates the area between Betwa and Pahuj rivers.

Irrigation through Lakes and Tanks:

In this district, there are numerous lakes and tanks which are used for the purpose of irrigating mainly the RABI-crops as well as for fisheries. Detailed account about these structures has already been given. Here we present brief information about salient features related to irrigation.

Pachwara Lake: Pachwara system of canals is 20.35 km irrigating an area of 397 hectares of RABI-crops in Mauranipur tehsil.

Kachneo Lake: Kachneo system of canals is 19.50 km long and irrigates an area of 960 hectares of RABI crops in Mauranipur tehsil.

Siaori Lake: The Siaori system of canals is 49.21 km long and irrigates mainly RABI-crops of 2027 hectares in Mauranipur tehsil.

Magarpur Lake: With 1.7 km long canal this irrigates only 74.06 hectares in Mauranipur tehsil.

Magarwara Lake: With a canal system ca. 3.10 km long this irrigates an area of 146 hectare in Mauranipur tehsil.

Barwasagar Lake: The Barwasagar canal-system irrigates ca. 336 hectares of RABI -crops in mainly Garautha tehsil.

Apart from the above, other smaller tanks irrigate the surrounding area as follows[15] :

S no	Name of Tank	Tehsil	Canal system length (km)	Irrigated RABI area (ha)
1.	Tindol	Jhansi	2.21	131.00
2	Palra	Mauranipur	n s	2 83
3	Shekhradhawa	-do-	n s	41.68
4	Arjar	-do-	23 15	1034 00
5	Garhmau	Jhansi	77.32	3818.00

MINOR IRRIGATION

The minor irrigation data available upto March 1996 for Jhansi district is as follows :

a.	Total area .	4,99,211 ha
b	Cultivated area	3,65,512 ha
c.	Irrigated by MI works	1,32,493 ha
d.	*minor irrigation works* (No.)	
1.	Wells	27,045
2.	Persian wheel	10,675
3.	Surface-pumpsets	18,836
4.	Pumpsets on borings	4,469
5.	Deep tubewell	174
6.	Artesian wells	-
7	Free Borings	4,523
8.	Private tbewells	1,376

source . Progress Report of Minor Irrigation Programme (Jhansi Division) Oct 1996.

C. VEGETATION :

THE FORESTS :

The district has been characterized by a dry central India type of climate and in consequence the dry tropical species of vegetation capable of sustaining on low rainfall, predominated.

The Forests of the district prior to its present depleted state could be divided into the following three types:

1. The northern-southern dry miscellaneous forests.

2. The northern thorn forests.

3. Dry tropical scrub forests.

The main species found under the first set here have been *kardhai, dhau, sain, dhak, sainja, khair, mahua, tendu, satan, salai, ghont, teak,* and *bans.* Other species along with these used to be *airwan, akola, bija, phaldu,* and sandalwood etc.

The second set of forests had the species like *khair,* and *thuar* which occurred are mixed with *markarar* and *ghont.*

The dry tropical scrub forests have been the victim of heavy fellings and grazing, their characteristic feature having been the stunted growth of species like *siari, katai, gunj, bel, ghont, khair* and occasional bamboo.

The situation of the forest has become very precarious in this district because of wrong forest-policies, commercialisation and pressure of needs. The Distt. Gazetteer of Jhansi (1965) reports the situation tehsil-wise in the year 1960-61 and the distt. statistics book (1992) gives the area of forests in the district for 1990-91 which are tabled as follows:

S.no.	Tehsil	Forest Area (ha.)	
		1960-61	1990-91
1	Garautha	10,581.93	14,805.00
2.	Jhansi	7,360 73	6,530.00
3.	Mauranipur	5,151.42	2,481.00
4.	Moth	7,326 72	8,955.00
	Urban area		3 00
Total		30,420.80	32,774.00

The above table shows that after the passage of thirty years although, on paper, the forest area, has differed in different tehsils, it has not, on the whole, decreased. Yet the actual forest area, in ground reality, is almost denuded.

AGRICULTURE:

Jhansi had less than half of its area as agricultural, including both, KHARIF-and RABI-crops. Horticulture has not been commercial here. ZAID-crops are taken only in a small area where irrigation is assured.

The table A in the box gives an account of main crops taken here in the year 1991-92:

The hilly topography of the district does not permit large-scale farming and cultivation of land under the so called improved cultural practices.

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of the district may be characterized by a hot dry summer and a cold winter and is marked for high variability of rainfall year to year. The year may be divided into four seasons: the cold, from December to February, followed by the hot seasons from March to the middle of June. The monsoon season is from mid-June to September, and the post-monsoon season is October and November.

TABLE A

S.no.	Crops	Area covered (ha)	Irrigated area (ha)	Average yield qtl/ha
KHARIF :				
1.	Paddy	1,684	336	6.61
2.	Juwar	24,326	2	5.02
3.	Bajra	37	-	7.46
4.	Maize	3,264	7	6.33
5.	Urd	9,397	11	1.46
6.	Moong	4,925	162	1 86
7.	Arhar	7,750	-	3 03
8	Til	3,993	4	0.77
9.	Soyabean	934	11	11.10
RABI				
1	Wheat	1,13,143	91,696	19.76
2.	Barley	2,622	1,417	17.40
3.	Gram	79,652	8,943	6.15
4.	Masoor	38,149	6,568	8.07
5.	Peas	20,651	6,213	13.22
6.	Mustard	5,895	3,578	5.67
7.	Linseed	8,258	3,094	3.87

Source : Sankhyikiya Patrika (Jhansi Division) 1993

Traditional Indian calendar is divided into six seasons *varsha, sharad,. Shishir, hemant, vasanta, greeshma* which is the more practical way of looking at the seasons.

Temperature:

The meteorological data available from the observatory at Jhansi could be taken as an average for the whole district. The temperature begins to drop rapidly by the middle of November, January being the coldest month of the year, becoming colder with cold waves caused by the western disturbances moving across north India. From March onwards both day and night temperatures begin to rise progressively, May being the hottest month. The rains bring down the temperature slowly which again rises during September. September-October is peculiarly more piercing as far as the sunlight is concerned and causes diseases predominantly loss of fluid and malaria.

The following table gives the record of month-wise average maximum and minimum and the highest and lowest temperatures duringthe period 1897 to 1957[13]: (also see* and#)

Month	Mean daily max	Mean daily min	Highest max /date	Lowest min/date
	°C	°C	°C	°C
January	24 3	8 9	33.3/16 1.46	1.7/20.1.35
February	27 3	11 4	37.8/20.2.30	0 6/2.2.29
March	33.4	17 1	43 3/27.3.1892	7.2/6.3.45
April	38.7	23.0	45 6/29 4 14	14.4/1 4.35
May	42.6	28.7	47 2/23 5.47	20.0/6.5.47
June	40 4	29.3	47 8/1 6.24	20.6/3.6.22
July	33 6	25 9	45.6/1 7.1900	21.7/3.7.36
August	31 9	24 9	42.2/1 8.11	21.7/7.8.39
September	32.9	24.1	40 6/28.9.13	18.3/3 9 42
October	33 7	19.3	40.6/9 10.13	12.2/27 10 57
November	29 6	12.7	36.1/2 11 41	5.0/30.11 38
December	25.4	8 9	32.8/6.12 40	2.2/26.12 37
Annual	32.8	19 5	-	-

* the above data pertains to combined district of Jhansi and Lalitpur
\# The maximum and minimum temperatures for Dist Jhansi recorded in the year 1991-92 are 46.8°C and 4.1°C respectively

Rainfall:

The average rainfall of the district as reported in the Distt. Gazetteer (1965) is 880.0 mm. The data for 1991-92 is 931 mm as against the normal 850 mm for Jhansi District. The rains are caused mainly by south-west monsoon and July has been recorded as the month for heaviest rainfall.

The record of the average rainfall, days of rains, maximum and minimum rainfall along with the year and the month-wise distribution between 1901 and 1950 is as follows:

Annual Average : 880.0 mm — **Days of rains : 41.6**
Maximum rainfall : 153% (1919)
Minimum rainfall : 41% (1905)

Month	Rainfall (mm)	Average rain-days (more than 2.5 mm)
Januray	11.5	1.1
February	11.1	1.0
March	7.2	0.7
April	4 3	0.4
May	6.0	0.6
June	73 6	4.3
July	299.0	12 3
August	279.4	12.3
September	147.7	6 6
October	23.9	1.1
November	10 5	0.6
December	5.8	0.6

Mean monsoonal rainfall data of Distt. Jhansi between 1978 and 1991 are as follows

1978	1256.5
1979	366.9
1980	1033.2
1981	681.85
1982	962.0
1983	910 4
1984	622.9
1985	896.2
1986	550.5
1987	599.5
1988	751 4
1989	617 4
1990	1039.5
1991	802 6

The Winds:

Winds are generally lighter in post-monsoon-and winter season and blow from the directions between south-west and north-west in the mornings and between north-west and north-east in the afternoons. The winds start blowing stronger from March increasing upto monsoon. It is generally the western or south-western during summers but changes direction during the rainy season.

Humidity:

The air is very dry in summer season especially in the afternoons when the average relative humidity is less than 20%. This increases in the rainy season and registers a decrease during winters.

The following table gives the data of relative humidity month-wise as reported in the Distt. Gazetteer.

Month	Relative humidity 8-30 AM	Relative humidity 5-30 PM
Januray	63	39
February	54	28
March	38	18
April	29	15
May	29	15
June	49	38
July	77	71
August	81	75
September	75	65
October	56	35
November	52	32
December	60	35
Annual	55	39

Cloudiness:

During monsoon season, the skies are sometimes heavily clouded and often overcast. During the rest of the year except for some period ranging upto a week when cold waves bring rains or fog, the skies are generally clear. This phenomena has become uncertain because of the overall environmental disturbances.

Special Weather Phenomena:

Thunderstorms occur during the pre-monsoon and monsoon months. The phenomena during winter-season is associated with western disturbances across north India; sometimes accompanied also with the hails. Fog may occur during winters while during summers hot winds and dust-storms are not uncommon.

2.2.3 LALITPUR DISTRICT

Carved out as a district in the year 1974 Lalitpur is really not only the heartland but also heart-shaped district of Bundelkhand region. This district lies between latitude 24° 11' and 25° 13' (north) and longitude 78°11' and 79° 0' (east) and is bounded by district Jhansi in the north, district Sagar in the south, Tikamgarh and Chhatarpur districts in the east and Shivpuri and Guna districts in the West. The geographical area of the district is 5,039 sq km.

A. PHYSICAL FEATURES :

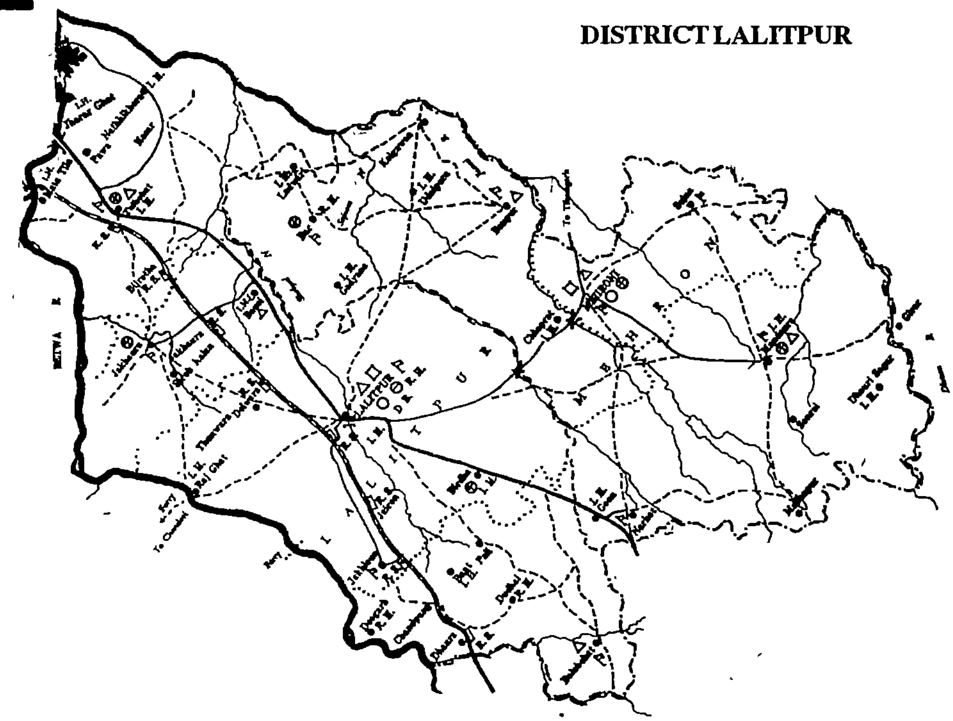
TOPOGRAPHY

The area is generally rocky. The highest ground is in the extreme south with scarps of the Vindhyan plateau, running from the Betwa in south-easterly direction and gradually breaking up into a confined mass of hills, parts of which approach a height of 650 m above mean sea level. The north of the scarp, undulating plain of black soil interrupted with scattered hills and scoured by numerous drainage channals, stretches north beyond the town of Lalitpur and gradually becomes more rocky. Low red hills of granitoid rock then appear with long ridges running from south-west to north-east[16].

Most of the area is being drained by river Jamni and its tributaries which form its eastern boundary, separating it from Tikamgarh district. River Betwa forms the western and northern boundary and drains the western part of the district. The south-eastern part is partly drained by Dhasan river. In general the slope is towards the north.

The hills in the south generally occur in small groups or in continuous narrow chains running parallel to each other from north-east to south-west, the ridges being mostly bare and sharp. The slopes are still comparatively more covered with scrub jungles.

The plateau is intersected by wide valleys particularly in the south west; and the entire tract,



once covered with vegetation, looks barren these days. Mining has affected the whole area considerably.

From the base of the plateau to the town of Lalitpur there stretches a black soil plain which is dissected by a number of seasonal rivulets and is characterized by an undulating topography. The principal rivers which traverse the area are the Shahzad, the Sajnam, and the Jamni.

There is an uneven red soil tract marked by the existence of numerous bare or rocky hills dotted with scrub upto the northern part of Lalitpur and Mahroni tehsils. It is also traversed by long quartz reefs and diversified by lines of rocky hills.

GEOLOGY

Geologically, Lalitpur is an interesting district as it comprises the rocks varying in age from 50 to 3000 million years. Except the southern fringe where the rocks belonging to Bijawar group, Vindhyan group and Deccan traps are exposed, the whole part of the district is occupied by the geological succession of the area as follows:

1. Deccan Trap
2. Vindhyan group of rocks
3. Bijawar Rocks
4. Dykes and veins
5. Granite gneiss, migmatite and granite
6. Meta-sedimentaries and meta basites.

A brief account of the above is as follows:

1. Deccan Trap: Small outlines of Basalt with intra-trappean beds occur at places in the southern part in the form of flat topped hills. Soil, sand and alluvium have covered major parts of the terrain.

2. Vindhyan Groups of rocks: Vindhyans comprising sandstones and quartizite, are exposed at the southern fringe of the district and forms great Vindhyan scarps.

3. Bijawar Rocks: Bijawars consist of limestone, dolomite, quartzite, shale, sandstone, banded hematite quartzite, basic dykes and lavas belonging to Bijawar group are exposed in a narrow zone in the south of the granitoid complex. The Bijawars are folded to form a large West-South-

West plunging synclinorium, the southern limb of which is concealed below the Vindhyan rocks. The northern limb is traversed by several strike and oblique faults.

4. Dykes and Veins: The granite activities were followed by intrusions of aplite, pegmatite diorite, granite porphyry, quartz reefs, dolerite and secondary veins of quartz and epidote. Aplite and pegmatite seen as minor veins are present in all the granite rocks. The porphyries particularly common in the northern part of the district (near Jamalpur-Talbehat etc.) generally trends in ENE-WSW direction. These are cut by reefs of quartz which are trending in NE-SW direction. The dolerites are trending in NW-SE direction.

5. Granite gneiss, Migmatite and granite: The granite gneisses and migmatite are closely associated with schistose rocks and exhibit minor folding. Medium grained granite gneiss which is porphyroblastic at places form low mounds in the area. The leucocratic fine to medium grained granite represents intrusive phase and forms bold hills.

6. Meta-Sedimentaries and meta-basites: which occur as enclaves within the granitic rocks forms good exposures in Mahroni tehsil. The meta-sedimentaries mainly comprise of quartzite, quartzose schist and quartz sericite schist. The meta-basites are represented by peridotite, serpentinite, pyroxinite, and amphibolite rocks. The scattered small exposures of these rocks are also found at many other places.

MINERALS

Pyrophyllite and Diaspore: These have been worked out at Tori-Bar and also at Patha area of Lalitpur district.

Iron Ore: To be used as sponge Iron, this ore has been located in Barwar-Girar area and also at Solda.

Base Metals: Extensive mineralization of copper in linear zones of weathering and state-bound lead-zinc has been investigated by the Directorate of Geology and Mining in the lower members of the Bijawar group near Sonrai.

Uranium: Uranium-Bitumen mineralization has been established in the upper parts of the Sonrai formation and is confined to brecciated zones with chalcopyrite, galena, sphalerite, coffinite, bitumen quartz and calcite.

Glass Sand: Large exposures of Dhandhraul quartzite have been reported to exist in the Murari and Talbehat forest reserve. This is a sedimentary quartzite often occurring in friable beds on gently sloping ground under a covering of soil. GSI has analysed these samples which could be used for the manufacture of plate-glass, sheet glass and white bottles.

Lime-Stone: A highly siliceous lime stone has been found near Piprat in smaller quantity.

The Soils:

The soils of Lalitpur are also representative of Bundelkhand comprising all the four varieties. The soils here have developed from the Vindhyan ranges of rocks which in this area are formed of gneiss, granite, quartzite and at times sandstone, limestone and slate.

The soils of the district are divided into two broader categories 1. black and 2. red soil groups. The four varieties of soils are derived from these two groups which are as follows:

1. Bundelkhand type 1: is under the red soil group and locally known as *rakar* which is also of two types: one known as Bundkelkhand 1A which occurs mainly around the rocky ridges in the southern most part of this district while the latter, classified as Bundelkhand 1B, mostly occurs in the northern part of the district. These are not very appropriate for farming but only suitable for afforestation. These soils are also subject to severe hazards of erosion; therefore need to be conserved through embankments.

2. Bundelkhand type 2. or *parua*. it is also a red soil subdivided as Bundelkhand type 2A and Bundelkhand type 2B. The 2B-soil is found in the central tract of Lalitpur district. This is sandy loam in texture, mature in profile and light to dark grey in colour. This loves water and also needs irrigation during farming.

3. Bundelkhand type 3. This is black soil group and consists of two kinds. The type 3A is locally known as *kabar* and the type 3B is the *mar.* It resembles very much the black cotton soils as found in central India. The *kabar* soil which is a coarse grained loam in texture and mature in profile, has high clayey element. It occurs mostly in the southern part of tehsil Lalitpur and Mahroni. This is a very productive soil but needs very careful and timely management; otherwise it becomes difficult to handle.

The *mar* soils are found around Balabehat in the southern part of tehsil Lalitpur. It is highly clayey in texture, mature in profile and black in colour. This is also a water retaining soil like the *kabar* but low in coarse sand and soluble salts. The drainage is poor on these soils and management has to be very careful like that in *kabar* soils.

A strip of alluvial soil is also found in the western part of Lalitpur district.

B. DRAINAGE AND WATER RESOURCES :

Lalitpur district has a good natural drainage towards north and north-east exhibited by the flow of the rivers like Betwa, Jamni, Dhasan, Narain, Shahzad, and Sajnam etc. This district has also numerous dams and reservoirs built during post-independence period although ponds have been there from ancient times like in other parts of Bundelkhand.

The rivers and streams of the district are summarized below:

1. Betwa River: Rising from near Bhopal, Betwa river first touches this district near Dhojri village and is joined by Narain river at the same point. Betwa flows northward to make the districts western boundary and turns north-east forming its boundary with Jhansi district. Betwa has been dammed at Matatila and a multi-purpose inter-state RAJGHAT project is under way to be built for generation of electricity as well as irrigation in U.P. and M.P.

2. Dhasan River: A tributary of Betwa, this river touches Lalitpur district at the south eastern tip and flows for about 38 km before it re-enters the neighboring district of Tikamgarh.

3. Jamni River: An important tributary of Betwa, this river enters Lalitpur district cutting through the forest near Madanpur village, and flows northward for ca. 45 km leaving the town of Mahroni on its right. It then takes north-easterly bend and after ca. 6 km further comes to form the boundary of the district for about 60 km. If comes very close to the Betwa just before it finally leaves the district. Jamni has been dammed within Lalitpur district.

Other Important Streams:

Important tributaries of Jamni are Sajnam and Shahzad rivers. While Sajanam joins it at Chandawali, Shahzad joins it near Hazaria village. These streams drain enormous volumes of water during rains while in other seasons they shrink to narrow channals. Shahzad, an important river flowing by the side of lalitpur town, has been dammed to make Gobind Sagar reservoir near Lalitpur. Sajanam has also been dammed in this district.

There is another small stream named *Rohini*, a tributary of river Dhasan, which flows in the north-east direction across the Mahroni tehsil in the south-west corner of the district. *Rohini* has a small dam built for the purpose of irrigation.

THE LAKES AND TANKS OF LALITPUR DISTRICT;

Like in other districts, lakes or big tanks had been built in this region also, important among them being at Talbehat, Jakhaura, Bar, Dhauri Sagar, Bant, Vijaipur, and Panari, Most of these have *Chandela*-architecture and date back to similar times.

These lakes/tanks have proved to be of great value, particularly during seasons of low rainfall. Apart from checking erosion they raise the ground water table in their neighbourhood.

THE DAMS:

As reported, most of the rivers passing through or by Lalitpur have been dammed. Salient features of these dams are given below.

S.no.	Dam year	River	Length (km)	Height(m)	Catchment area (sq km)	Total storage M.c.m.
1	Matatila 1952-64	Betwa	6.30	33 53	20,720	1132.68
2.	Jamni 1962-73	Jamni	6.40	19.18	414	92.89
3.	Rohini 1976-84	Rohini	1.65	15.50	44	12 12
4.	Shahzad 1973-92	Shahzad	4.16	18.00	514	130 00
5	Gobind Sagar 1947-53	Shahzad	3.60	18.29	368	96.80
6.	Sajanam 1977-90	Sajnam	5.15	18.78	290	83.50
source : Deptt. of irrigation U.P. (Jhansi)						

B.1 THE DRINKING WATER SITUATION :

The drinking water needs of this district had been met traditionally by the masonry wells or the rivers passing by the village. But since the dams were made, the rivers have ceased to be source of drinking water. Wells are still used as the primary source for meeting this need, though many of them get dried during summers. In order to meet drinking water need, India Mk II hand-pumps have been put up (though not appropriately located and also not adequate) in almost all the villages. Some efforts have also been done to run piped water supply schemes in both urban and the rural areas.

The details follow :

1. DRINKING WATER SITUATION IN URBAN AREA :

a. Urban Drinking Water Supply (under operation) :

S.no.	Place (year)	Covered population (approx.)	Source dam/R	H/P no.	Relevant information
1.	Lalitpur 1958 1985 (reorganised)	80,000	Gobind Sagar	200	The daily supply is ca. 6.846 m.l.d. OHT - 3 (450, 1500, 2200kl)
2	Talbehat 1968/1980	10,000	Matatila	40	This has been under Talbehat RDWS scheme CWR (200kl) OHT (115kl)
3.	Mahroni 1972	8,000	Jammi(R)	53	This had been a part of Madawara RDWS scheme
4.	Pali 1981	8,000	Betwa (R)	27	This has been under Piparwasa RDWS scheme CWR (110 kl) OHT (225 kl)

b. Rural Drinking Water Supply Schemes :

S.no.	Name	Villages covered	Source	OHT/CWR	H/P no.	Remarks
1	Talbehat	town+7vill.	Matatila	CWR (200kl)	130	initiated in 1968
2.	Bar	32	Bar-tank + TW-03	-	166	- do -
3	Lalitpur	45	Gobind Sagar	-	357	initiated in 1971
4.	Mahroni - Madawara	44	Jamini(R)	CWR (450kl) OHT (100 kl)	357	initiated in 1972
5	Piparwasa etc. Bamhori-Kalan, Birdha, Pali .	75	Betwa (R)	CWR-06 OHT (225 kl) +OHT - 29	383	initiated around 1971 this scheme is not serving the distant villages; some tubewells have also been put up

source . U.P. Jal-Nigam Report March 1996 (Executive Engineer, Jhansi branch I)

C. The Block-wise Distribution of Hand-pumps :

S.no.	Dev. block	Handpumps (no.)
1.	Bar	613
2	Birdha	716
3	Jakhaura	835
4	Madawara	644
5.	Mahroni	585
6.	Talbehat	670
	Total :	4,063
	In urban area	320
	Grand total upto March 1996 .	4,383

source : Jal Nigam - Report as cited above

B.2 IRRIGATION SITUATION IN THE DISTRICT

As already clear from the number of dams and reservoirs in this district, the irrigation potential is high. Prior to it, the main source of irrigation were masonry wells which used to be built by the farmers themselves. Records tell that 93% irrigation was done by these wells only. The initiation of the canal-system made wells irrelevant for the time being.

1. The status of different sources of irrigation in the district is as follows :

S no.	Source	Lenght km	Area ha	Number	
				1991-92	1992-93
1.	Canals	661 36	-	-	-
2	TW (Govt.)	-	-	01	01
3.	TW (Pvt)	-	-	229	260
4	Masonary Wells :	-	-	18,627	18,806
5.	Persian Wheels	-	-	17,317	17,393
6	Pumpsets				
	- on surface	-	-	5,589	6,554
	- on borings	-	-	6,829	6,840
7.	Embankments	-	4,444 63	-	-

2. The source wise irrigated area (1991-92) is as follows :

S.no.	Particulars	Area (ha)
1.	Total sown area	2,19,004
2.	Total irrigated area	1,20,662
3	Net irrigated area	1,18,440
	source-wise distribution	
	Canals	47,570
	TW (Govt.)	-
	TW (pvt)	394
	wells	38, 641
	Lakes/Tanks/Ponds	3,919
	others	27,916

source : Sankhyikiya Patrika (Distt. Lalitpur) State Planning Instt. U.P

CANAL SYSTEMS :

The various canal-systems based on the dams already outlined are as follows :

S.no.	Name	Particulars		
		Length (km)	Proposed irrigated area (ha)	Actual irrigated area (ha)
1	Gobind Sagar	190	10,830	17,921
2	Jamini	245	11,270	29,692
3	Rohini	20	1,312	2,395
4	Sajanam	102	14,346	9,729
5	Shahzad	70	20,243	10,788
6	others	85	12,867	6,980

Other Information :

- The Rajghat Multi-purpose Project on Betwa river when completed will give additional potential for irrigating another 17,000 ha within Lalitpur distt.
- The Matatila dam does not provide any irrigation to Lalitpur Distt.
- The Jakhlaun pump-canal when operable, will give additional irrigation potential to this district.
- The Deptt. of minor-irrigation is assisting in expansion of irrigation potential by way of boring and blasting.
- The tanks of Balabehat, Gauna, and Mahauli could be, after suitable repair, used for irrigation.

MINOR IRRIGATION

The minor irrigation data available upto March 1996 for Lalitpur district is as follows :

a	Total area	4,86,717 ha
b.	Cultivated area	2,18,995 ha
c	Irrigated by M I works	1,18,440 ha
d	Minor Irrigation works (no)	
1	Wells	29,676
2	Persian wheel	22, 896
3	Surface pumpsets	17, 989
4	Pumpsets on borings	223
5.	Deep Tube well	132
6	Artesian well	-
7	Free borings	93
8	Private Tube well	68

source Progress Report of Minor Irrigation Programme (Jhansi division) oct 1996

C. VEGETATION

As described for Jhansi, this district also is characterised by a dry central-India type of climate and therefore, the dry tropical species of vegetation capable of sustaining on low rainfall has been existing here.

THE FORESTS

Three types of forests had been found in this district :

1. The N-S dry miscellaneous forests,
2. The northern Thorn Forests, and
3. The dry tropical scrub forests.

The forests are managed by the State Forest Department which is supposed to be managing these scientifically. The present policy of granite mining has disturbed the entire region of Lalitpur and there is enormous destruction and denudation of the forests, erosion and loss of its soil, destruction of the base, and the sheer wastage of groundwater just in the pursuit of commercial benefit for a very few individuals, companies and the State Govt's apparent revenues.

Coming to the report of the actual forest area, we see that in 1960-61 this district has been reported to have 65799.70 ha while the extent of the forest area on paper in 1990-91 is 72,886.00 ha which is nearly 14.5% of the total area. But unfortunately, this figure is not of the forests but the land under possession of the Deptt. of Forests, U.P. in this district.

The industrial policy of the Government has affected the forests badly. The forests were cut and exported. The saw-mills were promoted which now, after finishing the forests, are turning towards finishing the left out big shade-giving trees of the villages and the road sides. Nobody seems to be bothered about it.

AGRICULTURE :

The land which is under agriculture, horticulture, pastures, and the fallow land capable of turning into arable land, altogether account for

76.46% of the total land. This is enormous land which, if properly utilized, can give quite a surplus production. The 1991-92 figure of agricultural land i.e. the land under cultivation is 2,19,004 ha which is 43.44 % of the total land of the district. Of this 1,18,440 ha is under irrigation i.e. 54.08% of the total area under agriculture, which as compared to other districts is far better.

The cropping pattern of this district is almost similar to other districts of Bundelkhand because of similarity of the soil and also the climate. Major crops are KHARIF and RABI and a brief account of the area covered and productivity is given below :

S.no.	Crops	Area covered (ha)	Area irrigated (ha)	Average yield (qt/ha)
KHARIF				
1	Paddy	8,817	07	4.44
2	Jowar	25,347	-	5.32
3.	Bajra	105	-	7.46
4.	Maize	20,828	07	12.80
5	Moong	3,463	1,398	2.33
6	Arhar	281	-	8.65
7	Til	5,765	-	0 66
8	Soyabean	1,962	30	3.89
RABI				
1	Wheat	90,994	68,898	16 01
2	Barley	3,290	3,007	17 40
3.	Gram	60,999	40,602	8 66
4	Masoor	5,549	3,617	13.22
5	Mustard	512	231	5.66
6	Linseed	8,087	246	4.50

Source Sankhyikiya Patrika Distt. Lalitpur, State Planning Instt., U P. (1993)

D.CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of the district is the central India type sub-tropical and may be characterised by a very hot dry summer and a cold winter. Like other districts of the region, this also shows four distinct seasons. Summer being from March to mid-June, Monsoon from mid-June to September, post-monsoonal transition between October and November while the winter months are December to February.

Temperature :

The day temperature is the highest during May/June which falls steeply with the onset of monsoon in mid-June or July. It rises again around September and goes a little higher during October. Then with the beginning of winter, the temperature falls and becomes minimal in January.

The record of temperature, as reported in the Distt Gazetteer, is the same as for Jhansi because during the period of temperature study (1901-1957) this was a part of Jhansi district only. Regarding this aspect please see the data for Jhansi district.

Rainfall :

Similar situation is with the rainfall data also. The usual months of rainfall are from mid-June to the end of September, July being the maximum raining month followed by August and September. Sometimes during winters, especially around the middle of January, there is a cold wave associated with the rains which may last for several days. The climate presently is not as marked and predictable as it was earlier in last century.

Mean monsoonal rainfall data of distt. Lalitpur taken at different rain guage stations, are as follows:

Year	Lalitpur
1978	1189 0
1979	802.7
1980	1030.5
1981	628.4
1982	1293.7
1983	1395.15
1984	793.35
1985	706.85
1986	604.5
1987	777.9
1988	604.5
1989	423.6
1990	709.4
1991	558.2

The Winds, Humidity and Special Weather Phenomena :

The district can be taken as broadly resembling that of Jhansi in all the aspects of climatology. Separate data for this district are not available. People, too, do not perceive any reckonable difference *in these aspects* between the two districts, Jhansi and Lalitpur.

Granite Outcrop, Jhansi District

2.3. SAGAR DIVISION

This comprises five districts namely Chhatarpur, Damoh, Panna, Sagar and Tikamgarh. After reorganisation of Jhansi division this is now the biggest division with maximum number of districts in Bundelkhand region. The source of information regarding these districts are the district gazetteers published by the Govt. of M.P., the Imperial Gazetteers of India published in 1908 and other reports and publications, besides our own surveys.

The district-wise information is presented below:

2.3.1 CHATTARPUR DISTRICT :

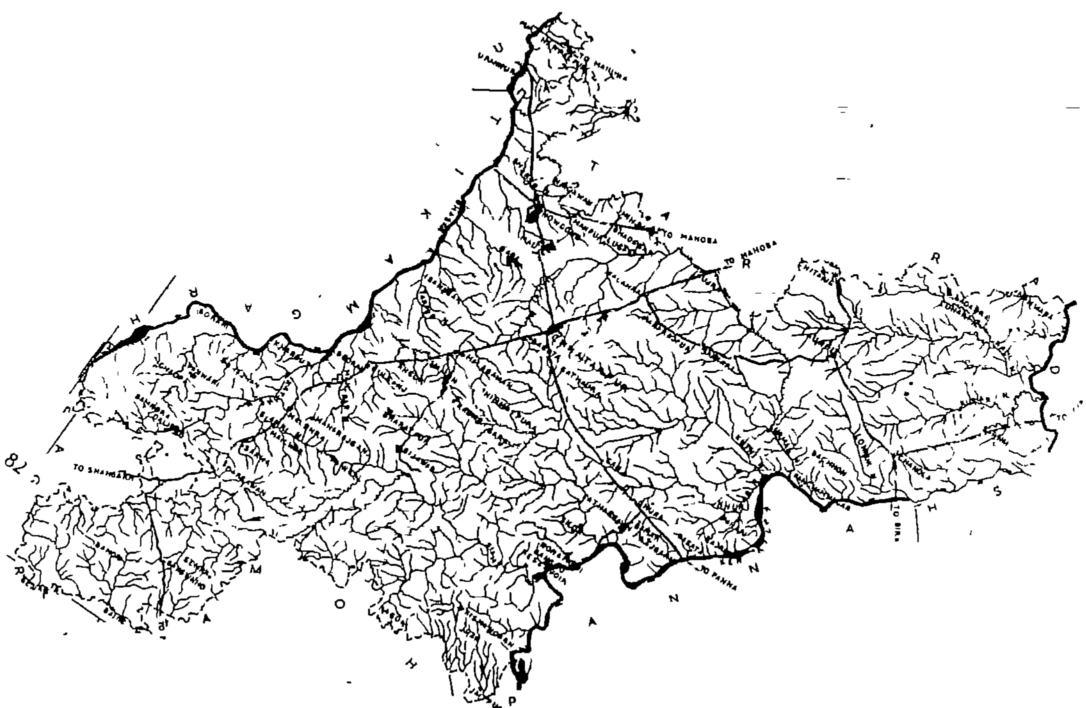
Chhatarpur is an important district of Bundelkhand. This area has been the centre of main power during the famous King Chhatrasaal's reign. The city of Chhatarpur was established by King Chhatrasaal himself in 1707 AD. During British raj also, Nowgong, a town of this district was the seat of Bundelkhand Agency and hence, the centre of power.

Chhatarpur district lies between Latitude 24°6' and 25°26' (north) and Longitude 79°0' and 80°27' (east). The district is elongated from south-west to north-east and has an area of 8,687 sq. km. The district is bounded on the north by Mahoba district, on the south by Damoh district, on the east by Panna and on the west by Tikamgarh district. Banda district occupies a north-easterly while Sagar and Lalitpur, a south-westerly position across the boundaries.

A. PHYSICAL FEATURES :

TOPOGRAPHY :

The district as a whole lies on the lower part of Bundelkhand plateau. The general height of the district is about 400 m. However, the most prominent parts are those traversed by the Panna hill range through the southern parts of the district. The range stands about 100 m from the surroundings and 500 m from above the mean sea level. From here the plateau gradually lowers down and converges into the alluvial plains in the north, particularly along the Ken and the Dhasan rivers[17].



DISTRICT CHHATARPUR

There are three physical divisions of the district :

1. The Panna range
2. The central plateau
3. The northern plains

1. The Panna Range : This is a branch of the Vindhyan mountains traversing Sagar, Chhatarpur and Panna districts from south-west to north-east. It separates the upper Bundelkhand from the lower Bundelkhand plateau. Overlying the Archaeans it is formed by the Bijawar and Vindhyan beds which have folded variously, and have also been much cut up by the superimposed drainage system in this area.

A few hill tops now capped by the Deccan Trap rocks stand evidence of their being covered by extensive lava flows. Since then, the drainage developed on the slopes of the original lava bed has eroded the surface deeper to the present level. On account of this and by the cutting back of the upstreams, the main rivers of the district flow across the Panna range.

The Panna range had developed several mild folds, each sloping to the south and scarping to the north, notably coinciding with the change of geological formations. The central syncline is drained by two small streams of the same name, Saimri, flowing in opposite directions to the east and the west, respectively. This separates the anticlinal hill ranges of Binjh and the local Panna ridge. The highest peak in the district (606 m) lies at 24° 37' (N) by 79° 45' (E). Kusmar hill on Buxwaha plateau is 551 m and Madanwa 564.2 m above the mean sea level.

2. The Central Plateau :

This runs to the north as if an offshoot of the Panna range. It lies mainly on the Bundelkhand granites and forms the central sub-water divide. The result is the presence of small hills and ridge everywhere at intervals, standing between the tributary streams. They give way to the lower plains along the Ken and the Dhasan, in the east and the west respectively.

3. The Northern Plain : The plain lies between 150 to 300 m above the mean sea level and is covered by varying thicknesses of alluvium. The rains and the drainage of the area results also in ravine-formation as in other parts of Bundelkhand.

GEOLOGY

Nearly three-fourths of the district is occupied by Archaean rocks, while the terraced hilly area in the southern part is formed mainly of the rocks of Bijawar and Vindhyan formations. The edges Bijawar-Semri- and Kaimur - groups and Rewa - groups form a succession of scarps trending in the direction from the east-north-east to the west-south-west.

A few isolated areas covered with basalts and associated rocks are also found in this part. Extensive areas of the Archaean rocks are covered with alluvium especially in the northern and western parts of the district. The extent of the alluvial capping progressively increases towards the north, particularly in Laundi tehsil.

A brief account regarding different rock-systems is given below :

Archaeans : The Archaean rocks in the district are formed mainly of coarse and medium grained pink granites and granitic gneisses. These are known as *Bundelkhand* - granites. Inclusions of amphibolite, and schistose rocks are sometimes observed in the rocks. The granitic rocks are traversed by numerous quartz reefs (locally known as *Dhaula Patthar*). These *Dhaula Patthars* form many of the prominent north-east to south-west trending ridges in the area. Granites are also traversed by a number of dolerite (*Telia Patthar*) dykes which usually run in a general north-west to south-east direction.

Bijawar Group : The town of Bijawar and the scarps immediately to the south are formed of Bijawar group of rocks , comprising mainly of chert breccia, lime-stone, quartzite, ferruginous breccia and basalt.

Vindhyan Formation : The second terrace, comprising the area from near Jatashankar southwards, is formed of rocks of lower Vindhyan formation (Semri and Kaimur groups) and comprise mainly of sandstones, quartzite, lime stone, porcellanitic shale, black carbonaceous shale, yellowish green shale and conglomerates.

The third terrace further southwards is formed mainly of quartzites, green to chocolate shales and conglomerates in Rewa-group of rocks.

Deccan Trap : Vesicular basalt occurs in four isolated areas in the southern hilly terrain of the district overlying the shales and quartzite of Rewa-group of rocks and sometimes over a calcareous sandstone.

Alluvium : A small area in Laundi tehsil and narrow strips along the Ken and the Dhasan rivers lie covered under the alluvium of varying thicknesses.

The mineral wealth of the area comprises of the Building Material (like sandstone, quartzite, slates, *kankar*, granite, reef-rock, dolerite etc.), Clays (china clay associated with granite, inferior quality of fire clay, red, white, and yellow ochres), Copper (only in traces), Impure Limestones and Dolomite, Pyrite at several places and a peculiar Iron Ore in small quantities within Bijawar rocks.

B. Drainage and Water Resources :

The general slope of the district is diverted to the north through the Ken and the Dhasan rivers. The drainage of this district is divided into two parts; on each side of the central sub-water divide which runs from the south to the north past Buxwaha, Ragauli, Chhatarpur and Lugasi. The streams east of this dividing line flow to the east and join Ken, while the west-bound streams join Dhasan.

The district as a whole lies in the Ganga drainage system. The nature of the drainage is seasonal and the pattern mostly dendritic.

The important streams are as follows :

THE RIVERS :

The Ken : Rising in Jabalpur district, river Ken flows through Panna district and makes the eastern boundary of Chhatarpur with Panna and Banda districts of Bundelkhand. The course of the river is towards the north. Between the two anticlines of the Panna range, the Bindhachal and the Panna range proper, flows a small tributary stream called the *Siamri*. The *Siamri* joins the Ken whose confluence is now submerged under the Gangau reservoir consequent to the weir constructed of Bundelkhand gneisses. The lower course of Ken on the alluvium is affected by ravine formation at several places.

The tributaries of Ken within Chhatarpur district are Siamri, Banne, Khuraran, Kutni, Urmil, Lohruk, Kusar and Kail, besides many of its small seasonal tributary-streams which drain off the district from the western side.

The Dhasan : Dhasan rises from Raisen district and flows to the north across Sagar district. It then forms the boundaries between Sagar and Jhansi, Chhatarpur and Tikamgarh, Chhatarpur and Jhansi and later Hirapur and Jhansi. In its early course, the river flows through the Trap-rocks but like the Ken, crosses it the Vindhyans, Bijawars, and Bundelkhand gneisses before entering the alluvial plains.

The tributaries of Dhasan within this district are mainly *Kathne* or *Bila, Mancrar, Tarper, Narkrer, Bharar*, and so many seasonal draining streams all joining the river from the eastern side. There are several islands and rocky portions in the course of the Dhasan. The lower course is cut up by ravines.

THE DAM RESERVOIR :

Gangau is the largest water body formed by damming the river Ken at Nonapanji within this district. *Gangau* reservoir serves as a feeder dam to the *Bariarpur* weir from where numerous cannals have been taken out to Panna and Banda districts of Bundelkhand.

Rangawa is another reservoir made by damming Banne river, a tributary of Ken in this district which also is used to feed *Bariarpur* weir as well as irrigation in Chhatarpur and Panna districts.

The salient technical features of these reservoirs are given below :

Reservoir	Catchment area sq.km.	Total capacity M.c.m.	Useful capacity M.c.m
GANGAU	18637	56.43	56.43
RANGAWA	828	164.14	155 08

M c m - million cubic metre

LAKES AND TANKS :

District Chhatarpur has been rich in the traditional resources. The *Chandela* and *Bundela* kings during their reign had excavated large tanks which look like lakes. The famous BILWA-TADAG of Khajuraho built by king Yashovarman during the last quarter of the 10th century which looked like sea was probably seen and appreciated by the famous traveller Ibn-Battuta during his visit around 1335 AD.

Some of the big-sized tanks situated in this district are :

1. Jagar Sagar at Mau,
2. Gora Tal at Gora,
3. Isha Nagar Tal, and
4. Niwari Tal, all located in Chhatarpur tehsil.

Several tanks within the town of Chhatarpur had good storage of water but slowly the urban expansion has swallowed these reservoirs.

In this region, almost every village has one or several tanks which serve the inhabitants. However some of the tanks of significance which had been built several centuries back, are situated in the locations as follows :

1. Bijawar tehsil : Angor, Bandha, Bhagwan Bazar, Patti, Imalia, Malhara, Malguwan, Panwari, Pura
2. Chhatarpur tehsil : Gor, Rajnagar, Sarani
3. Laundi tehsil : Badaura, Bhagwara, Chandla, Manwara

Smaller Tanks Built by Land-lords :

The tanks built by the Malguzars (the land-lords) in their villages are numerous. Some of these are listed below[17]:

S.no.	Name	Location (tehsil)	Designed area (ha)
1.	Gora Tal	Chhatarpur	32
2.	Lalpur Tank	-do-	32
3	Nayagaon	-do-	32
4.	Nandgaon	-do-	121
5	Amkhera	-do-	40
6.	Kishansagar	Bijawar	215
7.	Raipura	-do-	101
8	Kasar Tanak	-do-	101
9.	Ramsagar	-do-	73
10	Brijpur Tank	-do-	40
11.	Baramsagar	-do-	486
12.	Phutwari Tank	-do-	101
13	Sidhsagar	-do-	162
14	Motigarh	-do-	85
15.	Lampti	-do-	69
16.	Raichore Tank	-do-	40
17.	Machiyara Tank	-do-	97
18.	Baniyara Tank	-do-	51
19.	Kiratsagar	-do-	154
20.	Rugoli Tank	-do-	121
21.	Dilari Tank	-do-	60
22.	Gopital	Laundi	44
23.	Jhinna Tank	-do-	40

B.1 THE DRINKING WATER SITUATION :

Traditionally, Chhatarpur district has been an area dominated by masonry wells for provision of drinking water. This was a decentralised arrangement managed by the people themselves. During earlier days the local land-lords used to build such resources to manage the problem related to drinking water. But as this region came under centralised rule, Deptt. of Public Health Engineering (PHE) became solely responsible for looking after the water supply of towns while the Gram-Panchayats and the Development blocks were entrusted with the responsibility of arranging rural drinking water supply.

The management of drinking water was done in four ways :

1. Improvement of existing wells
2. Construction of the new wells
3. The installation of hand-pumps, and
4. The piped water supply.

The information available from the district Gazetteer (1982) and from reports received from the administration till December 1996 reveal that all the problem villages numbering 933 had reached some kind of arrangement of the drinking water. Of these 56 villages have been reached piped water supply from safe sources.

Drinking water has been reached to all the towns like Chhatarpur, Khajuraho, Nowgong, Laundi, Garhi Malhara, Chandla, Barigarh, Harpalpur, Maharajpur, and Bijawar etc. through piped supply managed by the Deptt. of Public Health Engineering, M.P. Govetnment. India mark II handpumps also have helped the situation, but their performance is very poor.

Source : Important Statistics of Sagar Division, Divisional Statistical Office, Sagar,(1996)

B.2 IRRIGATION SITUATION IN THE DISTRICT;

The old records reveal that the construction of wells, ponds, and tanks has been a strong tradition here in this region. The reservoirs built by *Chandela* and *Bundela* rulers could be seen as the most important irrigation works. These were to be renovated, repaired and modified to channelise water for irrigation sometime after the great famine of 1896-97. The reservoirs with an irrigation capacity exceeding 40 ha were handed over to the Irrigation Department while smaller reservoirs continued to be with the Department of Revenue.

The wells had occupied pride of place amongst the sources of irrigation. During 1950-51 the share of wells in irrigation was 95.4%. Later it declined gradually due to expansion of canal irrigation, but the net area of well-irrigation and also the number of wells in the district showed an increase. Since this is the most decentralised source of irrigation it has been liked and retained by the farmers. The relevant figures as reported in the District Gazetteer (1982) and a recent report from Deptt. of Agriculture are as follows :

Year	Well (no.)	Irrigation %	Irrigated area ha
1950-51	-	95 4	35,000
1965-66	-	-	42,300
1966-67	33,000	-	-
1968-69	33,503	-	48,300
1971-72	33,700	78 5	52,900
1995-96	52,899	63.4	79,348
1996-97	-	70 0	79,400

source : Progress report of the RABI-programme (1996-97) Deptt. of Agriculture, Chhatarpur, 1997

The mode of irrigation through wells has traditionally been the leather-bucket-rope arrangement known locally as *charas* or moth or the persian wheel (*rahat*) powered by the pair of bullocks. In the year 1966 the number of persian wheels and the *charas (moth) were reported to be 20,835 and 10,279 respectively.*

The mode of irrigation is still the same for small and marginal farmers but slightly well-to-do farmers have changed over to diesel-operated pumping sets or the electrical pumps. The promotive policy of the M.P. Govt. in granting electrical connections upto 5 h.p. has also encouraged farmers to take this benefit. The quick discharge of water from the wells, however, is not favoured by small farmers whose shallow wells need to be deepened with the lowering of the water table.

THE CANAL IRRIGATION :

The share of canals in irrigation is not high. Around 1950-51 the canal-irrigation was almost nil in this district. By 1971-72 it rose to 14.5% but after that there was spectacular increase. Initially all the canals were taken out from the tanks;

later on the Rangawa dam was utilised and also some lift canals were started. The anicuts on the Shiamri and Kail rivers also provide water for the canals irrigating a limited area.

The canal irrigation was promoted during the five year plan periods and large numbers of schemes had been planned and executed during these years. This is apparent from the enhancement of the area under canal-irrigation from 0 to over 25,000 ha. in 1996.

The area irrigated by different sources in 1997 is given as follows:

S.no.	Source of irrigation	Net irrigated area (ha.)
1.	Canals and Tanks	25,365
2	Lift Irrigation	1,514
3.	Tubewells	466
4.	Masonary Wells	79,400
5.	Stop-dams	340
6	Other sources	6,000
	Total	1,13,085
	% of the total area sown :	48.09
Source. Deptt. of Agriculture, Chhatarpur - Report (1997)		

C. VEGETATION

THE FORESTS :

The forests of this area have been mainly Southern Tropical Dry Deciduous forests sub-grouped in the following types :

1. Southern Tropical Dry Deciduous Mixed Forests
2. Southern Tropical Dry Deciduous Teak Forests
3. Anogeissus Pendula (Kardhai) Forests
4. Boswellia serrata (salai) Forests.

From local consideration, the types of forests in this district could be classified on the basis of prevalence of the species which used to be found in the forest area and also from its soil, slope, or water retention nature. These are Mixed, Teak, Bamboo, Kardhai, Salai, and Khair-forest-types.

The various Forest-types and their location within this district have been derived from the Distt. Gazetteer of Chhatarpur as follows[17] :

S NO.	RANGE	BLOCKS	AVAILABLE FOREST TYPES					
			MF	TF	BF	KF	SF*	KhF*
1.	Bijawar	Shahgarh	yes	yes	yes	-		
2.		Dilari	yes	yes	-	-		
3.		Dilari A	-	-	yes	-		
4.		Bharatpura	yes	yes	-	-		
5.		Kupia	yes	yes				
6.		Deora	yes	yes				
7		Deora A	-	-	yes	-		
8		Salpura	yes	yes	yes	yes		
9.		Pathar	-	-	yes	-		
10.		Amronia A	-	-	yes	-		
11.		Bakchur	-	-	yes	-		
12.	Kishangarh	Palkohan	yes	yes	yes			
13.		Raichur	yes	-	-	-		
14.		Matipura	yes	yes	-	-		
15.		Kishangarh	yes	-	yes	yes		
16.		Raipura	yes	-	-	yes		
17.		Jharkua	-	-	yes	-		
18	Chhatarpur	Silon-Salaiyesa	yes	yes	-	yes		
19		Pata	-	-	yes	-		
20	Laundi	Datla	yes	-	-	-		
21		Patna	-	yes	-	-		
22.		Barigarh	-	-	-	yes		
23.		Akona	-	-	-	yes		
24.		Dongawa	-	-	-	yes		
25.	Buxwaha	Dhanora	yes	-	-	-		
26		Bhimgarh	yes	-	-	-		
27		Jara	yes	yes	-	-		
28		Malar	yes	-	yes	-		
29		Samrachourle		-	yes	-		
30.		Bichhon	-	yes	-	-		
31		Issarmau	-	yes	-	-		
32.		Kahanjani	-	yes	-	yes		
33.		Sagoria	-	yes	yes	yes		
34		Goranad	yes	-	yes	-		
35	Malhera	Bajna	yes	yes	yes	-		
36		Baranad	yes	yes	yes	-		
37.		Sadwa	-	yes	-	-		
38.		Maharajganj	-	yes	-	-		
39.		Bhimkund	-	yes	-	-		
40		Patan	-	yes	-	-		
41.		Palda	-	-	yes	-		
42.		Dallpur	-	-	yes	-		
43		Bhagua	-	-	-	yes		

* These forest-types are found in all suitable locations preferred by the relevant types of vegetation.

MF=mixed forest, TF-teak forest, BF-bamboo forest, KF-kardhai forest, SF-salai forest and KhF-khair forest

The following table derived from the same source gives some more relevant information as follows:

Forest type	preferred nature of soils rainfalls slopes etc.	Associated vegetation		
		over wood	under wood	others
Mixed	all geological formations ill-drained soils except on the traps, rainfall: 1000-1600 mm	Saja Dhaora Lendia Aonla Achar Mahua	Achar Amaltas Jamrasi Papra Ber Bamboo	Karaunda Panwar Thuar Baikal Neel Chhind Makor, Chilati Gumchi
Teak	well drained localities over the Trap rocks, Conglomerates, or meta-morphics	as in above type; teak being the prevalent species		
Bamboo	under-storey amidst the above types, on moist hill slopes and upper reaches of Nallas where canopy of high forests is open.	This is associated with the above forests.		
Kardhai	on coarse, friable infertile, sandy soils on the exposed rocky and bolder stream areas over Vindhyans and Archaeans.	reunjha ghont Khair Ber Dudhi Thuar Lendia Salai	ghont dudhia jamrasi amaltas	baikal makor lumpa grass
Salai	upper slope of hills with dry, shallow and stoney soils	Moyan Kaim Dhaora	ghont Thuar Makor	shrubs climbers
Khair	Gravelly, eroded and barren sites under hard conditions.	Thuar, Gadbu, Dhaora, Kardhai, Moyan, Seja, Ghont etc.		

The trees like Koha (*arjun*) and *Jamun* are found along with the water-course.

Note : All types of forests during the past fifty years have faced denudation and destruction from commercial interests. The regeneration has been inadequate and therefore the environment has come under great danger.

AGRICULTURE :

Agriculture in this district has seen enormous increase in area during the past forty five years. From a figure of 205,000 ha in 1950-51 it has increased to 387,000 ha in 1996-97. The two-fold increase in area under agriculture reveals that people have taken up agriculture more seriously.

The normal two crops KHARIF and RABI are taken here with large numbers of cereals, pulses and oil-seeds. The Soyabean and Groundnut have shown increase during the past few years.

The following table gives the area covered under the major crops and their gross production in the year 1994-95:

S.no.	Crops	Area covered ha.	Production m. tonne
KHARIF :			
1	Paddy	20,241	18,124
2.	Jowar	24,562	15,876
3.	Urd	21,066	5,165
4	Soyabean	24,798	18,410
RABI			
1.	Wheat	1,34,127	2,30,463
2.	Gram	64,650	66,891
3.	Masoor	6,610	2,828
4.	Linseed	14,012	5,188
source . Important Statistics of Sagar Division, Divisional Statistics Office (1996)			

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of this district is characterised by general dryness except during the south-west monsoon season and a very hot summer. The year may be divided into four marked seasons. The summer months are from March to mid-June, followed by the rainy season between mid-June and September. The post monsoon months October to mid-November are transitional to the winter which starts in mid-November and lasts upto February. January happens to be the coldest month while May is the hottest month. July i.e. the month of *Asadha-Shravana* in Indian calender is the heaviest raining month. Some more details are as follows[17]:

Temperature :

The temperature in January is the lowest and starts increasing steeply from March onwards. May is the hottest month and the atmosphere cools only with the south-western monsoons coming to rain from mid-June. The temperature goes on gradually falling till it increases again in October because of the reduced cloudiness. The winter starts in the month of November.

The record of month-wise average of the maximum and minimum average of the temperatures at the Nowgong station, taken as average for Chhatarpur, from 1901 to 1960 and 1962 to 1992 are as follows :

Month	Maximum Average Temperature (°C)		Minimum Average Temperature (°C)	
	1901-61	1962-92	1901-61	1962-92
January	23.8	22.20	8.1	6.17
February	26.7	26.53	10 3	9 25
March	33.2	32.43	15.3	14 55
April	38 8	37.79	21.2	20 09
May	42.1	41.09	26.4	33.71
June	39.4	38 90	28 2	27.19
July	32 7	31 44	25.8	23 67
August	31.2	30.54	24 9	23 78
September	32.4	30 43	23 8	22.59
October	32.6	31.93	18.2	17 10
November	28.3	29.58	11 4	10 02
December	23 8	24 32	7 9	7 10
Annual	32.1	31.43	18 5	17 94
Source :IMD climatological Tables of observatories in India				

The highest among the maximum and the lowest among the minimum temperatures recorded during 1901-61 are as follows :

Month	Highest maximum (date) °C	Lowest minimum (date) °C
January	32.2 (16/1/46)	1.7 (19/1/35)
February	36.7 (27/2/34)	0.6 (2/2/05)
March	41.7 (28/3/31)	5.0 (7/3/45)
April	45.0 (30/4/48)	11.7 (3/4/05)
May	47 2 (24/5/47)	13.9 (6/5/32)
June	46.7 (1/6/54)	18.3 (9/6/57)
July	45.6 (1/7/31)	20.8 (27/7/58)
August	38.3 (10/8/45)	20.6 (8/8/57)
September	39.4 (26/9/29)	17.2 (29/9/44)
October	39.4 (17/10/30)	8.3 (27/10/57)
November	35.6 (4/11/29)	3.9 (30/11/41)
December	32.8 (14/12/29)	1.7 (27/12/61)

Rainfall :

The annual average rainfall as computed from the records available upto 1960 for Chhatarpur district is 892.1 mm and the days of rains, 44.7; while the maximum 156% of the average rainfall was recorded in the year 1942, the minimum being 38% in 1905. The records from 1961 onwards up to 1991 have also been kept in Chhatarpur rain-gauge station; the annual average of the rainfall taking the data of 91 years give the following figures :

Annual Average :	1067.66 mm
Maximum rainfall.	1633.82 mm (1971)
Minimum Rainfall .	195.10 mm (1948)
Mean Monthly Rainfall :	
Month	**Average rainfall (mm)**
January	21 65
February	13.64
March	6.04
April	3 25
May	5.02
June	97.92
July	429.24
August	349 07
September	177 40
October	32 84
November	12.86
December	6 32

Source . Hydrometeorology, by Dr. LP Chaurasia of the Deptt of Applied Geology, University of Sagar

From the data shown, it is clear that most of the rainfall upto the extent of 90% falls between the months of June to September of the year. The rains during June are mostly lost in evaporation. To some extent these contribute to the soil-moisture. The rains of August do contribute to the ground water. In September, the rains contribute to the ground water increment possibly due to infiltration to the upper aquifer bodies. The rains in other months are scanty and hardly enough to meet the soil moisture zone-requirements.

The Humidity :

Humidity plays a complementary role in the total climatic pattern of an area along with its rainfall and temperature. The mean monthly relative humidity percentages for 30 years (1962-92) for Nowgong station have been collected and presented in the following table. The data of relative humidity recorded earlier between 1901 and 1961 in the Nowgong station are also given in the table which follows :

month	Relative Humidity			
	1901-61		1962-92	
	8.30 AM	5.30 PM	8.30 AM	5.30 AM
January	76	41	79	38
February	67	30	66	28
March	46	23	57	20
April	34	24	30	11
May	34	27	31	19
June	54	46	74	39
July	50	76	74	63
August	83	76	77	69
September	81	67	75	59
October	69	44	66	43
November	73	39	61	39
December	77	40	72	40

Source : India Meteorological Department, Govt of India, Nagpur

The Winds :

The horizontal component of the air movement parallel to the earth's surface is generally known as the air current. Measurement of these air-currents by anemometer is called the wind velocity in terms of km per hour. The wind-velocity indirectly affects the intensity of the rainfall. The lower the velocity the chances of rainfall are more.

The mean wind velocity as recorded in the Nowgong station is as follows :

Month	Wind velocity (km/hr)
January	2.7
February	4 0
March	4.2
April	4.7
May	6 0
June	8 2
July	7.1
August	3 9
September	4 4
October	2 9
November	2 1
December	2.1

Source : India Meteorological Deptt., Govt. of India, Nagpur

It is observed that during winter months the winds are slower while the velocity increases from February upto June; then it comes down, August being quite slower. The winds during May-June are hotter and are sometimes associated with dust-storms.

Evaporation Losses :

Evaporation and Evapotranspiration is one aspect of the hydrological cycle. Evaporation of water into vapours is an ongoing process.

The monthly evaporation losses recorded at Chhatarpur are as follows :

Month	Evaporation losses (cm)
January	7 62
February	8 89
March	16.51
April	20.32
May	25 40
June	20 32
July	17 78
August	16 51
September	14 60
October	9.52
November	6 35
December	6.35
source . IMD (Govt. of India) Nagpur	

Cloudiness :

During the south-west monsoon season, skies are mostly heavily clouded or overcast. In the rest of the year clear or lightly clouded conditions prevail. Cloud cover recorded in Oktas two times a month and averaged at the Nowgong station is as follows[9] :

Month	Mean value (Oktas)
January	1.95
February	1.40
March	1.25
April	1.30
May	1.32
June	3.25
July	5.35
August	5 42
September	3.68
October	1.38
November	0.70
December	1.03

Special Weather Phenomena

Depressions from the Bay of Bengal in the south-west monsoon season which move in a westerly direction, reach the district or its neighbourhood and cause wide-spread heavy rains and gusty winds. An occasional storm or depression from the Bay of Bengal during October also had been noticed to affect the weather over the district.

Dust-storms occur occasionally in the summer season. Thunder storms generally occur during the period January to October, the highest incidence being in the period June to August. Occasional fog occurs during the cold-season.

2.3.2 DAMOH DISTRICT :

One of the constituent districts of the Sagar division, Damoh lies in between Latitude 23° 9' and 24° 27' (north) and Longitude 79° 3' and 79° 57' (east) and its geographical area is 7,306 sq. km. The district is bounded on the north by Chhatarpur district, on the east by Panna and Jabalpur districts, on the south by Jabalpur and Narsinghpur districts and on the west by Sagar district.

A. PHYSICAL FEATURES :

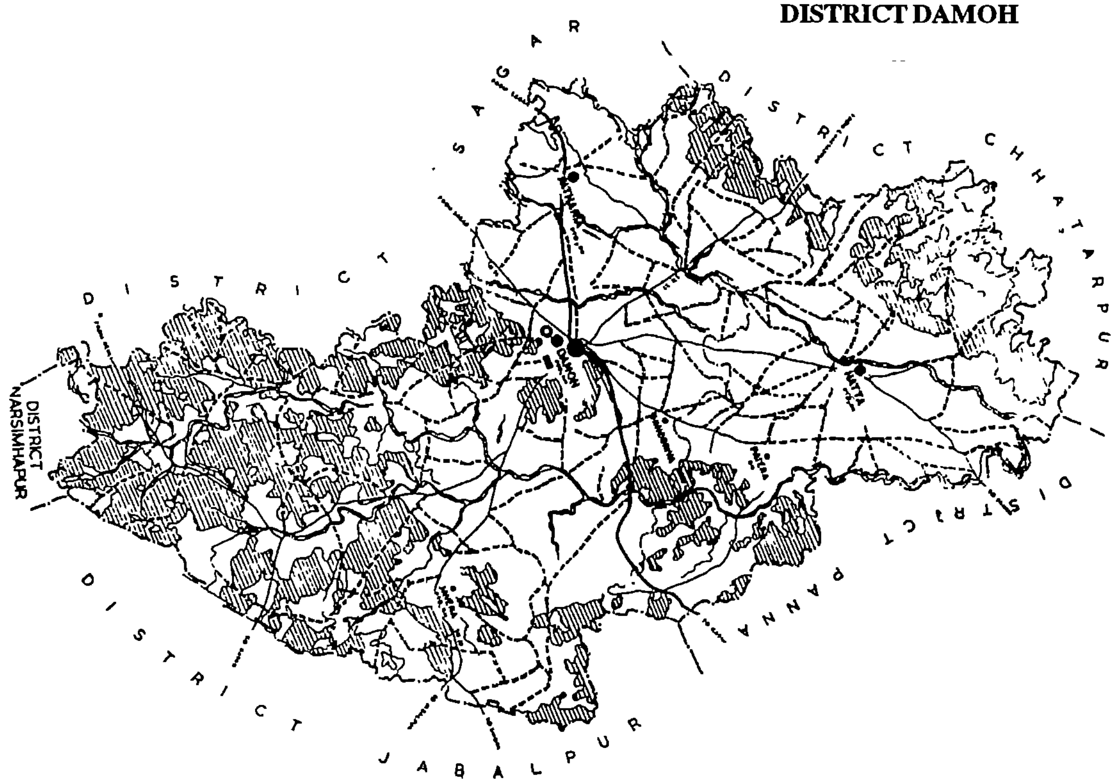
TOPOGRAPHY

Damoh district is situated in the south - east of the great Vindhyan plateau, which runs parallel to the river Narmada. The Vindhyachal hills, which, stretch for a considerable distance along the western boundary, though of no great height, have been forming the most picturesque feature of the district.

Damoh extends in a vast table-land, sloping gradually towards the north, till an abrupt dip in the surface occurs, beyond which the plains are seen stretching far away into the distant horizon. This district has three distinct physical divisions as follows :

1. Southern plateau
2. Sonar Valley
3. North-western mountain range

DISTRICT DAMOH



1. Southern Plateau : The southern plateau is situated at a height of approximately 450 m; of which the southern and south-eastern frontiers run with parallel mountain range. This mountain is like a vertical wall from where the Narmada and Hiran-valleys are quite visible[19]. The Vindhyanchal range here extends from the north of Sun-valley Bhander and Kaimur ranges. In fact this range is the last corner of the Vindhyan plateau.

A large plateau having slope towards the north east is situated to the north and north-west of Bhander mountain range and north-west of Kaimur mountain range. In the north it is spread upto Panna district. Certain peaks of these mountains ranging from 417 m to 479 m within this district are worth mentioning.

These are :

1. Fatehpur 450 m
2. Satiriya 479 m
3. Hindoriya >457 m
4. Jamuniya 447 m (triangle)

on the north-western border of the southern plateau, and

1. Lodhi-kheda 463.6 m
2. Gubra 417 m
3. Pateria 429.9 m

On the southern border of the district branching off the Bhander range running from the south to the north.

2. Sonar Valley : Sonar valley is spread like a belt across the entire north-central portion of the district nearly 80 km long and 32 to 40.3 km wide. The height of this tract is 335 m above the mean sea level. The soil of this tract is formed from the volcanic lava and is black in colour and very fertile. This area, also known as *haveli* area, is plain and possesses better soils. As a result this tract is considered to be of great agricultural potential. This it has come to be the main centre of industrial, commercial and administrative activities of this district.

3. The North-Western Range : The north western plateau rises like a 120 m high wall over the Sonar valley; The mountain range is spread from south west to north-eastern direction. The highest peak of this range is known as Furtal hill which is 525 m above the mean sea level. The forests around this plateau are reserved.

GEOLOGY :

Damoh district has a distinction of possessing the oldest rock systems like Precambrian and Deccan Trap. The Vindhyan super group which is spread over most of this district comprises of limestone, sandstone and shale.

Geologically, four rock-formations viz. Alluvium, Deccan Trap, Lamenta and Vindhyans are found in the district.

Predominant Vindhyan rocks consist of a succession of sand-stones and shales with a horizon of lime-stones and occupy a large part of the district. The system is subdivided into Bhander group, Rewah group, and Kaimur group

Lameta rocks consist of conglomerate, cherts, sand-stones, clays and lime-stones. Towards the west of the district, the Deccan Trap area and Sonar valley are entirely composed of the black cotton soil.

Damoh district does not have any valuable mineral deposit. However, the sandstone and limestone of the Kaimur, Rewah and Bhander group of the Vindhyan super group furnish excellent construction materials. Some galena deposit is also reported in this district.

Iron ore, in very small quantities, is found in the north near the boundaries of Panna and Chhatarpur district.

The general geological succession of the district is given below :

Recent		Alluvium
	unconformity	
Eocene	Deccan Trap	Bsalts and Inter-trappean
to Upper cretaceous		
Middle cretaceous		Lameta formation.
	Unconformity	
Pre - cambrian		upper Bhander group
Vindhyan		Rewah group
		Kaimur group

THE SOILS :

The soils of the Sonar valley are fertile and are mostly black cotton soils which contribute towards major productivity of the area. The valley of *Vyarma,* although very narrow, has the most fertile soils, and sometimes better than the Sonar-soils. The north-western and north eastern hilly tracts of the district, although plain, have inferior soils resulting into low productivity.

The local names of soils are *kabar, mund, rathia, patrua, bhatua, sihar,* and *kachhar* and the percentage of their availability in the district is as follows :

kabar (two kinds)	1%
mund (two kinds)-	48%
rathia	10%
patrua (two kinds)	37%
bhatua	3%
sihar	-
kachhar	1%

Note : *kabar* is good fertile black soil; where found with *domat,* it was classified as *mund,* which was the main soil of *HAVELI* area. The inferior *kabar* was termed as *rathia* found in the southern tract of the district; other inferior soils were termed as *patrua* i.e. the light soil. This is suitable for coarse grains as well as paddy and is found second in abundance. *Sihar* is the sandy fine soil which is preferred by the paddy. The soil found in slopes and hill sides was classified as *bhatua. Kachhar* is the alluvial soil usually by the side of the rivers which is preferred by the vegetable growers.

B. DRAINAGE AND WATER RESOURCES :

Except for some streams which join Hiran, a tributary to river Narmada, all rivers and streams of this district, flowing into river Ken, form the drainage system of river Yamuna and thus of the river Ganga. The main river systems of this district are of *Sonar* and *Vyarma* which follow the normal slope of the district towards the north-east. Though these rivers are perennial and carry enormous volume of water during the rainy season, these become lean during the rest of the year to form streams, smaller and limited. Thus, during floods these rivers cause enormous destruction; during summer season there is scarcity of even the necessary amount of water.

THE RIVERS:

Sonar : Rising from the hills situated south-west of the Sagar District (23° 22'-78° 37'), *Sonar* flows in the north-east direction in these districts. In Damoh it flows through a tract known as *HAVELI*, a rich fertile and productive area with black cotton soils. *Sonar*, after traversing a distance of 102.4 km within Damoh district meets Ken beyond the north-eastern boundary. This is not a very wide river and flows in a deep channel on a rocky bed. Except for the place where this is joined by *Vyarma*, the width of this river is never more than 320 metre.

The major tributaries of this river are *Kopra* and *Vyarma* on right bank and the *Bewas* on the left bank.

Vyarma : Rising from Rehli tehsil of Sagar district, this river forms a serpentine flow from south-west to north-east. Towards the end of its course, it forms the boundary between Damoh and Panna districts and joins *Sonar* on the north-eastern border. *Vyarma* within this district flows through a well defined channal flanked by vertical rocky banks on both the sides. The valley of *Vyarma* is nowhere wide. In the course of its total length of 193 km its gradient is 1.1 m per km. This results in the flood water off-flowing with enormous velocity. Just before meeting *Sonar*, the river has its widest course i.e. 320 metre.

On the right bank rivers *Goraiya, Sun* and *Padari* and *Jabera Nallah* are the main tributaries while on the left bank it is joined by *Bamner* and *Kathera Nallah.*

The Streams of Singrampur

The small valley of Singrampur which has separated itself from the open tract of Jabalpur by the Kaimur-range has its own drainage system. The small streams of this region meet *Hiran* which, flowing south, makes its way into river Narmada.

THE TANKS :

The district does not have any natural lake. The number of reservoirs or the tanks is also not very high. People, for their water-needs, have been depending on the rivers, streams, and the wells. A few reservoirs, however, need to be mentioned here.

The Mala Reservoir : Formed by damming *the Sun* river. Mala-reservoir is the biggest water body built within this district. This is at present used for the purpose of irrigation. Another two reservoirs namely Richhai and Jamnera, are also associated with the Mala-canal system.

The Rajnagar Tank : This tank situated nearly 5 km south-east of Damoh is the main supplier of drinking water to the city. At least 14 tanks were built in the municipal area of Damoh and used by the local inhabitants for domestic purposes. One of these tanks, which silted up some years ago, was converted into a market place. Two more tanks have also silted up[20].

Other reservoirs built on smaller streams known as *Baharia* and *Bechai* are smaller in dimension. South-west of Taradehi, there is one more reservoir known as *Baheria*. On the Padari-upstream the reservoirs which have been built are *Majhgawa, Dhangawa,* and *Patna.*

Other such reservoirs are :

Dhangri, Chirai-Pani, Jamnera, Deori, Futera, Bandar Kola, Barpati, and Puraina, all of them being used for irrigation. The Department of Forests looks after the following tanks which fall within the forest ranges :

Damoh Range:	**Kishan Talaiya and Chirain Bandh**
Tendukhera :	**Sahajpur Talab**
Taradehi Range :	**Dhakarwaha Talab**
Singrampur range:	**Singorgarh Talab and Douni Tal**

Some of the important tanks which have been constructed under the five-year plan periods, especially for irrigation purpose and reported in the Distt. Gazetteer, are as follows[18]:

S.no.	Tank	Year	Dam-length (m)	Height (m)	Storage (M.c.m.)
1	Daroli	1958-63	885.14	16.46	4.87
2.	Tejgarh	1958	351 70	24.48	5.72
3	Jabera	1958	1,064 18	14,56	ns
4	Motinala	1958	434 32	15.64	2.87
5.	Barpati	1958	844.91	9.88	1.77
6	Mala	1913-14	1,661 65	16.76	ns
7	Barat	1965	376.59	ns	ns

THE FALLS:

A few waterfalls are conspicuous in this district. These are :

1. *Bagdari* and *Jhapan* in Tendukhera forest range
2. *Rampura* in Taradehi forest range
3. *Deotara, Dayont, Jamunia* and *Bhawarpani* in Singrampur forest range.

B. 1 THE DRINKING WATER SITUATION :

As in other parts of Bundelkhand, the masonry wells had been the major traditional sources of drinking water in Damoh district also. While the urban drinking water supply depended upon the tanks and wells in Damoh and river *Sonar* in Hatta, the rural drinking water arrangement was through the masonry wells. The related *Gram-Panchayat* or the *Janpad Panchayat* (Development Block) was assigned the responsibility of building new wells or renovating the old ones. All the 1,193 villages are reported to have been reached safe drinking water through wells or the newly spread India Mk-II handpumps.

Damoh Town : Drinking water and domestic supply has been arranged through pipe-lines. A raised tank on *Naugaja* hillock has been constructed which gets water from various sources. The Rajnagar tank built in 1919 and the anicuts on river Kopra built in 1976 are the main suppliers of raw water to the supply system of Damoh. The Rajnagar tank is not properly maintained and is slowly being overtaken by the dangerous weeds polluting the stagnant water.

A proposal for using the Sonar-river water in order to meet the growing need of drinking water of the citizens of Damoh has been chalked out and proposed as described later but, that being exorbitantly costly has to wait for financial approval of the state and central Governments. This proposal definitely needs thorough revision and rethinking, looking at cheaper and better alternatives.

There is a growing tendency of the people here to sink tubewell and to put up jet pumps for meeting their needs; but through this way a lot of this scarce resource is being wasted. This is depleting the ground-water reserve.

Hatta : Hatta is another important town in Damoh district whose water supply has been planned with river Sonar as the source.

Sonar itself is facing problems of inadequate water flow throughout the year partly because of the large-scale deforestation and lime-stone mining by the Diamond Cement Factory, Narsinghgarh, which is also dumping the effluent on the banks of river Sonar.

Patharia, Jabera, Tendukhera, Patera, Batiagarh and other towns of Damoh district are striving for piped water supply to its citizens through upgrading their wells, sinking tubewells or tapping any nearby tank or the river as an adequate source.

Narsinghgarh factory-area and its newly developed township is using the water of river Sonar for its domestic needs.

The Proposed Plan of Tapping Sonar River :

An ambitious proposal of tapping river Sonar near village Harat a few km from Sitānagar, the confluence of *Sonar* and *Kopra* rivers, has been prepared by the Public Health Engg. department of Damoh known as Madkoleswar Scheme, under which an anicut is proposed across the river to form a 9 km long water pool. Raw water is planned to be transported from this point to Damoh's supply-system by putting up nearly 40 km long pipeline.

Concerned citizens of Damoh have objected to this ambitious plan which may cost nearly Rs. 1000 million and is likely to affect the irrigation schemes planned earlier. Their suggestion of tapping *Vyarma* river at Hatari instead, seems better alternative.

Comparison between Madkoleshwar and Hatari Schemes :

S.no.	Particulars	Madkoleshwar (PHE plan)	Hatari (citizen's plan)
1	river to be tapped	Sonar	Vyarma
2	anicut site	Harat	Hatari
3.	Intake well	Patna	Kaniaghat pati
4	Feeding Point	-	Dinari
5	Treatment Plant	Luhari	Aghrauta
6.	Catchment Area	5,760 sq. km.	1,500 sq. km.
7	Lenght of pool	8 km	22 km
8	Distribution centre	Gajanan Tekri	Hathni hillock
9	Flow during May	0.51 cusec	0.78 cusec
10	water storage capacity	6 20 M cubic metre	16 0 M. cubic metre
11.	water-supply capacity	70 days	193 days
12.	Pool-water required for	30 days	flowing water will meet the need for this period
13.	Available water.	135litre per day per person	135 litre per day per person
14.	Cost of the project (1993-94)	530 million rupees	180 million rupees

souice : Sabki Khabar Weekly - V.K Shrivastava's article, Ed. Santosh Bharati : (Damoh) 15 July 1994.

B.2 IRRIGATION SITUATION IN THE DISTRICT:

Before 1908, artificial irrigation was almost negligible. Till then hardly 1,400 ha of the agricultural land was under some kind of irrigation. That was through the masonry wells or the river water carried manually. Indian Irrigation Commission (1901) had recommended the development of irrigation in this district and on the basis of comprehensive survey between 1904 and 1908 some work was started.

The projects Chirai-Pani, Dhangri, Richhai, Baheria, Patna and Majgawan were taken up to initiate irrigation here. However, 1917-18 could be taken as the year when irrigation was really started, that was done through using water stored in the tanks built for the same purpose.

The reservoirs of Mala (1913-14), Jamnera (1914-15), Hardua, Muran (1917) Dhangaur (1918) and Chhoti Deori (1921) were built but irrigation could not become popular with people who felt it superfluous as they thought it would spoil the wheat crop. During post-independence period, the village projects, namely Nonpani, Kulari, Bhat-Khamaria, Futera, Alag Sagar, and Hardua were completed by 1953. In the first five-year plan period Barpati, Tejgarh, Jabera, Jhalehra Chhana, Piparia, Jograj, and Motinala projects were started. This work was further strengthened in later period. The irrigated area gradually increased to 12,390 ha. by 1964-65.

The tanks reserved for irrigation by the Irrigation branch of the P.W.D. as reported in the District Gazetteer (1980) were as follows :

S.no.	Project	Year	Length of canal (zone)	Irrigation capaciry (acre)
1.	Baheria	1910	105	405
2	Garh ghat	1912	330	1,024
3.	Patna	1912	55	230
4.	Mala	1913-14	117	6,500
5.	Chiraipani	1913	440	1,320
6.	Jamnera	1914-15	160	810
7	Majhguwan-Hansraj	1914-15	435	2,000
8.	Majguwan	1914-15	25	150
9.	Hardua Muder	1917	95	922
10	Dhangor	1918	140	788
11	Ricchai	1918	239	2,000
12	Chhoti Deori	1921	53	650
13	Bhat Khamaria	1953	02	450
14.	Hardua Sadak	1953	947	250
15.	Alag Sagar	1953	05	66
16.	Keolari	1953	232	390
17	Futera	1953	160	490
18	Nonpani	1953	107	580
19	Barpati	1957	71	1,170
20.	Tejgarh	1958	217	8,230
21.	Jabera	1958	234	2,250
22	Jhalehari Ghana	1958	102	694
23.	Piparıya Jugiaj	1958	95	546
24.	Motinala	1958	165	1,665
25	Jharoli-Nala Weir	1962	195	400
26	Singrampur Regu	1962	40	750
27.	Shahzadpura Regu.	1962	113	500
28.	Seedfarm	1962	600	100
29	Killai	1962	20	60
30.	Pipariya Ramnath	1963	-	100
31.	Daroli	1964	320	5,531
32.	Baret	1964	06	94
33	Semra Madiya	1964	-	30
34	Doomar	1964	-	85

The Irrigation Resources :

In the year 1970-71 the land irrigated was only 10.6% by 2,290 masonry wells. 208 tanks were also counted as the potential source of irrigation. In 1965-66 well digging or deepening and boring was promoted which the farmers welcomed. Locational preferences were seen in this district as follows:

Wells were promoted in Patharia, Damoh, Batiagarh, and Hatta while the *Nallah-bunding*, canal irrigation and well digging found potential in Patharia, Damoh and Jabera areas.

Later, the introduction of diesel pumpsets and electrically operated pumps with highly subsidised electricity were promoted and popularised. This turned all the river sides humming with the irrigational activities. This effort killed the already deficient rivers affecting flow of their water throughout the year.

The Present Situation:

The information from the Deptt. of Agriculture gives the source-wise distribution of the irrigated area in 1995 as follows.

S.no.	Resources/schemes	No.	Irrigated area(ha)
1.	medium projects	04	6,100
2.	small projects	-	8,900
3.	Stop-dam	07	150
4	Wells	12,994	13,600
5.	Tubewells	426	2,556
6.	other sources	-	15,070

The 1994-95 figure of irrigated area in the district was 74,796 ha out of the total sown area 3,52,514 ha.

C. VEGETATION :

THE FORESTS :

In 1904-05 almost half of this district was covered by dense forests, bushes and the grasses, which included 2,058.4 sq. km of the Govt. reserved forests and 1,502.2 sq. km of the revenue-forests under control of the land-lords.

The forests of this region were classified as the dry tropical deciduous forests which had variations from place to place. The local classifications included:

1. Mixed Forests: This is the general type of forest in this district, spread in Fatehpur (Hatta) range, Damoh, Singrampur, and Sagoni ranges, nearby agricultural area of Taradehi and south-east of Tendukhera. Mixed Forests prefer the low-lying areas with moist soils. The popular species in such forests have been *Saaj, Bija, Dhaura, Tendu, Tinsa, Jamun, Baheda, Mahua, Sagon, Rohar, Palash, Khair,* and *Lendia* as the trees and *Anthoni, Kodar, Ail,* and *Plamingia* as bushes and shrubs.

The medium type forests found in the semi-deep soils and slopes away from the streams preferred the dry varieties. The bushes included *Ail, Bharrati, Jhilbil, Karaunda, Gangerua* and *Ghont* as underwood.

The inferior quality of the mixed forests found in slopes and less deep sandy soils included *Salai, Gunja, Dudhi, Papra, Kari, Lendia, Bhirra, Ghont, Tendu, Aonla,* and *Achar* but lacked *Sagon.*

2. Sagon Forests : Availability of more than 20% Sagon in a forest makes it the SAGON-forest. It prefers to grow in well-drained *domat* and sandy *domat* soils. There are locational differences like in mixed forests. The associated vegetation with these forests has been that of *Tinsa, Rohar, Seja, Dhaura, Koha, Lendia, Dhaman, Harra, Gular, Mahua* and *Tendu* as trees. In the medium and inferior forests the dry varieties like *Salai, Gunja, Kachar, Dhovin, Semal, Kari, Kulloo,* and *Bhirra* etc. have been relatively more dominant. The shrubs and bushes were similar to the earlier forests.

Such forests have been common as rich belts in the eastern and western boundaries, on the hills south of Tejgarh, from south-west to Tendukhera upto the southern border and on the northern border also. Such forests *in small patches* were found in Hatta, Damoh, Taradehi, Tendukhera and Singrampur ranges.

3. The Grassland : The clayey, hard, black and water-resistant soils do not allow the trees to grow. In these tracts the shrubby *Saaj, Ber, Palash* and Ficcus species are abundant. Here the grass grows very dense and high. Such tracts are spread in various locations in this district.

4. Salai-Forests : These forests are found in dry, shallow rocky soils and are associated with *Gunia, Aonla, Dhovin,* and others. In Damoh district such forests were found at Brijpani and Salapani in Hatta range, Pipariya in Damoh range, and Unjari kheda in Taradehi range.

5. Kardhai Forests : Such forest of very good quality were found in some patches in Hatta range.

6. Ghont Forests : Although *ghont* is mixed in all the forests, yet, in some places *Ghont* is found individually.

7. Khair Forests : *Khair* is also found everywhere but is more common in shallow, undulating, and ravinous land. Such forests could be seen near Dudhia in Taradehi range and Manakpur in Hatta range.

8. Bhirra Forests : *Bhirra* is grown well in the dry and sandy soils. Some inferior varieties were found here in Tendukheda range.

9. Inferior Forests : In the vertical rocky area or on the plain plateau over the hills, known locally as Bhatari, such forests were found. These included *Ghont, Ber, Salai, lendia, Kardhai, Chichwa, Bilsena, Astu, Bhirra,* and *Kari.* The *makor* is found as the climbers. *Thuar* is also found. Such tracts in Damoh have been near Batiagarh in Hatta range, near Damoh in Damoh range, in some patches in Tendukhera, Taradehi and Singrampur ranges.

In the villages *Mahua, Neem, Bargad, Pipal, Imli,* and *munga* trees are generally found. There are very few mango-groves in Damoh.

AGRICULTURE :

Both KHARIF and RABI season-crops are grown in Damoh. Reports tell that wheat has always been the principal crop of this area. The type of soil required by wheat is found here in *Haveli* area, and the farmers try to cultivate maximum possible land because they fear the arrival of *kans* as a dangerous weed which does not allow any cultivation until its cycle is over.

Other important crops in RABI are the gram (*chana*), Mustard, linseed, and *Tuar* (*arhar*) besides paddy, the other major Kharif crops in this districts are : *Jowar, Urad, Moong, Til* and recently Soyabean. Soyabean has replaced many important crops of the area. Since the expansion of irrigation only few of these crops have become important; they are Wheat, Paddy and Soyabeans. The old crops of Kodon and Kutki etc. which used to be grown in bad soils, have slowly disappeared from the main cropping pattern.

In the year 1994-95 the area covered by major crops under the above two seasons and their production has been reported as follows :

S. no.	Crops	Area covered ha	Production m.tonne
KHARIF:			
1.	Paddy	53,163	40,475
2	Jowar	9,185	6,448
3	Urd	2,323	460
4	Soyabean	38,963	31,974
RABI			
1.	Wheat	87,251	1,29,600
2	Gram	70,603	66,130
3	Masoor	39,572	18,031
4	Linseed	22,310	7,706

Source Important Statistics of Sagar Divison, Divisional Statistics Office, Sagar, (1996)

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of the district is generally pleasant. Except for the rainy months which are visited by south-western monsoon, the winds are generally dry. During the year one encounters four different seasons, the summer being from March to Mid-June followed by the rains which occur between mid-June and September. October records the transition while from November to February it is winter. Various indicators of climate for Damoh district are described below :

Temperature :

As in other surrounding districts the temperature starts increasing from March and goes on increasing till June until it rains. The rains bring down the temperature which rises slightly in October and then from November onwards the temperature falls to record the lowest in January. The western disturbances during the winter season bring cold wave and the temperature may go further down. Frost may occur during the cold-wave period.

The temperature of this area is generally lower as compared to the adjoining Narmada valley. In general throughout the year, the nights are cool. The figures of monthly average of maximum and minimum temperatures for Damoh as recorded by Indian Meteorological Department on the basis of the data for 1985 to 1995 are as follows :

Month	Average Temperature (Max) °C	Average Temperature (Min) °C
January	24 4	7 9
February	28.6	10.7
March	33.4	14.4
April	39.2	26.5
May	40.1	27.9
June	32 9	24.3
July	29 00	23.2
August	29 6	23 4
September	22.9	20.7
October	32.9	18 5
November	28 3	10.9
December	26.4	7 5

Source · Hydrometeorology : Dr LP Chaurasia, Deptt of Applied Geology, University of Sagar

Rainfall:

The rainfall pattern in Damoh is almost identical to the nearby Bundelkhand districts. The rainfall generally increases from the north-west towards the south-east in the area. About 90% of the annual rainfall is received in the south-west monsoon season, July and August being the rainiest months.

The rainfall data recorded at the Damoh-Rainguage station from 1901 to 1995 has been used to come to the following information:

S. no.	Particulars	Data
1	Average Rainfall (mm) .	1,237.68
2	Maximum Rainfall (mm) . (Year)	2,154.80 (1956)
3	Minimum Rainfall (mm) . (Year)	542.10 (1979)
4	Number of years above Average :	46
5	Number of years below average :	59
6	Average no of rainy days	55

The monthly average for Damoh on the basis of the above record and that derived from the Distt. Gazetteer (19) on the basis of data of 60 years (1900-1959) are given as follows:

Month	Average Rainfall (mm)	Average Rainfall (mm) (rainy days)
	(1901-95)	(1900-1959)
January	17.80	19.3(1.7)
February	7.86	16.6 (1.5)
March	11.20	12.7 (0.9)
April	8 65	5.8 (0.6)
May	3.07	6.0 (0.7)
June	146.07	118.1 (6.9)
July	371.13	398.3 (16.1)
August	406.96	372.5(14.8)
September	256.74	192.1(8.7)
October	26 52	31 2(2.0)
November	9 82	17.4(0.9)
December	12.91	8.3(0.7)
Source : Hydrometeorology - by Dr LP Chaurasia (Sagar)		

Most of the rainfall during the month of June is lost due to intense evaporation and only a small part of it goes to contribute to the building up of the soil moisture water requirements. A little of it goes as run-off. In July a part of the rainfall is utilized for saturating the soil moisture zone in the basin area. The rest goes mostly as run-off and evapo-transpiration losses, and very little goes towards the ground-water increments. In the month of August, the ground water increment to the underground reservoirs takes place and by this time, the soil moisture zone is saturated. September is also a month when rainfall adds to the ground water reserve through infiltration in the basin area to the upper aquifer bodies. The rainfall in other months are scanty and just help the soil moisture zone.

Humidity:

Humidity plays a very important role in ascertaining the climate of any region. 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. The mean monthly values of relative humidity percentages for the years 1985-1995 for Damoh are given in the following table:

Month	Relative Humidity (%)	
	8-30 AM	5-30 PM
January	75	55
February	65	45
March	48	28
April	33	27
May	36	32
June	75	69
July	85	80
August	87	80
September	81	70
October	66	43
November	58	40
December	68	50
Source: India Meteorological Deptt Govt of India, Nagpur		

The above data corroborate the observation that the summer months are extremely dry while August is the most humid month. The relative humidity in the afternoon is generally lower than in the morning.

The Winds:

The horizontal component of the air movement parallel to the earth's surface (i.e. the wind) influences the climate. The winds have almost identical nature as found in other nearby districts of Bundelkhand. The winds are slower during winter season, slowly increase in February and then go on increasing till the arrival of south-west monsoon. By August the winds get again slower.

Evaporation Losses:

Evaporation is one of the most important and most complex phase of the hydrological cycle. The monthly evaporation losses data from the Damoh observatory are shown in the following table:

Month	Evaporation Losses (cm)
January	7.6
February	10.2
March	17.8
April	26.7
May	38.1
June	23.5
July	9.5
August	8.3
September	10.2
October	8.9
November	7.0
December	7.0

Cloudiness:

This is the most uncertain indicator of the climate at the present times. Usually in the past, cloudiness in this district was seen only during the south-west monsoons and sometimes during winters associated with western disturbances, but these days such disturbances are becoming more frequent.

Special Weather Phenomena:

The south-western monsoon associated with the storms and depression, causes heavy rains in this district. Sometimes throughout the year the storms come with lightning and thunder.

During winters frosts are common and sometimes there are hailstorms too.

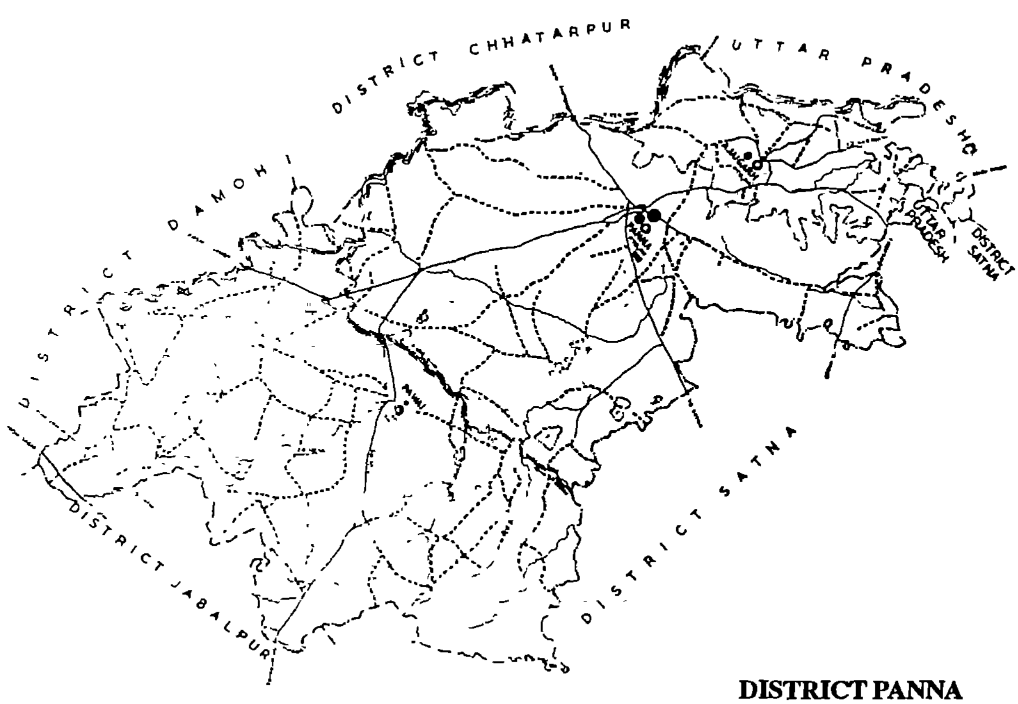
2.3.3 PANNA DISTRICT :

Panna is historically an important town of Bundelkhand. The district lies between Latitude 23° 45' and 25° 15' (north) and Longitude 79° 45' and 80° 45' (east) and its geographical area is 7,135 sq. km. Panna district is bounded on the north by Banda district, on east by Satna district, on the south by Jabalpur district and on the west by Damoh and Chhatarpur districts.

A. PHYSICAL FEATURES :

TOPOGRAPHY :

The district is mostly hilly and traversed by hills and valleys. The greater part of its area lies on the branch of Vindhyas, known as Panna Range, which traverses Bundelkhand from the south-



DISTRICT PANNA

west to the north-east. Panna range forms a watershed in itself. The southern Panna district forms a plateau which is formed by cascade-type rocks of Vindhyan series. The height of this district over the mean sea level ranges from 400 m to 900 m.

The main drainage of this district is through river Ken and its numerous tributaries. River Baghein originates from here and the district is adorned with beautiful falls such as *Vrihaspati Kund, Pandav Prapat* and *Chanda*-falls etc. on different streams.

GEOLOGY:

The geology of this district is unusually interesting, owing to the valuable mineral deposits which exist within its boundaries. The Panna range consists principally of the upper Rewah sandstone of the Vindhyan rocks and has long been famous for its diamond mines. These mines are found scattered over an area of about 75 km lying east and west of the town of Panna. The diamonds occur as pebbles in a conglomerate, and also in pebbly clay derived from it by disintegration. Diamond is mined from the kimberlite pipe near manjhguan in Panna district.

The lower Rewah group is composed of three strata, the upper being the Jhiri shales, the second lower Rewah sand-stone and the third a narrow shale band known as Panna shales. Lameta outcrops occur near Panna, and are overlaid by some of the easternmost remnants of the Deccan Trap known to exist on the Vindhyan table land.

BOX 1

Recent	--------------	laterite, soil alluvium
--------------	Unconformity	------
Deccan Trap	----------	Basalt, (lava flows)
--------------	Unconformity	-------
Vindhyan-	-------	Rewa group
Super group	-------	Kaimur group
-------------	unconformity	----
		Semri group
------------	unconformity	------------
Bijawar group	----------	Ferruginous Quartzite shale
-----------	unconformity	-----------
	Bundelkhand granite gneisses	

The Bundelkhand granite rocks are found in Ajaigarh Tehsil of Panna district. The general geological succession of the district is given in the box 1:

B. DRAINAGE AND WATER-RESOURCES :

The drainage of the district is towards the north and north-east and the major river is Ken whose tributaries are other rivers of the district, namely *Sonar* and *Vyarma* flowing north and east ward and *Mirhasan, Patan, Ranj, Gurne* and *Kilkila* flowing westerly or south-westerly. River *Baghein* originates here and flows along the drainage line to enter into adjacent Banda district. Some information about rivers is as follows :

River Ken: Rising from the north-west slopes of the Kaimur hills in Jabalpur district at an elevation of about 500 m above the mean sea level, river Ken flows initially north-ward and is joined by a river *Aloni*. Ken then flows westward and turns at right angle to north where it is met with *Sonar*. Before that other streams meet Ken to give it slightly more volume. During its north-ward flow it borders on Chhatarpur district. Gangau reservoir is situated in the district of Chhatarpur while Bariarpur weir is built in Panna district. Ken then enters Banda district.

River Vyarma: Flowing from Damoh district, Vyarma forms Panna district's south-west boundary for certain distance. It joins *Sonar* on Panna's boundary which flowing north-east joins the river Ken.

***River Sonar*:** Although this does not traverse a great distance in this district, yet joined by *Vyarma*, this forms the main tributary to *Ken*.

As river Ken passes through the thick forests on the rocky bed, it is joined by numerous streams and seasonal drains. *Kilkila*, as a small river flowing by Panna town, joins Ken, but this stream is now lacking the year-round flow of water due to large scale human intervention in the forests. Similar situation is with other streams like *Chanda* which had beautiful fall but the stone-mining is spoiling its grandeur.

Natural Water Resources:

Panna district, having been one of the most densely forested and a natural abode of the elephants at one time, has been a good source of perennial streams, picturesque waterfalls, natural reservoirs called *kund* and *Sehas*. Some of them are described below:

1. ***Kund Prapat*:** Situated nearby Panna town, not far from Padmavati Temple, *Kund Prapat* is a waterfall associated with a deep water body called *kund*. Jhiriya is another water body near *Kund Prapat*.

2. ***Pandav Prapat:*** Situated by the side of Panna-Chhatarpur road, down the valley of Ken river *Pandav Prapat* is a beautiful natural fall which is associated with caves and *Jhirna*.*

3. ***Chiraipani Seha*:** This is situated near Fatepur in the vicinity of *Vyarma* river. In addition to the water fall and reservoir (*kund*) this has numerous caves supposed to be early man's abode with rock-paintings.

* Jhirna from which *Jhiriya* is derived, literally means a place where spontaneous stream or droplets come out of the rocks or the soils. All *kund/Seha* are associated with such phenomena.

4. ***Mata ka Seha*:** Near Bhairo-Tek, not far from Panna town, *Mata ka Seha* is a picturesque waterfall and the water-body. There are also early man's caves and the protection-posts for water which would have been important even in ancient times.

5. ***Lakhanpur Seha*:** Situated in a deep forest setting, this is the biggest seha also associated with early man's abode; there are caves, rock paintings and water protection posts as in *Mata Ka Seha*.

Other than the above the Saligpur and Kauva Seha are important water falls and waterbodies in this district.

6. ***Vrihaspati Kund*:** Situated on the right side of Banda-Panna road before Pahadi-Khera, in the interior forests and on the bank of *Baghein* river, *Brihaspati kund* exists as one of the most picturesque, deep, and difficult water falls associated with deep reservoir of water with natural caves and old temples.

7. ***Bedhak*:** Nearly a few km downstream is *Bedhak* which is an unique place and water stream, where the water dropping from the top is highly siliceous and turns the wood of the trees into stony form. The local *vaidyas* term this water to be SHALODAK.

The Lakes and Ponds:

People believe that Panna town is situated where at one time there was a huge lake. Whatever it is, the *Bundela* kings constructed a number of big-sized tanks almost like lakes, which are serving today as the sources for drinking water as well as for irrigation. Some such tanks are listed below.

1. **Dharma-Sagar**: This tank as situated at high rise over Panna town wherefrom water is taken to feed the drinking water supply. Inspite of this fact, two things look disturbing : 1. people are not advised not to use detergents and soaps while bathing and washing there, and 2. the same place is used as burning ghat and remains extremely dirty all around.

2. **Nirpat Sagar**: This is the main tank from where Panna town is supplied drinking water; situated far from the town, this used to be quite clean. The depth of the lake is 102-104 feet during the rainy season while in other seasons water recedes and during summer only 10% water remains.

The only problems which is being felt these days is the mindless use of this lake for fish-rearing by the Bengali contractors since 1996. This makes the water of the lake very dirty and filthy and unfit for drinking purpose especially during summer season.

3. Kamala Sagar: Kamala Sagar is a big tank which is normally used these days for fish-rearing.

4. Lok Pal Sagar: This tank as also one of the suppliers of drinking water to the city. In addition to it, this is used for fisheries as well as irrigation purpose.

In addition to the above, there are some more tanks in Panna as well as other places which are used for irrigation. Along the Shahnagar-Panna road one can see at least two places where the streams have been checked through a masonry bund along the road which is an appreciable technique to have smaller water-bodies wherever a stream crosses any road.

Dams of Significance:

1. Devendranagar Dam:

Built to serve for irrigation in 1968, Devendranagar Dam gets water from numerous streams including the *Satne* river. Some technical details of Devendranagar dam are as follows:

1. Name of the dam;	Devendra Nagar Dam
2. Sources:	Seasonal streams and *Satne* river
3. Catchment area	36.91 sq. km.
4. Length of the dam:	426.72 metre
5. Maximum height :	15.62 metre
6. Total storage capacity :	10.88 Million cubic metre

2. Bariarpur Weir:

Built on Ken river during 1900-1905 Bariarpur weir was built essentially to irrigate the agricultural area of Banda through Ken-canal system but since the reservoir was located in this district, the benefit of recharging of ground water reserve naturally goes to Panna district. Salient features of this reservoir are as follows.

1. Name of Reservoir:	Bariarpur Weir
2. Source:	Ken river
3. Catchment Area:	20,760 sq. km.
4. Total Storage Capacity:	12.59 million cubic metre

B. 1 THE DRINKING WATER SITUATION :

Panna district has been traditionally using masonry wells and the water from nearby streams or ponds for drinking and domestic purpose. The most problematic area is the Pawai and Shahnagar region the area of the Kalda-Parasmania Pathar) where water seepage is difficult and therefore there is hardly any groundwater reserve. The geophysical nature of this region does not allow the borings of tubewells etc. Thus the installation of India Mk II handpumps promoted by the Deptt. of Public Health Engineering have by and large benefited Panna and Ajaigarh area.

Till 1995-96 the number of such handpumps in this district was 4,053 and the average depth of these handpumps was 90 metre.

Some 6 towns and 27 villages have been provided drinking water through laying pipeline using 2 surface water- and 31 ground water sources. The problematic villages upto March 1996 were 872, which have reportedly been reached drinking water through some or other means. Despite such reports, the situation of the villages in Pawai Shahnagar region is far from satisfactory.

As already mentioned the drinking water supply in Panna town is mainly from the three tanks Nirpat Sagar, Lokpal Sagar and Dharma Sagar. The raw water is collected at Pahad-kothi where it is filtered and chlorinated and then supplied to the town for domestic use. The Deptt. of Public Health Engg. has been looking after this setup since 1970 but now this has been transferred to the Nagar Panchayat (Municipal Committee), while the Chief Medical Officer of Panna looks after the quality-control aspects.

B.2 THE SITUATION OF IRRIGATION IN THE DISTRICT :

Panna, being basically a forest-dominated tract and its non-forest area having a poor soil-base, agriculture was not very popular. Since formation of this district as a part of M.P. state in 1956, some consistent efforts have been here made to raise its irrigation potential and thus to popularise agriculture. The data of 1994-95 reveals that out of the total sown area of 2,38,534 ha, the irrigated area is 41,916 ha which is just 17.6% only.

The irrigation of cultivated area has been done by various means; through masonry wells, ponds and tanks, canal-system taken out from some of the dams and lakes, by using the stop dams especially built for the purpose, lift irrigation projects watershed development projects and sprinklers. Some available information in this aspect is given in box 1:

1. Source-wise irrigated Area:

BOX 1

S.no.	Irrigation projects	No.	Irrigated area (ha)
1.	Medium scale schemes	01	2,400
2.	Small-scale schemes	-	12,254
3.	Stop-dam	54	2,160
4.	Wells	-	12,734
5.	Tubewells	28	168
6.	Tanks and others	-	1,320

2. The Lift Irrigation Schemes in Panna district including sprinklers:

The M.P. State Government has planned a number of schemes to enhance irrigation potential including lift-irrigation and sprinkler systems. Till 1995, 80 sprinklers were installed. The 10 of the 16 lift irrigation schemes were approved for the Harijan/tribal cooperatives to operate for small areas. More information on these lift irrigation schemes is given in box 2:

BOX 2

S.no.	Dev.Block	Source	Location	Beneficiaries	Area to be irrigated (ha)
1.	Panna	Ken	Latwara	29	4 00
2.	-do-	Itawan	Itawan khas	17	29.60
3.	-do-	Baghein	Lohrai	27	31.30
4.	Ajaigarh	Ranj	Sukwaha	60	51.63
5.	-do-	-do-	Rajapur	63	49.41
6.	-do-	Nala	Ranipur	23	30.93
7.	-do-	Bairaha	Majhgawa	16	25.45
8.	-do-	Kudian	Gararian Purwa	25	40.65
9.	-do-	Biloo	Nayagaon	28	39.63
10.	-do-	Nala	Kalyanpur	35	32.73
11.	-do-	Ken	Mudwari	70	44.19
12.	Pawai	Kudli	Bagha	26	23.28
13.	-do-	-do-	Narayanpur	18	23.18
14.	Gunnaur	Gurma	Hijaura	29	28.44
15.	-do-	Sohjani	Matia	42	56.51
16.	Shahnagar	Ken	Pipariya	57	52.17

Source: Information provided by the Deptt. of Agriculture, Panna (1995)

3. The work under National Watershed Area Development:

Till 1995, the following projects were taken up under the national Watershed Development programme:

Name of Project	Dev. Block	Villages covered (ha)	Area covered	Cost (lakh Rs.)
Sawaiganj	Panna	07	1,952	64.04
Piparwaha	Gunnaur	07	2,804	65.59
Kudian	Ajaigarh	08	1,778	50.80
Baraj Nala	Pawai	08	2,236	69.49
Arthai Nala	Shahanagar	06	7,019	31 76

4. Irrigation through Devendranagar dam:

The available capaicty of Devendranagar dam is 10.10 million cubic metre. Water is supplied for irrigation through a total of about 32 km long canals, covering nearly 2430 ha of which almost 70 % comprise the RABI-area.

C. VEGETATION :

THE FORESTS:

Forests used to cover considerable area of the erstwhile Panna state which is now a major part of Panna district. The 1908 references mention that Panna forests were largely consisting of stunted teak and thick small trees and scrub jungles of species of Gracia, zizyphus, Carissa, Woodfordia, Fluggia, Phyllanthus, Capparis, Acacia, Anogeissus, Terminalia, Butea, Bassia, Diosphyris and others[40]. The forests could be classified in the same category as in the surrounding districts of Damoh or the south-eastern Chhatarpur or southern Banda distt.

The earlier references mention that the Panna forests used to be natural abode of elephants; the Bundelkhand kings used to keep them, offer others as gifts and even the Moghuls used to hunt elephants from here only. That must be because of the extreme richness of flora and immense water sources around this tract.

The forest of Panna district has been classified as Tropical Dry Deciduous forests. The main species locally known as *sagon, saja, salai, bahra, tinsa, khair* and *tendu* and has been exploited for timber, fuel-wood, charcoal, and bamboo.

The present status of forests in Panna, however, is one of decay and denudation; the able-bodied trees have been prey to commercialization through the Govt. department of forests and also people's pressure. Since the forests were appropriated by the British Govt. during later half of the last century, the normal care of people in protecting the forests was almost forgotten. The self-rule after 1947 miserably failed to bring back the forests to people's fold and the policy of exploiting it for easy revenue was continued, which resulted in enormous damage to the natural resources in Bundelkhand as in other parts of India.

AGRICULTURE:

Panna district is not, on the whole, a very fertile area and therefore agriculture was not very popular here. Still people who lived here always tried to grow something for their consumption. Irrigation was almost a private affair till the irrigation projects were initiated and water was made available for artificial irrigation of the fields under cultivation.

From the point of land-use, the following was the picture of Panna district in the census year 1981:

PARTICULARS	NO.	AREA(HA)
No of inhabited villages:	947	5,85,626 19
Total area:		3,17,409.96
Cultivable area (%):		3,17,409.96 (54 20%)
Irrigated Area (of cultivable area)		13,885.11 (4.37%)

source Distt. census Handbook (Panna) 1981

The figure for the year 1994-95 regarding the cultivated area under major crops and their gross production is as follows:

S.no.	Particulars	Area(ha)	
a. b c.	Total cultivated area: Total irrigated area: Cropwise area and production	2,38,334 41,916	
		Area (ha)	Production m. tonne
	KHARIF:		
	1. Paddy	61,435	40,738
	2. Jowar	6,762	4,783
	3. Urd	1,863	678
	4. Soyabean	2,679	2,061
	RABI		
	1. Wheat	78,409	1,07,876
	2. Gram	64,398	48,314
	3. Masoor	13,151	5,515
	4 Linseed	14,892	6,384

Source. Important Statistics of Sagar Division, Divisional Statistics Office, Sagar, 1996

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of Panna district is generally hot but during winter season it sometimes becomes severely cold. The district receives rainfall from south-west monsoon. Various indicators are discussed below:

Temperature :

The summer season is spread from March to June after which it receives rainfall. The temperature of May and June are the highest while December and January are the colder months. During the rest of the months the temperature rises or falls like in other districts of the region

Rainfall :

July to September are the months of rainy season and 90% of the total annual rain precipitates in August and September only. During winter season, with the western disturbances, there are cold waves and that is also associated with rains. Some unusual rains can be caused any time but they are all scanty.

The average annual rainfall as recorded for Panna district is 1,213.5 mm.

Other Indicators :

Other climatic indicators include the relative humidity, the wind velocity and the evaporation losses. Since no separate data in these respects were available to us about this district, we suggest to look at the statistics of nearby districts for understanding the situation of Panna district.

2.3.4 SAGAR DISTRICT :

Sagar district is the south-western district of Bundelkhand lies between latitude 23° 10' & 24° 27' (north) and 78° 4' & 79° 21' (east) and has the largest geographical area i.e. 10,252 sq. km. among Bundelkhand districts. Sagar district is bounded on the north by Guna, Lalitpur and Chhatarpur districts, on the east by Chhatarpur and Damoh districts, on the south by Raisen and Narsinghpur districts and on the west by Vidisha and Raisen districts.

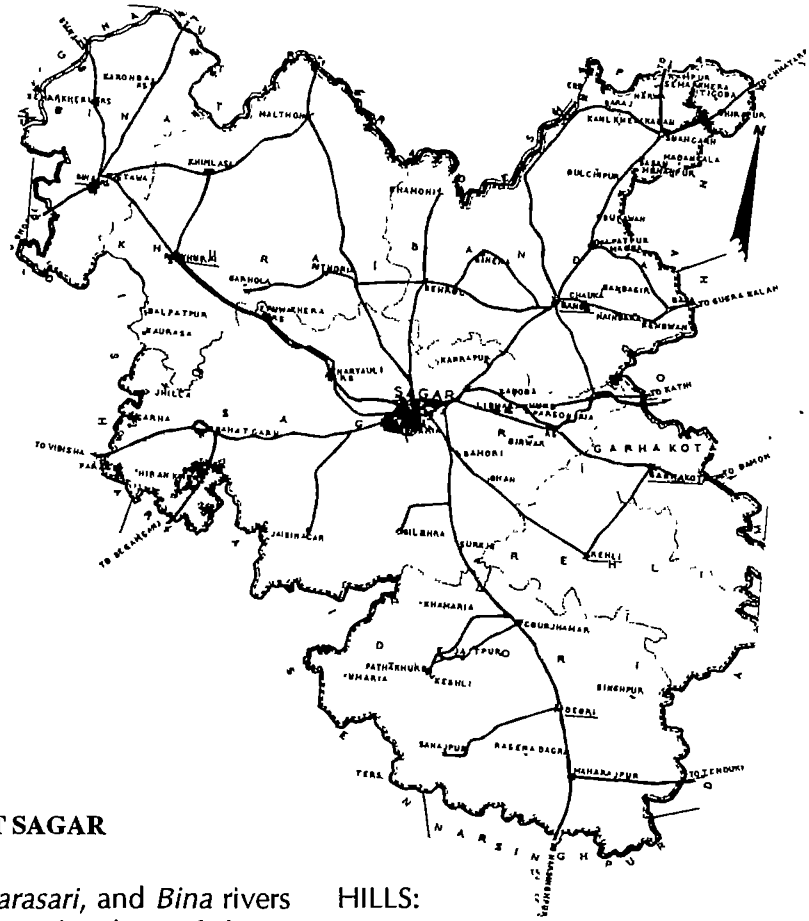
A. PHYSICAL FEATURES :

TOPOGRAPHY:

The terrain is generally undulating with numerous isolated hills. Sagar district is situated in the south-eastern corner of great Malwa Plateau spread in north and north-west. This situates north of Narmada river. The district is covered mostly by Deccan Trap lava except for a few locations near Sagar town where Vindhyan sand-stones are found.

The tract is on average 447.2 to 533.4 m above the mean sea level. Towards the north around the Dhasan river bed, the elevation is upto 353.56 m while in the south-west, the Naharmau peak is nearly 683.36 m above the mean sea level. The topography of the district is understood properly by looking at its physical divisions formed by the river basins which run mostly south to north or south-west to north-east.

The tract of Khurai tehsil is the only clearly demarcated separate region situated north-west of Sagar which is plain and the most fertile wheat-producing area of the district. This is almost [illegible]1.5 to 426.7 m above the mean sea level and is



DISTRICT SAGAR

drained by the *Jimpa*, *Parasari*, and *Bina* rivers all paying tributes to *Betwa*. The plains of Khurai are distinctly separate from the rest of the district which has forest-clad long range of hills spread north-east to south-west from Pithoriya to Rahatgarh. These hills, on an average 533.40 m above the mean sea level, act as water-divider between *Bina-Jhimpa* rivers on the one side and the tributaries of *Dhasan* river on the other. The highest peak in this range is Tora peak which is 642.51 m above the mean seal level.

On the east and south-east of the above range are five parallel river valleys of Dhasan, Bewas, Sonar, *Kopra* and *Bamner*, forming a special feature in the geography of this district. These valleys are narrower in south-west getting wider as one moves towards the north east. This is an important agricultural belt of Sagar district. These valley-plains are over 457.20 metre above the mean seal level and slope towards the north-east[22].

HILLS:

The most important hill range of this region spreads from Lidhora to Jaisinghnagar via Bandaa; these are flat-topped hills covered with forests and are high ranging from 609.60 m to 665.07 m at different places. Naharmau, as reported earlier, is the highest point of the district.

GEOLOGY:

Most of this district is situated over Vindhyan Super group and Deccan Trap volcanic rocks. The two third of this district is made up of Deccan Trap. In the north-eastern corner around Shahgarh and Hirapur, the Archaean Bundelkhand granite and Bijawar rocks are found while to the east and south-east of Sagar, Lameta groups of the rocks are visible upto ca. 56 cm along with the Trap. The level of Lameta group is the bottom layer of the Deccan Trap.

Generally, the Deccan Trap shows flat topped hills, conical hills, plateaus, etc., whereas Vindhyan show steep escarpments. Deccan Trap in Sagar district consists of 9 lava flows. Each flow has its own characteristics, Some of these flows are well separated by intertrapean and red bole beds. Some intertrappean beds are fossiliferous.

The Bijawar group of rocks are found near Hirapur village in Sagar district. These rocks consist of dolomite limestones, ferruginous shale, ferruginous quartzites, conglomerate etc. The ferruginous shale and ferruginous quartzite contain very good deposits of phosphorite. Mining of this deposit is in progress by the M.P.State Mining Corporation, Govt. of Madhya Pradesh. The Bijawar rocks are ovarlain and underlain unconformably by Vindhyan super group and Bundelkhand granite rocks.

BOX 2

Recent	--------	lateritic soil, aluminium
-------	unconformity	---------
lower eocene		
Upper cretaceous	Deccan Trap	Basalt
Intertrappean beds		
Middle createaceous		
	Lameta	limestone, grit, etc.
---------	unconformity	----------
Pre - cambrian	Upper- Vindhyan	Bhander group Rewah group
	lower vindhyan	Kaimur group Semri group
-------	unconformity	--------
	Bijawar Group	
--------	Unconformity	-------
Archaen	Bundelkhand granite	Gneiss and metamorphics

The Bundelkhand granite and gneisses are Archaen in age. These are the basement rocks of the Bundelkhand region and occur in the extreme part of Sagar district. These are introduced in metamorphics. The Bundelkhand granite is also intruded upon by dykes and quartz reefs.

The general geological succession of the district is given in box 2.

The Soils :

There are different soil-varieties in this district depending upon the location, the elevation, the draining behaviour, the rock-systems, the distance from the streams and the slopes etc. In local dialect the different soils are :

MAR, KABAR, MUND (I), MUND (II), RATHIA, RAYAN, PATRUA, BHATUA AND KACHHAR.

MAR: This is the best soil found in the plains, grey to black colour, deep, which retains moisture and does not crack. Such soils are mostly found in Sagar distt. at Khurai, Etawa, Barodia, Nevnagar, and Eran.

KABAR: This is the best black cotton soil. This is fine in texture, prone to cracking, clayey and soft sometimes mixed with *kankar.* Such soils are found in Rehli, Gorjhamar, Baleh groups of villages. This is also found in Dhana groups in Sagar tehsil.

MUND (I): This is also a grey or black coloured, coarse-grained soil, mixed with moderate *kankar,* fertile rich in organic matter, and capable of continuous wheat-cropping.

MUND (II) : This is found in shallow- based and undulating land. If mixed with alluvium and on plains this gives good crops but this is incapable of wheat production. This is an ordinary soil and is found at Sagar tehsil (Sihora, Nariavali, Jhilla, and Dhana groups of villages) Khurai tehsil (Etawa, Khurai, Khimalasa, and Kanaiya groups of villages and Rehli tehsil (Garhakota and Baraho groups of villages). This is generally a one-cropping soil.

RATHIA: This is a grey coloured inferior KABAR soil, mixed with *kankar,* and dries to form solid mass. This is difficult to cultivate and needs timely operation. This is found in Sagar tehsil (Sihora and Nariavali groups of villages).

RAYAN: This is black coloured soil with some black stones. This is a shallow based soil, with good draining nature and is found near the hills. This can give good Kharif-crops during the years of higher rainfall. This is a cracking soil, but capable of two crops. This is found here in Sagar tehsil (Dhana and Jaisinghnagar groups) and Rehli tehsil (Naharmau groups).

PATRUA : This is inferior Mund soil which is drained badly. This is brown in colour and is fibre-grained. This is found in undulating land. Another kind of PATRUA is found in Vindhyan range which is light coloured sandy soil. This is good for rice-cultivation and found in Rehli groups in Rehli tehsil, Dhana groups in Sagar tehsil, and Vinayaka groups & Shahgarh groups in Bandaa tehsil.

BHATUA: This is red coloured inferior soil with stones. This is suitable only for coarse crops and is found in Rehli and Bandaa tehsils.

KACHHAR: It is good fertile soil formed by flooding the rivers or streams and usually used for garden crops. This is found in Khurai tehsil.

B. DRAINAGE AND WATER RESOURCES :

The drainage of this district is towards north and north-east since all the rivers and rivulets of this district, namely *Babne, Kongara, Bina, Narayan, Jhimpa, Bonkheri, Bila, Dehar, Bewas, Sonar, Kopra* and *Bamner* etc. and their numerous tributaries flowing any direction ultimately meet the *Betwa, Dhasan* and *Ken* which flowing towards north-or north-east finally join Yamuna river.

A remarkable pattern of drainage system here is of radial drainage. A few elevated locations give rise to flow of their drainage towards all the directions. Such examples could be seen at Khimlasa near Khurai and Jayceenagar (Jaisinghnagar) south-west of Sagar.

RIVER SYSTEM :

Sagar distt. is just 9 km away from Narmada, yet all its rivers and streams form contributries to catchment of the Ganga. The three main rivers *Betwa, Dhasan* and *Ken* are filled with the water drained out from this district.

Betwa does not pass through this district but forms for some distance its boundary with Lalitpur district. This also receives water from many west-bound rivers of this district including *Bina, Narayan* and Jhimpa etc.

Bina river rises a few km south of Sagar district touching it at Mahuna village, and flowing through Rahatgarh turns north-east forming the boundary with Vidisha district. Near Rahatgarh there is a picturesque fall on *Bina.* This joins *Betwa* 15 km west of Bina-Etawa town.

Dhasan rising south of this district, cuts through Sagar at the central tract and flows almost north-east, having contributed all the drainage of central and partial northern tract of Sagar district to flow further towards Tikamgarh district.

Bewas river also passes through the central tract of Sagar district, flowing north-east and is an important tributary to *Sonar.*

Sonar rises from this district and enters Damoh from its eastern boundary. It attracts many small streams and rivers like *Bewas, Bamner* and *Kopra* as its tributaries and finally surrenders to KEN.

SAGAR LAKE

Sagar Lake is the most important natural water reservoir of this tract which has influenced the habitation in Sagar town. In fact the town is named after Sagar Lake and it serves as the life-line of this town.

BILA RESERVOIR

Built on Bila river north-east of Sagar, the Bila reservoir meant for irrigation in Sagar and Chhatarpur districts, is a reasonably big water body and is situated at a beautiful location.

B.2 THE DRINKING WATER SITUATION :

Sagar district traditionally has been fully dependent on the masonry wells for its drinking water needs. The well-laid Vindhyans and Trap-rocks normally resist the seepage to ground water and therefore, the wells generally get dry during summer season. Upto 1970 tubewells were not recommended at all. Some fractured zones of limestones were, of course, found which promised reasonably good amount of ground-water.

The drinking water supply schemes to the towns therefore, were mainly dependent on the rivers, reservoirs, stop-dams on local streams, or somewhere, on the wells which could give sufficient water discharge. Recently efforts have been made to install the India Mk. (II) hand-pumps in some towns and villages.

B.2 THE IRRIGATION SITUATION IN THE DISTRICT :

Traditionally the masonry wells were the only means of irrigation which normally used to irrigate the sugarcane or garden-crops. In 1864-65 the total no. of wells were 3,190 which irrigated ca. 2,310 ha land forming 90% of the total irrigated area of the year. Around 1960-61 nearly 6,643 Govt. as well as private wells were utilised for irrigating 3,756 ha land forming 64% of the total irrigated area of that year. 137 tubewells also wereregistered in that year. Tanks were also used to irrigate some land in some places. In 1894-95, 23 tanks were reported to have irrigated 82.15 ha land forming 3% of the irrigated area of that year. In 1960-61 the number of reservoirs went upto five and tanks forty-three. The canals were reported to have irrigated ca. 1,740.6 ha which formed 30% of the total irrigated area of that year. Like in other districts, embankment on the fields were helpful in raising RABI crops in this district also.

IRRIGATION PROJECTS TILL 1993 is given in box A of page112:

Sagar District Gazetteer (Supplement 1992) also mentions few more projects built under five-year plans, namely :

1. Zinda Regulator (1950)
2. Kodi Simaria Regulator (1960)
3. SimariyaNala Regulator (1963)
4. Mokiya Nala Regulator (1963)
5. Madantal Tank (1963)
6. Baroda Tank (1965)
7. Dhanora Regulator (1963)
8. Kharrana Regulator (1967)

The source-wise irrigation as reported is as follows:

S.no.	Source/scheme	No.	Irrigated area (ha) 1994-95
1.	Medium Projects:	02	4,800
2.	Minor projects :	-	6,800
3.	Stop-dam .	50	1,200
4.	Wells	31,379	33,520
5	Tubewells	285	2,225
6	Tanks and others .	-	32,000

Source : Information from the Deptt. of Agriculture, Sagar, 1995

C. VEGETATION :

THE FORESTS :

The forests, not in very good condition now, are confined to only the hilly areas where the land is incapable of agricultural operations. The forests here were classified as the Tropical Dry Deciduous forests. A large part of this district is covered by the Deccan Traps which prefer pure teak forests. The sandy *domat* soil is suitable for the mixed forests. The type of forest generally depends upon the soils and the draining pattern of the area and thus there have been many different forest-types in this tract.

Major forest-types are described below :

Teak-Forests: These used to be found mostly in Sagar and Rehli Tehsils, on the flat top of the hills rather than on slopes. Later, when the soil cover was lost from the tops these used to grow along with the major water courses. On the slopes

BOX A

S.No.	Name of the project	Dev. Block	Year of completion	Proposed irrigation (ha)	Actual Irrigation (1995-96) (ha)
1.	Ratauna Tank	Sagar	1924	121	25
2.	Bhanhari Tank	Sagar	1969	145	52
3.	Bhipel Regulator	Rahatgarh	1952	45	-
4.	Naya Kheda Tank	Sagar	1991	59	20
5.	Sanodha LIS	Sagar	1988	243	60
6.	Bachhlon Tank	Sagar	1991	243	20
7.	Surkhi Tank	Sagar	1980	419	370
8.	Parasari Anicut	Rahatgarh	1960	162	-
9.	Padrai Tank	Jayceenagar	1991	198	-
10.	Hirapur Tank	Jayceenagar	1991	313	15
11.	Devalchauri LIS	Jayceenagar	1993	344	28
12.	Mansoorwari Tank	Deori	1985	1801	1642
13.	Sagaranala Regulator	Deori	1960	36	-
14.	Chhewala Tank	Deori	1992	242	304
15.	Machhariya Tank	Deori	1992	556	232
16.	Tora Tank	Kesli	1992	136	45
17.	Gangasagar Tank	Rehli	1950	138	-
18.	Bhorai Nala Regulator	Rehli	1960	162	-
19.	Vijaipura LIS	Rehli	1988	152	25
20.	Imalia LIS	Rehli	1988	162	45
21.	Bichhia LIS	Rehli	1988	243	-
22.	Dattapura LIS	Rehli	1977	243	30
23.	Sagar Lake Regulator	Sagar	1960	61	-
24.	Bila Reservoir*	Shahgarh	1973	4332	3050
25.	Chandiya Tank	Shahgarh	1926	1214	1016
26.	Narayanpura Tank	Shahgarh	1926	155	145
27.	Barayatha Tank	Shahgarh	N.S.	142	90
28.	Tigoda Tank	Shahgarh	1963	121	95
29.	Tigoda Anicut	Shahgarh	NS	145	-
30.	Amarman Regulator	Shahgarh	NS	04	10
31.	Binaika Tank	Bandaa	1970	68	30
32.	Indora Tank	Shahgarh	1990	109	-
33.	Bandari Tank	Malthone	1974	121	115
34.	Malthone Tank	Malthone	1974	149	110
35.	Rasoola Anicut	Khurai	1960	24	-
36.	Garhaula Tank	Khurai	1967	121	100
37.	Teora Tank	Khurai	1967	89	50
38.	Basari Tank	Khurai	1967	51	50
39.	Khimlasa Tank	Khurai	1967	162	-
40.	Mala Tank	Khurai	1987	182	150
41.	Girhani Tank	Khurai	1990	182	160
42.	Silarpur Tank	Khurai	1990	182	135

* Bila Reservoir is planned to irrigate 12257 ha of which 4332 ha is in Sagar Distt; the rest is in Chhatarpur Distt.
Source · Irrigation Division No. 1 and 2 (Sagar) Report 1996

teaks could be seen mixed with *Palash, Moyan, Gunja, Salai, Bel, Reunjha, Berga, Papra, Dhaman, Khair, Bhirra, Mokha, Ghont,* and *Mahua* etc.

On the eroded soils with rocky outcrops *Ghont, Thuar, Reunjha, Lokhandi, Khair, Ber, Bhirra, Gongal, Harua, Kayankar,* and *Bel* trees are found. The overwood in these forests used to have *Saal, Bija, Haldu, Kalam, Chirol,* and *Dhavara.* Others included *Kekad, Moyan, Dhovin, Gumar, Baheda, Mahua, Lendia, Chichwa* and *Karmata.*

The second set of trees which have been found in abundance in these forests are : *Achar, Aonla, Barga, Dhaman, Kari, Jamrasi, Papra, Bel, Asta, Lokhandi* and *Amaltas.* In the Marshy tract *Palash* is common while by the side of streams *Arjun* has been the main vegetation. *Jamun* on the banks of streams and *Jhau* under the raised bed of the streams, were visible.

Mixed Forests: The mixed forests were largely found in Bandaa and Khurai tehsils and in the Mohli block, east of Rehli tehsil. These included *Saaj, Tendu, Seja, Dhavara, Aonla, Tinsa, Achar, Bel, Kari, Kasai, Mokha, Semal, Salai, Reunjha, Kem, Harua, Bhirra, Khair, Bhilawa, Papra, Amaltas, Arjun,* and *Kumbhi. Kardhai* has also been found in abundance in Ramana and Dulchipur reserved forests.

On the rocky and eroded soil-tract, the growth of the trees remains poor, and the trees which were mostly found are : *Seja, Tinsa, Reunjha, Khair, Ghont, Ber, Rohan, Bhirra, Papra, Achar,* and *Kaankar* etc.. *Kulloo* with scant leaves in the dry weather, also used to be seen at some places, rooted on the steep slopes and rocks.

Ghont and Khair Forests : In the areas which are lightly eroded, one could see the presence of *Khair,* and *Ghont* along with *Seja, Tinsa, Kaankar, Reunjha, Dhavara,* and *Kardhai.*

In heavily eroded soils, *e.g.* near Dhamoni, where the rocks are totally uncovered, forests are seen comprising of vegetation like *Harua, Gongal, Thuar, Ber, Rohan,* and *Makor.* These grow well by the side of the streams.

In the heavy soils *Palash* grows very well which could be recognized from its beautiful flowers, the *flame of the forest* during the spring season. The denuded forests have the shrubs and bushes in abundance.

Vegetation on Roads or in the Villages :

On the roadsides, *Reunjha, Arjun, Sheesham, Babul, Karanj, Neem, kachnar, Akashneem, Maharukh, Bargad, Goolar,* and *Mango* trees used to be commonly planted. Other naturally growing species like *Palash, Mahua, Seja, Bel, Saaj, Kaankar,* and *Tendu* used to be protected on the roadsides.

In the villages, *Bargad, Goolar, Pipal, Imli, Mango, Jamun, Munga, Bel, Lasodha, Neem* and *Mahua* are normally planted. In the ruins or in the house-premises, *Sitaphal* is seen growing.

There are many other varieties of plants, climbers, bushes, parasites, and grasses which grow or grown within and outside the forest-areas in Sagar District..

AGRICULTURE:

Sagar district has been famous for its RABI-crops. Wheat has been the principal crop followed by Gram, and linseed. In KHARIF, paddy, Jowar and Til are normally grown. During last century, sugarcane and cotton were very important cash-crops. Both these crops are at low key now. Potato is, of course, grown in abundance especially in Sagar tehsil. Mango is the fruit crop of this district while in some areas Betel-leaves are also grown.

Important Crops and its Production :

The table A gives the area occupied by important crops and its production during the years mentioned :

TABLE A							
S.no.	Crops	1965-66		1985-86		1994-95	
		area ha	prod. m.t.	area ha	prod. m.t.	area ha	prod. m.t.
KHARIF :							
1.	Paddy	15,000	4,000	15,000	12,000	22,965	19,676
2.	Jowar	31,000	27,000	23,000	26,000	14,213	9,643
RABI :							
1.	Wheat	2,14,00	1,26,000	2,63,000	2,45,000	1,17,778	2,41,346
2.	Gram	36,000	19,000	67,000	99,000	26,967	37,739
3.	Sugarcane	400	900	250	400	649	2,617

Source : Report from Agriculture Deptt. Sagar (MP) : Important Divisional Statistics. Divisional Statistics Office, Sagar (1996)

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of this district is generally pleasant. The winter season covers November to February followed by the summer season lasting upto mid-June. The rainy months are from mid-June to September. The fourth season of October is the transition month. This is semi-arid and subhumid zone of the state. The air is generally dry except in the south-west monsoon season. Various indicators are given below.

Temperature : :

Sagar district experiences hottest temperature in the month of May and coldest during December. Sometimes January is colder than December. The mean monthly temperature (maximum and minimum) for the period 1985-95 as per record of the India Meteorological Department, Govt. of India give the following information related to Sagar district in the Table A 1:

Rainfall :

The average annual rainfall calculated on the basis of 95 years' data (1901-1995) at Sagar is 1,241.33 mm. The maximum rainfall was recorded as 2,340.00 mm in 1973 and the minimum rainfall 487.40 mm in 1981. Average number of rainy days per annum were 58 when it rained for more than 2.5 mm. The mean monthly rainfall for Sagar District is given in the table A 2:

The Winds :

The horizontal component of the air-movement parallel to earth's surface is the wind which is measured by anemometer in km per hour units. The mean wind-velocity recorded for Sagar are given in table A3 :

June is the month for the highest wind-velocity, while the minimum has been recorded for the month of December. The seasonal variation of atmospheric pressure takes place in a systematic manner with a maximum in the winter (January) and a minimum in the monsoon season (July). Except in the post-monsoon and early winter months winds are moderate, strengthening in the late summer and early monsoon seasons. During late summer and the monsoon season, winds blow mostly from directions between south-west and north-west. In October winds from other directions also set in.

October is the month of transition with weakest pressure gradient. From October onwards, the

TABLE A 1		
Month	Mean Maximum Temp. (°C) 1985-95	Mean minimum Temp (°C) 1985-95
January	22.70	12.30
February	27 40	12 30
March	30.68	16.24
April	34.87	20.47
May	38.07	24.25
June	34.64	21.14
July	29.39	23.19
August	28 25	21.43
September	25 50	20.60
October	30 45	19.78
November	28 20	14 88
December	25.90	10.90

Source : Hydrometeorology (Dr. LP Charausia), as cited earlier

TABLE A2	
Month	Mean monthly rainfall
January	20.88
February	11.06
March	9 33
April	4.41
May	8.16
June	132.14
July	572.01
August	402.20
September	197.70
October	45.55
November	23 02
December	8.42

Source : Same as above

TABLE A3			
Month	Wind velocity	Predominant Wind-direction	
	km/hr	morning	evening
January	6 9	ENE	ENE
February	7 1	ENE	WNW
March	8 3	variable	WNW
April	9.0	WSW	WNW
May	10.1	WNW	WNW
June	11.0	WSW	WSW
July	10 5	-do-	-do-
August	10.3	-do-	-do-
September	9 6	WSW	WNW
October	7 1	WSW	NNE
November	6 7	ENE	NNE
December	6 5	ENE	NNE

Source Same as above.

change-over of the pressure and wind pattern to the winter pattern commences. In the winter season winds blow mostly from directions between north and south-east. These winds continue in early summer also, though these are less predominant, and south-westerly to north-westerly winds makes their appearance.

The Humidity :

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. The mean monthly values of relative humidity percentages for the past 11 years (1985-1995) for Sagar observatory stations have been collected and presented in the table which follows :

Month	Relative Humidity	
	8.30 a m	5.30 p.m.
January	57.10	40.00
February	52 55	31 20
March	44 35	27 60
April	32 90	23 25
May	31.00	17.50
June	58.55	41 60
July	86.35	71.45
August	89.50	79 40
September	81 40	70.45
October	60.90	46.15
November	52.65	41 05
December	57.80	39 70

Source . IMD (Govt of India) Nagpur

Evaporation Losses :

The formation of gaseous state from water or ice (in winter) near its surface and the distribution of these vapours into atmosphere is what is known as evaporation loss measured in centimetres. The monthly evaporation data for Sagar is given in the following table. A glance at this brings out the fact that the evaporation losses gradually decrease till August and after a small increase in September, it decreases again from November.

Month	Evaporation Losses (cm)
January	7.62
February	10.16
March	18 41
April	27.94
May	38.10
June	23.49
July	10.16
August	8.25
September	10 79
October	9.52
November	7.62
December	7.62
Souıce : IMD (Govt. of India) Nagpur	

Cloudiness :

Generally, the sky is clear or lightly cloudy in the non-monsoon season. The cloud-intensity, however, is high during south-west monsoons. The normal cloud-cover values are available for station Sagar; we present here the mean value in order to understand this phenomena (the unit of this indicator is in Oktas):

Month	Mean Value (OKtas)
January	1.75
February	1.18
March	1 25
April	1.38
May	1.65
June	3.60
July	5.65
August	5.58
September	4.05
October	1 60
November	0.99
December	1 15
Source: The In-RIMT Technical Report (1994) · ref 9	

It is quite in tune with Nature that July and August have maximum cloud-cover over the sky while the lowest is in November.

Special Weather Phenomena :

During the rainy season, depressions due to south-west monsoon rising from the Bay of Bengal brings storms followed by heavy rains. The depression in October also sometimes causes rains as well as high velocity winds. The storms are generally during the summer and rainy seasons. The rains during winters are sometime followed by hails. Frost and Fog also appear during the winter months.

CLIMATIC WATER BALANCE :

The water balance in different geographical areas in Sagar district have been computed which are given below :

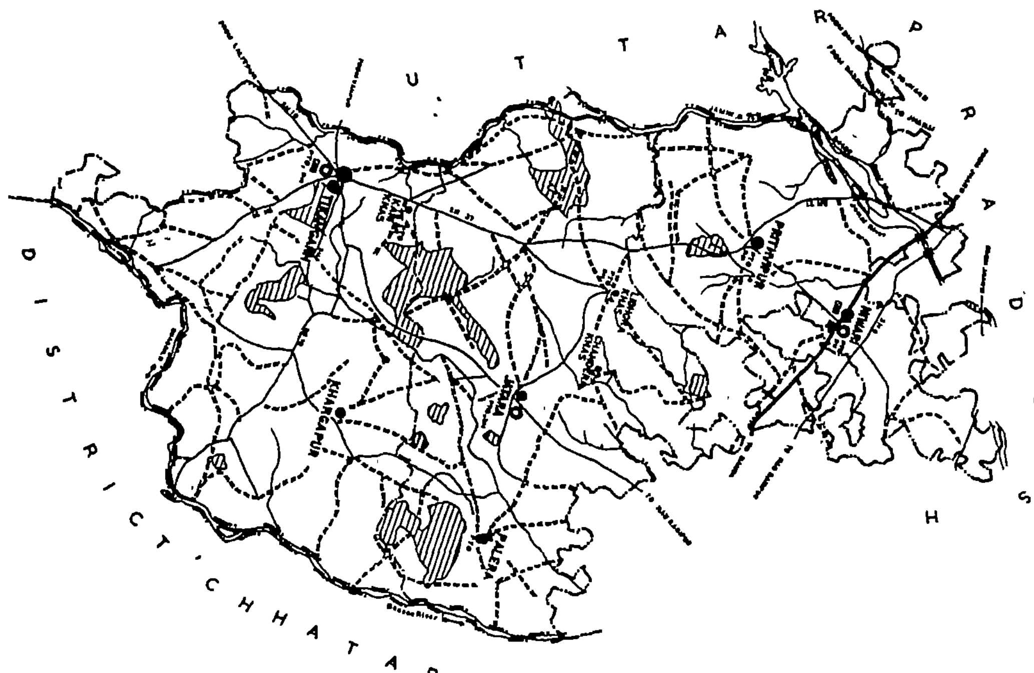
1. Actual evaporation (AE) = 847 mm
2. Potential evaporation (PE) = 1270 mm
3. Index of moisture adequacy (Ima) = 60.6
4. Aridity Index (Ia) = 25.2%
5. Humidity Index (Ih) = 30.3 %
6. Moisture Index (Im) = + 5.1%
7. Summer concentration (%) = 44 4%
8. Moisture regime - Type - C2
   - Sub type - S2
9. Thermal regime - Type - A'2
   - Sub type - b'2

the climatic Water balance of Sagar station is shown in figure 3.17. From this figure and the above parameters it is clear that the study area has moist sub-humid climate. According to Oliver (1970), it has a tropical wet dry climate. On the whole, winters are normally cold, while summers are hot. The rainy season is quite pleasant with greenery. Generally, December and January are the coldest months. May and June are the hottest months whereas July and August are the rainiest months of the year.

2.3.5 TIKAMGARH DISTRICT :

A central district of Bundelkhand, Tikamgarh (Tehri) has been the capital of famous Orchha state since 1783 A.D. The district lies between Latitude 24°26' & 26°40' (north) and Longitude 78° 26' & 79° 26' (east) and has a geographical area of 5,048 sq. km. To the north of Tikamgarh is Jhansi district; to the east are Mahoba and Chhatarpur districts; to the south are Lalitpur and Chhatarpur districts; and to the west is Lalitpur district. The eastern boundary is entirely made up by *Dhasan* river while the western boundary is mostly bordered by *Jamni* river.

DISTRICT TIKAMGARH



1.PHYSICAL FEATURES :

TOPOGRAPHY AND GEOLOGY :

The district lies in the level plane which forms the *Betwa-Dhasan Doab.* This tract is fairly cultivable. Though all the representative soils of Bundelkhand are present in this district, the productivity is low. The northern part of the district near Tahrauli has the best productive soil.

Tikamgarh lies in the area of Bundelkhand gneiss, a hard greyish pink grantiodal rock of simple composition traversed by conspicuous quartz fields, which constitute an integral part of this formation and almost invariably strike in a north-easterly direction. A number of basaltic dykes strike approximately north-west, at right angles to these reefs. These dykes are probably disintegrated representatives of volcanic rocks of Bijawar group[23].

The Minerals : Important mineral wealth of this district is the famous Bundelkhand granite, the sandstone and lime-stone. Main products are the building materials like stone-gravels, boulders and the slabs.

The Soils : All ;the four representative soils are found here; major share is that of red-yellow soils found in the gneissic area. The blacks soils also are deposited in some tracts which are fertile.

B.DRAINAGE AND WATER RESOURCES :

Tikamgarh is drained by the rivers *Betwa* and *Dhasan* and its numerous tributaries like *Jamni, Bargi, Ur* and *Barwa* and other seasonal streams flowing mostly in the north-or north-easterly direction. While *Jamni* gets the drainage of the district on its western side, *Dhasan* forms the draining line towards eastern side. *Jamni* takes all the water on the western side and joins *Betwa* at the north-western corner of this district.

THE RIVERS:

The important rivers of this district are described as follows :

1. **Betwa** river touches at the north-west corner of this district and flows through Orchha, the original capital and important historical town of this district. It goes further towards Jhansi district. The main tributary to this river is *Jamni.*

2. **Jamni** forms its boundary with Lalitpur district on the west. Rising from Sagar district, *Jamni is* an important river which flows through Lalitpur district and receives all the west-bound drain of the Tikamgarh district. It finally meets *Betwa* within Tikamgarh district only.

3. **Dhasan** forms the total eastern boundary of Tikamgarh district separating it from Chhatarpur and Mahoba districts. This is an important river rising from south of Sagar district serving as the central draining river of Bundelkhand region. *Dhasan*, in ancient days, used to be called *Dasharna* literally meaning ten forts or ten rivers which was also the name of this region. *Dhasan* joins *Betwa* before the latter touches Yamuna river.

4. **Barwa** rises in Barora hills and flows into Barwasagar Lake situated in Jhansi district.

5. **UR**: This is a perennial river rising from this distrtict which joins *Dhasan*.

Bargi, Saprar, Sorda, Nagda, Umrar, and *Jamrar* are other important streams which drain this district and also give life to people here by way of forming certain good water-bodies, helping irrigation as well as recharging the ground-water reserve.

THE LAKES AND TANKS:

Tikamgarh district is very rich in lakes and tanks which form very important sources of irrigation as well as recharging the ground water-reserve. To name a few :

1. Mahendra Sagar	2. Padma Sagar
3. Dharma Sagar	4. Madan Sagar
5. Barana Tank	6. Nandanwara Tank
7. Sanera Tank	8. Bir Sagar
9. Dip Sagar	10. Nagda Sagar

B.1 THE DRINKING WATER SITUATION :

Tikamgarh has been a tradition-bound area where the wells, tanks, and perennial streams formed the basic lifeline as far as water is concerned. The tanks or lakes here seek their origin to the *Chandela* and *Bundela* kings who were extremely fond of building large tanks with stone-masonry wall to hold large quantities of water.

Since the drinking water became the responsibility of the State Govt., several rural and urban projects were planned. To give a rough sketch :

The Urban Drinking Water Supply :

1. Tikamgarh:

Tikamgarh town has a well planned water supply scheme with more than one source to feed the water requirements of the town. In addition to river *Jamni* and its reservoir, the following sources are used to keep the supply of the town going :

1. Tal-Darwaja-well
2. Bajaj Ki Bagiya-Well
3. Mahendra Bag-well
4. Haridas Mandir-well
5. Old Tehri-well
6. Mau-Nala-*Bavari*
7. Hospital-Tubewell
8. Gol Quarter Tubewell
9. Vinodkunj Tigaila-Tubewell
10. Dr. Khan Lane- Tubewell

Upto 1995, some 41 India Mk. II hand-pumps were also installed in the town. An extension plan has also been proposed. Nagar Panchayat Tikamgarh looks after this arrangement.

2. Other towns :

Piped water supply has been arranged for other urban locations also. India Mk. II - hand-pumps have also been installed to be able to reach sufficient water for domestic purposes. The table A in page 119 gives the available information :

Rural Water Supply :

Tikamgarh district upto 1995 had 38 rural drinking water supply schemes through pipelines. These are looked after by the Gram Panchayats. One of the Rural Drinking water schemes which used to supply water to Kundeshwar, Ganeshganj, and Kamnaura have now been provided separate water sources.

TABLE A

S.no.	Urban centre	Population 1991	Source of water	Maintained by
1.	Orchha	2,500	River TW-01 HP-02	Nagar Panchayat
2.	Kari	6,649	River TW-01 HP-02	-do-
3.	Kharagapur*	9,649	TW-01 HP-20	-do-
4.	Jatara	12,300	TW-02 HP-16	-do-
5.	Jeraun Khalsa*	6,729	River HP-24	-do-
6.	Tarichar Kalan*	5,202	TW-01 HP-19	-do-
7.	Niwari*	15,040	TW-03 HP-15	-do-
8.	Palera*	10,493	TW-03 HP-13	-do-
9.	Prithvipur*	17,020	TW-03 HP-12	-do-
10.	Badagaon*	7,111	River TW-01 HP-16	-do-
11.	Baldeogarh*	5,959	TW-01 HP-10	-do-
12.	Lidhaura	8,490	TW-03 HP-05	-do-

* Extension of the urban drinking water scheme has been proposed.

Installation of Hand-Pumps:

Out of 858 villages inhabited in 1991, some 818 villages have been provided at least one source of drinking water. The problem villages which numbered 760, have all been arranged safe water supply by any means. Some 58 non-problem villages have also been strengthened in drinking water supply. Upto December 1995, 3,437 hand-pumps had been installed out of which 2,849 are in working order.

B.2 THE IRRIGATION SITUATION IN THE DISTRICT :

Like all other Bundelkhand districts, Tikamgarh, has been dependent mostly on masonry wells for its essential irrigation. The usual means of irrigation on wells have been the MOTH (the leather-bucket/rope) and Persian Wheels both powered by a pair of bullocks. This has slowly been replaced by the diesel/electrical pump-sets.

The presence of many artificial lakes and tanks, however, give this district a great potential of canal irrigation. Most of the lakes and tanks described earlier, have been used for irrigation. That gave rise to several canal systems including Kuriyala and Nagda canals.In the whole district comprising of 869 villages, 995 tanks have been reported[24]. Of these, at least 49 tanks have an area of more than 40 hectare each. The ownership of the tanks rests with different departments, namely the Forest Deptt. (9), Agriculture Deptt. (10), Irrigation Deptt. (88), Panchayat (211), Revenue Deptt. (35). The rest are private or general-use tanks spread over the villages. The active tanks which are fully or partially used for irrigation, blockwise are given below (The number within brackets refers to the potential area irrigated)

1. Tikamgarh Block : of many tanks in this block the following are used partially for irrigation : Girora Tal (45), Majna (03), Bamhori - Nakiban (20), Purainiya (20).

The tanks within Tikamgarh Town are in bad shape. Six of them have been either flattened or misused & dumped.

2. Baldeogarh Block : of the fourteen tanks the following are used for irrigation : Tuharra (50), Besa (35), Gukhrai (60) Brishbhanpur (70), Hata (50), Surajpur (30), Hirapur (45), Babar (40), Ramsagra (45), Gaiti (35) and Guna (55).

3. Jatara Block : of thirtythree tanks, only five are in a condition to serve the purpose of irrigation - These are : Mitha Tal, Gaur Tal, Toriya Tal, Raghnath Tal, and Bharguwan; the rest 28 are in a very bad shape.

4. Niwari Block : Fourteen tanks are used for irrigation : These are : Ladwari (20), Kalua (10), Neemkhera (20), Astari (20), Kuthar Purailiya (10), Sadikpura (10), Salooki, 2 tanks (20), Dhudhni (10), Ladpar (15), Lathesra and Pathari (10), Maharajpura (20) and Janauli (10)

5. Prithvipur Block : has eighteen tanks. Nadanwara tank used to irrigate ca. 4495 ha. but its situation has become very precarious these days because of tussle between miners and the people. Other tanks like Chamra Tal, Sane Talaiya, Kakawani, Amroomata, and Purainiya are potentially big tanks. Salera village has two big tanks whose bund and sluice both are damaged. Kandhari tank is also in a bad shape.

6. Palera Block : has eighteen tanks. Of these, thirteen are smaller, irrigating less than 50 acres each. The five larger tanks are Kudwara (130) Gajadhar Tal (120), Sumera (110), Majhguwan (120) and Lidhaura Tal (100).

District Department of Agriculture provided some information up to 1995 which is placed below :

S.no.	Scheme	No.	Benefited area (ha)
1.	Medium Irrigation Projects	03	2,400
2.	Minor Irrigation Works:	-	16,000
3	Stop-Dam	81	2,000
4.	Wells	65,126	1,17,306
5	Tubewells	175	1,050
6	Tanks and other sources*	-	7,999

From these figures also the importance of masonry wells could be assessed.

Rivers flowing this district have not been dammed in pursuance of any "modern" irrigation scheme.

C. VEGETATION :

THE FORESTS:

The forests in this district have been tropical Dry Mixed Deciduous type and upto the last century large areas were under thick forests. The forest of Orchha was famous for its wildlife where Mughals also enjoyed hunting.

The common trees and plants of this area were as follows:

Trees: *Achar, Aam (mango), Amaltas, Aonla, Babul, Bel, Ber, Dhaora, Ghont, Imli, Jamun, Kardhai, Khair, Mahua, Neem, Palash, Pipal, Saaja, Sej, Salai, Shisham, and Tendu,.*

Shrubs and Herbs : *Harishingar, Jharberi, Karaunda, Sitaphal, and Thuar.*

Bamboo has been thriving here and the popular grasses within forests have been **Doob, Kans, Khus** and ***Munj***.

AGRICULTURE :

This district is not a very fertile tract and therefore, agriculture here, except for a few areas, has been marginal. Both the KHARIF and RABI crops are sown. Wheat and rice are the main staple food of the rural population and although the district lies in wheat growing belt, rice is an important crop here.

District statistics regarding cultivable and irrigated areas, as noted in the Distt. Census Handbook, (1981) are as follows :

Total inhabited Villages:	869
Total Area:	4,10,886.60 ha
Cultivable Area :	3,31,586.00 ha
% of cultivable to total area :	80 70
Irrigated Area :	81,526.59 ha
% of Irrigated to cultivable area :	24.59

The northern part of the district comprising Niwari and Prithvipur tehsils is the main agriculturally productive belt.

THE CROPPING PATTERN :

The cropping pattern of the district as reported for 1980-81, is given in the following table :

Crop	Area sown (ha)	% of total area
KHARIF:		
1 Paddy	28,914	10.08
2 Jowar	38,944	13.58
3 Maize	2,720	0.95
4. Tur (Arhar)	1,225	0.43
5 Mung	5,513	1 92
6 Urd	14,719	5.13
7. Til	11,714	4 08
RABI:		
1 Wheat	71,396	24.89
2. Gram	13,932	4.86
3 Barley	12,208	4.26
5 Linseed	1,036	0.36
6 Mustard (Rape)	120	-

Source : Distt Census Handbook (Tikamgarh) 1981

In later years Soyabean has appeared as a potential crop but that has affected many of the Kharif crops. This crop has also done damage to the ground water recharge and soil moisture retention which ensued from the old practice of holding water on the fields by embanking the sides.

The 1994-95 figure provided by the Divisional Statistics Office, Sagar for this district mentions that out of the total sown area of 3,62,589 ha, the irrigated area was 1,85,525 ha. The area covered and production of the main crops are given in table A.

The table clearly shows the turn of agriculture of this district towards Soyabeans.

D. CLIMATIC INDICATORS AND HYDROMETEOROLOGY :

The climate of the district is extreme type with maximum temperature touching 44 °C in hot summer days. The minimum drops to 5 °c during winter season. Hot winds (locally known as LOO) are common during May and June. With the onset of monsoons the temperature drops appreciably.

The rain commences from early July; August and September are peak rainy months. During rainy season, the weather remains sultry associated with high humidity. The average annual rainfall of this district is ca. 1,000 mm.

The winter season starts from November; December and January are the coldest months. From April the mercury starts rising; summer season extends upto June.

Separate climatic data were not available; therefore, climate-wise this district can be taken as parallel to the adjoining districts.

TABLE A

S.no.	Crops	Area covered (ha)	Production (m.tonne)
KHARIF			
1.	Paddy	22,965	19,676
2	Jowar	14,213	9,643
3.	Urd	26,762	9,569
4	Soyabean	50,060	62,455
RABI			
1.	Wheat	1,17,778	2,41,346
2	Gram	26,967	37,739
3.	Masoor	3,164	1,883
4.	Linseed	2,717	909

2.4. GWALIOR DIVISION

Datia of the Gwalior division has been included in present study related to water in Bundelkhand. The other districts like Bhind, Shivpuri and Guna which are partially geophysically akin to Bundelkhand will be included in future editions of this publication.

2.4.1. DATIA DISTRICT :

Datia district consists of one mainland body mostly on the Sind-Pahuj *Doab* and five enclaves. These enclaves are surrounded by the portions of Shivpuri and the bordering Jhansi district. Datia happens to be the smallest district of M.P. and is surrounded by Gwalior on two sides. The district is bounded on north by Bhind, on the east and the west by Gwalior, on the south by Jhansi and Shivpuri and is located on the margins of the Ganga valley and the great Vindhyan plateau.

The main body of the district extends between the parallels of Latitude 25° 33' & 26°18' (north) and Longitude 78° 13' & 78° 51' (east). The geographical area of Datia is 2,038 sq.km.

A. PHYSICAL FEATURES :

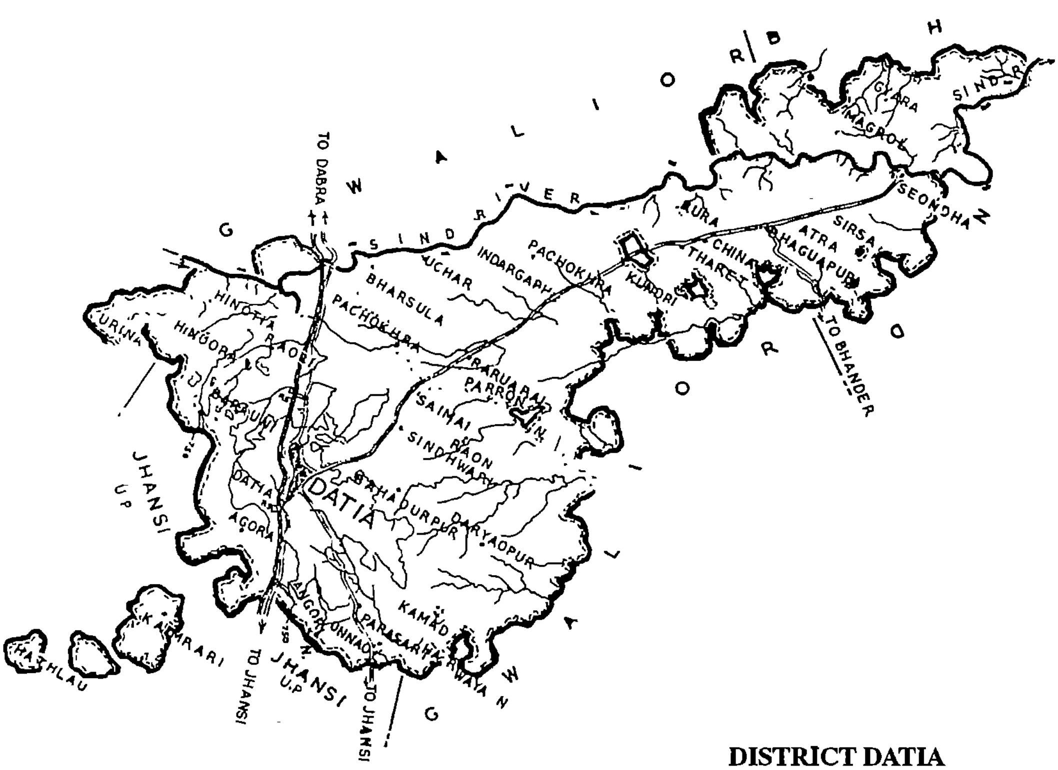
TOPOGRAPHY:

The general level of the country is about 198 metres but the variations range from about 152 to 335 m above the mean sea level. The whole district is uniformly sloping towards the north-east but the mounds and hillocks of otherwise concealed granite are also marked intermittently on the plains(24). The district has the following two distinct physiographic divisions :

1. The lower Bundelkhand Plateau, and
2. The Gangetic plain.

1. The Lower Bundelkhand Plateau:

The southern part around Datia town lies in the granitic area and forms a somewhat barren and rocky tract. The tract lies above 213 m and the prominent hills lie to the south-east and west of Datia. The hill near Gharwa is 308 m, Udnu-ki-



DISTRICT DATIA

Toria 326 m and Baroni hill 317 m. The southern enclaves lie at about 305 m above the mean sea level; and the highest point of district, the peak of Burdwan, is 337 m high in the Basai block. The hills show steep rise on their sides and a few rise to over 91 m from their immediate neighbourhood. The tact is gradually covered by the alluvium and the hard masses reappear only across the Sind on its north-western side.

North -west of Seondha as well as on the left bank of the Sind, a low range of sandstone hills overlooks the river and extends upto its north-eastern bend in the district. The height of the scarp on its south-eastern face is 30 to 91 m. These hills join the Gwalior range in the west and slope towards the north, where also the rocks beneath the alluvium disappear. Among these hills there are three peaks which rise above 244 m. the highest with 263m being in the south. Seondha hill on the northern bank of the Sind, opposite the village is over 183m.

The plateau area is either bare and stony on steep slopes or is covered with reddish soil or black cotton soil.

2. The Gangetic Plain:

Most of the central and northern parts of the district lie in the *Sind-Pahuj doab* which form the southern margin of the Gangetic valley. The central part of the district is from 183 to 213m above the mean sea level, whereas the northern part and the area south-east of Maithana (Bhander tehsil of Gwalior) lie below 183 m. Although dotted with hillocks and low mounds of granite, the valley is flat, uniformly and gently sloping towards the north-east, and formed mostly of river alluvium.

Other types of soil are also met with near the mounds and on the upper reaches. Deeper alluvial deposits occur along the major rivers and streams of the district. The alluvial soil is loamy and fertile. Admixtures of sand, in varying proportions and of various sizes of grains produce a number of soil types. Due to locational factors also, some sub-types are added. The soil in low lying flats with poor drainage is usually saline. It is generally brown in colour. The alkaline soil is grey, sticky on wetting and hard in drying, acquiring a cloddy structure. Growth of crops or flora is difficult at places where undulating *kankar* layer often comes up on the surface in any soil region. Due to alternate leaching and capillary rise of moisture the subordinate layer of calcium carbonate is also unsuitable for agriculture.

The Gully Erosion:

The alluvial tract is marked by gullies along the major rivers and their tributary streams caused by water-action on the loose soil. The banks of the deep streams and their upper reaches in the alluvial tracts are experiencing rill-erosion which is the early stage of gully formation. To some extent it is a natural process but is accelerated because of the removal of the natural flora, uncontrolled grazing, careless ploughing, and unplanned management of field drainage. Gullies have developed in the alluvium all along the *Sind*, the *Mahuar*, and the *Parron*. The *NALA*-banks are also cut up around Imalia, Bauthara, Badora and Taga.

GEOLOGY:

The main geological formations exposed in the district are the Bundelkhand granites, Gwaliors and alluvium. The sequence of rock formations is shown below in order of increasing antiquity[25]

Sequence of Geological Formation

Recent	Alluvium and Kankar	
	Unconformity	
	Morar Shales	
Purana	Gwalior series	Par Quantzites
	Unconformity	
Archaean	Bundelkhand Granite	Graniotes and granitic genisses with associated schists, pegmative veins, basic dykes and quartz-reefs

Bundelkhand Granite:

The chief characteristics of these granites are their massive structure, obscurely developed foliation and scarcity of accessory minerals. It is a medium-to-coarse-grained rock chiefly consisting of orthoclase quartz and biotite. Pink felspar is more common in the porphyritic granite that crops out in the Sind river.

The bulk of the granite exposed in the southern tract of the district or as inliers in the alluvium, hardly shows pink appearance. The prominent felspars in these rocks are microcline and microcline miscroperthite. Plagioclase is present in subordinate quantity. Quartz rarely occurs in large quantity. A dark coloured hornblend is often present but is never abundant.

Gwalior Series:

The Gwalior rocks were deposited on the irregular denuded surface of the granite. The age of the trap that forms the upper portion of the Gwalior series (in the adjoining district of Gwalior) is 500 million years. They constitute the plateau range north of the Sind river in Seondha tehsil. The dip of the rocks is towards the north and seldom exceeds 75 mm.

The quartzite is intruded by numerous veins of quartz. Near Lagadhu a small quartz-galena load occupies a fracture in the intercalated quartzite and shale at the base of the Parquartzite. Near Ucher, there are two outcrops of red ferruginous quartzite which stand out from the alluvium.

Morar shales are represented by thin flaggy siliceous or ferruginous shales copiously interblended with chert, both finely bedded and concretionary. Though foldings are quite common and the exposures, as a whole, exhibit a slight roll, at Gayara and Diroli, white clay underlies the shale. Bands of red ochre in the shales are noticed at many places between Gumanpura to the east and Lokendrapur to the West.

Alluvium and Kankar :

Nearly three-fourth of the area of the district are covered by alluvium. Along the Sind river section the thickness of the alluvium often exceeds 15 m. The Nallahs and ravines are often thickly covered with *Kankar* (calcareous concretions), a material used locally for lime-burning.

THE SOILS:

The soils if Datia are all the representative soils of Bundelkhand i.e. the *Mar, Kabar, Parua, Rankar* and also *Kachhar* at various places.

The Mar: This soil is very fertile, and black coloured with fine mixture of small calcareous stones and sheel. It has a good water-rentention capacity. The soil causes fissuresduring summer season. *Mar* is usually found in pockets where the intrusive dykes of Trap have disintegrated. Going to a depth of 0.3 to 0.6 metres from the surface it needs little manure and yields crops without artificial irrigation.

The Kabar : This is also black-coloured soil and is lighter than *Mar*. It is more stiff in character and does not possess calcereous stones or shells. The soil cracks during summer and does not need artificial irrigation normally during cultivation.

The Parua: This is brown or yellowish in appearance and is less fertile than the above two types.

The Rakar: An inferior soil found in hilly region, consists mostly of stones, with less soil and goes only to a depth of 0.15 m to 0.30 m from the surface.

The Kachhar: This soil is normally found in the vicinity of villages, along the banks of the rivers or streams and the bed of tanks. This is the most fertile soil with fine texture.

In Datia district USAR soils are also found in some tracts.

B. DRAINAGE AND WATER-RESOURCES :

The main body of the district is drained by two important rivers, viz; *Sind* and *Pahuj*. The overall slope of the district is like other Bundelkhand districts, towards north-east, which forms the water parting line and is guided by the flow of *sind* river. The character of other streams is seasonal.

THE RIVERS;

The two principal rivers, Sind and Pahuj are described below:

1. The Sind: Rising from Vidisha district of M.P., it touches this district near 25°40'-78°17', and forms the western boundary twice, to the north and south of village Baraun Kalan. It flows due north-east and crosses the district in the extreme north and forms the north-eastern boundary beyond Seondha.

Mahuar is the only important tributary which flows in the western part of Datia tehsil and joins the *Sind* within the district at its right bank. *Vaisali* joins it at its left bank before *Sind* meets river Yamuna. The total length of this river in the district is 106 km.

2. The Pahuj: Rising near Jhansi-Sheopuri border, this river flows north-east past Jhansi and Bhander towns. On the south-east it enters Datia distt., near Unnao for nearly 2 km and again on its western bend it touches the district boundary for about 1.6 km to flow north-east to join *Sind* river. The important streams joining it on its left bank from Datia district are the *Angoori, Marwaya, Setol, Parron, Oon, and Somain.*

3. The Betwa: is the major river of this region but it does not touch the main body of the district. It touches the enclaves Mudra and Basai only for about 9.7 km.

THE TANKS :

Datia, like other districts, has also been known as the home of ancient tanks. Several tanks were excavated during *Bundela* Kingship. The table A gives some information about these tanks.[25]

THE BAVDIS;

In Datia there has been a tradition of constructing *Bavdis* which served the purpose of drinking water for the travellers or for bathing of the women-folk within the town as these were protected from the outside.

TABLE A

S.no.	Tank(year)	Nature	Area(ha)	Depth(m)
1	Ram Sagar (1720)	perennial	167.6	8.1
2	Karan Sagar (1680)	-do-	14 6	5 0
3.	Lala Ka Tal (1715)	-do-	14 7	5 4
4.	Makrai	-do-	9.4	2 4
5.	Badoni Khurd	-do-	13.4	2 7
6	Banda no 5	-do-	40 5	3 0
7.	Bardhab	seasonal	2 4	-
8.	Basai	-do-	2 4	-
9.	Siral	-do-	6 5	-
10.	Kamar	-do-	1.6	-
11	Dhuisera	-do-	1 6	-
12	Chergara	-do-	0 8	-
13	Pachora	-do-	4 0	-
14.	Radha Sagar	-do-	2 0	-
15	Laxman Tal	-do-	1 6	-
16.	Taran Taran (1600)	-do-	1 2	-
17	Sita Sagar (1736)	-do-	3.6	-
18.	Sena Bal	-do-	0 8	-
19	Ashar	-do-	2.4	-
20.	Naya Taal	-do-	8 1	-
21.	Parasari	-do-	6.1	-
22.	Sunar	-do-	2.0	-

Note: the depths of the seasonal tanks vary each year,

Such Bavdies under reference are:

1. Siraul ki Bavdi:

2. Chandeva ki Bavdi: Built by Raja Bir Singh Deo (first) around 1618 A.D.

3. Rani ki Bavdi: Built by Raja Parichhat in the year 1810 AD.

4. Sirsa ki Bavdi: This was built by a Lakha Banzara sometime during 13th Century AD.,

Raja Bir Singh Deo also built the BIR-SAGAR at Agora[26].

Lakha Banzaras were well-known for the construction of the tanks, and big masonry wells in many parts of India including Rajasthan, Chhatisgarh and Bundelkhand etc.[27].

B.1 THE DRINKING WATER SITUATION :

District Datia is essentially a tradition-bound society which believed in self-reliance. Thus masonry wells formed the major resource of drinking water from antiquity.

The urban Drinking water Supply in Datia and other towns like Seondha and Indergarh have been arranged by tapping nearby tanks, masonry wells and wherever possible, through tubewells. Some available information is given below.

DATIA TOWN :

The water supply is being managed by the Nagar Panchayat (Municipality) taking main supply of water from Ramsagar tank. This arrangement started in 1966. The water of the wells within the town being brackish, are not suited for water-supply. Some of the wells located outside the town have sweet water and these have been used for drinking purpose.

With the expansion of the town, this source proved inadequate. Therefore, new schemes have been chalked out for enhancing the supply by constructing a stop-dam at Murera with useful capacity of water ca. 1 M.l.d. This was made to associate with a gravel-packed deep tubewell to contribute available water to the pool being used for supply to the town.

The Rural Drinking Water Supply : Information provided by the Deptt. of Public Health Engineering, Datia during 1995-96 outlines the arrangement being made to provide drinking water for some problem villages. These are as follows:

a. 1,545 Handpumps in 355 villages have been installed.

b. 89 Hand-pumps in 89 villages were under process of installation. (in 1996).

All 402 villages of Datia have been provided at least one hand-pump each which have to be maintained by the Gram-Panchayats; with a provision of Rs. 500/- per hand-pump per annum. The cost of one hand-pump bored to a depth of 60-75 metres here costs nearly Rs. 40,000/.

c. Piped Water Supply to the villages: 32 schemes of piped water supply to villages have been completed till 1992. There are some more in the process, each of them costing ca. one to five lakh rupees to benefit the 33 villages.

B.2 IRRIGATION SITUATION IN THE DISTRICT:

The major source of irrigation in this district have been the masonry wells. Later the available tanks were also put to use for irrigation. Numerous tanks built by the local kings were of such a nature that in the post-rainy season, the available beds could be used for cultivation. These are Ram Sagar, Agora, Badoni, Bhadewara, Makrari, Dhursera, Parasari, Raja ka Taal, Lalaua, Rawatpura, Unnav, Gyarahgarhi, Gyarah Naya, Magrol, Silori, Thakurpura, Pipra and Jigania. Together, the above tanks are supposed to irrigate 2,634 ha land. A few more tanks have already been listed.

THE DAMS:

The Matatila Dam did help in expanding the irrigation potential here. The Bhander canal (131 km long) of Matalia system irrigates ca. 9,580 ha land of 105 villages in Datia district. The Betwa water travels a very long distance before it reaches this part of Datia to irrigate the dry tract.

Another ambitious plan is under way to tap the Rajghat Dam on *Betwa* in Lalitpur district for irrigation purpose. The Rajghat Scheme is supposed to provide 7,56,000 cubic metre water to M.P. which will benefit Guna, Shivpuri, and Basai enclave of Datia nearing almost 3,442.5 ha. The 2nd phase of Rajghat project is going to help Datia most. A canal has been dug from the left bank of Dhkuwan reservoir which will feed water to Anguri river. A barrage is being constructed on Anguri and Bhatan Nala near Chirula village which is planned to generate 6.5 mega watt electricity too to assist the power situation of the province, in addition to the irrigation of this area.

Some salient features of the benefit from the Rajghat Project to district Datia are outlined below.

S no	Canal system benefited villages	Length of main canal (km) proposed irrigated area (ha)		
1	Left Bank canal	92 70	14	3,393.81
2	Datia canal	32.75	143	50,388 79
3.	Bhander-Lahar canal	81 03	103	24,593 21

Source. *Rajghat-Pariyojana* - Dr. Alok Chaurasia, *DATIA: Udhbava Aur Vikas*- Late Shri Shyam Sunder Shyam Smriti Granth (1986)

SOURCE WISE IRRIGATION ACCOUNT

The following table gives the irrigated area by different means of irrigation in the year 1993-94:

S.no	Irrigation source	Number	Irrigated area (ha)
1.	Govt canal	02	16,002
2	Tubewells	46	213
3	Wells	14,925	36,986
4	Tanks	2	-
5	Others	-	865

The above figure corroborates that the wells are still important sources of irrigation, *while the absence of tanks during this year is an unexpected and shocking finding.*

Upto 1993-94 the diesel pumpsets and the electrically operated pumps were recorded to be 3,429 and 7,650 respectively.

C. VEGETATION:

THE FORESTS:

The reference regarding forests given here date back to two decades; a lot of change has taken place during this period . This account gives at least information which could be compared to the present state.

The forest area which was almost 30% of the total area of the district in 1901 reduced to only 7% during 1950-51. Thereafter, it showed a little increase but gradually decreased since then.

The forests of this district were classified under two main heads:

1. Group 5-Tropical Dry Deciduous Forest: subdivision 5El-*Kardhai Forests.*
2. Group 6B-Northern Tropical Thorn Forests-subdivision C2 *Ravine Thorn Forests.*

1. Kardhai Forests: Kardhai has been gregarious and formed pure patches in these forests. If the species is protected, it grows dense. The density in better stocked areas varied from 0.5 to 1.0 and has been highest in flat areas with deeper soil. It used to be less in hillocks. If the forests are not properly protected against grazing, the *kardhai* spreads on the ground like creepers. *Kardhai* tends to regenerate in even aged masses after several years of scanty rainfall and in a condition well protected from browsing and grazing.

Associated trees in *Kardhsai* Forests are:

Trees: *Seja, Khair, palash, reunjha and ashta. Occasionally with ghont and ber and rarely with bel, tendu, chirol, kullu, salai, dudhi, kaim, kala siris, dhaora, mahua, kasai, arjun and bahera. Others are rare.*

Small trees: *hingot and kakai with velati, medhsing, datranga, sehind* and at some places manphal.

In addition to the above, several kinds of shrubs, bushes, and climbers as found elsewhere in similar forests are met here.

2. Ravine Thorn Forests: Due to the formation of large number of gullies and ravines and the presence of *kankar* pan layers in the soil along the banks of the rivers *Sind, Mahuar* and the *Parron,* the associated forest blocks in the region have been dominated by the xerophytic trees and shrubs,. The associated trees and other vegetation with this type are given below.

The common species are *chenkur, reunjha, babul, and khair. Chiro* is occasionally met while *karanj* is rare.

Among the small trees, *hingot, velati,* and *pilur* are common while *aal* is rare. *Karil* is the commonest shrub while *Adusa, Aak, Ulatkanta,* and *Trawar* are common. *Panwar, Inni* and others are rare. *Nagbel* is the most seen climber. *Gunja, Keywanch* and *Makoy* are less common.

Kush has been the most prevalent grass.

AGRICULTURE:

The two recognised growing seasons of KHARIF and RABI are known locally as SIYARI and UNHARI respectively.

KHARIF: The crops in the district have been Jowar, Bajra, Paddy, Urad, Moong Arhar (Tur), Kodon, Kutki, Til, Maize, Cotton, and Patsan. The present crops, of course, of Kodon, Kutki and even Til are not of significance. Instead, Soyabean has been popularised more than others.

RABI:

The main crops under this group are Wheat, Gram, Barley, Masoor (lentil), Linseed and Mustard.

Area under main crops and their production:

Following is the information received for 1993-94, regarding the crop-wise area and its production in Datia district:

S.no	Crops	Area Covered ha	Production kg/ha
KHARIF			
1	Paddy	340	629
2	Jowar	5,824	867
3	Maize	718	1,189
4.	Arhar	4,471	
5	Urad	2,961	na
6	Soyabean	1,193	1,065
7.	Til	2,660	339
8	Groundnut	3,141	972
RABI			
1	Wheat	51,169	2,471
2.	Gram	34,722	1,126

source· Distt Statistics Handbook Distt. Datia 1994

D. Climatic Indicators and Hydrometeorology

The climate of this district is generally dry, Monsoon brings humidity and the average rainfall is 760.4 mm. There are three distinct seasons:

1. **The Summer Season** Starts from or about the festival of Holi around late March but the temperature rises to its peak during May and June.

2. **The Rainy Season** The Monsoon sets in by the third week of June. July and August experience good downpour.

3. **The Winter Season** Which starts from October and the temperature gradually falls thereafter. January is generally the coldest month.,

Temperature :

There is no observatory in the district. The situation of this district is broadly the same as in the neighbouring districts. From about the end of February the temperature increases rapidly. May is the hottest month with the mean daily maximum temperature at about 42°C, and the mean daily minimum at about 28°C. On some days the day temperature may go above 47°C. The heat is intense and hot dusty winds blow to the discomfort of the people.

Afternoon thunderstorms which occur on some days bring welcome relief though temporarily. With the rains in June, the temperature drops appreciably. After September, there is slight increase in day temperature, but the nights become progressively cooler.

After October the temperature decreases, January registering the lowest. With the western disturbances, the minimum temperature drops rapidly to near freezing point and slight frost may occur.

Rainfall:

Records of rainfall in the district are available from three stations, Datia, Seondha,& Indragarh for periods ranging from 18 to 70 years. The following table gives average monthly rainfall for the district and also the extreme rainfalls and its year.

Month	Rainfall (mm)	Rainy days*
January	10.0	0.9
February	9.8	0.8
March	6.3	0.6
April	6.2	0.4
May	7.2	0.6
June	60.2	3.3
July	252.9	11.0
August	248.2	10.7
September	135.2	5.6
October	15.0	0 7
November	6.7	0 4
December	4.7	0.3
* days with minimum rainfall 2.5 mm.		
Average annual Rainfall	:	760.4 mm
Rain-days(annual average)	:	35.3 days
Maximum Rainfall	:	167% (1917)
Minimum Rainfall	:	37% (1905)

The Winds: Winds are generally light which become stronger in force during summer and monsoon seasons. Winds are generally from west or South-West during the South-west monsoon season. In the post-monsoon and cold seasons winds are generally light and variable in direction, with the predominant direction being south-west in the morning and between north-west and north-east in the afternoon. In summer winds are from directions between south-west and north-west.

Humidity:

Humidity is generally high during the south-west monsoon season, and decreases after the withdrawal of the monsoon. The driest part of the year is the summer season, when in the afternoons the relative humidities are less than 20%.

Cloudiness:

During the south west monsoon season skies are moderately to heavily clouded. In the rest of the year the skies are generally clear or lightly clouded except for some days affected by the Western disturbance.

Special Weather Phenomena:

Depressions originating in the Bay of Bengal during the monsoon season which move across the central part of the country reach the neighbourhood of the district and cause widespread heavy rain and gusty winds. Dust-storms and dust-raising wind occur during the summer season. Thunder storms occur generally during the period from May to September. Occasional thunderstorms also occur in the cold season in association with the western disturbances[24].

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CHAPTER THREE

PEOPLE'S PERCEPTIONS OF THE PROBLEMS

The previous chapter has given the profiles and salient features of the districts in Bundelkhand region spread over U.P. and M.P. states in central India. Along with the topography, geology, water resources, drainage, vegetation and the climatic indicators of Bundelkhand, the data available from both official and unofficial sources regarding the facilities created for drinking water and irrigation etc. have also been presented.

The main focus of the study has been on understanding the type and extent of water-resources both for drinking and irrigation, the quality of water (based on perception of the people), mechanism of maintennce of these sources, agricultural practices etc. The forest cover, floods and drought situation, water supply through other modes, traditional relevant practices, specific problems of the area, and the Governmental efforts in this direction have also been surveyed.

This chapter would seek to give the people's perceptions about the roots of their water problems; and the measures, they feel, can mitigate or solve these problems. While the previous chapter presented the results of survey of literature from official and non-official sources and the broad finding of our study teams traversing extensively the thirteen districts of Bundelkhand, this chapter would present the results of in-depth surveys of the water situation in villages selected at random and the people's suggestions thereon. The in-depth survey covered 185 villages of Banda district (now bifurcated into Banda and C. Sahuji Maharaj Nagar districts), 132 villages of Hamirpur district and 82 villages of Mahoba district (under Chitrakut division); 179 villages of Jalaun, 274 villages of Jhansi and 22 villages of Lalitpur district (under Jhansi division); 143 villages of Chhatarpur, 28 villages of Damoh , 78 villages of Panna, 43 villages of Sagar and 100 villages of Tikamgarh (under Sagar division); and 41 villages of Datia (the lone Bundelkhandi district under Gwalior division). The villages, as reported earlier, were *selected at random*. The variation in the number of villages taken up for in-depth studies depended partly on the size of the district and partly on the availability of qualified local personnel for the survey.

3.1 General Picture Emerging from the In-depth Surveys

The following tables 3.1 to 3.4 bring into bold relief the problem. Table 3.1 gives information about the drinking water sources, irrigation sources and the situation of forests which have a great influence on both local precipitation and groundwater recharging. Table 3.2 (a) describes the incidence of floods in the districts; Table 3.2 (b) describes the incidence of droughts. The discussions would show that the floods and droughts often alternate in the same areas.

Tables 3.3 and 3.4 belong to a different order. The former deals with the problems encountered by the people and their classification into ecological problems; infrastructural problems and the problems emanating from the ways of functioning of Administration (its attitudes, procedures etc.) The latter deals with people's suggestions, possible solutions as envisaged by them. It has been observed that the rainfall in this region is of the order of 1000 mm which should normally be considered enough. But the precipitation is certainly sporadic, frequently resulting in alter-

Table 3.1 Information regarding Water Situation in Surveyed Villages

(Villages for Survey Selected at Random)

(a) Chitrakut Division

S.no.	Particulars	Districts		
		Banda+C. S. Nagar	**Hamirpur**	**Mahoba**
1.	Villages surveyd	185	132	82
2.	Approx. Population Covered *	2,89,989	2,24,415	90,656
3.	**Drinking Water Sources**			
	(i) Wells (Total):	2,290	2,433	1,066
	Non-functional	63	510	135
	(ii) Tanks	363	208	127
	(iii) Handpumps (Total)	2,506	2,096	792
	Non-functional	54	382	258
4.	**Irrigation Sources :**			
	Wells 499	218	2099	
	Tanks 70	29	10	
	Tubewells	775	2,300	305
5.	**Situation of Forests** Banda while some patches with thin forest can be seen in C.S. Nagar part.	totally depleted in depleted	completely left in patches	thin forest

* The population pertaining to these villages shown here has been taken from the Census 1991.

some of which are of a general nature and some very specific, often both type-wise and location wise.

The discussions in this chapter revolve around these tables.

The observed facts do not normally correspond to official statistics and the people's perception remains different from the official view. During our field study and survey people revealed the facts and expressed their views in relation to the situation of water, its problems, potential and the nating floods and droughts, thus indicating mismanagement of the water which falls as rain in this region.

3.1.1. The Traditional Methods of Resource use:

Bundelkhand as a region, close to nature and away from highly urbanised locations, has always been dependent on the traditional resources for meeting its major drinking water and domestic needs. The masonry wells have undoubtedly been the most appropriate because of their simplicity, long life and low maintenance requirements. The wells had become a part of Bundelkhand culture as these were considered holy places. In tradition, none would speak an untruth or think ill of anybody, while sitting near these wells.

Looking at the villages surveyed, one can clearly see that on an average, 14 drinking water-wells and at least one pond are present in each village. (ref. Table 3.1). Most of these have been people's own creation and except for some villages where the sweet wells are located out of the habitat, these are evenly dispersed within the village to allow people from all sections to draw water without much trouble. Of course, the caste-culture had vitiated the atmosphere in certain villages where the Harijan community-members were not allowed to use the wells at certain locations. But this tendency which had historical roots in the mediaeval age is fast disappearing. Moreover, many wells were constructed later in the Harijan localities which solved the problem to some extent. Feudal atmosphere due to improper education and lack of land reforms coupled with political blackmail have been the major causes of caste-tension in the rural society. This could be removed only by putting more emphasis on social and educational inputs and making people aware of the real political process.

A well-built masonry well on Jhansi-Orai Road

The ancient people of Bundelkhand aided by the then *Chandela*- and *Bundela*-kings tapped many streams and the sloping topography of the region by building embankments on the downstream sides to create big lakes and surface-reservoirs. Each village in almost all the districts of Bundelkhand had developed a culture of creating ponds/tanks to help the inhabitants for meeting their domestic water needs. These ponds/tanks also helped the

Dharam Sagar Tal at Panna

villagers to fight out breaks of fire which could occur anytime here because of dry and hot summers aided by hot winds and the nature of wood dominated house-roofs.

One of the big tanks of Datia town

The drinking water needs used to be met mostly by the masonry wells. Such wells were also the mainstays for irrigating the fields. Large number of masonry wells have been reported from almost all the districts which used to irrigate the garden crops and sugarcanes. Now surgarcane growing for commercial purposes has become rare. The total area irrigated by the wells in all the districts of Bundelkhand had touched roughly 4,00,000 ha. by the end of the 19th century. The old and new tanks also played an important role in expanding the irrigation. Inspite of their major share, these tanks were allowed to decay and disappear.

3.1.2. Neglect of Traditional Resources :

The lakes, ponds, masonry wells and the *bavdi* all have been left uncared. The age old beautiful structures which could be saved and maintained at a cheaper cost, have been allowed to get damaged. At the same time, more expensive yet temporary alternative resources have been sought to be put up. All this has affected the village-poor who depended on the traditional resources. The loss of these resources has also affected people's culture. The communities like *Kahar, Dheemar,* and *Nishad* who used to depend upon the wells, ponds and rivers, respectively, have been forced to become agricultural labourers and/or migrate towards big cities in search of jobs.

An Irrigation well lies neglected today

3.1.3. The Natural Resources:

The Rivers and Streams :

Bundelkhand, also termed as

(b) Jhansi Division				
		Districts		
S.no.	**Particulars**	**Jalaun**	**Jhansi**	**Lalitpur**
1.	Villages surveyd	179	274	022
2.	Approx. Population Covered *	1,87,518	3,14,736	20,855
3.	**Drinking Water Sources :**			
(i)	Wells (total):	1,625	5,150	190
	Non Functional :	276	246	10
(ii)	Tanks :	313	145	18
(iii)	Handpumps (Total):	2,437	2,792	192
	Non-Functional :	252	372	-
4.	**Irrigation Source:**			
	Wells	06	637	200
	Tanks	-	06	-
	Tubewells	1,049	59	-
	Bandhi	-	59	-
	Checkdam	-	-	18
	Artesian Wells	30	-	-
5.	**Situation of the Forests:**	fully depleted	Very thin cover in a small patch left	Southern Lalitpur has some forests, the rest is depleted
* The population pertaining to these villages shown here has been taken from the Census 1991				

Dasharna Pradesh, was full of the rivers, streams, springs and water- falls with plentiful natural water flowing across this part of the country. Major perennial rivers like *Chambal, Sind, Pahuj, Betwa, Dhasan, Ken, Baghein, Paisuni* and *Tons* and their numerous tributaries along with countless seasonal streams, all of them finally ending as tributaries to the river Yamuna, exhibited this tract to be abundant in water. Sufficient moisture was retained by the soils to generate dense forests.

However, the depletion of the forest during the past hundred years has changed the whole scenario. Consequently, many streams have reduced to seasonal, flood-prone, and soil-eroding drains creating problems during the rains while drying up totally during non-rainy seasons. Even the major rivers face scarcity of water during non-rainy months. In many rivers now-a-days water can be found only in scattered pools.

The Artesian Flows

The artesian flows, found at many places in Bundelkhand, are of two kinds. Both flow under natural pressure. One is the surge of water upwards from rockbeds under the force of ground water flows. The other is oozing of millions of droplets from sideways from the river banks under hydrostatic pressure. The former are called artesian wells, the latter *jhirna* in layman's language.

(c) Sagar Division						
		Districts				
S.no.	Particulars	Chhatarpur	Damoh	Panna	Sagar	Tikamgarh
1.	Villages surveyed:	143	28	78	43	100
2.	Approx. Population Covered *	1,21,687	17,964	75,745	33,853	96,671
3.	**Drinking Water Sources:**					
(i)	Wells: (Total)	2,156	292	1,282	540	1,336
	Non-Functional.	243	51	88	156	211
(ii)	Tanks:	37	20	82	04	34
(iii)	Handpumps (Total)	1,575	106	430	141	343
	Non-Functional:	914	48	73	47	13
4.	**Irrigation Sources:**					
	Wells:	447	60	45	380	1838
	Tanks	02	09	142	01	23
	Tubewells:	29	01	-	75	24
5	**Situation of Forests:**	southern part has a thin patch, the rest depleted	almost depleted thin cover	some patches left with	some patches left	almost depleted

* The population shown here is the total of the population figures pertaining to these villages as given in Census 1991

(d) Gwalior Division		
S.no.	Particulars	DATIA Distt.
1.	Villages Surveyed :	41
2.	Approx. Population Covered:	52,478
3.	**Drinking Water Sources :**	
(i)	Wells : (Total)	505
	Non-functional	33
(ii)	Tanks :	07
(iii)	Handpumps (Total):	172
	Non Functional:	22
4	**Irrigation Sources:**	
	Wells:	808
	Tanks	-
	Tubewells:	58
5	**Situation of Forests :**	Almost depleted.

*Population shown here pertaining to these villages, is taken from the census 1991.

Artesian well at Salaiya Buzurg village in Jalaun Distirct

The artesian flows - wells and jhirnas - are found in Chitrakut, Jalaun, Datia, Banda, Chhatarpur and Jhansi, in the vicinity of Pahuj, Paisuni (Mandakini), Gadra rivers and the seasonal Bisahil stream. As the legends have it, Paisuni derives its name from the milk like flows in the midstream in the segment of the river where the current is at its slowest.

The flows through artesian wells have mostly been allowed to overflow and drain out. No effort at creation of community-facility has been made to use artesian flows in an organised way, whether for supplying drinking water to village homes or for the purposes of irrigation.

The State of forests :

This region was particularly known for its forests. The epic *Ramayana* depicts this region as being densely forested with perennial streams, rich wild life and picturesque hills. The forests of Panna district were once famous for their fauna; elephants used to be procured from here for *Chandela*-and *Bundela* armies and the imperial Moghul armies of Delhi. Chitrakut, Kalinjar, Vrishaspati Kund, Bandakpur, Deogarh and Jatashankar etc. have been great forest-based pilgrim centres for ages. The forests were rich in multiple varieties of trees which included fruit-bearing, fuelwood-yielding, medicinal, timber-giving and other beneficial trees. The undergrowth in the forests included enormous species of medicinal herbs and plants. Some of these have been listed in the Appendix 'D'.

Beautiful landscape of river Sind on Jhansi-Sheopuri Road

The greatest event of far-reaching consequences in Bundelkhand was the destruction of forests. It changed the climate, the rainfall pattern, the perennial character of the rivers,

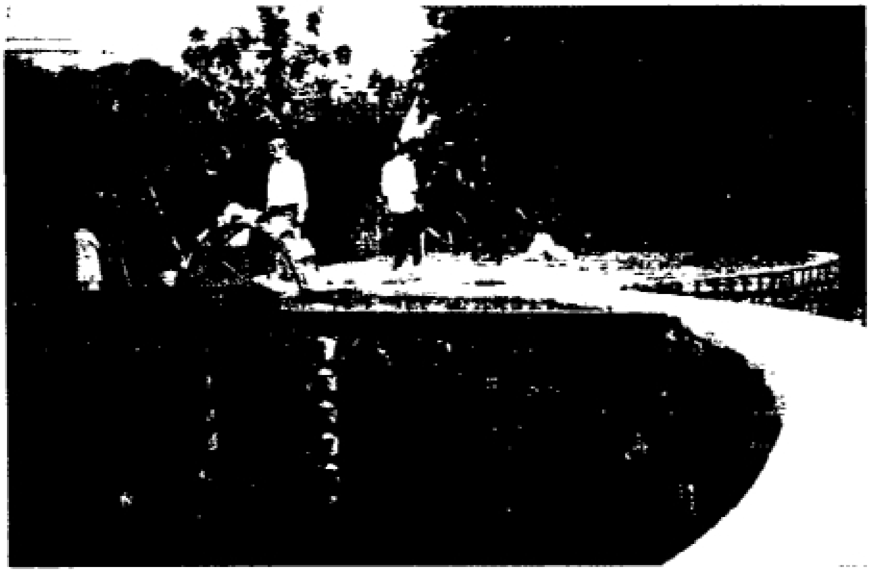
One of the few picturesque water falls on Kilkila River

the groundwater recharge pattern, soil productivity, people's life pattern, social mores and ethos.

It began with the appropriation of forests by the British rulers in the name of "Scientific Management". Their sylviculture was the use of forests for commercial purposes, which paved the way towards the forests' destruction. The Britishers were the one nation which had destroyed the forests in their own country in the name of development of rail road, shipping, steel and other industries. They pursued the same policy with much greater vehemence in India, whose casualty was Bundelkhand, which was perhaps the most densely forested region in this country.

In consequence, the region which was said to be the abode of Lord Rama during his exile (living in the forest) became the most denuded. The hills, whose dense forests were once the sources of numerous cris-crossing rivers, now, in their denuded state, radiate intense heat making people's lives unbearable.

The same exploitative policies towards the forests and other natural resources continued even during the post-independence period. This continued denudation of forests affected the wildlife and deeply hurt the interests of the poor people who were deprived of the benefits of even the minor forest produce. Moreover, it triggered the indiscriminate and uncontrolled exploitatiton of minerals in the once forested areas.



Persian Wheel to lift water

Panna, Lalitpur, Damoh, Mahoba and Banda are presently the scene of such irreversible destruction where mining of diamond, granite, lime-stone and gneisses are causing the worst environmental disruption.

The loss of forest cover gave rise to the flash floods in the

Ravine-formation due to fast flowing rain-water in the rivers

streams; and the rivers eroding the surface soils gave rise to ravines. A report of M.P. Govt. (1979) mentions that 21% of the total ravines of the state are located in just six districts of Bundelkhand region, namely Chhatarpur, Damoh, Datia, Panna, Sagar and Tikamgarh. The soil erosion rate has been increasing every year. The Pahuj, Dhasan, and Ken have been the main ravine-forming rivers. Banda, Jalaun, Hamirpur districts have been the most ravine-affected areas of the state of U.P. beyond Bundelkhand, to its west, lies the Chambal basin which is known as the country's worst ravine - affected area.

The situation as it stands today is extremely precarious. The forests have been thinned to near-extinction and the undergrowth has stopped due to lack of moisture and shade. The destruction of forests is not a very old story. Elderly people over 70 years of age still remember these forests as having been in much better condition just half a century ago.

3.1.4. Agricultural Situation

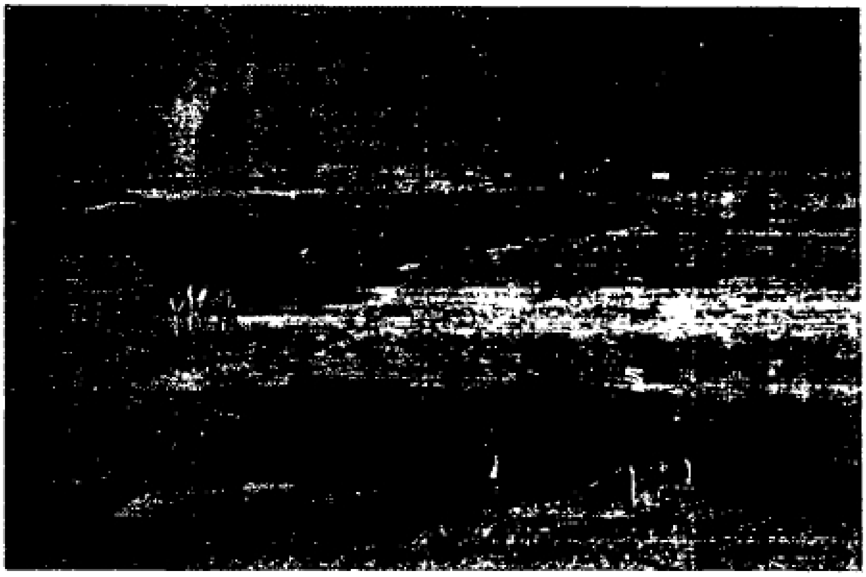
As described earlier this region was all along traditional in farming; artificial irrigation was a new factor initiated during the early years of the present century. The *Mar* and *Kabar* were highly water-retaining and fertile soils, and with them the presence of excess water was known to create problems.

Clearing of the forests brought more land to agriculture. Expansion of canal and tubewell irrigation encouraged the adoption of high-water-demanding crops. In the presence of excess water the cropping pattern in many areas in Bundelkhand has become very inappropriate and ruinous to the soil. The use of chemicals as fertilizers has affected the soils and has yielded harmful and un-anticipated results.

Technology-Intensive Agriculture : The traditional farmers of Bundelkhand are being lured to adopt growing of cash crops using technology intensive, multiple irrigation and hybrid seed-based farming. Soyabean has been largely promoted in these districts, which has replaced many of the coarse cereals, pulses and oil seeds and helped towards growth of soyabean processing industries.

In the name of 'scientific' agriculture, monocropping was promoted and people in many areas turned to the crops of Masoor and Mustard instead of food-grains, coarse or fine. This affected employment of the seasonal agricultural labourers who now felt bound to migrate to Delhi or Punjab. Invasion of Soyabean disturbed the whole food-chain and also the land and water situation. There is hardly any effort to plan agriculture which could suit the soils and help share equitably the available water resources and generate a sustainable farming system.

The dryness in summer season affects the vegetation, as well as the animal-hunbandry of the villages. Mention has been made of ANNA-



Electrical pumps operating day and night on the rivers

tradition in some of these districts under which all the cattle are let free for four summer months i.e. from mid-March to mid-July. This tradition must have been initiated and carried on in the past because of the presence of deep forests associated with water bodies, streams and grass-lands all around, adding definitely to the health of the animals. But in the present cirumstances, this can be attributed only to the lack of resources, grass and water within the village. The cattle are let free to discover by themselves their means of survival. Such a tradition is suicidal these days because the vegetation has become scarce. Now-a-days during the ANNA-period, many of the cattle die or move out and get lost to the distant areas.

Government of Madhya Pradesh has heavily subsidised electrical power for the farmer using upto 5 h .p. motors for pumping water and/or other agricultural operations. This has led to the installation of large numbers of pumping sets on each river-bank lifting out the precious water for wheat-rice crops affecting on the one hand the perennial flows of these streams and on the other the production of coarse cereals and other food-stuffs. Lack of water in rivers and streams during post-monsoon period coupled with hot winds and dust storms create withering of the soils, affecting the micro-organisms and the earthworms.

Lifting of the water and its use in technology intensive agriculture gives profits to a few well-to-do farmers while the loss has to be shared by large numbers of small farmers and people of that region. The masonry wells dry up at much faster rate, the river-water becomes unpotable, thus giving rise to a chronic drinking water scarcity.

Recently there have been growing incidents of suicides being committed by youths of Bundelkhand villages.

3.2 The External Intervention :

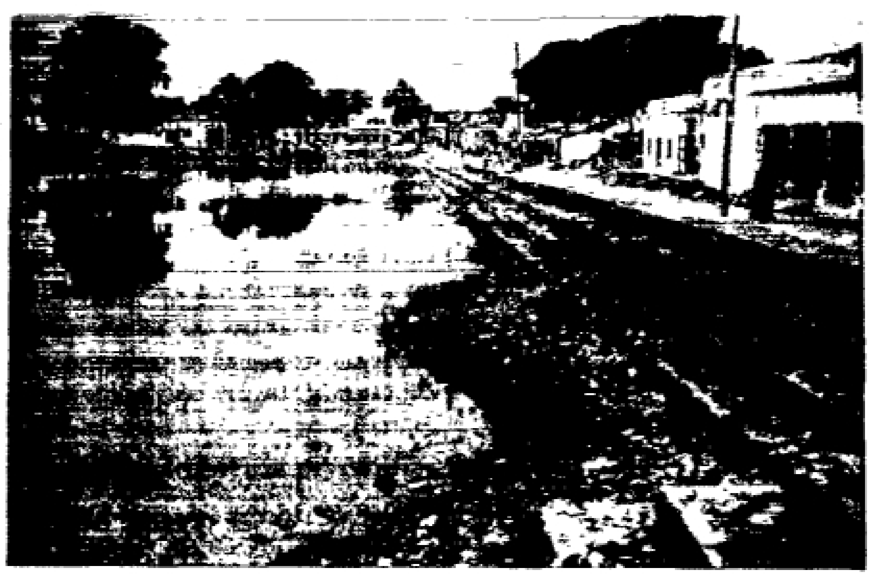
Government's intervention in the form of piped water supply to some villages adjoining towns seemed more oriented to reaching safe drinking water to the townships rather than villages. The villages have been included in the scheme probably for tactical purposes. Installation of high-cost India Mark II pumps on deep-borings helped only the industries and the middlemen. In many areas people complained that the handpumps have been installed at shallower depth than shown on papers. There seems no concern in officials regarding reaching safe water to villagers; otherwise, they would have been taken into confidence and the system of the repair and maintenance of these set-ups kept simpler, decentralised and village based. In M.P. districts the Gram-Panchayats have been made responsible for this work but a meagre amount of Rs. 500/- per annum per handpump without proper training and transfer of the technology involved has little sense.

Hand-pumps have been advertised as the magic solution to the drinking water problem although

Rani KI BAVDI, Datia Town

those who know the extent of ground water depletion through irrigation and industrial use in this region, will confirm that the handpumps in the villages are an ephemeral solution. That too at the cost of the traditional dug wells which if repaired, would have been ready and serviceable in cheaper and easier ways. That would have been a more permanent solution for reaching drinking water to the villages.

BAVDI - culture which helped the travellers or pilgrims and respected the poor by way of making steps in the wells upto the water level was totally abandoned. Instead of managing them well, getting them cleaned and arranged for the fresh inflow of ground or surface water, these *bavdis* were defamed as spreaders of diseases and subsequently either destroyed or allowed to decay. In many places like Datia, Chitrakut, Jalaun, Jhansi beautiful structures of *Bavdis* lie ruined. In some part of Bundelkhand *JAL-MANDIR* (temple tanks) are also seen in the same kind of decayed state.



The urban tank under threat- Konch In Distt Jalaun

Flush Irrigation :

In the traditional farming pattern of Bundelkhand the masonry wells and tanks were the major sources of irrigation helping the farmers grow garden crops, fruits, sugarcane etc. The black cotton soils particularly the *Mar* and *Kabar* were never irrigated upto the last century. Since the depletion of the forests and introduction of canals, both simultaneously during the British rule, artificial irrigation expanded, initially during the first quarter of the present century. The expansion of irrigation continued even after 1947 under various five-year plans. Dams and tanks were built and canals were laid in several districts; some of the old tanks were also renovated for irrigation purposes.

Jamni dam emptied prematurely for fishing (Distt. Lalitpur)

nals. These are ill-maintained and lead to large-scale wastage of the water serving nobody's purpose. But in some areas of Jhansi and Lalitpur, the lakes or dammed reservoirs are purposely emptied to serve the interest of the fish contractors or the influential farmers who cultivate the reservoir bed; the profits are shared by all conspirators involved in this process. Concern for increasing agricultural productivity of the community is absent and the administration/Govt. departments seems to serve only themselves and the powerful.

But overall neglect of the tanks and the ponds continued; and slowly the culture of ponds prevalent in Bundelkhand was overpowered by the commercial culture. In the villages these common resources have been privatised in the name of development of the fisheries. Many tanks were flattened to raise paddy crops or for expansion of the village-*bustee*. In urban areas several posh colonies rose in the catchment area and even on the beds of tanks. Large-scale shopping complexes were raised while the tanks got filled up with filth and drain/sewer disposals. The beautification of the tanks, wherever undertaken, were limited to fixing light-posts, repairing the boundaries and/or sometimes removing the water hyacinth and other weeds. The encroachments on tank-beds or the catchment area were never removed, and the natural fresh input of water to these tanks or lakes was never restored. The present generation has been kept totally unaware of the importance of the tanks, which can further lead to neglect of these rich resources needed for survival.

Dams and Canals:

During our survey and field visits people reported the neglect of upkeep of the dams and the ca-

Strange enough, the districts Lalitpur and Jhansi which have large numbers of dams and lakes respectively, also face lack of drinking water during summers. In other areas the poor drainage and canal-seepage create water-logging situation which spoils the soils, and increases salinity all over affecting even the *pucca* houses. Indiscreet use of canal water and the leaking taps have been wasting enromous water because the concern for conservation of the resources is being miserably lost from the ethics of people's lives.

The general analysis of this situation takes us back to the colonial days during which canals were forced on the people not so much for enhancing productivity as for earning revenue from the water which was earlier free and commonly accessible to farmers through their farmland wells and village-ponds. Major part of the farmlands of Bundelkhand during those days comprised of the black soils like *Mar* and *Kabar* which were not suited for artificial irrigation.

The Tube-wells:

During the past 25-30 years the tendency of exploiting ground water through deep tubewells has increased in Bundelkhand. The indiscriminate borings through various Govt. departments, private companies, and farmers themselves, have led to continuous depletion of ground water. While the forests have been completely denuded and the surface storage in lakes and ponds has reduced, the ground water-recharge is already in danger. In this light, the uncontrolled exploitation of the ground water might lead to a very serious situation, cause subsidence over large areas and other related environmental disturbances.

Handpump installed at the cost of a traditional masonry well (well in the background)

In several districts the ground water departments, have already declared some areas as dark zones. These dark zones are on the increase and may engulf entire Bundelkhand region soon.

Yet, tubewells are the most in demand. The reason is that the real situation of ground water is not known either to people or the politicians; and the departments and agencies which have the information such as the Central Ground Water Board, the State Ground Water Departments and the Remote Sensing Applications Centres guard their data as close secrets. This may aggravate the situation in future and lead to irreversible environmental damage.

Handpumps

Handpumps (India Mk II) presumably on deep borings, have been installed in large numbers in order to meet the need of safe drinking water for the rural as well as the urban population.

Handpumps are yet another example of external intervention planned and executed from above without either bothering about people's choices or ensuring adequate repair and maintenance services. Though the installation of handpumps initially helped in minimizing the water-borne diseases the problems which were faced later were of greater significance. In brief, installation of the handpumps in villages had the following effects:

- This undermined the importance of traditional village-well which had been serving the populace for ages;
- The technology is incomprehensible for the villagers and therefore, when some thing goes wrong, they have to depend upon external agencies such as Jal-Nigam or the Block personnel. These services are neither timely nor satisfactory.
- The socio-cultural aspect of village life turns around the wells: the famous PANGHAT culture has been lost where village women gathered, sang songs and made friends. Instead the hand-pumps or the piped supply which gives single point service has become the source of feuds between people who fight for snatching their turn for filling their buckets. One can see long queue of ladies waiting for water around any tap or hand-pump.
- The handpumps or the piped water supply, being easy in drawal of water, have encour-

aged wastage of resource and created stagnant pools of dirty water in the lanes and bylanes of villages; hence mosquitoes and flies are spreading numerous diseases.

G.C. Nayak's observation regarding the handpumps in Damoh is worth mentioning :

"After the drought of 1985-88 handpumps were installed. There was abundance of water in the first year. Then the water-table went down over the next three years by 15 metre a year on average. All the 5000 wells of Damoh which used to serve as a secondary water supply scheme, became defunct, and the problem of water supply became acute."

(Dying Wisdom, CSE, New Delhi, 1997 p. 167)

Patha Jal-Kal :

The famous Patha Jal-Kal scheme in the south-eastern Banda district (the part recently carved out as Chhatrapati Shahuji Maharaj Nagar district) advertised as the biggest in Asia, inaugurated in 1973 by the then Prime Minister Smt. Indira Gandhi, covers much less area than envisaged. Patha inhabitants are mostly scheduled caste and tribes people who for the lack of alternative resources, have been depending upon tanks, ponds and *Chohnras* (the shallow earthen dug wells excavated by the people at certain points to meet their needs of drinking water and domestic use). But these sources generally dry up during summer season. The water table of the bigger and deeper wells also goes very much down. The handpumps of this area, also exhibit similar situation. More than half of them are damaged, inoperative, or dry; the agency concernd for its repairs and maintenance fails to reach the problem-spot in time, thus aggravating the problem of availability of drinking water in Patha area during summers. People have to walk miles in search of potable water.

In other areas also, there are at least 10% villages which lack any source of water within reasonable distance. During summer season most of the villages face shortage of water, because of drying up of village ponds and streams, thinning of rivers or their limitation within certain pool, depletion of wells due to overexploitation of ground water. Deforestation has resulted in diminishing recharge of ground water.

Piped Water Supply

Piped water supply in few towns and villages have been observed and reported, though this service is hardly satisfactory except in towns where limited supply is maintained at a great cost. This seems to have been forced on the villagers under various schemes of the Government, chalked out without taking village-people into confidence at any stage.

All these external interventions have been planned at great costs while the traditional sources which required much less investment have been allowed to decay or get abandoned. People point to the corrupt tendencies under which only those technologies are promoted which help the industrialists and fetch commission to the concerned officers of the administration and the politicians.

The situation of this region is peculiar because this is split into two political states, U.P. and M.P. The mountains, the forests and the rivers all get politically divided. One can see several dams built by U.P. over rivers whose entire catchment falls in M.P. During construction of the dams, the canal-systems in the command areas were planned for U.P. Districts and their share of water was definitely larger in the beginning. But later, M.P. districts expanded agriculture and demanded irrigation which became the bone of contention between the people of the two states (though having close kith and kin relationship). Instead of sharing the resources equitably, they are placed against one another fighting for their respective rights on political instigation.

3.3. The Calamities:

People of the surveyed villages have given an account of the floods and droughts which occurred during the past twenty five years. Tables 3.2 (a & b) mention the years of floods and the situation of the droughts as reported. One can see that almost every year there is one or the other problem in this area, and people's life remains vulnerable. Floods have been more common in the tail districts of the watershed in U.P., namely Banda, Hamirpur, Jhansi and Jalaun while Chhatarpur and Tikamgarh districts in M.P. have been reported to be more flood-prone.

Table 3.2(a)

The Situation of Flood in the districts (Chitrakut and Jhansi Divisions)

Year	Banda*	Hamirpur	Mahoba	Jalaun	Jhansi	Lalitpur
1971	yes	-	-	-	-	-
1972	Yes	yes	-	-	-	-
1977	-	yes	-	-	yes	-
1978	Yes	yes	yes	yes	-	-
1979	yes	-	-	yes	-	-
1980	yes	yes	yes	yes	-	-
1981	yes	-	-	-	-	-
1982	yes	yes	yes	yes	yes	yes
1983	-	-	-	-	yes	yes
1984	-	-	-	yes	yes	yes
1985	-	-	-	-	-	-
1986	yes	-	-	-	-	-
1987	yes	yes	-	-	-	-
1988	-	yes	-	-	yes	-
1989	yes	-	-	-	-	-
1990	yes	-	-	-	-	yes
1991	yes	-	-	-	yes	-
1992	yes	-	-	-	yes	-
1993	yes	yes	-	-	yes	-
1994	yes	yes	-	yes	-	-
1995	yes	yes	yes	yes	yes	yes
1996-	yes	-	yes	-	-	-

* Banda includes the present C Shahuji M Nagar Distt

The situation of Flood in the districts (Sagar and Gwalior Divisions)

Year	Chhatarpur	Damoh	Panna	Sagar	Tikamgarh	Datia
1971	yes	-	-	-	yes	-
1972	-	-	-	-	yes	-
1973	yes	-	-	-	-	-
1974	yes	-	-	-	yes	-
1975	yes	-	-	-	yes	-
1978	-	-	-	-	-	-
1979	-	-	-	-	yes	-
1980	-	yes	-	-	yes	-
1981	-	yes	-	-	yes	-
1983	yes	-	-	yes	-	-
1984	yes	yes	yes	-	yes	-
1985	yes	yes	-	-	-	-
1986	yes	yes	-	-	yes	-
1989	-	-	yes	-	-	-
1990	yes	-	-	-	yes	-
1991	-	-	yes	-	-	yes
1992	-	-	yes	-	-	yes
1993	-	-	-	-	-	yes
1994	yes	-	-	-	yes	-

Table 3.2(b)

The Drought Situation of the Districts (Chitrakut and Jhansi Divisions)

Year	Banda*	Hamirpur	Mahoba	Jalaun	Jhansi	Lalitpur
1970	yes	-	-	-	yes	yes
1972	-	-	-	-	yes	yes
1977	-	-	-	-	yes	yes
1978	Yes	yes	-	-	yes	-
1979	yes	yes	yes	-	yes	yes
1980	yes	yes	-	yes	yes	yes
1981	-	-	-	yes	yes	-
1982	-	-	-	-	yes	-
1983	-	-	-	-	yes	yes
1984	-	yes	-	-	yes	yes
1985	-	-	yes	-	yes	-
1986	-	yes	-	-	yes	yes
1987	-	yes	-	-	-	-
1988	-	-	-	-	yes	yes
1989	-	-	-	-	yes	-
1990	-	-	-	yes	yes	yes
1991	-	-	-	-	yes	-
1992	-	-	-	-	yes	yes
1993	-	yes	-	yes	yes	yes
1994	-	yes	-	yes	yes	yes

* Banda includes the present C. Shahuji M Nagar Distt

The droughts, as reported by people for the districts of Chhatarpur, Damoh, Panna, Sagar, Tikamgarh and Datia during the survey, occurred every alternate year, Drought has become major problem in these districts especially for the past fifty years.

The years 1978, 1980, 1982, 1984, 1986, 1992 to 1995 have been more problematic from the view point of floods, while the years 1978 to 1980, 1984, 1986, 1990 and 1993-1995 have been marked by droughts when more than four districts of the region were affected by the calamity. The elderly persons are emphatic that such frequency of floods and droughts was not seen during their childhood.

3.4. The Complex of Problems Encountered:

The problems encountered by the villagers have been presented in the table 3.3 (a & b) under following four heads:

1. Problems related to Drinking Water,
2. Ecological Problems,
3. Infrastructural Problems
4. Administrative Problems.

From the aforesaid table, it appears that general scarcity of water, irregular power supply and high cost of diesel, insufficient rains, lack of adequate number of wells and ponds and their problem of drying up during summer months, ground-water table going further down, depletion of the forests, wastages of water, and leakage from the dam-connected canals and reservoirs etc. have been the most felt problems by people of all the districts. In addition, non-functional handpumps have been reported from everywhere.

Drinking water becomes the real problem during summers because of the drying up of the wells, inoperable handpumps, and pollution of ponds/tanks and rivers. Irrigation for common people is inadequate and costly. The bigger farmers put deep tubewells and also influence the Govt appointed tubewell operators to secure timely services.

The problems both related to drinking water and irrigation are most felt by the scheduled caste communities and the tribals. While the villages are suffering from feudal atmoshpere under which all the resources are controlled by influential persons, the concerned administrative officials of the Government do not bother about the real problems faced by poor and only pay lip service to them.

3.5. People's Suggestions:

Those who face the problems are the best judges and the most competent for suggesting solutions. Each villager whom we met had one solution for the problem he/she faced. Of course, it was not expected that the individuals would suggest comprehensive solutions. They suggest what they considered feasible.

The suggestion from the field interviews have been categorized under three main heads :

1. related to improvement/modification of the traditional sources,
2. suggestions about new construction/projects,
3. demands from the Government/departments concerned

The detailed *general* suggestions under each category ; the *specific* suggestions for the district are listed in table 3.4 (a) and (b).

Table 3.3 (a) :

People's Perception of the Problems (Chitrakut and Jhansi Division)

S.No.	Problems encountered	Banda*	Hamirpur	Mahoba	Jalaun	Jhansi	Lalitpur
	Related to Drinking water						
1.	General Scarcity of drinking water	yes	yes	yes	yes	yes	yes
2	Scarcity of water even in post-monsoon periods	yes	yes	-	-	yes	yes
3	Water of Handpumps/ wells, unpotable/brackish	yes	yes	-	yes	yes	-
4	Ground water table at very low level	yes	yes	yes	yes	-	-
5	Potable water at long distance	yes	yes	-	-	yes	-
6.	Water scracity for cattle	yes	-	yes	-	yes	-
	Infra-structural Problems						
1	Irregular power supply/ lack of electricity/ costly diesels	yes	yes	yes	yes	yes	yes
2.	Insufficient number of wells	yes	yes	yes	yes	yes	-
3	Storage capacity of ponds getting reduced	yes	yes	-	-	yes	-
4	Insufficient number of tubewells	yes	yes	yes	yes	-	-
5.	Handpumps are insufficient	yes	yes	-	yes	-	-
6.	Non-Functional/brackish Hand-pumps	yes	yes	yes	-	yes	
7	Wells are far off	yes	-	yes	-	-	-
8	Trunk Canals not supplying water in time and creating unwanted effects	yes	yes	-	-	-	-
9	Damaged Bunds/Dams not repaired	-	-	yes	yes	yes	-
	Ecological Problems						
1	Lessening of Rain as compared to early periods of the Century	yes	yes	yes	yes	yes	yes
2	Unseasonability of rain	yes	-	-	-	-	-
3.	Wells/Ponds dry up during summers	yes	yes	yes	yes	yes	yes
4.	Soil erosion	yes	yes	yes	yes	yes	-
5	Ground water table going further down/wells drying	yes	yes	yes	yes	yes	yes
6	Depletion of Forest	yes	yes	yes	yes	yes	yes
7	Polluted water bodies	yes	yes	yes	yes	yes	-
8	General Wastage of water	yes	yes	yes	yes	yes	yes
9.	Seepage loss in Canals/ dams	yes	yes	yes	yes	yes	yes
10	Granite surface does not allow water penetration to aquifers	yes	-	-	-	yes	-

	Administrative Problems						
1	Dammed Reservoir water is not released in time ·	yes	yes	-	-	-	-
2	Canals are not periodically cleaned and repaired :	yes	yes	yes	yes	yes	-
3	Inadequate Irrigation in non-*Mar*, non-*Kabar* soils	yes	yes	yes	yes	yes	-
4.	Irrigation Deptt. is not People-friendly ·	yes	yes	yes	yes	-	-
5.	Govt appointed irrigation Tubewell operators are careless	yes	yes	-	-	-	-
6.	Dam water is released untimely :	yes	-	-	yes	yes	yes
7	Handpumps non-functional	yes	-	-	yes	yes	yes
8	Irregularity of piped drinking water supply where the facility is provided	yes	yes	-	-	-	-

* Banda includes the new district of C. Shahuji Maharaj Nagar

Table 3.3 (b)
People's perception of the problems (Sagar and Gwalior Divisions)

S.no.	Problems encountered	Chattarpur	Damoh	Panna	Sagar	Tikamgarh	Datia
	Related to Drinking Water						
1.	General Scarcity of drinking water	yes	yes	yes	yes	yes	yes
2	Post Monsoon Scarcity	yes	yes	yes	yes	yes	yes
3	Water of Handpumps/wells unpotable/brackish	-	-	yes	-	-	-
4	Ground water table at very low level	yes	yes	yes	yes	yes	yes
5.	Potable water at long distance :	-	yes	yes	-	yes	-
6	Water scarcity for cattle	-	-	yes	-	yes	=
	Infrastructural Problems						
1.	Irregular power supply/ lack of electricity/costly diesels	-	-	yes	yes	-	-
2	Insufficient number of wells	yes	yes	yes	yes	yes	yes
3.	Storage capacity of ponds getting reduced	yes	yes	yes	yes	yes	
4.	Insufficient number of tubewells	yes	yes	yes	yes	yes	yes
5	Handpumps are insufficient	yes	yes	yes	yes	yes	yes
6.	Non-Functional/brackish water-yielding Hand-pumps.	-	-	yes	-	yes	-
7	Wells are far off	-	-	yes	-	-	-
8	Canals not functioning well	-	-	-	-	-	-
9	Damaged Bunds/dams not repaired	-	-	yes	yes	yes	-
10	Insufficient canals/dams	yes	yes	yes	yes	yes	yes

	Ecological Problems						
1	Insufficient Rains	yes	yes	yes	yes	yes	yes
2	Waterlogging	-	-	-	-	-	-
3	Wells/Ponds dry up during summers	-	yes	yes	-	yes	yes
4	Soil Erosion/loss of fertility	-	yes	yes	-	yes	yes
5	Ground water table going further down/wells drying	yes	yes	yes	yes	yes	yes
6	Depletion of Forest	yes	yes	yes	yes	yes	yes
7	Polluted water bodies	yes	yes	yes	yes	yes	yes
8.	General Wastage of water	yes	yes	yes	yes	yes	yes
9	Seepage loss in Canals/ dams	yes	-	-	-	yes	yes
10.	Granite surface does not allow water penetration :	yes	-	-	-	yes	-
	Administrative Problems						
1.	Canal-water is not released in time.	-	-	-	-	-	-
2.	Canals are not periodically cleaned and repaired.	-	-	-	-	-	-
3	Inadequate Irrigation	yes	yes	yes	yes	yes	yes
4.	Irrigation Deptt is not People-friendly	-	-	-	-	-	-
5.	Govt appointed irrigation Tubewell-operators are careless.	yes	yes	-	-	-	-
6.	Dam-water is released untimely	-	-	-	-	-	-
7	Handpumps non-functional	yes	yes	yes	yes	yes	yes
8.	Irregularity of Piped Drinking water supply, where the facility is provided	yes	yes	yes	yes	yes	yes

Table 3.4

a) General Suggestions :

s.no.	Improvement of traditional sources	New constructions	Demands from Govt.
1.	Deepening of the wells	More deep hand-pumps to be installed	adequate and timely supply in the canals
2.	Ponds to be cleaned and deepened	New ponds be excavated	More tube-wells to be installed
3.	Streams should be cleaned and broadened	Embankments on the fields be made	The canal-water be reached upto the tail.
4.	The *Chohnras* be cleaned and repaired	Checkdams be made.	Electric supply be regularised.
5.	The wells should be bored and blasted if needed.	Lift pumps be energised and renovated.	The broken dams be repaired.

s.no.	Improvement of traditional sources	New constructions	Demands from Govt.
6.	The banks of the tanks/ ponds	The undulating land be be strengthened.	The canal-supply to be levelled activated during summers.
7.	Traditional seeds be raised and organic-farming promoted.	The slopy fields be contour-bunded	Villagers be trained for handpump repairs.
8	The tanks be filled by tubewells during summers.	The canals be equipped with good channels.	
9.	Natural resources be conserved.	Intensive afforestation be taken up.	
10.	Handpumps be regularly serviced periodically.	The breached checkdams be repaired	The canals under construction be completed soon.
11.	Leaking pipeline be repaired or changed.	Artesian-wells be excavated and managed	Soil-testing facilities be made available.
12.	Small ponds be broadened.	Mangal-turbine be installed on shallow rivers.	The canal-channels be cleaned and lined.
13.	*Bavdies* be repaired and constructed.	New public wells be constructed.	To avoid wastage of water the tanks/ponds should not be leased out
14.	The lakes be cleaned and desilted.	Stop-dam be fitted with shutters	Piped-water supply be fitted with overhead tanks.
15.	Bamboo plantation is needed for checking erosion.		Afforestation and grass land development are needed.

b. Specific Suggestions, District wise :

S.no.	District	Suggestion
1.	Banda (C Shahuji M. Nagar included)	1. Check-dam be constructed on Chakra Nala. 2. Mirgadon and Sarbhanga-dams be constructed and canals be taken out. 3. Stop-dam at appropriate places. 4. Stop-dam on Karka-Padariya Nala be built. 5. Check dam on Usrah Nala. 6. Lift pumps on Yamuna at Mau, and Shivpur. 7. PATHA-drinking water scheme be set right. 8. The height of the Kihunia-embankment be raised. 9. Checkdam on Pahari Nala near Datiha.

		10. Checkdam on Pipariha Nala near Markandeya Ashram. 11. Earthen dams be made at Doda society. 12. Dams on Pinjara Nala, Karahi-dhar and Paparchua. 13. Checkdam on Chandana river. 14. New reservoir near Bagraha village. 15. Lift pump and canal on Bagein at Darsenda. 16. Lift pump canal on Paisuni river. 17. Lift pump-canal on Bardaha river. 18. Tubewell installation on the basis of Geological survey of India-survey-reports. 19. Checkdam at Khaddi Nala. 20. Checkdam at Gadara river. 21. Masauni pump canal be completed. 22. Pahadia Nala or Agona Nala be stop-dammed.
2.	Hamirpur	1. Dams at Kamhariya and Patanpur could be saved from damage by timely release of the water. 2. The drinking water to Kapsa village could be met by taking out connection from Bhuragarh Scheme. 3. Lift pump on Dhasan river. 4. Dam near Lahchura be built. 5. Lift Pump on Betwa river, Canal to Mamna village. 6. Maudaha dam be completed soon.
3.	Mahoba	1. Two checkdams on Badaiya Nala. 2. Checkdam on Nuna Nala.
4.	Jhansi	1. Irrigation to be arrangead from Athodana dam. 2. Raksha-Sijwaha Drinking Water scheme be taken up. 3. Putanya and Khapdaila dam should be enlarged. 4. Lift irrigation from Parichha system. 5. Canals to be taken out from Patrai dam. 6. Checkdam on duderi river. 7. Mangal Turbine on the Dhasan river.
5.	Lalitpur	1. Mathra pump canal be expedited. 2. Kharaila embankment be set right. 3. Checkdam on Sajnam river. 4. More canals from Jamni Dam.
6.	Chhatarpur	1. Stop-dam on Gunda Nala. 2. Panchamnagar dam be built. 3. Sunwaha Tubewell-pipe scheme be taken up. 4. Stopdam near Badgar. 5. Dam on Sakra Nala be built. 6. Bhadkua Dam be built. 7. Small lift schemes on dhasan river. 8. Urmil Dam should be made operative. 9. Lift Canal from rangawa Dam. 10. Canals be taken out from Beniganj Dam. 11. Canals be taken out from Budha dam after deepening it.

7.	Damoh	1. Irrigation be arranged from Raiyatvari. 2. Chirain Chonch water should be brought through pipelines. 3. Irrigation from Dhangaur Tank. 4. Karaunja scheme near Mada be expedited. 5. Dam on Vyarma river at Kaniaghat, to augment, the drinking water of Damoh town. 6. Stopdam near Rohani. 7. Lift irrigation on Bhadar and Dhungi rivers.
8.	Panna	1. Lift pump on Aloni river. 2. Lift canal from Rujh river. 3. Lift pump canal from Ken river.
9.	Sagar	1. Tinsimar Dam scheme be expedited. 2. Dam could be built between Toriya hillocks. 3. Dam on Sonar river. 4. Dam on Gurar-Dahar river. 5. Dam on Kaith river. 6. Stop-dam across Rosra Nala.
10.	Tikamgarh	1. Stop-dam across Sharda Nala. 2. Dam across Barwa Nala.

In the above statements, the dams demanded by the people refer mostly to the weirs and check dams, all of which are, in popular parlance, called "dams". This should not obscure the fact that wherever big across-the-river dams have been built impounding large volumes of water, causing water logging and salinity in certain areas and drastically reducing the downstream flows, the people have been highly critical of such dams.

CHAPTER FOUR

KEY FACTORS IN THE REGION'S GEOGRPAHY AND SOCIO-POLITICO-ECONOMIC REALITY

During the survey and field studies and scanning of all available literature, a huge amount of data have been obtained basin-wise, district-wise. Massive data can sometimes be a disadvantage if these tend to divert attention from the crucial aspects which should be the focus of attention.

Hence, in this penultimate chapter, we are giving an overview of the key socio-politico-economic facts, a re-look at the basic geologic and geographic data, and a statement of the issues crying for answers and a summary of the people's perceptions and the technologists opinions.

This region was endowed by Nature with beautiful mountains, dense forests, perennial rivers with numerous picturesque falls, springs and pools, innumerable seasonal streams, widespread rich black cotton soils, and alluvial deposits in its northeastern, northwestern and westerly central parts. In ancient and medieval times, this region's forest wealth was fabulous. All these are now gone. Human depredations have reduced this to a region of denuded hills radiating intense heat during summers.

Even then, the annual rainfall of this region is about 950 mm on an average, which is not insufficient. But the average hides a grim reality : the rainfall is capricious and erratic in amount, pattern, intensity and distribution. Extreme deviations from the normal are quite common. About 90 percent of the total rainfall is received during four months, July to September. The high intensity of rain hardly leaves any time for the water to infiltrate into the soil; and the deforestation has left little scope to capture the rainwater and transport it to groundwater levels. On the other hand this fast-flowing water causes some extra havoc to Bundelkhand because of its terrain.

Among the regions to the south of the Himalayan foothills, Bundelkhand has a larger share of rocky formation with slopy terrain. Because of the Vindhyan plateaus flanked by high steep cliffs, this region has an unusually high rate of water run-off gushing towards the north, creating deep gorges and rapids. This has meant greater problems of water retention.

Hence, despite the sufficiency of rainfall, this region—particularly its southern and central parts forming the districts of Sagar, Damoh, Panna, Tikamgarh and Chhatarpur face more the problem of water depletion.

The soil run-off rate, too is very high in Bundelkhand. The problem gets accentuated in the middle segments of the rivers' long stretches where many downflowing streams conjoin to lend even greater force to the surging waters. The softer formations—the ancient alluvial deposits in these segments — contribute to this higher

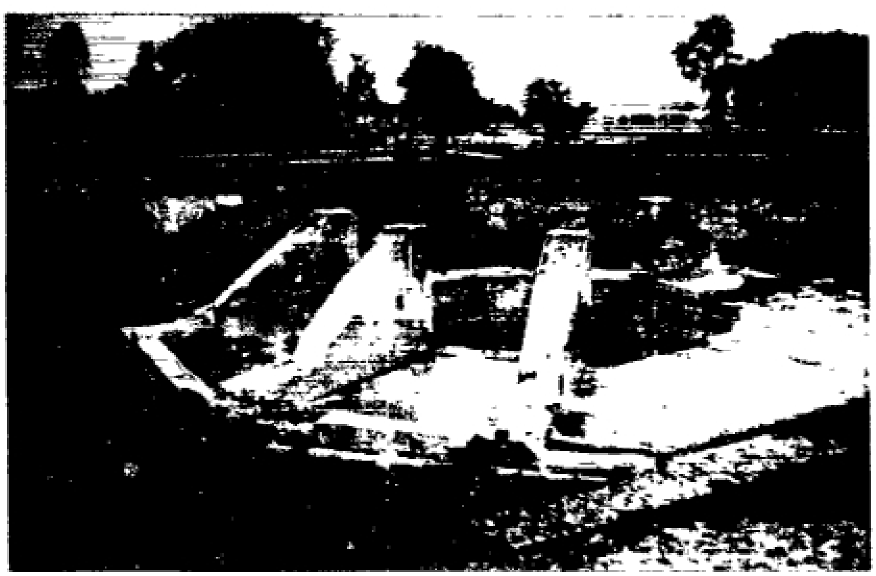
Ravines, Cultivation, check-bund broken due to fast water-current

soil run-off rate, creating ravines which look like big ugly pockmarks on the once-lovely Bundelkhand's landscape.

Yet another peculiarity of Bundelkhand is the pervasiveness of impermeable base rocks at shallow depths. This has prevented the downflowing water from going deep into the subsurface. This conduces to the formation of subterranean flow-channels in many areas.

Phreatic water, i.e. ground water below the water table, occurs here in the fractured and jointed granite and gneissis. But discovering the water stored in the cracks/fissures and in the weathered rocks is a difficult job. The high evaporation loss of the region's surface waters is also a difficult problem now.

Soil characteristics are also very peculiar in this region. In some areas the soil's water holding capacity is extremely low, while in others, drainage is poor resulting in waterlogging situation. The undulating topography and ravine-formation increases the rate of surface water run-off and reduces the water storage capacity. RAKAR soils, being rocky and shallow, has low water holding capacity. PARUA soils, being light, require frequent irrigation. KABAR soils, being black clayey *domat*, has higher water holding capacity but due to lime-granules on the surface it becomes sticky while wet and very hard when dry. This soil is, therefore, slightly difficult for agricultural operations. MAR soils are black cotton soils, and, allthough very fertile, are more smooth and clayey and create obstacles in the drainage of water. When these dry up, cracks usually appear in the black soils.



A beautiful masonry well alongwith BAVDI grossly neglected

The rocky surface, high temperature, fast run-off of water, lowered ground water table, abundance of *moram* - lighter soils, and deforestation of the upper slopes are the main factors causing water-scarcity in this region. The cracking in the soils like *Mar* and *Kabar* also contribute to the loss of moisture from the top and sub-soil region.

A village pond full of water-chest nut crop of a Dheemar family

The Water Resource and Traditional Culture : The natural water resources of this tract included numerous perennial rivers, flowing on rocky bed through thick forest, mostly towards north or in the north-easterly direction, paying tribute to river Yamuna which flows north-west to south-west on the northern boundary of Bundelkhand region. Each such river has been joined by umpteen seasonal rivulets and streams on a south-to-north slopy tract, like arteries in a biological system.

The drinking water needs used to be met mostly by the masonry wells. Such wells were also the mainstays for irrigating the fields.

In almost all the districts of Bundelkhand, each village had developed a culture of creating ponds/tanks to help the inhabitants for meeting their domestic water-needs. With the onset of colonial pattern of administration, divesting people of their control over local natural resources, introduction of canal irrigation and decimation of forests, this culture began to decay and is now moribund.

The Famines : Nature being geneous, there was no dearth of water or food scarcity in this region. The famines or droughts did not visit here frequently. The earliest reference available today of such a calamity is during 1344 AD. This was the time when Mohammad Bin Tughlak, while passing through the adjacent Malwa region, mentioned about famine condition around this tract. Later, 1595 AD and 1630 AD were also reported to be the years of famine. This famine of 1783 AD is, however, known to be the most widespread and dreadful. This was remembered as *chalisa ka saal*, this year having been 1840 according to Indian traditional Vikrami Samvatsar Calendar, which is 57 years older than the Gregory Calendar. However, one of the European travellers who visited Sagar-Damoh in 1790, found the villages of this area very clean, and affluent abodes of happiness. He mentioned that people here were well looked after and no untoward events seemed to have happened in this region in the past. This clearly shows that the famous 1783-famine did not have any lasting influence here. The arrival of British seems to have brought the fear of famines and scarcity to this region, and the first such encounter was in 1809-10 when the northern Bundelkhand, especially the districts of Banda and Hamirpur were badly affected. The famines or severe droughts since then have been reported almost 3-4 times in a decade and sometimes continually for years in succession. The famine of 1868-69 AD (1925 V.S) was again extremely dreadful and widespread, known as *pachisaa ka saal*, which affected the population of Bundelkhand considerably. Several years of severe scarcity were lived by people before 1895-96 which was again a severe famine year. This situation of famine or flood continued for five years upto 1900-01 affecting all the districts of Bundelkhand.

The records of the twentieth century are extremely bad so far as people's miseries are concerned References of 1905-06 to 1907-08, 1911-12, 1913-14, 1914-15, 1916-17, 1918-19, 1920-21, 1922-23, 1926-27, to 1931-32, 1933-34, 1940-41, 1946-47, 1947-48, 1950-51, 1952-53, 1954-55, 1956-57 to 1958-59, 1965-66 to 1975-76 being famine or flood years for some or all the districts of Bundelkhand are on record. Thus it is clear that the past two centuries have been the most dreadful for people of this region. The region's natural resources were mis-appropriated by the government, commereialized and destroyed during this period.

Political Upheaval : This was the same period when there was great upheaval in the political history of this region. The beginning of the 19th century saw the arrival of the aliens as rulers. Having no roots in India, they had hardly any interest in the well-being of the people or the natural system here. They had only selfish interest of earning as much revenue as possible. Thus, the fiscal and forest related policies of British administration were anti-people. This was continuously resented by local population which called as 1840 Bundela revolt at Sagar and Damoh, revolt of Pandits of Jaitpur, heroic struggle of Rani Jhansi, struggle of the people and Nawab of Banda during the first independence struggle of 1857-60.

The greatest event of far-reaching consequences in the life of Bundelkhand was the wholesale destruction of its forests. This began with the British rulers, has continued during the Swadeshi regime and has been at the root of all miseries of Bundelkhand.

Thus, the overall picture of this region that emerges is not one of having any shortage of rainfall, but its availability. It is definitely highly spasmodic both in space and time. In fact, the region suffers from over-runoff and high rate of evaporation due to harsh climatic conditions rather than inadequate rainfall. The problem also lies in the deprivation of the people from their natural right to forest resources in the forced appropriation, centralisation and commercialisation of all natural resources by the government and destruction of the traditional culture of local community controlled water resources. This conclusion emerged after a painstaking survey and soul-searching. We had, from the beginning, endeavoured to find :

answers to the question : Why the water scarcity ?

Was it because

* **there is lack of reservoirs for storage ?**
* **water is not conserved ?**
* **rains are not uniformly distributed over the year ?**
* **the community is not aware ?**
* **the community's perception towarads use of water is changing ?**
* **or any other reason ?**

On the basis of intensive study and analysis of people's perceptions during the field-survey and discussions with eminent scientists and technologists, the following reasons became evident.

a) **Geo-Meteorological Characteristics of Bundelkhand:**

- fast runoff of surface water,
- low water holding capacity of some of the soils,
- high intensity of the short rain-spell,
- poor recharge of the ground water source,
- increased evaporation of the surface water due to naked plateau-areas,
- high temperature during summer season resulting in higher evaporation rate
- unsuitable geological condition for harnessing ground water potential due to complex granite structures.

b) Changing attitude of people as well as Government towards Traditional Water Harvesting System:

- total neglect of traditional water resources and low priority to these in the Govt. planning,
- poor maintenance resulting in decreased capacity of the ponds/lakes due to siltation,
- encrochment on both the catchment areas and the beds of the ponds/tanks, thus decreasing overall capacity of the reservoirs,
- emergence and growth of different types of aquatic weeds within the reservoirs,
- urban tanks being used as the garbage dumping ground, or for commercial exploitation of the space for building either shopping complexes or certain posh colonies,
- lack of sense of responsibility in people and wastage of this precious resource.

c) Issues neglected at the Policy-Planning levels

- total neglect of local resources and traditions in the name of modernization, development, and process of growth,
- irrational and blind policies related to forests, mines, mountains, and rivers etc. for short-term monetary gains,
- lack of proper scientific study before execution of projects related to roads, forests, and tubewells,
- growing tendency to exploit and export agro and forest-based products, ignoring people's subsistence needs and undermining the resource base,
- decreasing horticulture and changing cropping-pattern demanding intensive irrigation,

d) The Neglect of Environment Related Issues

- extensive plantation of exotic plants under mono-culture,
- irrational exploitation of ground water,
- lack of long-term eco-friendly planning for resource utilization
- massive deforestation,
- indiscriminate and uncontrolled mining,
- increased urbanisation,
- centralised water supply systems putting undesirable load over the ground-water
- emphasis on the construction of big dams,
- wastage of water due to uncontrolled mining,
- increase in soil-salinity and brackishness due to dams/canal- systems,
- aggravated health-problems due to water pollution including eutrophication in ponds,
- wastage of water from the Artesian wells.

e) Political Issues:

Bundelkhand region has been divided between two political formations—two states. U.P. and M.P., resulting in mis-management of resources and various kinds of administrative problems. This has politically divided the natural systems-hills, the rivers, the watersheds, and made holistic considerations impossible, hampering the equitable distribution of natural resources including water and creating tension among the people of the two states.

(Details of a few studies pertaining to the above issues have been included in the Appendix A-C.)

CHAPTER FIVE
RECOMMENDATIONS

Discussions in the foregoing chapters bring out the following characteristics of Bundelkhand :

- In ancient times, this region was densely forested and the home of heavy rain-bearing cloud formations. Although it has lost this status over millennia, the rainfall that this region receives even now is reasonably good by world standards.

- Since Bundelkhand's rainfall is subject to tropical monsoonal regimen, it receives the rainfall in only three to four months, and about half of the total rain occurs in just 24-30 hours. During most part of the year, there is a long dry spell. Moreover, rainfall is becoming increasingly erratic in this region. *This region now forms part of the dry climatic zone.*

- Bundelkhand has some extraordinary features, which are common to both its U.P. part and M.P. part. It is bounded in the south and the south-east by the Vindhyan mountain system. The region's topography is marked by a succession of downsliding gradients from the South to the North. Within these successions rise a number of plateaus whose total areal extent accounts for no less than 24 per cent of the region's geographical area. Such frequency and dominance of plateaus is not noticeable anywhere else in this country. Hence, the rain that falls in this region gets drained at superfast speed, after creating flash floods during the rains and causing long-term water scarcity thereafter. Despite the relative sufficiency of the rain, the region becomes chronically drought-prone because of these geologic and topographic features.

- Although scarcity of water is felt everywhere in Bundelkhand, the plateau areas, known locally as *pathas*, are the worst hit.

- (a) Since the water runs off with a high velocity, the topsoil also runs off fast, creating problems of quick siltation of rivers, *nallahs*, lakes and ponds. Because of scanty vegetal cover, undulating topography and heterogeneous structural characteristics of rocks, the run-off of both water and soil is the maximum from the plateau areas.

  (b) Because of the same factor, almost all rivers and even "nallahs" (tiny streamflows) in Bundelkhand tend to create ravines.

- Large parts of this region are occupied by bare hills, denuded mountain ranges and trap rocks, *emitting heat* from three sides—the region's south, east and west. Hence the region is now subject to high temperature regimen, where mercury shoots up to 45-47° Celsius and more, in summer, making the lives of humans, cattle and other animals unbearable, withering the crops and pulverizing the soil. This raises the challenge to a new level where finding the solution to chronic water scarcity and initiating climatic restoration become one integral programme.

- Large parts of Bundelkhand have hard rock formations extrusive to the surface. Most, if not all, of Bundelkhand's plateaus are among them. Such formations have low potential for sustained groundwater supply. Hence, in this region, greater attention needs to be paid to utilising the full potential of rain water harvesting. Fortunately, Bundelkhand's topography is suitable for tanks, ponds, foothill lakes, chains of tanks to capture the spill-over from the tanks at a higher plane — and of course, the dug wells. This was well known to the generations of people in this region. This knowledge needs to be revivified. People's wisdom must be given the greatest importance in the planning of these.

- Since *confined aquifers* have been found in many parts of the world, in the cracks/ fissures and weathered parts of hard rocks overlain and underlain by impervious rocks---- these have been found in Bundelkhand itself -----exploration of ground water potential even in the hard rocks, by remote sensing and other geophysical techniques, needs to be expedited.

  Scientific agencies need to give urgent attention to this task.

- Since some geoscientists, who have specialised in Bundelkhand's geology, are hopeful of finding channels of underground riverine flows in this region, geoscientific exploration to that end needs to be encouraged.

Within these guiding considerations and policy goals, the following programmes/measures are recommended.

1. Afforestation of the Hills

The first need is to afforest the Panna range of the Vindhya mountain and the Chitrakut Hills, and a few other less known hills which together occupy a considerable segment of the hill space. Forests are primarily the producers of water and only secondarily, of wood. Since the disappearance of forests from Vindhyachal, the temperature of the region has shot up in this region with twin disadvantages. It has on the one hand sharply raised the demand for water and on the other made the preservation of crop plants difficult. Until the hills became green and topped by tall montane trees again, no respite from the heat wave can be expected. Hence, for capturing rain water, for providing shelter belts to the crops and all other creatures including humans, of this region, for checking the hills slope's soil erosion, for protecting soil fertility in the hill slopes and the valleys, for minimising the siltation of river beds, and for minimising the chances of flash floods, afforestation of the hills in this region should be the first priority.

That the forests are the most potent means of retaining a large percentage of rainfall and of recharging the groundwater is beyond dispute. Since Bundelkhand gets enough rainfall even now and the region's main problem is minimising the run-off, afforestation ought to be its foremost task. The present study has shown that there is no multi-canopy forest now in existence in this once heavily forested region, except in the few hills which are considered sacred and centres of pilgrimage.

In afforestation, one major problem will have to be faced. Many hills have been so denuded that there is no soil where the plants can strike roots. Even then, holes can be drilled and saplings with nutrient base can be planted therein, moistened and nurtured over months so that these can strike roots in the crevices of rocks. In cases of inevitability, rocks can be blasted to form cavities capable of holding of few cubic feet of water on the plain surfaces of rocks.

But the most important step is fencing of the hills taken up for afforestation. If the hills are fenced, the latent seeds of the pre-existing plants lying in the rockbeds will sprout creating congenial condition for the sprouting of seeds newly broadcast by birds, other creatures and men. Such fencing to prevent cattle grazing and depredation by men is possible only if people participate in its planning and execution. But development of grasslands, as sources of fodder for cattle is necessary to prevent cattle grazing in the hills slopes. Grasslands, apart from providing fodder and contributing to the success of afforestation of hills, will help soaking of the rain and recharging groundwater. The Grassland Research Institute's work in promotion of grasslands as complementary to crop-farming can offer valuable guidance in this respect.

2. Need for Numerous Small ponds and Some Large Tanks in Each Cluster of Villages in the Pediments*, Alluvial Areas, and Valley Plains of Plateau Areas

Alluvial Areas, Pediments, and Valley Plains of Plateaus together occupy 70%, if not more, of Bundelkhand's geographical area. These areas are suitable for surface storage which are in any case less expensive than underground storage.

Two points need to be clarified first. The surface storage does not supplant the need for storage in dugwells or artificial recharging of groundwater. Dugwells have certain functions which surface storage cannot perform and *vice versa*. Besides, dugwells are important in all hot climatic zones for preserving water in evaporation-free condition. Ponds are amenable to many types of economic uses including pisciculture and the growing of aquatic plants capable of yielding foods.

Secondly, we have included plateau's Valley Plains as sites for surface water purposely. That tanks cannot be constructed at the top of plateau areas (formed by Deccan Traps i.e. basalts) is well known. But tanks can certainly be constructed in their valley plains and these should be encouraged as a matter of policy.

Numerous small ponds and some large *talabs* should be provided for in every village. Farm ponds outside the village and separate ponds for the bathing of humans and cattle near the households would go a long way to meeting the requirements. Field-ponds are, in fact, an ancient system : these used to trap the run-off topsoil, recycle it, supply irrigation water, and also grow fish and/or other aquatic plants of economic value. In some areas of Bundelkhand, there was also a system of a chain of tanks, the spill-over from the upland tanks filling the tanks in the lowland. These very helpful ancient systems need to be resurrected.

Notably, the reservoirs constructed at the foothills by the Chandelas between the ninth and thirteenth centuries and by the Bundelas later, are still existing, partially fulfilling the need for irrigation and even drinking water in their respective areas. All these reservoirs seem to have been scientifically designed, with provision of spillways for surplus water. Some reservoirs are found to have been connected with canals which were used as recharging sources for the downstream irrigation wells and/or for irrigating the fields directly. In addition, checkdams, weirs, barrages, wells, step-wells (*bavdis*) and artesian wells were constructed. Bundelkhand has, thus, a glorious tradition of reservoirs, tanks, ponds, wells, which have gone into disuse in certain parts of the region.

Since building small-scale surface storage is not much in fashion now, the statement of an internationally acclaimed meteorologist-cum-social philosopher, Dr. P.R. Pisharoty may be recalled here.

"The... water management system established a thousand years ago is better suited to a tropical

*Pediment is a plain of eroded bedrock (which may or may not be covered by a thin veneer of alluvium) in an arid region developed between mountain and basin areas.

India than what our modern water managers adopt with World Bank loan and advice. The system consists of numerous ponds and tanks or small reservoirs which store the water which falls over a catchment area fifty times that of each pond and tank.

"If the rainfall over the area is (merely) 50 cm per year, and the catchment area 50 times that of the surface area of the pond, and if we assume a minimum 40 per cent run-off on the average, water to a depth of 10 meters can be collected in each pond. Allowing for two meters of water loss by evaporation during the year, a depth of 8 meters of water would be available during the year. There may be some seepage in the neighbouring underground. Even that part, which is not compensated by a subsurface inflow during the rain spells, is not a loss. It would feed water into the neighbouring dug wells. With some care like low parapet walls round the wells they can provide water. If eight metres of water is available in each pond at the end of the rainy season, some will be available for use the next year, if that year experiences a deficient rainfall.

"Canal system from major irrigation works cannot cover every village even for irrigation, let alone drinking water for the dry period.... Minor irrigation works appear to be the only solution". (Source : "Meteorology for the Indian Farmers" published by Indian Space Research Organization, Bangalore in 1986).

Planning of each "*talab*" (the large tank) should be so ordained that its surface areas can vary from a tenth of one hectare to one or two hectares; and they should be so located that each has a catchment area fifty to hundred times the surface area of the pond.

4. Need to convert *Bavdis, Chohnras* etc into Masonry Wells

In earlier times, *bavdis, chohnras* and *Jal-mandirs* (temple tanks) used to be quite common.

Bavdis, also called Vapis — are stepwells. In ancient times, these used to be constructed to allay the thirst of pilgrims and at places, for use as protected bathing places for women. Construction of bavdis used to be regarded as holy service.

Although these were very useful, their steps provided scope for people going down to the water level and polluting the water. These should be converted into masonry wells.

Chohnras are shallow Kutcha wells. In earlier times, these were used as yielders of potable water. The general practice was to keep this water in the pitchers, allow the little dirt in the water precipitate and to decant the clean water to another container without stirring the sediment. *Chohnras* still exist. To get safer drinking water, these too, should be converted into masonry wells.

5. Need to Revive the Culture of *Jal-mandirs* with a New Understanding

Jal-mandirs in earlier times, used to be constructed as tanks around the temples. Preserving the tanks' purity was part of worship. These tanks served also to keep the climate cool. The water in these tanks, now-a-days, is not pure and their catchment areas, too, are filled with dirt. The need today is to revive the *Jal-mandir* culture with meticulous care to keep its catchment areas clean and to shut out the chances of people using these tanks' water even for any domestic purpose.

6. Contour Bunding on Gently Sloping Terrain

This is a time-tested method for moisture conservation. It requires cooperation between the adjacent farmers because the rainwater that falls on the land of A would have been, without this bunding, primarily useful to B whose land is just lower to the land of A.

This system, too, was in usage in the long past. This came to be neglected when the Government started emphasising canal irrigation replacing local irrigation.

7. Shallow Broad-Area Percolation Tanks

Due to the intensity of rainfall in Bundelkhand even in the present times, the rainwater does not find much time to penetrate into the soil in proportion to the quantity. Since the rate of penetration over Bundelkhand area is, on an average about 15% of the rainfall, Percolation Tanks would be useful to enhance the percolation rate.

8. Digging Narrow Channels within the Farms

Just as the region as a whole needs to minimise run-off from its boundaries, each individual farmer ought to prevent the rainwater falling on his farm from running out of the farmland. This can be done by digging several narrow channels 15 meters long, 15 cm deep and 15 cm wide within the farm itself, wherever possible. Alternatively, a bund of one metre height all along the boundary can also prevent an outflow. This has an advantage that in a week's time all the water that accumulates would seep into the ground. This arrangement would also prevent soil erosion : the loosened soil will settle on the site itself.

Later, during the non-rainy season, the owner of the land can lift the water through shallow wells dug in the farmland.

In some areas, farmers have improvised novel methods of conserving water. Instead of building earthern bunds, they create bunds around individual plots by a series of hollow bamboo pipes with side holes. When the plots are full of water, the bamboo pipes get filled. The water in the pipes leak out into the arable land during non-rainy periods.

9. Rainwater Harvesting : Need for Applying Some Techniques Prevalent in Arid Zones of Western India.

Although hydrometeorologically, Bundelkhand does not belong to an arid or even to a semi-arid zone it certainly belongs to this category biologically. Even though it receives substantial amounts of rainwater, its retention for use locally is pretty little. Hence most of the methods of rainwater harvesting, which are in vogue in areas like Rajasthan, should be taken recourse to in Bundelkhand, more so in its plateau and pediment areas.

In all the water-scarce parts of the region, (i) roofwater harvesting and storage of this water in cemented tanks in the basement for individual household-and-neighbourhood use for drinking purpose; and (ii) construction of dugwells with a parapet and cemented catchment area with multiple inlet points with steel meshes serving as sieves to keep out stones, leaves and other impurities -- both within in the village and **in the farmlands for community use,** must be given high priority.

Tapping of water from streamlets (locally called "nallahs") in the post-rainfall hours is also a useful technique. This water could be led to some dugwells by some dug-up channels or even by a hose pipe, for augmenting the dugwell water level. Suggestions have been received that a funnel can be put up in the middle of the "nallah" and the former's tapering end can be fitted into a hose pipe 70-100 mm in diameter, and the other end of hose pipe lowered into the well. If a steel mesh is placed firmly on the funnel top, it would keep out vegetation, stones and solid materials. This seems a practicable proposition and needs to be tried.

10. Need to Revive *Haveli/Bandhan* System, Wherever Possible

Now that landholdings have become highly fragmented, the scope for havelis, called bandhans in Bundelkhand, somewhat analogous to the smaller versions of Tamil Nadu's *Ery* System, has become severly limited. Even then, several farmers can join in a cooperative venture, to restore the bandhan/haveli system to conserve moisture.

11. Groundwater Utilisation in Alluvial Areas and Valley Fills

Alluvial Areas are rich in groundwater. The Valley Fills (formed by the eroded soils flown down the hills to fill the valleys) too are rich in groundwater potential. Both dugwells and tubewells are useful for tapping groundwater.

But a law needs to be passed to prevent the over-exploitation of groundwater. Minimum spacing between irrigation tubewells must be one kilometre.

Groundwater tapping should be made somewhat labour-intensive to prevent over-exploitation of groundwater. Handpumps are preferable to other forms of tubewells. Motorised tubewells should be disallowed even for irrigation purposes. This is necessary (i) to protect the interests of small farmers who find their wells depleted because of the overdrawal by rich farmers by means of their motorised systems; (ii) to preserve subsurface ecosystem and prevent subsidence; and (iii) to prevent salinization of soil which results from excess of irrigation.

12. Need to Encourage Mangal Singh's Multipurpose Turbine (Water Wheel)

Several years back, Mangal Singh, a farmer from Lalitpur district, devised a highly efficient, yet inexpensive turbine which can be used for pumping water as well as for electricity generation. Its speciality is that it does not require a large waterhead :,a waterhead of even one metre or even less is sufficient for its operation. It can easily be fabricated by the villagers themselves, using locally available material.

This model of water wheel is a source of rotational energy which can be used for any purpose. Its performance as a pumping system for irrigation has been found excellent. It is also being used for sugarcane crushing, grain threshing, grinding — and for operating machine tools.

On the basis of some locational studies within Bundelkhand, some 500 hydrosites have already been found suitable for its installation. On an average, two turbines per site will have the potential to irrigate 200 hectares of land.

In camparison with the uncontrolled flush irrigation through big-dam-connected trunk canals, the irrigation by Mangal turbine can be controlled by local people as per their crops' requirements.

This turbine as a fine example of common people's inventiveness, should be encouraged by all means for people's benefit. It is unfortunate that in the pervasive atmosphere of "foreignomania" this device has not got the recognition it deserves. (For details *Vide* Appendix 'A.5')

13. Need to Revive "*Masak*" and "*Mote*" Systems and to Encourage Persian Wheels

Since water is a precious resource, its extravagant use must be discouraged by all means. The study team has felt that labour-saving devices, which were intended to free people from drudgery and the inhumanity of back-breaking labour, are now being used to waste water. There is, therefore, the need for adopting a "golden mean".

In this context, the traditional system of irrigating small holdings with "*Masak*" and "*Mote*" system acquires new importance. The former is wholly manually operated while the "*Mote*" system is a combination of animal labour and man's manual labour. It is a system of drawal of water from open wells or ponds with the help of a bullock moving linearly — from the pond to the field and *vice versa*. Undoubtedly, both "*Masak*" and "*Mote*" systems promote thrifty use of water.

At the level of larger holdings, the use of "*Rahat*" (i.e. Persian Wheel) is economical and preventive of water wastage. While relieving humans of the hardship of carrying water, it also promotes thrifty use.

14. Underground Check Dams

These have the advantage of preventing the flows of underground water into river channels during rainy as well as non-rainy months. Since Bundelkhand is known to have substantial subterranean flows, this will be particularly suitable for this region.

15. Artificial Recharging

This will be useful if water from the river courses is pumped into deep wells, dug or bored a kilometer or so away from the river channels. (For details, *Vide* Appendix C.4) Small check dams across the river would provide pools from which the water can be pumped.

16. Need for Geoscientific Exploration

Meanwhile, the geoscientific ventures, both for locating the pathways of subterranean flows and testing the suspected potential for groundwater even under the hard rocks of Bundelkhand should be encouraged and the data made available to the public.

17. Need for All-Pervasive Endeavour for Improving the Organic Matter Status of Soils.

More than the sum total of the water holding capacites of the ponds, tanks and wells, could be the water holding capacity of the soils if the latter's organic matter status was high. Organic matter content has a profound effect on the soil's capacity for water retention in the sub-soil zones and on land productivity. Conciousness about this fundamental fact is getting buried under the country's current craze for chemical fertiliser application.

Wherever chemical fertilizer has been applied, the soils have lost their porosity and permeability and hence their water holding capacity. This has resulted in quicker run-off of both water and topsoil from these areas. Fortunately for Bundelkhand, chemical fertiliser application has not made much headway in most parts of this region.

Yet, due to high deforestation and heat wave, the topsoil has been scorched and degraded in many parts of the region. Neglect in supplying organic manure is adding to this problem. The organic matter content of even the alluvial deposits in Bundelkhand's northern plains is getting diminished. Hence the need for upgrading the organic matter status of the soils is no less important here.

The importance of raising the organic matter status of the soils pervasively may perhaps be explained by an analogy. In the same manner as each of the billions of cells in an animal biological system contains fluids, each inter-space between the soil particles should have the potential to hold water. This is possible only when the soil is rich in organic matter.

The organic matter status of the soils can be enriched by the ploughing-in of *dhaincha, jayanti* (Sesbania cannabina), application of farmyard manure, tank silt, compost and biogas slurry.

All the above seventeen measures are feasible and can be implemented by the people with cooperative efforts. The government, on its part, instead of squandering resources on grandiose projects, would do well to help people in the implementation of these measures on decentralized levels.

RECOMMENDATIONS FOR PROHIBITIVE MEASURES

We have suggested above some positive actions. Below are recommendations for some strong measures to counteract certain practices which have acquired an inertial force but have highly adverse consequences. In fact, these prohibitive measures are a condition for the success of some of the crucial positive steps.

1. Need for Banning the Mining of Granites

In ages long past, granites had come to be overlain by soil on which forests grew. Mining of granites caused the felling of these forests. Continued mining of granites is ruining the chances of their restoration. Since the forests are the foster-mother of agriculture in perpetuity, it is permanently damaging the chances of agriculture also.

Since granites are used for reinforced concrete constructions, road laying, rail-road laying and decorative tiles for housebuilding, these are in high demand in national urban markets and for exports. Granite business has now become a highly lucrative business. As a result, there is a furious urge to flatten the hillls and also to remove the granites from deeper levels. Where the granites underlay the cultivable lands, the overburdens (the heaps of earth cover) have been removed, allowing these to get washed down to the rivers, rivulets and the dammed reservoirs and to silt these up. The rot does not stop there. As granite mining goes deeper, considerable quantities of groundwater flow to the areas of mining operation. These are considered a hindrance, Hence these are pumped out and left to dry up on the surface, thus causing waste of large volumes of water. *This is just the reverse of artificial recharging of groundwater.*

Moreover, the dynamiting of granites has been causing deep vibrations in the neighbourhood. In the districts of Lalitpur and Jhansi, where the mining of granite is endemic, the housing and other constructions are becoming unstable. The frequency of rail accidents in Lalitpur area is attributable to the weakening of rail tracks caused by the continuing blasting of granites. At least this is the perception of the people.

The huge cavities in the ground here have been inviting another damage of grave proportions. There was a proposal to cover the cavities by earthfills burying radioactive wastes, both indigenous and imported. If this is done, or will be, a crime against the people.

If this process continues, afforestation of the hills and wastelands will be an impossibility.

Thus, the losses in terms of ecosystemic damage, worsening climatic harshness, and choking of waterways, and permanent damage to agriculture far outweigh the little gains in export earnings and the private gains to the men engaged in granite trade. The national losses are too great in comparision with the litttle gains. Yet, since export has now become the "mantra", no heed has been paid to this overall national accounting in terms of losses and gains.

Hence Mining of granites should now be banned

2. Need for Regulation and Reduction of the Mining of Gneissis

Gneissis is a metamorphosis of granites. Its slabs are used for building constructions. Its mining also causes damage to the ecosystem. Yet, its complete stoppage is problematic for two reasons. Since gneissis mining is done mostly manually in the post-dynamiting stage (as against granite mining, which is almost wholly mechanised), it provides employment to many people. Moreover, buyers for its products are the middle class people.

For the above reasons, the mining of gneissis would have to be continued for some time. At the same time, it should be regulated and reduced. The filling of the cavities caused by the mining of gneissis and their afforestation should be an obligation of the leaseholders.

3. Need to Ban the Crushing of Sandstone

Sandstones, too, are in demand for R.C.C., road and rail-road laying. The number of sandstone crushers is much too large. They are near the households, near arable lands, filling the air with the dust from sandstone crushing and causing respiratory ailments among the populace. Their dust fills the arable lands and reduces soil fertility, and also covers the foliage with dust, reducing the photosynthetic process and leading the plants to slow death.

Since these are so near the human habitation, their adverse impact on people's life and living is apparent. The districts of Banda and Mahoba are the worst hit.

Once it had been ordained that each sandstone crusher would have to grow a dense and tall forest-like barrier surrounding each site of stone crushing It is doubtful if it could contain the damage to bearable levels. In any case, the order has remained a dead letter.

Sandstone crushing needs to be banned in the interest of people's health. In the interest of afforestation of hills, which is this region's priority number one for a variety of purposes, this process of further flattening of hills by sandstone mining must be banned.

4. Need to Ban the Quarrying of River Sand Banks

Although the sands which get separated and deposited near the edges of rivers by natural riverine processes can be harnessed without any damaging effect, the trouble starts when man's greed leads to the quarrying of sandbanks themselves.

Since Bundelkhand's river sands are fine, stony sands, clayless and without impurities, these are in high demand for house construction. As a result, the quarrying of sand banks has been going on, on a large scale, in Bundelkhand, endangering the river courses and aggravating the dangers of floods.

The sand banks are known as inducers of filtration, water purification, and maintainability of underground flows of water. Hence their removal is a danger to both the quantity and quality of water.

Therefore, the Quarrying of River Sand Banks should, be banned

5. Need to stop the waste of water from flowing artesian wells

Artesian wells are the ones which pass through, and pierce, the stratum confining the aquifer and allow a welling up of water from the subsurface. Where the artesian pressure is high, the groundwater comes up as a fountain reaching above the ground surface. Here we are referring to only the flowing artesian wells.

In Bundelkhand region, the artesian flowing wells occur in the alluvial formations. Groundwater from these wells flow out continuously throughout the year. The high pressure head is more in the rainy season and becomes slightly less thereafter. It is observed that the people of these areas are wasting groundwater by allowing it to flow out when they are not using it for drinking or agricultural purposes.

This waste of precious groundwater must stop. For this purpose, check dams can be prepared to impound the outflows from the artesian wells. The number of artesian wells that could be covered by a check dam will be determined by the quanta of outflows from the respective artesian wells.

The Positive and the Prohibitive measures recommended above integrate the characteristics of different elements of the ecosystem, meet the variegated needs of people in differing situations in the most natural and inexpensive ways, seek to enhance the substratum of resources and to harmonise the relationship between man and Nature.

WATER RESOURCES AND ITS MANAGEMENT WITH SPECIAL REFERENCE TO BUNDELKHAND REGION

Importance of water needs no emphasis. No form of life can exist without it. Water is a key resource for human development. Almost all the civilisations of past existed and flourished along the water courses. As a matter of fact the whole human history can be written in terms of water. Right from the drinking requirements. domestic need, irrigational purposes, industrial demands. recreational facilities etc. water has its pre-emptory role. Use of water is manyfold in comparison to that of all other resources taken together. Water is plentiful and available everywhere. It comes through rains, brought down by rivers, discharged by springs , a little dig in the earth produces water and many such other misconcepts prompted the people all over the world to indulge in wasteful use of this vital and scarce resource. They used it for cleaning cverything and disposing the industrial waste. They did not realise or took it seriously that though replenishable, the water is a scarce resource. Out of the total quantity of water on the earth only 2.7 per cent is fresh and usable and the rest 97.3 percent is unfit for human use for its qualitative distinction. In the early stages of human development the demand of the water was very much limited and it posed no problem. But with the colossal increase in population, rapid and extensive industrialisation, large scale disposal of factory waste and wasteful use of water, the pressure on water resource has increased tremendously. This fact along with other factors leading to the environmental degradation has posed the present problem, necessitating the assessment of the resource, collection of basic data on surface and sub-surface water, on quantity, quality, storage, supply, consumption, drawl. waste water and other related information on regular and continuous basis. Importance of proper storage of hydrogeological data for meaningful interpretation through mathematical models for decision making has now been fully recognised and emphasised.

Our country is no exception to this global problem. For one reason or the other major part of our country experiences shortage of water. Being a part of the hard rock terrain of the country the problem is acutely felt in the Bundelkhand region.

The land in between Yamuna and Narmada rivers. bounded by Chambal on the west and Tons river on the east had been known as Bundelkhand in the past. It covered an area of 1,23,674 sq. km. and was included within Latitude N. 23° 00' & 26° 5o' and Longitude E. 76° 30' & 82° 00'. It has no locus standi now in the political map of India. However, a part of it still has its recognition as Bundelkhand Division in governnent records. Spread over in two states of Uttar Pradesh and Madhya Pradesh it covers a total area of 70,000 sq. km. including twelve districts of which six viz. Jhansi, Lalitpur, Mahoba. Hamirpur, Banda and Jalaun are in Uttar Pradesh and the remaining six districts viz Datia, Tikamgarh, Chatarpur, Panna, Damoh and Sagar in Madhya Pradesh. It is located between Latitude N. 23° 10' & 26° 30' and Longitude E. 78° 20' & 81° 40'.

Geologically Bundelkhand region is occupied by (1) the Bundelkhand Granitic Complex (2) Rocks of Vindhyan Super Group and (3) Alluvium. Bijawar and Lameta Formations underlying and overlying the Vindhyan Super Group respectively have very small and limited exposure and as such are of no importance. Trap rocks cover part of Vindhyan Super Group in the districts of Sagar and Damoh.

Rocks of Bundelkhand Granitic complex occupy a semicircular area which is about 334 km. long in east-west direction and nearly 200 km in width in north-south direction. It covers the districts of Jhansi, Lalitpur, Tikamgarh, Chhatarpur and southern parts of Mahoba. Hamirpur and Banda districts. The gneissic terrain is gently undulating with isolated hills and comprises

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vast pediment and piedmont plain in the northwest and south central part of the region.

Vindhyan Super Group flanking the Gneissic terrain on the southern, eastern and western sides invariable stands up in scarpments roughly demarcated by 300, 375 and 450 metre contours. This constitutes eroded, flat to gently undulating terrain characterised by low swell wide crests and shallow basins and at places southwest of the region behind escarpments.

On the southern end of the region the Vindhyans are partly covered by the trap rocks in the districts of Sagar and Damoh. The trap rock country is characterised by flat topped hills and step like terraces.

In contrast to the hard rock area about 12.931 sq. km. of the region on the north is occupied by Quanternary to Recent sediments of alluvial, aeolian and sub-aerial origin. Its thickness increases towards north and varies from a few metres to more than 200 metres. Much older Bundelkhand alluvium slopes under the Ganga alluvium.

The region is drained by northward flowing Betwa, Dhasan and Ken rivers. In the plateau area these rivers have carved out deep gorges with a number of waterfalls and rapids. Geomorphic units of the region can be grouped as (1) Hills and Ridges (2) Plateau (3) Inter-Plateau Basin (4) Pediment (5) Piedmont Plain and (6) alluvial Plain. Broadly speaking the percentage of the total geographic area of the region occupied by these geomorphic units is Hill and Ridges 4, Plateau 24. Pediment 11, Alluvium 56 and Cut Up and Denuded 5.

The Bundelkhand suffers most from the vagaries of rainfall and unbalanced situation of water against time and demand. The imbalance is destructive both ways. During rains when it is mostly available in wasteful plenty it ravages the land, effects severe soil erosion and gully formation, damages the property and often takes heavy toll on human lives. During summer months it becomes a matter of tough toil and misery. Most of the streams. lakes and tanks almost dry up. Dug wells which are the main source of water supply dwindle in their yield and at times fall altogether. Drought grips the area. Instances are known when famine or near famine conditions have destroyed life and shattered the economic structure in the past. During the famine of 1905-08 the population of Banda district was reduced to half. In the year 1963 about 2014 villages of the district were drought affected.

Shortage of water is felt everywhere in the Bundelkhand but the plateau area locally known as 'Patha' is most problematic. Drought and famine is almost a tradition there. British Settlement Officer Mr. Powell in 1905 mentioned in his report that scarcity of water is inherent to this (Patha area) terrain. Famine Commission constituted by the British Government in 1935 was so terribly moved by the gravity of the situation that it very strongly recommended immediate shifting of the entire population and deserting the area forever. It is said that with perpetual scarcity every fourth year is a drought year in the area.

About 80 percent of rainfall is received during monsoon season extending from June end to September. Average annual rainfall is around 1,000 mm but it is capricious and erratic in amount, pattern, intensity and distribution. Extreme deviations from normal are not uncommon.

Population of the Bundelkhand seems to have compromised with adversities. Destruction brought by flash floods and cruel killings by drought and famines destroy the socio-economic structure time and again pushing them to depths of penury and distressed living. Out of the total population (1991) of the Bundelkhand, 83.5 percent is rural. Out of this rural population 85.7 percent depends exclusively on agriculture. Cultivated area in Bundelkhand (U..P.) is about 60 percent and around 42 percent in Bundelkhand (M.P.). Even after 50 years of independence the form of the agriculture still continues to be traditional and rudimentary. Uncertainty of rainfall, lack of adequate irrigational facilities and other agricultural support, the dryland farming is still in vogue in greater part of the region. Life is hard, agriculture is overburdened and avenues of employment are not diversified. Consequences are obviously ill or improper deployment of human resources which encourages crimes and criminals.

Prima Facie the shortage of water appears to be the main constraint in agronomical, irrigational, industrial and socio-economical development of the Bundelkhand. Is this constraint due to despotism of rain-god or to some other reason like geological setup. geomorphic features, lack of assessment of water resources, mismanagement of water etc? The geological set up and geomorphic feature of the Bundelkhand may be taken as constant. The only variable is water. Bundelkhand on an average receives 70,008 million cubic metre of water by way of rainfall every year which is about 1.000 millimetre. What percentage of this water goes off the region has not been assessed precisely. However, the Central Ground Water Board has established 12,477 Hydrograph Network Stations (H.N.S.) all over the Country by March 1990. Out of these 191 are in Bundelkhand. Districtwise break up is:-

District	Number of H.N.S.	District	Number of H.N.S.
Chhatarpur	19	Banda	21
Damoh	13	Hamirpur/Mahoba	30
Datia	6	Jalaun	20
Panna	11	Jhansi	23
Sagar	18	Lalitpur	19
Tikamgarh	11		

Ground water potential for the entire country is being estimated on the basis of water table rise from rainfall and recharge from other sources and the specific yield of the formations which contain water. As water is dynamic and ground water is the largest available source of fresh water on the earth its continuous accounting and periodical assessment are essential to predict future consequences.

According to the 'Ground Water Statistics' March 1991, prepared by the Central Ground Water Board, Union Ministry of Water Resources, out of 70.008 MCM that Bundelkhand recieves per year from rainfall 59,317 MCM i.e. 84.72 percent goes out of the region as surface run off and the remaining 10,691 MCM i e. 15.28 percent accounts for ground water increment The district wise details are.-

District	Forest cover (%)	Rainfall (m.m.)	Replenishable G.W. Resource (MCM per year)	Level of G.W. Development (% in 1990)
Jhansi	6	822	896	33
Lalitpur	13	822	699	36
Jalaun	6	794	1239	10
Hamirpur	5	794	1229	12
Banda	11	1024	1426	12
Chhatarpur	10	1083	1036	24 40
Datia	9	900	313	22 18
Damoh	36	1115	829	6 24
Panna	34	1248	812	5.80
Sagar	28	1279	1434	10 66
Tikamgarh	13	1045	818	33.67

The figure of ground water recharge as estimated by the Central Ground Water Board is for the Bundelkhand as a whole. In fact it varies with the lithological variations. Because of scanty vegetal cover, undulating topography. heterogeneous structural characteristics of rocks, run off is maximum in the plateau area.

In overall picture there is no shortage of water so far its annual input in the region is concerned. Infact the region suffers more from over drainage than from inadequate rainfall. The ground water resources are also not developed to their yielding capacity i.e. specific yield. According to Central Ground Water Board, the level of ground water development by 1990 is only 20 percent. It is primarily due to ignorance of water resources. Studies made and surveys conducted in selected areas in recent years by the Geological Survey of India, Central Ground Water Board, Central Water Commission and other State Agencies have given very encouraging results.

Alluvial plain comprising river sediments, valley fills and piedmont deposits have been explored in sufficient details and areas have already been demarcated where the tubewells tapping the potential aquifers are capable of yielding discharge varying between 1,527 and 4,275 litres per minute. Geohydrological data collected from some of the exploratory borings is given below.

Locality (Metres)	Depth Drilled (Litres per	Discharge (Metres) Minute)	Draw Down
Jalaun	97 80	3420	6.9
Konch	75 90	2236	6 9
Kalpi	-	1575	2.5
Oral	81.00	1560	5.4
Hamirpur	87.90	2250	2.8
Samthar	66.90	2385	3.3
Kamasin	58.83	1527	16 27
Murwal	85 72	3811	3.03
Maharajpur	130.72	2546	3.74
Kanwara	44.94	4275	-
Coyra Mughli	107.00	2700	-

The most problematic plateau or patha area comprises sandstone. shale and limestone. Sandstones are most abundant in the area. Generally the sandstones are joined, fractured and weathered on the surface. Though porosity percentage varies from 3.2 to 15.2 useful supplies of water area available from sandstones particularly where they are favourably disposed structuraly. At places they may even support heavy duty tube wells. An average yield of about 750 litres per minute can he had at most of the places. A well drilled down to depth of 68.55 m in sandstone at *Bai-*

ka-Purwa gave a discharge of 2125 litres per minute. The technique of blast well or hydrofracturing does help to a great extent in hard rock areas. One well in *Khichri* village tapping water from an aquifer located at a depth of 30 metres in sandstone formation gave an yield of 75 litres per minute which after adoption of technique of hydrofracturtng rose to 375 litres per minute.

Boreholes Drilled by CGWB in the Patha area of district Banda, Uttar Pradesh (In the Vindhyan Sandstone/ Limestone)

Site	Depth Drilled (metres gl)	Fracture zone	Discharge litre/minute
1. Bai ka Purva	68 55	44-68	2125
2 Saraiyan	68.55	41-60	926
3 Malin ka Purwa	68 65	26-68	2521
4 Ekdahri	99.05	76-94	1130
5 Barui	100.00	81-87	926
6 Devangana	114-00	37-53	926
		53.35	749
7 Bhaunri	56.35	36-54	1130
8- Manikapur	251 55	50-166	110

Borehole sizes selected on the basis of hydrogeological and geophysical field investigations

Shales are no doubt poor supplier of water. Whatever water is available it is through its bedding plane and joints. In topographic low to moderate supplies may be obtained by large diameter open wells.

No rock differs more radically with respect to yield of water than limestone. Some rank among the best aquifers while others may be totally unproductive. Solution channels at times give rise to caverns of extremely large dimentions or caves where the water flows like a stream. Thick beds of limestone in Vindhyan Super Group are found in the lowest Semeri formation and the upper most Bhander formation which covers a major part of the region. The limestone, in general is caverneous and mostly supports a number of springs at the scarpment faces. Presence of a number of caves on the first scarpment face like Gupt Godavari, Mordhwaj.Temple cave, Banke Siddh etc, stand in testimony to that effect. Gupt Godavari cave is about 45 metres long, 15 metres wide and 3 metres high. A number of sink holes in the Kaimur plateau located about 14 kms south of Hanuman Dhara prove the southward extention and the caverneous nature of this limestone bed. Biradh Kund is the largest of all the sink holes known in the area. It has a semi-circular opening with a diameter of about 75 metres and a vertical depth of 150 metres. Gravity and Resistivity analysis of about 15.708 sq.km. of plateau area lying between latitudes 24°30′ to 25°30' and the longitudes 80°15' to 81°30' brings out clearly a gravity 'low' zone correlatable with the solution cavaties hetherto postulated in the Tirohan Limestone of Semeri formation. The mass deficit created due to removal of limestone in sloution has been reflected as a gravity low. This analysis clearly points out the possibility of an alternative source of ground water of gigantic magnitude in the drought prone plateau area. If explored for ground water and developed by proper drilling and pumping technique, the socio-economic condition of the populace there can positively be changed.

Thus it is clear that even in the present condition the water supply of the region can be increased substantially by detailed hydrogeological explorations and use of latest technique.

Bundelkhand that needs water most cares least for its conservation and management. They possibly consider surface water to be different from ground water. Water is dynamic and it always moves on whether by overland or subterranean routes. Aquifers are the greatest repository of water like surface water reservoirs. For the prosperity of the region continuous and adequate supply of water is a must. It is, therefore, essential to conserve and manage this resource. Water balancing and budgeting is to be done periodically.

Water conservation measures include reduction of evapotranspiration, maximum recharge of the ground water reservoirs, water harvesting and conjunctive use of surface and ground water. The natural recharge takes place from rain water and it constitutes the maximum ground water recharge. The artificial recharge is through man made means. Some of the prominent methods are irrigation: water spreading, recharge through pits and excavations, inverted wells and shafts, induced recharge etc.

In the Bundelkhand.about 80 percent of rain water goes off the area and that too with a scar on the progress. Topography of the region is favourable for creating surface reservoirs. In fact importance of surface storage of water had been realised in the past and as consequence there are number of lakes in the region. But unfortunately the up keep and maintenane of these lakes is very appalling. This source which is a boon to the region is lying in desolation and desuetude. Revival of the practice of age old water harvesting is the need of the hour. Conjuctive use of surface and ground water is essential to meet the growing demand of water. Moreover the water harvesting is multipurpose. It stores water for irrigation, regulates the soil moisture, reduces soil erosion. recharges the ground water and attenuates the floods.

Management of water resources include resource evaluation, balancing the recharge and discharge, ground water budgeting, qualitative and quantitative accounting, pollution control. watershed management etc..

Fresh water is a scarce resource and as such it must be used judiciously and with caution. For uncertainity of the availability of surface water, load on ground water has increased considerably. Ground water development has now become people's programme as it has been found to be most reliable and convenient source in the hands of farmers. It has also been estimated that ground water irrigation is twice as productive in comparison to other means of irrigation. It is therefore vital to manage it strictly. Periodical assessment of this resource has to be done and a safeguard for the water supplies and over exploitation of ground water. A practical water management policy has to be evolved in respect of the Bundelkhand.

Water is everybody's concern. Every individual is concerned with its use in one way or the other. Unless every person is aware about his role in the efficient upkeep and the use of this vital resource, it will not be possible to avoid waste and utlilisation of this scarce resource to the best advantage. Society's awareness is of prime importance.

Environmental constraints play an important role and have to be accounted for in the long term planning and management of water resources. Thus the responsibility of the Geographers in this respect is obvious and needs no emphasis.

ASPECT OF GROUND WATER REGENERATION BY CONJUNCTIVE USE PLANNING

The world's total water resources are estimated to be 1.36×10^3 Mham, of this 97.2% is salt water, only 2.8% water is available as fresh water, 22% is available as surface water, and 0.6% as ground water. Out of 0.6% of ground water only about 0.25% can be economically extracted with different water lifting devices.,

The above reference shows that though ground water quantity available is very small but use of ground water is more economical than other sources due to the fact of its availability in-situ, and pure in quality, in case it is fresh. Therefore, special care is required for ground water management and replenishment of resources so as to ensure its adequate quantity when needed.

The acute water shortages have been observed periodically from Southern part of U.P., as surface and ground water bodies recede or get dried during dry periods, making life of inhabitants in this region hardship-ridden. Under such critical situation, there is no alternative other than to supply drinking water through tankers. The situation can be improved by adopting suitable ground water management approach in conjunction with surface water planning.

General Feature of Conjunctive use

Ever since collosal ground water exploitation have started, no adequate efforts have been made to maintain the balance between ground water extraction and its recharge which have resulted, progressively lowering of water table even in Indo Gangetic planes which were understood to be comprising of good aquifers for the yield of ground water. Fig.1 shows continuously lowering of water table profile of well in village 'Niwari', Block 'Bangra' of District-Jhansi. This can be assumed as a representative trend of ground water status and behaviour in the region.

The situation of non availability of ground water resource in this southern part of U.P. is more critical, due to non availability of regenerating rivers and excessive surface run off during monsoon periods.

The entire area or sourthern U.P. is facing acute shortage of water. Rainfall infiltration is the main source of ground water recharge. During monsoon period the uneven and complex character of aquifer system leads to saturate superficial fractures in short span resulting into overflowing condition in some places where the thickness of black cotton soil is considerably thick or massive rock exposures are there, negligible recharge to ground water takes place. Thus comparatively deep fractures which are understood to be better and reliable sources of ground water storage receive little recharge due to irregular occurrence and physiographical obstructions. More so happens in areas with scant vegetative cover undulating topography, and impervious texture of surface soil. During dry periods when superficial and perched storage of ground water recedes rapidly followed by extensive pan evaporation, evapo-transpiration and base flows losses the depletion in water levels sharply takes place. As a result, the situation becomes critical regularly in middle of summer or in the year of scant precipitation. Under such circumstances most of the dug wells/ dug cum blast well/blast wells, hand pumps give little discharge or become dry. The entire socio-economic activities in the region are therefore, adversely affected due to abounding water famine in these areas every year, during hot weather conditions.

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The human and vegetative demand of water in the area in such time largely depend upon storage capacity of ground water. Therefore the study and endeavour to make enrichment and regeneration of ground water reservoirs become very essential aspect to promote availability of ground water prosperity of the region..

Artificial Recharge and Watershed Management by Conjuctive use of Ground Water & Surface Water

The year long water availability in drought prone area of southern U.P. is complex. Only ground water is available source to shelter human and vegetative activities but its exploitation is challenging due to poor potential and uneven occurrence.

The plan towards ground water development, which can prove as assured and ultimate resource to combat human and vegetative survival requirements, shall have to be oriented to problems in the region with modified and more scientific parameters based management and exploitation approaches, identified for region to region separately.

The scant vegetative cover, undulating topography, impervious texture of surface soil, heterogeneous structural characteristics of rocks and, scanty and irratic behaviour of rainfall in the area do not allow substantial precipitation to percolate under ground, due to natural inhibitions and prevailing conditions. Consequently major portion of monsoon precipitation runs off into tributaries and *nalas*. It is observed and presumed that not more than 8% of the monsoon precipitation percolates into ground water regime in these areas. Out of this recharge, nearly 60% recedes within short span due to base flows and evapotranspiration losses. The remaining quantity is stored in suitable geological structures, depending upon space, time and water availability for safe yield.

The subsurface storage potential of the area can be increased to large extent by adopting suitable scientific approaches of artificial recharge for each water shed, by adopting Basin Management by conjunctive use methodology. Hence this practice is the only hope for augmenting water availability towards catering human needs and upliftment of economic standards of people and to meet future demands of water in the region.

In the above context systematic delineation of different geological, hydrogeological and geomorphological, structures on micro level is necessary, to identify scientifically conductive and technically productive zones suitable for regeneration and conservation practices. The otherwise wasteful monsoon runoff, which does not touch ground water regime may be arrested by constructing check dams, deepening of ponds etc.as a primary water conservation practice. To increase recharge factor of horizontal permeability may be promoted as it is more than vertical permeability.

In order to take the benefit of horizontal permeability the ponds should be deepened and recharge wells should be constructed at the bed of reservoir ponds. The construction of recharge well in the bed is necessary due to the fact that the bed of reservoirs become impermeable due to sedimentation of fine particles or configuration of granitic rocks in pond bed. (Typical diagram of recharge well is shown in Fig. 2.)

Benefits from Conjuctive use

The rainfall data shows that after two-three years only sufficient precipitation has been received and in remaining years have been scarcity of precipitation to meet the normal demands. More so with increasing population agricultural and socio-economical activities, regeneration and conservation of ground water resources by adopting artificial recharge methods have to be depended upon.

The necessity of conjunctive use is foremost important which can be plannned when there is sufficient precipitation and surface water is stored in ponds, reservoirs which can be used for irrigation etc. and surplus water may be diverted into ground water reservoirs by constructing bored wells at technically suitable points as shown in Fig 3.

The water once stored in ground water reservoirs is not exposed to excessive evaporation, and evapotranspiration losses, which takes place when water is spread on land surface and gradually gets lost. When water is available on surface, it must be used on priority to avoid stagnation, whereas ground water stored may be safely reserved and used in critical periods and demands. The typical schematic lay out of sub basin to be exploited and regenerated by conjunctive use planning is presented in Fig. 4.

By adopting balanced water management practice, the water table can be raised up and controlled to help protect entire ecology, and increase well economics of ground water structures, as the discharge of structures is inversely proportional to depth of water discharge, in controlled situation shall reduce and help in "Energy Conservation Programme". Similarly wear and tear losses of pumps and prime movers can be minimised by controlling water table as operation hours shall be reduced due to availability of more water in less time.

e.g. H.P. required = $\frac{W.H.}{75}$

Discharge $Q \alpha \frac{1}{H}$

where, W = Unit weight of water
H = Depth of water table from ground level

Advantages of Conjunctive use of Surface Water and Ground Water

Resources are shown below in tables

1. Greater water conservation
2. Smaller surface storage.
3. Smaller surface distribution system
4 Smaller drainage system
5. Reduced canal lining.
6. Greater flood control
7. Storage development facilitation
8. Smaller evaporation and evapotranspiration losses
9. Greater control over outflow
10. Improvement of power load and pumping plant use factors.
11. Less danger from failure.
12. Reduction in weed seed distribution.
13. Better timing of water distribution.
14. Greater job opportunities.
15. Better use of money invested in minor irrigation schemes as it will be used on scientifically planned projects.

CONCLUSION

Ground water resource is the only alternative to depend on for sustainable human and vegetative needs; due to its availability near the place of application, and its requirements. Therefore it is most essential to conserve protect and ensure, its balanced utilization.

The resource planning and conservation, proposals discussed in the present paper are to simply generate thoughts about its valuable aspect and essentialities in the minds of people and planners, so that a better future can be foreseen, even during water famines and in difficult areas of human inhabitation.

FIG. 1: WATER TABLE DEPTH CURVE OF WELL NIWARI VILLAGE, BLOCK-BANGRA, DISTRICT JHANSI

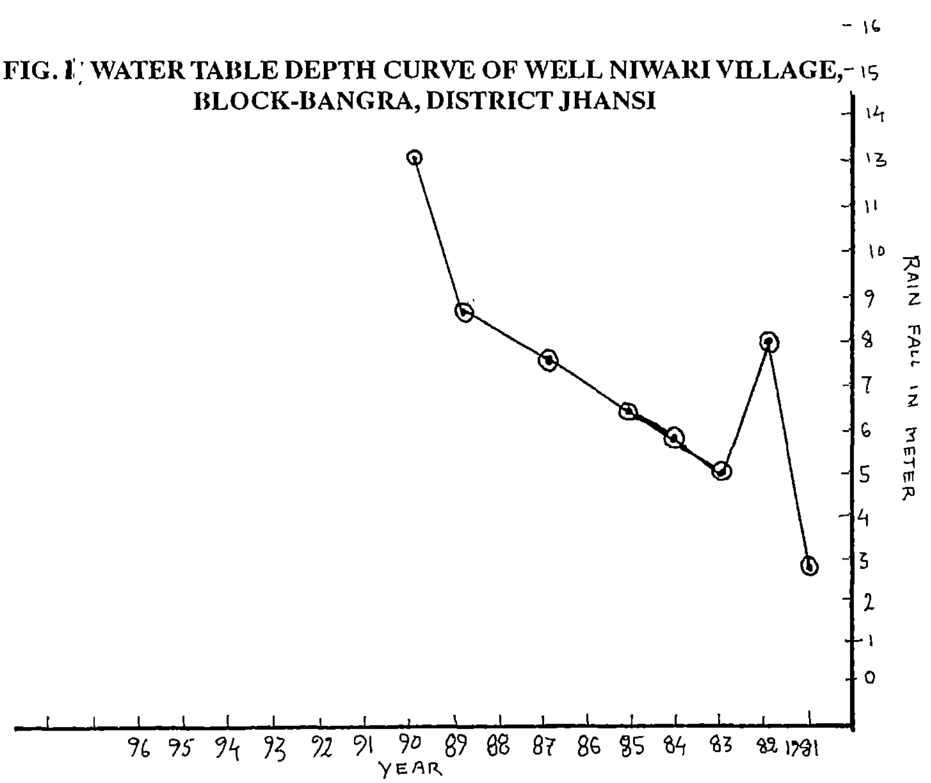


FIG. 2 POND BED RECHARGE WELL

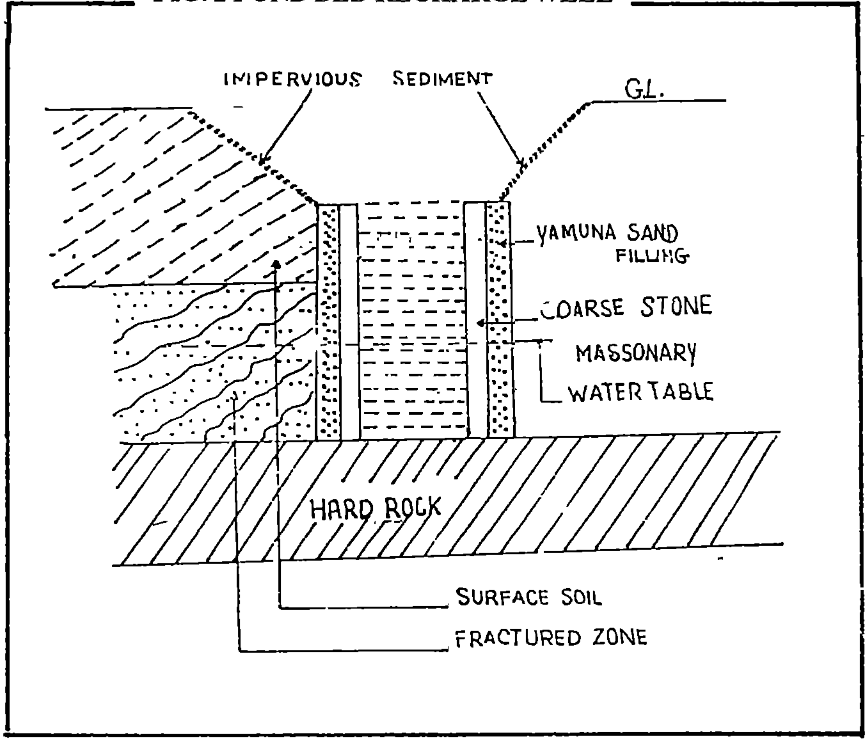
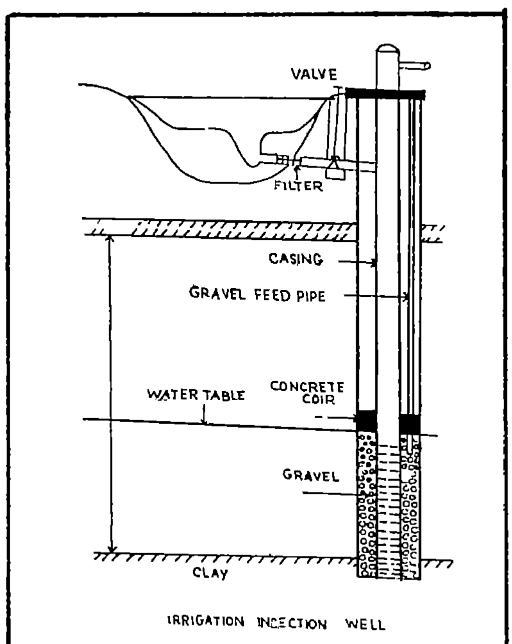


FIG. 3 IRRIGATION TAIL WATER POND



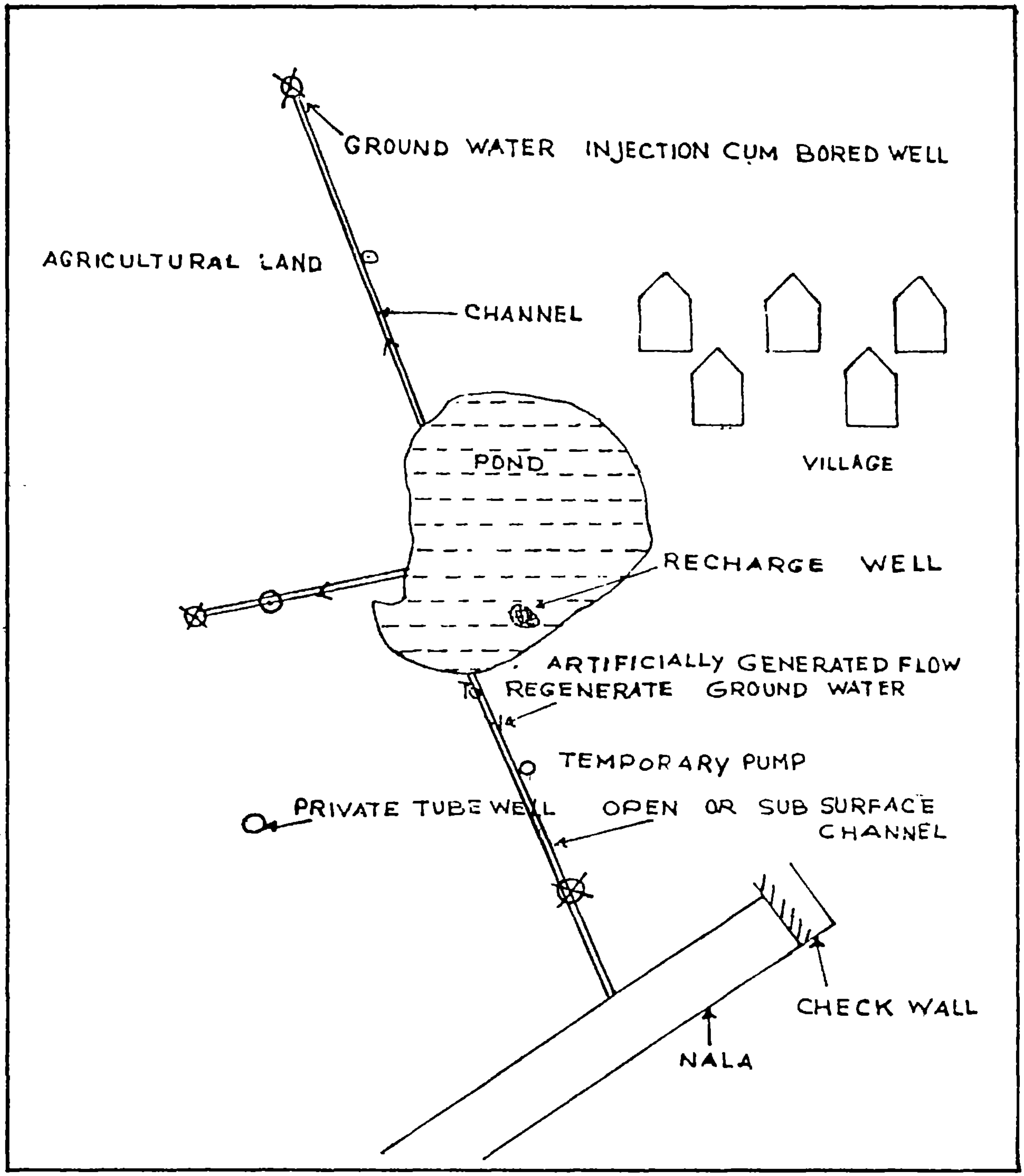


FIG. 4 TYPICAL SKETCH OF SUB BASIN ENVISAGED IN CONJUNCTIVE USE PLANNING

THE ROLE OF TRADITIONAL WATER SOURCES IN SOLVING WATER SCARCITY PROBLEMS

While massive sums of money, including a big share of aid funds, are being used for water resource development and a technology mission to provide relief to scarcity villages has been functioning for several years, large areas of the country continue to face extreme forms of water shortage. In recent times even cases of suicides and *near riots* have been reported from people desperate to draw attention to the shortage of this most basic necessity of life. The signs of desperation are also evident in the fact that special trains have been started just to carry water to some water scarce cities (for instance Dewas in Madhya Pradesh) and possibilities of seriously evacuating entire towns (for instance Raisen, near Bhopal)have been seriously considered as water was not available for their thirsty residents.

Failure of rains is often mentioned as the most important factor in explaining the water scarcity being experienced by a particular area. However, the experience of people of many areas has been that the rivers, streams, springs, wells and tanks in or near their villages now dry up at a much faster pace compared to earlier years. Their ability to withstand the stress of a rain-failure and enable villagers to tide over the dry period has lessened considerably. At other places there is considerable water scarcity even when the rains do not depart from the norm observed over a long period.

The more important question is not whether rain failures have been a little less or a little more in a particular area. The more important question is whether man's ability to withstand these rain failures has been improving or worsening. And for many years, despite all the modern technology and government plans, the ability to withstand rain failures has been decreasing. The reports of acute distress received during the summer season not just from remote villages but also from several towns, even towns located near rivers, bear ample testimony to this dismal trend.

Due to reduced river flow over vast stretches of land as well as deforestation, the recharge of ground water has also been adversely affected and so the possibilities of the use of groundwater for reducing the water scarcity have also been adversely affected. This process has been further aggravated by the neglect of traditional water harvesting methods and irrigation systems based on various types of tanks and other storage structures which for the sake of simplicity may be described here as similar to tanks. Several parts of India, including those who are very adversely affected today by water scarcity, had a very well developed system of tank irrigation in the not too distant past, which, however, suffered badly from neglect and mismanagemnt in colonial times, a mistake that sadly was not remedied even after independence, thanks to the craze for the big dams and other expensive, dazzling projects.

A study of several reports received from various parts of the country experiencing water scarcity in recent years would reveal that the question of the neglect of tanks comes up again and again. Some tanks which provided water to a large number of people have been turned into a dumping ground. There is another familiar pattern in some of these reports. Promise of receiving water from a dam or other spectacular project leads to a neglect of the traditional sources. Later when the new promise proves to be a false one, people find they cannot even go back to the earlier source.

In Manikpur block of Banda district (U.P.) an ambi-

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tious pipelines project based on multistage pumping had at one time held a lot of attraction for people. But the project brought more publicity glitter than actual water to the settlements of the poor people. But in the meanwhile there had been some neglect of tanks and *chohanras*. So deprived of the water from pipelines some people even could not get reasonably clean water from these old sources.

While the neglect of tanks, reduced river flow and deforestation are leading to lesser groundwater recharge in several areas, the availability of modern technology to the rich landowners of these areas has made it possible for them to exploit for private benefit whatever water is still available. They have been opting for water intensive crops even in areas which are known for extreme water scarcity. In the process the risk to water availability for meeting essential needs becomes ever graver. Another factor is that having gained access to these private sources of irrigation for some time these prosperous farmers became less interested in the community efforts to conserve water.

Thus the crisis of water scarcity that exists in vast areas of the country is a man-made crisis from various points of view and it is not helpful to hide this fact behind pretexts of rain-failure. This has always been a part of life but the question is how best we can cope with it. And in this respect we have been guilty of simply too many mistakes despite all the scientific knowledge and technological capabilities at our disposal. The mistakes have just not happened like that; these are a reflection of the various inequalities and distortions that exist in our political economy (the ability of contractors to fell large areas of forests by giving bribes, the ability of industrial interests to create pressures for raising commercial plantations in place of natural forests, the ability of more influential areas to obtain excessive water while starving other areas of basic needs, the power of industrialists to dump water into rivers while ignoring the plea of villagers, the power of big farmers to indulge in intensive irrigation even in areas of water scarcity.)It is not enough to merely give a higher allocation or priority for water resource development in the development plains; the various inequalities and distortions at various levels also have to be confronted with firm hands.

When we examine more specifically why water scarcity is being reported from several villages despite considerable funds having been already spent on providing drinking water facilities there, then the role of these various distortions becomes apparent. This has been confirmed to some extent by a recent experts' committee, and some of its important findings are worth quoting.

On the recharge side things have been worsening not only because of deforestation and soil-erosion but also because of the neglect of traditional water harvesting and storage methods, particularly the wide range of various types of village tanks. Commenting on this aspect, the recent report of EC-RWSP noted "it must be recognised that time-tested water harvesting and conservation structures like *kunds* and *ooranis* represent human ingenuity at its best and embody cultural traits and practices which allowed the local community to survive in water scarce and hostile environments for centuries. Having noted this importance however the expert committee was constrained to admit. "The traditional water supply systems and water harvesting methods seem to have suffered neglect as spot sources have been provided in the villages.This causes concern as it could be safely presumed that with the disappearance of the traditional water harvesting and storage structures also disappeared the traditional water conservation ethos."

Role of Traditional Sources:

Both irrigation and drinking water supply provide a glaring example of neglecting the potential of small-scale (or relatively small scale) village level works for which enormous skills and wisdom were available in India's rural areas. In most parts the bulk of the rain is concentrated within a few weeks, and its capacity to erode soil is generally much higher than in Europe. Therefore a wide range of traditional works have evolved over the centuries aimed at conserving as much water as possible, or diverting water towards fields in a variety of ways, or a combination of these.In many areas as long as these traditional water works were maintained, villagers remained self-reliant in meeting their water needs even in very low rainfall situation.

In some low rainfall parts of Rajasthan, there has been provision for collecting as much rainwater as possible in specially constructed wells called 'kundis'. The catchments of these kundis were specially prepared and protected to conserve the maximum water Elsewhere in the same province even the seepage from tanks was skillfully obtained by simple structures called 'kuis'. In the state of Meghalaya, easily available local bamboos were used to carry water to fields located at a considerable distance from the water source, minimising wastage of water. In several places a well-integrated system of tanks linked to each other existed.

However, these time honoured methods of conservation have been neglected while a lot of attention has been given to extracting as much water as possible through hand pumps and tubewells. These led to a dangerous fall in water table in several places. In parts of west Bengal this has played a significant role in the arsenic poisoning of groundwater. Even more dangerous was the heavy emphasis placed on the construction of large dam projects.

One of the most tragic aspects of the development experience of India during the last two centuries or so has been the neglect and the decay of traditional irrigation systems. This aspects has proved extremely costly in terms of the financial loss, the human misery and longer-term ecological crisis.

Various parts of India had developed highly ingenious and viable irrigation systems suited to their topography and needs. Some of these have been studied in detail and in most cases scholars have been highly impressed by the strength of these systems.

Sir Arthus Cotton, the founder of modern irrigation programmes during the British rule, acknowledged the strength of traditional irrigation works. He wrote in 1874, "There are multitudes of old native works in various parts of India...These are noble works, and show both boldness and engineering talent. They have stood for hundreds of years."

However, Sir cotton also acknowledged the wide-spread contempt that existed in India for new rulers at that time because of their inability even to maintain and existing systems properly, not to speak of extending or strengthening them further. He wrote"when I first arrived in India, the contempt with which the natives justly spoke of us on account of this neglect of material improvement was very striking. They used to say we were a kind of civilised savages, wonderfully expert about fighting, but so inferior to their great men, that we would not even keep in repair the works they had constructed, much less imitate them in extending the systems."

Numerous other scholars have drawn attention to the earlier strength and recent decay of these irrigation systems.

In a paper titled 'Traditional Irrigation System of a tribal area:a case study of the ex-state of Sonepur, P.K. Chhotroy presents evidence to show that in the Sixteenth and Seventeeth centuries there were profilic irrigation works, comprising Katas or tanks, bandhas or percolation tanks constructed below these,small-scale streams, diversion embankments and wells.In the early twentieth century more than 3000 tanks were counted in this small region astride the lower Tel river. However, in later years the traditional irrigation system suffered a significant decline. Prolonged strife and unrest, British revenue policies and collapse of tribal leadership roles are among the important factors held responsible for this.

A report on the tanks of Bundelkhand region, and more specifically on the extensive and admirably well-built tank system of Hamirpur district (U.P.) by Sudhir Jain says that the British were also impressed by this traditional system, specially the Bijanagar tank of Mahoba. Although they made some efforts to collect information about this tank system, the system did not receive proper care during the years of British rule. On the other hand some big new irrigation scheme designed by them in the area proved destructive. In the post-independence period this neglect has continued, and many tanks have been silting up rapidly. Some tank sites are even being used as dumping grounds.

The famous five tanks of Mahoba, inter-connected to each other, continued to provide a living testimony of the ingenuity of their designers even in their state of neglect. Instead of desilting, cleaning and repairing these tanks, the authorities decided to build a new, much bigger tank. However, the ratio of the submergence area to the irrigated area turned out to be much higher for this project, indicating that the old masters had a better appreciation of site-selection, design and other factors which could bring more benefits at less cost.

Tragically the authorities also decided to link their new creation to the old integrated system of five tanks This proved disastrous, and as the existing system based on long-term experience of water inflows broke down, there was a big flood in one of the five tanks-keerat sagar in 1978. Its walls were breached, and there was a lot of destruction.

In his paper water management in areas irrigated by tanks' S.T. Somashekhara has described how local participation and decision making concerning, the example, the distribution of water and the timing of irrigation played a crucial role in the efficiency of traditional tank irrigation of Karnataka. In later years when various aspects of management were taken over by government experts or local bodies, tanks were neglected.

In his paper on the Phad system of irrigation in Maharashtra R.K.Patil shows that while small scale irrigation systems in the Tapi tributaries in Khandesh may have been built by medieval rulers or local leaders, management of the water by the beneficiaries themselves was an essential component of irrigation. So also was the local maintenance of irrigation channels.

In Malwa region of Madhya Pradesh water table is not suitable for large-scale extraction of water by tube wells but this is the path several rich landowners have chosen in recent years. Apart from the longer-term water crisis this may cause, this has also temporarily reduced the dependence on tanks of richer and influential persons. Thus the community effort necessary for the maintenance of tanks has been weakened.Such trends of short-term private gain causing long term social loss have been reported from other parts as well.

Anantpur district of Andhra Pradesh had a reliable supply of tank irrigation based on 2500 tanks in 934 villages. But in more recent years, a research paper points out (quoted in the Deccan Herald), "The series of droughts on the one hand and the Govt. policy of giving preference to anything large appear to have led to the breakdown of the tank system through sustained neglect."

In a recent report on Kalahandi district (Orissa). (Economic and Political Weekly November 2, 1988) Hutasan Purohit, R.S.Rao and P.K.Tripathi write, "As late as 1959, the composition of irrigation in the district showed that about 77 per cent of the area irrigated was by tanks. By the year, 1976-77 the area irrigated by tanks had declined to 28 per cent while canals contributed to as much as 53 percent. The shift in the structure of irrigation is due not to a net addition by canals but due to the decline in the area irrigated by tanks. Tanks irrigated about 40000 hectares in 1960-61 whereas by 1976-77 this area had declined to 7481 hectares. The total area under irrigation also declined from 52000 ha. to about 26312 ha."

Similarly the area under wells declined from 3642 ha. to 1681 ha during the same period.

The authors of this report conclude "Thus the two processes one the modern irrigation system replacing the traditional forms instead of supplementing them and two, the derelict condition of the traditional forms of irrigation have combined to knock out whatever internal insurance measures the society had developed over centuries of struggle with nature."

Among the various scholars who have studied carefully the traditional irrigation system, one of the most valuable works has been done by Nirmal Sengupta. His widely discussed paper 'Irrigation-Traditional vs. Modern' is a fine example of careful and clear-headed study of several types of traditional irrigation which is related also to present day debates and development tasks.

Describing anicuts he writes 'Infact anicuts are the names popularly reserved for controlling of major rivers though the same technique is used for diverting small rivers, even field channels. Anicuts differ from the inundation canals in that the latter do not have any controlling work in the bed of the rivers. The anicuts consist of weirs but no storage facility in the river beds, a feature common to many modern multipurpose projects."

This device is of particular use in foothills. In the foothill regions, where the land is relatively flat but still retains sufficient slope for the water to flow, a weir erected on the bed of a river or a channel does not merely obstruct the flow but also helps its level to rise gradually. The level may be raised sufficiently to divert those to distributaries or to irrigable fields, which are often above the normal water levels in the channels. The technique thus uses ingeniously gravity flow for lifting of water, thus saving much effort.

The weirs are temporary, and are removed after the purpose is met, thus allowing the normal flow to resume.

More or less similar methods are followed in different parts of the country under different names"The abundance of such diversion techniques was found in the eastern coast of the peninsula, in Tamil Nadu and Andhra Pradesh followed by South Gangetic Bihar where Chotanagpur plateau gradually descends to the level of Ganga. The channels are known as Kalvai in South and as pynes in Bihar. In the West Coast these are known as bandharas. Along the Himalayas the technique is used, with channel construction as more complex operation from Himachal Pradesh through Nepal to Cachar hills."

Describing another - a related traditional irrigation work Sengupta continues,

"But why should one be on the look out for a natural stream? In such a sloping country the run-off water itself before it meets a drainage stream can be appropriated. The topographical conditions permit throwing of an embankment along the slope of the country to retain the run off water after precipitation. These are the so-called 'tanks' though the name is misleading. Essentially these are three sided reservoirs with one side (the high side) open for run-off water to enter. Unlike the regular tanks these are not dug out but consist of elevated embankments over the surface and thus facilitate gravity flow instead of requiring lifting for irrigation."

These irrigation works may appear crude but a careful study would reveal that crude 'Eries' "often formed such interconnected chains that every bit of run-off water flowing through vast land-scapes were appropriated for irrigation, every bit of surplus water from one level reached another requiring water for irrigation."

The 'Eries' are generally small, irrigating 20 to 50 ha. each, although very big 'Eries' are also known to exist. Tamil Nadu alone has 38000 Eries. Andhra Pradesh and Bihar are other leading states in irrigation by Eries. The total number of Eries in the country may be about 2 lakh (one lakh One hundred thousand).

The work of Nirmal Sengupta which reveals the big potential of 'pynes' and 'Ahars' in South Bihar has immediate relevance in the debates going on in this region on the relevance of the large dam projects like the Suvarnarekha project and the Auranga Project. These projects will cause massive displacement of people and one of the important arguments against some of these projects has been that the sort of canal irrigation sought to be provided by these projects is not really suitable for the topography of this area, while on the other hand there is a big potential for smaller schemes on rivers and streams. According to M.Von Oppen and K.V.Subha Rao, writing in their paper 'Tank irrigation in semi-arid tropical India' (1980), 3.6 million hectares is still irrigated by tanks., Nirmal Sengupta thinks that in view of some tank area which has been left out in this estimate, the actual tank irrigated areas will be closer to 4.5 million hectares.

The lessons of this study of Nirmal Sengupta (and of similar work by some other scholars) is clear-in trying to provide irrigation to water starved crops, our modern irrigation planners cannot afford to neglect the accumulated wisdom of centuries reflected in traditional irrigation works. It is by further building on them, extending their work that they can best hope to succeed, not by negating or ignoring them.

Several years after, Sir Cotton succeeded in implementing a plan (based on indigenous technology) for the renovation of the Grand Anicut on river Cauvery, he wrote "....it was from them (the native Indians) we learnt how to secure a foundation in loose sand of unmeasured depth,. In fact, what we learnt from them made the difference betweeen financial success and failure, for the Madras river irrigation executed by our engineers have been from the first the greatest financial successes of any engineering works in the world, solely because we learnt from them...With this lesson about foundation we built bridges, weirs, acqueducts, and every kind of hydraulic work...we are thus deeply indebted to the native engineers."

Do we need to say more on the need to learn from traditional irrigation?

SOLVING WATER PROBLEM OF BUNDELKHAND - SUGGESTIONS

1. Introduction

Fresh water is essential for sustenance of life-human, animal and plant About 65% of the humanbody is water. 5% of it is to be replaced everyday. Large deficiencies of the order of 15% can prove fatal. Therefore any society should give the highest priority to "Drinking Water". About 70% of our people live in rural areas, where domestic water supply cannot be centralised as in the urban areas. The growing population is significantly adding to the difficulties in the supply of drinking water to the rural areas. A hundred years ago the population of the Indian Sub Continent (i.e. the present India, Pakistan and Bangladesh) was only about 280 million. Today we alone have a population of nearly 900 million and it is expected to stabilize at the 1000 million level by 2010 A.D.

In spite of Rajiv Gandhi National Drinking Water Mission, all our villages do not yet have arrangements for an adequate drinking water supply. Over India as a whole 22,000 villages and one lakh habitations have been identified as "non-source" category, and around 2 lakh villages and 2.3 lakh habitations as "partially covered" category. I do not know what fraction of these problem villages and habitations belong to the Bundelkhand area.

Besides the needs of free water for drinking and other domestic purposes, large quantities are needed for agricultural production of food and for the industrial production of consumer goods. For India as a whole, drinking water need represents only 5% of the total need. I believe that this ratio holds good for the Bundelkhand area also.

As for most of the areas in India, Bundelkhand area also has a water scarcity problem for domestic, agricultural and industrial uses.

2. The Root of the Problem

For the solution of any problem we must first understand the root of the problem. The characteristics of our rainfall- the only renewable water supply, are such that the water managment here requires much innovative and different skills compared to the managment of water in the middle latitude countries like England, where the characteristics of rainfall are different.

Here we are concerned with the Bundelkhand area.

The annual rainfall of this area is about 95 cms. Of this, nearly 85 cms falls in about 40 effective rainy days (rainfall equal to or more than 2.5 mm in a day), distributed within the four months June to September - the Monsoon season. The remaining 10 cms fall in another 6 days distributed within the remaining eight months, some of them with no rain at all.

On the other hand, the mean annual rainfall over London is only 60 cms. It is distributed fairly uniformly over the twelve months; each month there are 8 to 11 days of rainfall or snowfall, the total number of days of precipitation being on an average 107 per year.

The other important characteristics of Bundelkhand rainfall, is its considerably higher intensity. Half the total monsoon rainfall amount, falls in heavy spells, whose total duration is only about 20 hours distributed during the four months. On these occasion the rainfall intensity is 3 to 5 cms per hour, each spell lasting for 15 minutes to half-an-hour. The rainwater has no time to penetrate into the soil and recharge ground water. The rainwater during these spells practically flows off the ground, filling drains and water course with temporary currents causing damaging floods, and is finally lost to Bundelkhand.

Worse still, is the soil erosion and the carrying away of the fertile top soil by the flood water.

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The high soil erosion is caused by the large kinetic energy of the rain drops, a thousand to two thousand time that of the rain drops encountered in England. The medium size of the Indian raindrops encountered during the heavy monsoon spells, is 2 to 3 millimetres in diameter. the medium size of the raindrops encountered in England is only 0.6 mm in diameter.

Thus although the Bundelkhand area has good rainfall, about 60% of it runs out of the area, during the monsoon months when about 90% of the annual rainfall occurs. During the remaining eight months, only 10 cms of rain fall, with a few months being rainless.

3. The solution of the water scarcity problem is conservation of the rainwater, which is the only renewable water source for this area not watered by any snow-bed rivers, outside it.

No rain water should be allowed to flow out of Bundelkhand. This can be achieved only through a full cooperation of the people at the grass root level. The people should be involved in Rain-water Harvesting employing various kinds of innovative methods.

Once water gets into rivers only 30% of it can be made use of. The Hydraulic Engineers are vociferous about building big dams. The constraint is caused by our *orography*. Therefore, our water harvesting methods should not allow rainwater to get into river channels. Once people become aware of this objective, they will innovate and put in efforts to achieve it.

Our ancients prayed :
श नो खनित्रामा आप
शमया कुमाभृता
शिवा न सन्तु वार्षिकी
May the Water from wells give us prosperity
May the stored water give us prosperity
May the rainwater give us prosperity

(Atharva Veda.)

If the wells should have water, recharge of ground water must be ensured. Before the introduction of diesel or electricity for pumping ground water we had accumulated a large quantity of ground water. But now we have pumped out all the underground stored water and can pump only the annual recharge. As mentioned earlier, the great intensity of our rainfall, the percolation into ground and the natural recharge of ground water is inadequate. We must adopt artificially enhanced percolation methods like pumping surface water in rivers or talabs into deep "recharge" wells.

Since a large fraction of our rainfall is in the form of heavy spells, the riverine reservoirs constructed by dams across rivers, utilise less than 20% of the river flows. The rest of the river flow during the floods has to be let off via large spillway for saving the dam.

Therefore, India has to resort to surface storage of water in numerous small ponds, and in less numerous large "talabs". Unfortunately many of the old water ponds and talabs have been filled up either due to want of proper upkeep, or due to pressure of population requiring more houses for living. People feeling water scarcity should locate those surface water storages and renovate them, as well as dig new ones. These tables would significantly help in the recharging of ground water.

4. Water Harvesting Systems

Some of the water harvesting methods, ancient and modern are indicated in what follows :

(i) Contour bunding on gently sloping terrain.

This is necessarily a village level system based on cooperation between adjacent farmers. The rainwater that falls on the land of A, is primarily useful to B whose lands are just lower to the land of A.

(ii) Under ground checkbunds which prevent flow of underground water into river channels during rainy as well as non-rainy months.

(iii) Construction of a large number of water ponds, three to four in each village, each of the ponds being at least 8 meters deep. The surface area of each pond can vary from a tenth of a hectare to one or two hectares. They should be so located that each has a catchment area fifty to hundred times its surface area. A depth of 8 meters at least is necessary, since the average evaporation over the Bundelkhand area is two to three metres of water per year. As mentioned earlier, water from some of these tanks can be pumped into deep wells as a method of recharging ground water.

(iv) Individual houses or housing complexes should have underground, cement lined "reservoirs" into which the rain water falling on the roofs of the buildings and the open spaces around them can be led through suitable closed pipes or channels.

(v) Shallow broad area percolation tanks.

Due to the heaviness of our rainfall, it is less penetrating in proportion to quantity than in those countries where much of it falls in a state of fine division. The rate of penetration over Bundelkhand area is likely to be 10 to 15 percent of the monsoon rainfalls. Hence the need for special efforts to increase the ground water recharge.

(vi) It will be useful if water in the river courses are pumped into deep wells a kilometre or so away from the river channels. Small check dams across the river would provide small pools from which the water can be pumped.

(vii) Individual farmers should be encouraged and guided to prevent rainwater falling on their farms flowing out of their farms. This can be done by digging numerous narrow channels - 15 metre long, 15 cm deep and 15 cm broad within the farm wherever possible. A bund of a metre height all along the bound will also prevent any outflow. In a week's time all that rainwater which accumulates would seep into the ground. This arrangement would also prevent soil erosion, the loosened soil will settle in sites.

Later on, during the non-rainy season the owner of the land can lift the water from wells dug in the area.

(viii) Recently another innovative methods of conserving water has been suggested. The bund's around the individual plots of crop land are formed over hollow bamboo pipes with side holes. When the plots are full of water, the bamboo pipes get filled. The water in the pipes leak out into the farm during non-raining period.

As mentioned earlier, all these water harvesting actions have to be carried out by the people mostly on a "Shram-dan" basis for their own and their neighbour's benefits. Governmental and non-governmental organisations can only provide guidance. Much financial support from them cannot be expected.

I wish and hope that the people would rise up to the occasion and solve their water scarcity problems through innovation and self-help.

MANGAL TURBINE (WATER WHEEL)

(An Example of People's Innovation)

Bundelkhand is endowed with nature's bounties in terms of large number of riverlets, streams, perennial Nallahas etc. Farmers generally lift water from these water sources for irrigation by installing diesel/electrical pumps at the site itself. Obviously, this system requires commercial energy and expertise for its maintenance. Specialists have to be called from the nearby town. Mangal Singh, a farmer of village Bhailoni lodh (distt. Lalitpur) realised the problems associated with these irrigation systems and thought of a situation where pump can be operated using the energy of flowing water itself. He started working on this concept and suceeded in inventing an efficient, simple and low-cost turbine i.e. water wheel.

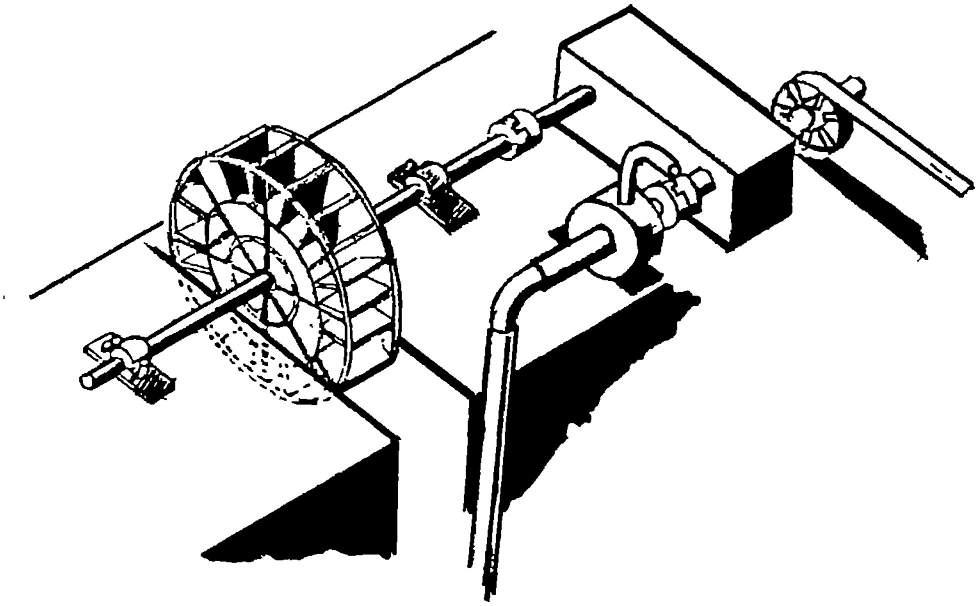
The concept of Mangal Turbine is somewhat similar to that of chinese water wheel, the major differnce being that Mangal Turbine requires very low water head compared to the chinese and other turbines which require a larger water head. A water-head of even one metre or less is sufficient for the Mangal Turbine. Most significant aspect is that the entire system designed by Mangal Singh is easily fabricated in the village itself, using available material and local workmanship.

Besides, it requires minimal maintenance as compared to other types, expertise for maintenance is available in the village itself.

To experiment with his ideas, Mangal Singh, got a wooden water wheel of 2 meter diameter fabricated with 12 blades. Blades are nothing but flat slabs of wood radially fixed to the rim. Later, these were fabricated using iron sheets. To the shaft was coupled a pump through a gear box of ratio 1:120 to increase the speed to 1500 - 1800 rpm. This pump was earlier driven by a diesel operated motor. The results were amazing. Performance as a pumping system was excellent. Using his engineering skills (though he had no formal training in engineering), Mangal Singh coupled a sugar cane crushar to the main shaft using a belt drive. Simultaneously, both water pumping and crushing could also be done. Simi-

A view of Mangal Turbine

Santosh, Yashpal Singh and Parthasarthy, IIT, Delhi



Mangal water wheel turbine pump-cum-power take off machine

larly, the energy generated could be used for running a grain thresher, grinder etc. He uses this energy for operating the machines. tools of a local workshop. Effectively water wheel becomes a source of rotational energy which can be used for any purpose.

In fact the design of Mangal turbine is very simple and can be operated by opening the wooden or steel gate valve of the check dam. The low water head can be easily obtained from this check dam. It is heartening that now-a-days 2 such units have been installed by Mangal Singh in his village fulfilling the irrigation demand of the agricultural land of the entire village. This has resulted in increased crop productivity. Installation, operation and maintenance cost is very little as compared to other types of turbines.

Thus, Mangal turbine would prove a boon for fullfilling the energy need of irrigation, agro processing etc. in the rural sector wherever low water head exists in the rivers/Nallah. The approximate manufacturing cost of one unit of turbine is 1.8 lacs. Preliminary study of this system conducted by IIT personnel has indicated that its efficiency can be further improved by using some modern scientific-technical inputs.

Considering 500 suitable hydrosites in one district of Bundelkhand, for installing Mangal turbine, it is estimated that by using this sytem, about 25 MW energy can be easily generated. On an average two turbines on one site have the potential to irrigate 200 hectares of land. Thus total command area of 500 hydro-sites would be 0.1 million hectare.

PEOPLE'S PARTICIPATION IN WATER MANAGEMENT IN HAMIRPUR DISTRICT

Hamirpur district situated between 25°-26° latitude and 79.5-80.5' longitude has several important rivers like Yamuna, Betwa, Ken, Dhasan, Chandrawal and Birma which have catchment area 250, 1500, 400, 600, 1500 and 200 sq.km respectively. Water level of most of these rivers is too low to construct major canals. The small streams carry a little water during major part of the year, but during the rainy season a considerable area sometimes comes within the reach of their destructive catchment. Besides these rivers, the district has five lakes viz. Belatal. Vijaisagar. Madansagar. Kiratsagar, Kalyan Sagar and many big ponds and tanks situated near Charkhari and Mahoba. District has not any major irrigation project. Presently 4 medium irrigation projects and 12 Minor pump Canal projects are in operation. The details of these projects are given in table 1 and 2. These tables show that 4 medium and 12 minor projects together have 105.29 thousand hectares irrigation potential.

Ground Water

Major part of the district lying south covering parts of Panwari, Kulpahar, Charkharl, Mahoba and Kabrai is rocky where installation of public or private tubewell is very costly and difficult task, the findings of the geohydrological survey of the district indicate that in only a part of the whole district, alluvium area is suitable for exploration and drilling which lies in the belt of river Yamuna and Betwa. Blockwise water availability and its net draft in hectare metre are given in the table 3. This shows that only 21% of new recharge has been drafted so far. According to ground water engineer this percentage can be raised up to 65%. This shows there is further scope of development of ground water in the district. For this, huge investment in irrigation infrastructure is required.

Irrigation Facilities :

Block-wise net irrigated area by different sources in the district is given in table 4. Out of the net cropped area 5.09 lakh hectares, the net irrigated area is 1.48 lakh hectares which is about 29%. Rath block has largest irrigated area (53.01%) followed by Jaitpur (47.6%). Gohand (44.92%) and Panwari (41.56%). In the District. Canals which are 975 km. in length irrigating an area of about 0.78 lakh hectares, are the main source of irrigation which cover about 53% of the net irrigated area. State tubewells which are 495

Table 1 - Medium Irrigation Projects

S.No.	Name of the Project	Year of sanction	Estimated cost (In Rs. Lakhs)	Irrigation Potential (In 000 ha)
1.	Maudaha dam on Birma	1975	3744.00	27:70
2.	Urmil Dam on Urmil	1978	2945.15	4.77
3	Lachura Dam on Dhasan	1955-56	2877.00	10.76
4.	Chandrawal Dam on Chandrawal river	1962	90.00	43.10

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Table 2 Pump Canal Project in Hamirpur					
S.N.	Name of Project	Block	Estimated cost (Rs. Lacs)	Irrigation Potential (ha)	Discharge capacity (Cusec)
1.	Bilota Pump canal on Yamuna river	Kurara	6.00	923.00	22.50
2.	Baijemau (south) pump canal on Ken river	Maudaha	13.03	1600.00	20.00
3.	Baijemau pump canal on Ken river	Maudaha	12.40	1884.00	30.00
4.	Bholi pump canal on Yamuna river	Kurara	7.62	1275.00	35.00
5.	Rameri chain pump canal on Betwa	Kurara	5.00	376.00	7.50
6.	Merapur chain pump canal on Yamuna	Kurara	5.00	397.00	10.00
7.	Pateora pump canal on Yamuna	Sumerpur	38.53	2400.00	60.00
8.	Surauli Buzurg pump canal on Yamuna	Sumerpur	29.69	80.00	2.50
9.	Shajane pump canal on Betwa	Sumerpur	23.44	1262.00	13.00
10.	Surapur pump canal on Betwa	Sumerpur	46.60	2500.00	80.00
11.	Kamiha pump canal on Dahasan	Jaitpur	22.20	2437.00	-
12.	Chani pump canal	Sumerpur	-	3825.00	100.00

Table : 3 Ground Water Availability in Hamirpur District (Block-wise)					
S.No.	Block	Net recharge (ham.)	New draft (ham.)	Balance	%of Net draft to net recharge
1.	Kurara	7587.44	1248.06	6339.38	16.44
2.	Sumerpur	10226.51	3320.41	6906.10	32.47
3.	Maudaha	10826.73	2049.32	8777.41	18.93
4.	Muskara	7527.68	1053.78	6473.90	13.99
5.	Charkhari	7058.43	585.23	6473 20	8.29
6.	Panwari	4899.94	1503.53	3396.41	30 68
7.	Kabrai	6746.85	2023.67	4723.18	29.99
8.	Jaitpur	4430.96	1569.72	2861.24	35.42
9.	Sareela	8738.61	1474.97	7263.64	16.87
10.	Gohand	6498.95	1082.27	5416.80	16.65
11.	Rath	7146.87	1593.48	5553.39	22 29
	Total	81688.97	17504.44	64184.65	21.43

Source - Ground Water Department Division, Hamirpur in number irrigate about 9.4% of net irrigated area. The same area is irrigated by private tubewells. Masonry wells account for 18.81% and rest is irrigated by other sources like ponds and tanks. The large ponds exist mostly in Charkhari and Mahoba. Out of these 6 ponds are being used for irrigation by canals and from rest, water is being lifted by pumping set.

People's Participation in Irrigation Management
A. Canal Irrigation Management :

Managing the canal is a difficult task. Use of excess water through diversion and unauthorised cuttings at the head reach and inadequate and untimely availability of water at the tail-end is the general problem of canal irrigation. The excess use of water has far reaching implication not only from users' point of view but also from ecological point of view. Excess irrigation leads to the leaching of plant nutrients, increases water logging and soil salinity problems and ultimately results in the loss in per hectare yield of crops. Wastage of water during the course of its transit from outlet to the field due to lack of proper maintenance.and supervision of field channels and wastage due to over irrigation are some of the deficiencies to be rectified by Panchayats at village level.

At persent district has 4 medium and 12 minor pump Canal projects with 105 thousand hectares irrigation potential but the actual area irrigated by these projects is much below the potential level due to lack of proper maintenance and management. (Table-3). The actual irrigated area may be augmented with the existing facilities through better management of these projects. PRIs may play vital role in this regard. Thus, the three tier system of Panchayat may motivate farmers to manage these projects for equitable and efficient

Table 4. Block-wise Net irrigated Area by Different sources in Hamirpur District (Year 1992-93)

S.N.	Block	NSA	NLA	%of NIA to NSA (ha)	Canal (ha) (cusec)	Area under GTW (ha)	PTW (ha)	Masonry (ha)	Other (ha)
1	Kurara	31660	6981	22.05	3137	3356	371	67	50
					(44.94)	(48.07)	(5.31)	(0.96)	(0 72)
2.	Sumerpur	48673	12860	26.42	2620	4955	4786	194	305
					(20 37)	(38 53)	(37.22)	(1 51)	(2 37)
3	Sareela	36474	6113	16.76	9997	2408	694	1271	743
					(16.31)	(39.39)	(11.35)	(20 79)	(12 15)
4.	Gohand	39067	17548	44 92	9623	557	685	6217	466
					(54 84)	(3.17)	(3.90)	(35.43)	(2.66)
5	Rath	30595	16217	53.01	13318	69	2511	-	319
					(82.12)	(0 43)	(15.48)	-	(1.97)
6	Panwari	44716	18585	41 55	11095	-	173	4628	2689
					(59.70)	-	(0.93)	(24.90)	(14.47)
7.	Charkhari	58597	9114	15.55	5202	55	33	844	2980
					(57 08)	(0.60)	(0 36)	(9.26)	(32 70)
8.	Muskara	38564	11692	30.32	9099	320	1412	428	433
					(77 82)	(2.74)	(12.08)	(3 66)	(3.70)
9	Maudaha	79262	12412	15.66	5881	2138	2963	354	1076
					(47.48)	(17.23)	(23.87)	(2.85)	(8.67)
10.	Jaitpur	36535	9114	15.55	8334	-	-	6882	2178
					(47 91)	-	-	(39 57)	(12.52)
11	Kabrai	64747	18917	29 22	8349	27	209	6923	3409
					(44 13)	(0.14)	(1 10)	(36 60)	(18 02)
	Total	508890	147833	29.05	77655	13885	13837	27808	14648
					(50.53)	(9 39)	(9 36)	(18.81)	(9 91)

Sources Compiled from District Statistical Hand Book, Hamirpur
Note Figures in Parentheses are percentages to net sown area.

distribution of water through rotational basis. Our National water policy (1987) and Hanumanta Rao Committee (1994) on DPAP and DDP also highlighted the need of people's involvement in the irrigation management. In the words of National Water policy :

"Efforts should be made to involve farmers progressively in various aspects of management of irrigation system, particularly in water distribution and collection of water rates. Assistance of Voluntary Agencies should be enlisted in education of the farmers in efficient use and water management".

B. Tubewell Irrigation Management :

Ground water schemes owned and operated by the government are not working well while privately owned tubewell is comparatively better managed. Private tubewells actually have no management problems except the problem of electricity and diesel. But the performance of public tubewells is very dismal. The Tubewell Area Management Committee (TAMC) supervises water distribution and also settles the disputes, but it is not working well. The meetings of TAMC are hardly held, farmers do not maintain irrigation system and complaints of farmers are only occasionally attended by the irrigation staff.

There are 495 public tubewells of 1.2 cusec discharge capacity in the district. On the basis of 100 hectare command area of one tubewell, total irrigation potential of these tubewells is worked out to be 49,500 hectares but according to the latest available information net irrigated area by these tubewells is only 13,885 hectares. The average area irrigated by a tubewell is only 29 hectares which is much below the targeted area of 100 hectares. The reason of low irrigated area is inadequate availability of power, poor maintenance and absence of timely repairs of motor pumps etc. To enhance the actual irrigated area of these tubewells, farmers' participation in the management of these tubewells may be the best option because people's involvement in lift irrigation is found productive in the area where it has been attempted. Community tubewells in East U.P. and Salunke's Pani Panchayat in Maharashtra are the examples of successful participation.

Panchayat, particularly at the lower tier can play a strategic role in tubewell irrigation management. As minor irrigation is given in the XIth Schedule, adequate funds and powers will be devolved to the Panchayats to manage the public tubewells and encourage the installation of private tubewells in the canal command to augment the water certainty. The funds earmarked for water management may be utilised in maintaining field channels. Panchayat may also keep eyes on the Electricity staff for adequate supply of power as rural electrification is also the subject of Panchayats. They may also encourage the small and marginal farmers for installation of tubewells on cooperative basis. Panchayats may constitute water users committee at tubewell level which may look after all the matter related to water distribution, water disputes and maintenance of field channels etc. Kshetra Panachayat, may form block level committee which may settle the matter related to the mechanical, civil and hydel defects of tubewells, installation of new tubewells and solving electricity problem etc. Similarly district level committee (DLC) may be formed which may deal with the matter related to development of ground water irrigation without depleting the water tables. Besides it, district level committee may make perspective plan for minor irrigation development in the district

C. Watershed Management :

Watershed is a geohydrological unit of an area that drains at a common point. It requires contour bunding, broadbed and furrow system, land shaping, water harvesting structure such as *Nala*-bunding and soil conservation structure. In this regard.the whole process of planning, execution and sharing of projects can be done through support of farmers in which panchayats can play a significant role.

The Watershed development programme is being operated in 5 development blocks of the district viz. Sumerpur. Maudaha, Kabrali, Charkhari and Sareela. These blocks come under DPAP of government of India. The whole of the drought prone area of the district falls in the two major watershed viz. watershed of Chandrawal and watershed of Betwa. Sumerpur, Maudaha, Kabrai and Charkhari blocks are the part of Chandrawal watershed whereas Sarila forms the part of Betwa watershed. Further, the watershed of Chandrawal has been divided in to two sub-watersheds. First being Chandrawal upper catchment comprising the block Sumerpur and Maudaha and the second lower Chandrawal catchment with the block Kabrai and Charkhari. In the Betwa watershed, the sub Watershed of Padwar *Nala* stands which covers the part of Sarila. Block. The following Micro Watershed Areas have been selected for the watershed development project in the district.

TABLE: 5

S.No.	Block	Micro watershed area
1	Sumerpur	Karoran *Nala*
2.	Maudaha	Shyam *Nala*
3.	Kabrai	Mangaria *Nala*, Shyam *Nala*, Imilia *Nala* and Chandrawal *Nala*.
4	Chaikhari	Chandrawal *Nala*.
5.	Saiila	Padwar *Nala*, Vamaraha *Nala*.

In the financial year 1994-95, 10 check dams with estimated cost of Rs 53.93 lakh were proposed to be built on Karoran *Nala*, Chandrawal *Nala*, Magarla *Nala* and Shyam *Nala* which would irrigate 529 hectares area and create 54,100 mandays of employment It was, no doubt, an ambitious programme with basic objective to improve the economic condition of the people of drought prone area. It has minimised the impact of drought, increased the income and employment opportunities and facilitated the restoration of ecological balance in these blocks. However, for better results of these projects total participation of the beneficiaries in the maintenance and development of watersheds is essential.

Hanumanta Rao committee (1994) also recommends the involvement of Panchayats in watershed management. It recommends that Panchayats should constitute Watershed DevelopmentAdvisory Committee (WDAC), Watershed Development Team, (WDT) Watershed Association (WA) and Watershed Committee (WC) etc. WDAC may be constituted under the chairmanship of chief executive officer of district Panchayat/Project Director of DRDA consisting 3 or 4 members from District Panchayat. 5 or 6 from Voluntary Agencies/Project Implementing Agencies and 1 or 2 from research institution of the district. WDT shall consist of 10 members of whom at least 5 shall be women. WA shall be a registered body consisting all members of Gram Sabha where watershed project is being implemented. Watershed association shall constitute watershed committee to carry routine activities of the watershed development project This Committee consists 10-12 members nominated by WA on rotational basis from among the users group (4-5) Self help group (3-4) gram Panchayat (2-3) and a member of WDT. To make the people's Participation effective, the Rao Committee also recommends that 5% of the cost of investment for community work and 10% for individual work shall be contributed by the beneficiaries (Community/individual) to the watershed Development fund.

Panchayat may be the most important institutions to involve people in watershed management. They can involve farmers in contour bunding, land levelling and shaping, water harvesting structure such as channel construction, soil conservation, afforestation, pasture development, horticulture and other land based activities. The lower tier may constituteWatershed Panchayat at the village level. Watershed Panchayat may help in collecting the rain water in Nalas by constructing checkdam and then distribute among the members of the users group on rotational basis.

Conclusion :

Water is a scarce and precious resource to be planned, developed, conserved and managed on an integrated and environmentally sound basis. The large gap between irrigation potential created in the district and its utilisation indicated the mismanagement of the water resource which needs to be rectified with the participation of users group, voluntary agencies and irrigation staff. Panchayati Raj Act 1993, which has entrusted more power and responsibilities to the Panchayat for undertaking development works listed in the XI schedule, may be the land mark in involving people in irrigation and water management. Now, all the rural development funds will be routed through PRIs and Panchayats have been given the power of planning, sanctioning, execution and monitoring of minor irrigation projects, they can implement new plans based on latest water harvesting technology like sprinkler and **Drip irrigation in the district.** For that, proper training of Panachayats representatives and farmers who are directly involved in the irrigation management in the capacity of members of different irrigation committees, should be given. In certain training programmes a composite group of trainees of irrigation staff and farmers representatives should be included as trainees so that farmers and officials both can understand the view point of each other. However, the success of the irrigation management programme will depend on adequacy of funds, positive attitudes of irrigation staff and above all how efficiently the funds are utilised. Hope for the better future lies in the effective participation of the people, positive response of the government staff and political will to devolve adequate powers and responsibilities to Panchayats to make them the real institutions of decentralised governance and planning.

INCIDENCE OF GROUND WATER POLLUTION DUE TO NITRATE AND FLUORIDE IN BUNDELKHAND AREA (U.P.)

Introduction

Water is one of the essential natural resources responsible for the existence and development of life and vegetation on the earth. Surface water and ground water are the only major sources to meet out the entire requirement. Water being a good natural solvent, it dissolves out double organic and inorganic substances when brought in contact during the course of its flow on the surface and sub surface. With the advancement of science, the merits and demerits of various dissolved ions of the water has come into knowledge and are responsible for the gradation of its suitability for various uses. Nitrate and fluoride are the major and minor dissolved constituents of natural water.

Nitrate is the ultimate stable form of nitrogen. Nitrogen is an essential plant nutrient. It enters into the structures of chlorophyll II and is a constituent of amino acids, amides, alkaloids, protein and protoplasm of the plant cells. The increased dosage of nitrogen to certain level results in the increase in size of leaves, vegetative and fruiting branches and also in the number of fruits and seeds. Since nitrogen is the most important ingredient in the plasma, its deficiency results in reduced protein and consequently reduced tissue synthesis. Nitrogen deficient plants flower prematurely and set few flowers and seeds. Thus while on the one side the presence of nitrate in abundance in natural water is beneficial to vegetation, on the other hand it is harmful to human especially to infants.

The presence of fluoride of the level 1 .5 mg/L, is deemed essential in potable water for human consumption. The higher concentration of fluoride is reported to have adverse physiological effects such as mottled teeth, osteo-clerosis, crippling fluorosis, kidney change etc. on human beings for long continuous use of such water.

Topography and Hydrogeology of the Area

Bundelkhand area comprises Jhansi, Jalaun. Lalitpur, Banda and Hamirpur districts of Uttar Pradesh. It is situated in the southern part of the state and is bounded by the state boundary of Madhya Pradesh in the west and south and by Yamuna river in the north and east. The area is located in between latitude 24° 10' to 26° 30' and longitude 78° 10' to 81° 30' in Survey of India toposheets no. 54 (N.O.K.L.), 63 (C and D). The main perennial rivers of the area are Betwa, Yamuna, Dhasan. Pahuj and Ken etc. Coarse (red) and black soils are the main soils in the region. The red soil which is derived from disintegration of pink granite in the eastern part of Jhansi and Lalitpur districts has poor water retention capacity. Black clayey soil is dominant in Hamirpur, Jalaun and Banda districts. The size of this soil varies from fine to medium and have high water retention capacity.

Materials and Methods

Systematic collection of water samples was carried out from the dug wells from the entire Bundelkhand area during various investigations. The water samples were analysed in the Central Chemical Laboratory, Central Ground Water Board, Lucknow as per standard methods of water and waste water analysis (APHA 1980).

Sources of Nitrate and Fluoride in Ground water

Nitrate :

Among the major point sources of nitrogen entry into water bodies are municipal and industrial waste

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waters, septic tanks and feed lot discharges. Diffuse sources of nitrogen include farm site fertilizer and animal wastes, lawn fertilizer, leachate from waste disposal in dumps or sanitary land fills, atmospheric fall outs, nitric oxide and nitric discharges from automobile exhausts and combustion processes and losses from natural sources such as mineralization of soil organic matter (NAS 1972).

The occurrence of high nitrate in dugwells of the agriculture field may be attributed to the return agriculture flow where high doses of nitrate fertilizers are used.

Fluoride :

Fluoride in natural waters is contributed as a result of weathering of alkali. silicic, igneous and sedimentary rocks especially shales (Mc Neelay et al 1979). The main fluoride bearing minerals are (a) fluorite, which occurs both in igneous and sedimentary rocks; (b) flour (c) amphiboles such as hornblende, micas etc: (d) volcanic and fumarolic gases in some areas. Fluoride is also released to atmosphere by burning of coal and some of the fertilizers also contain fluoride as an impurity.

Results and Discussion

(i) Pollution due to nitrate :-

It is the end product of aerobic decomposition of organic nitrogen and is often an indicator of pollution from sewage and agricultural sources. The main source of nitrate in ground water are (a) atmospheric precipitation, (b) geological deposits. (c) sewage, animal excrement and agricultural sources.

Nitrate concentration in ground water of the study area is high at several places and maximum of 1446 mg/L. has been obtained in Udotpur, Jalaun district. The district wise range and high values of nitrate have been summarized in tables 1 and 2 respectively.

Infants when ingested with high concentrations of nitrate suffer from cyanosis (Mathemoglobinaemia) or 'blue baby' disease. In the human system, nitrate is converted to nitrite and then to ammonia by bacterial reduction. Excess of nitrate is absorbed by haemoglobin and converted to methemoglobin that renders the haemoglobin molecule incapable of transporting oxygen. Infants are only affected due to under developed metabolic enzyme system, the greater reactivity of fatal haemoglobin and relatively small volumes in comparison to fluid intake. I.S.I. (1983) have proposed a limit of 45 mg/L. for nitrate in drinking water supplies. Since the high values of nitrate have been met with in local patches of the region it is presumed that the incidence of pollution due to nitrate may be because of human and animal excrement and excessive use of nitrogenous fertilizers.

(ii) High fluoride waters :

In the study area, the maximum fluoride value has been observed as 7.38 mg/L in Nandjia. Jhansi district. District wise range of fluoride has been summarized in table 1 and the anamolous values are given under table 3.

With the establishment of direct relationship between fluoride level of water and disease like dental and skeletal fluorosils, the fluoride concentration in ground water is an important consideration Some of the physiological effects of fluoride intake through drinking water are given under table 4.

I.S.I. (1983) have proposed the highest desirable level of 0. 6-1.2 and a maximum permissible level of 1.5 mg F/l in drinking water. In the region under study, one of the reasons of fluoride values may be due to incidence of localized pollution by impurities or due to phosphatic fertilizers.

Table 1 :Districtwise Ranges of Nitrate and fluoride in Bundelkhand Area

Sl. No.	District	Nitrate	Fluoride
		Conc. in mg/l	
1.	Jhansi	2.5- 140	0 56- 7.38
2.	Lalitpur	1.3-480	0.2- 1.71
3	Jalaun	0.25-1446	0 6-4.8
4.	Banda	3.8-505	0 56-4 0
5.	Hamirpur	1 0-650	0.08-4 5

Table 2 : Anamolous Values of Nitrate (>45 mg/L) in Bundelkhand Area

S.no.	Location	Nitrate in mg/l
JHANSI DISTRICT		
1	Chirgaon	110
2	Sakrat	140
3	Indi	80
4.	Konch	90
5.	Jhansi I	58
6	Babina	80
LALITPUR DISTRICT		
7	Bansi	205
8	Birdha	340
9.	Jakhlaun	130
10	Charrau	67
11.	Udaipur	248
12.	Maranpur	53
13.	Tikra	63
14	Khria Chalara	480
15	Harer Kalan	64
JALAUN DISTRICT		
16	Konch	55
17	Dekor	90
18	Said Nagar	72
19.	Udotpur	1446
BANDA DISTIRCT		
20.	Menikpur	48
21	Badausa	245
22.	Dadoghat	50
23.	Mataundh	505
24	Pahrakapurwa	200
25	Rajapur	70
HAMIRPUR DISTRICT		
26.	Maudaha	465
27	Charkhari	230
28.	Mahoba	508
29	Dhagwan	650
30	Bewar	145
31	Lalpura	74
32	Charma	86
33	Kunehta	400
34	Kharela	425

Table 3 : Anamolous Values of Fluroide (>1.5mg/L) in Bundelkhand Area

S.NO.	Location	Fluoride In mg/l
JHANSI DISTRICT		
1	Gursaral	2
2	Samthar	2.4
3.	Nenora	1.85
4	Aulden	1 84
5.	sujwan	1 82
6.	Churaral	1 62
7	Bhitora	2 98
8.	Silgawan	1.84
9.	Bangara	2.28
10.	Ramnagar	1 63
11.	Ghisauli	1 64
12.	Barora	1.63
13	Nandjia	7.38
14.	Samri	4 88
LALITPUR DISTRICT		
15.	Jakhaura	1.71
16	Pali	1.70
JALAUN DISTRICT		
17.	Bangar	4 8
BANDA DISTRICT		
18.	Baberu	4 0
19.	Papranda	2 8
20.	Pahrakapurwa	3.2
HAMIRPUR DISTRICT		
21.	Maudaha	3 4
22.	Charkhari	4.0
23.	Kabaral	4.25
24.	Kulpahar 1	4.5
25	Kulpahar II	4.25
26	Jalla	1.94
27.	Ajnair	2 02
28.	Sagunia	1 84
29	Dhasen Mainhead	1 8
30.	Murhari	3 26
31.	Bela Tal	2 22
32	Rath	2 00
33	Panwari	2.0
34.	Maskara	2.05
35.	Chhami Burzing	2 0
36	Gohand.	2 0
37.	Talya	2 1
38.	Chandaut	2 1
39	Lalpura	2 0
40.	Pipra Mauf	2 0
41.	Shrinagar	1.9

Table 4 : Effects of Excess Fluoride on Human Body		
Sl. No.	Physiological effect	Amount of F in mg/l
1	Dental caries reduction	1 0
2.	Mottled Enamel	2.0
3	Osteoclerosis	5 0
4	10% Osteoclerosis	8.0
5	Crippling fluorisis and thyroid changes	20-80
6	Retardation	100
7	Kidney changes	125
8.	Death	>2500

Conclusion and Recommendation

Since the area having high nitrate are agricultural fields and the wells are mostly shallow with permeable soil conditions. It is very likely that these high values may be due to return irrigation flow. It is suggested that excessive use of nitrogenous fertilizer . should be avoided. Beside this. the areas having high fluoride waters may be due to excessive use of phosphatic fertilizers which should be controlled. Further there is necessity for defluoridation of high fluoride waters by Amalgamation Technique.

A CASE STUDY OF SONAR RIVER BASIN

Introduction

The river basin bounded by its drainage divide and subjected to surface and sub-surface drainage under gravity to the ocean or to the interior lakes, forms the logical areal unit for hydrological studies. Within this framework, the water balance and assessment of water resources estimate the probability of the occurrence of extreme events such as floods and droughts, particularly as they affect the reservoir storage and water use by man. It gives hydrological information to manage the water resource more effectively by knowing when and in what ways, it is to his advantage to intervene locally in the hydrological cycle. A significant contribution in the study of environmental impact of river is given by Forstner and Muller (1973), Gibbs (1967, 1980), Meybeck (1979), Sarin and Krishnaswami (1984), Subramanyan (1979), Subramanyan and Sitasawad (1986), Subramanyan et al. (1987), Sharma and Ghose (1987), Dey et al. (1987), Sahu (1990), Hardikar (1990), Kar (1997), and Bharadwaj (1997), etc.

The 'Sonar river' is the major river of Sagar and Damoh districts. It is the main source of water for domestic use for townships and contribute an ideal topic to study the hydrology, geomorphology and environmental impact studies.

Preliminary studies suggest that the geological environment is indeed a significant factor in the incidence of several problems such as cardiovascular disease and cancer. Medical geology, radiological pathology and geographical disease, all describe relationship between the health and geology. Recent environmental health studies and investigations have shown a direct link between the various chronic diseases and particular geological environment. The work of Crawford et al. (1971), Blackley (1969), Livingston (1970), Voors (1969-70), has shown that the cardiovascular disease are apparently inversly related with the hardness of water.

As the river Sonar is the only source of water supply, people of the villages situated on the banks of it depend upon the river water for their daily use (domestic, drinking, ablution, etc.). An attempt has been made to collect data for various health problems associated with the people using the waters of Sonar river. Even the wells located in the villages get re-charged by the Sonar river water. The water (both river and dug wells) are unfiltered, and falls between hard and moderately hard categories. Its pH falls between neutral to alkaline. Hence, health hazard study was undertaken to establish a correlation between quality of water and the disease prevalent in the villages situated along the Sonar river It is very necessary to make it clear that the disease prevalent may be due to other interacting parameters as well and hence, this study is an attempt to explore whether the quality of water is one among them or not. Therefore, it is presumptuous to come to definite conclusions from these studies; neverthless, it gives a broad generalized idea of the relation between the health and the surrounding geological environment.

(a) Impact of Sonar river on community health

As stated earlier the Sonar river is the only source to supply drinking water for the people of the villages situated along its banks, a health study of the people living along the bank of Sonar river has been undertaken. In order to carryout this study, villages situated in close proximity to the river have been selected for a health survey. Secondly, every care has been taken that the inhabitants of the villages , who have been constantly using the river water continuously have been sampled for various diseases. In all, a total 15 villages have been selected and in each village, 100-200 people have been sampled familywise or housewise, including both males and females in various age groups (<10, 10-25, 25-50, >50).

The results of the health survey carried out on 2117

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people from 15 villages are presented in Table 1. From this it is seen that out of 2117, only 421 people are unhealthy constituting only 19.88% which clearly indicates that the river water is not much polluted, as evident from 80.1 1% healthy people using the river water.

The diseases prevailing among the unhealthy people of 15 villages, for purpose of broad categorization have been grouped in to three main categories. They are :

(a) Respiratory diseases (b) Stomach diseases and (c) Miscellaneous diseases. Percentage wise study of the people among the three broad categories, irrespective of male or female, indicates that stomach disease is the least, followed by respiratory disease while miscellaneous diseases predominate. The three broad categories of disease in various age groups is presented in table 2. Between male and female, the male seems to be more unhealthy in comparison to female and the stomach disease is more common among females than males.

Further, to correlate the density and frequency of disease in the three categories, entire population (2117) has been sampled into three categories : (1) People living in the upstream area of the river (2) People living in the midstream area of the river (3) People living in the down stream area of the river.

Table 1

Health survey data on the basis of Age group along Sonar river (M.P.)

	Disease	**Respiratory**	**Stomach**	**Miscellaneous**	**Total**	**Male**	**Female**
Region	Age group						
UP	<10	2	2	5			
Stream	10-25	6	4	11	118	61	57
	25-50	9	7	19			
	>50	15	10	28			
Mid-	<10	3	3	16			
Stream	10-25	7	8	9	137	73	64
	25-50	12	10	7			
	>50	15	23	24			
Down-	<10	6	2	4			
Stream	10-25	10	14	10	166	94	72
	25-50	11	22	14			
	>50	23	31	19			
	Total	119	130	166	421	228	193

Table 2 : Gender wise health survey data along Sonar river

Total surveyed people	Male		Female
2117	1203		914
Percentage	56.82%		43.17%
Total surveyed people	Healthy		Unhealthy
2117	1696		421
Percentage	80.11%		19.88%
Total unhealthy people	Respiratory Disease	Stomach Disease	Miscellaneous Disease
421	119	136	166
Percentage	28.26%	32.30%	39.42%

The data regarding the healthy and unhealthy people in the three regions (up stream, midstream, and downstream), along with the percentage of diseases in three categories is presented in Table 3. This shows that the number of people suffering from diseases increases from upstream to down stream, being maximum towards downstream. Stomach disease seems to be maximum in the villages situated downstream side followed by midstream side and least along the upstream side while the miscellaneous diseases progressively decrease from upstream to down stream side. The gradual decrease of the miscellaneous diseases may be described to gradual decrease of suspended impurities, Phytoplanktons, etc. Miscellaneous disease includes, scalp, falling of hair, skin disease etc.

In order to bring out a vivid picture, the environmental health survey carried out along the Sonar river and the data is presented in Figure 1. This figure shows the incidence of the three categories of diseases in percentage of the total people sampled and surveyed.

Fig. 2 is a bar diagram representing the unhealthy people among the males and females as well as three categories of diseases among the males and females. It clearly shows that diseases are more prevalent among males than the females. Further, it also shows that stomach diseases are more common in female than the male.

Fig. 3 is a graphic representation where the three diseases (in%) are plotted against the age group. It clearly shows that stomach and miscellaneous diseases are more among the age group of 25 and above while the incidence of these diseases are negligible below 25 years of age.

Fig. 4, is a plot of unhealthy people (in%) against upstream, midstream, and downstream. It clearly shows that percentage of unhealthy people increase towards downstream and histogram presented in Fig. 5 further, shows that stomach disease and respiratory disease increases from upstream to downstream being maximum in downstream side, while miscellaneous disease shows a steep rise from upstream to downstream.

Relationship between water quality and disease

As the river Sonar originates from the Deccan Trap hill, it is more prone to chemical weathering rather than physical weathering. The calcic felspar, ferromagnesian minerals alter to clay and secondary green earth which contributes to hardness also act as an absorbant for the chemical effluents, but relatively abundant in suspended impurities. Hence, this factor account for the high incidence of miscellaneous diseases in the upstream side. The downstream side is characterised by the location of cement factory as well as the belt of limestone culminating in limestone quarry not only accounts for the extreme hardness of water but also for the maximum incidence of miscellaneous disease,owing to maximum fall of lime particulate into the river from the quarry as well as the Diamond Cement Factory.

Table 3 : Healthy and unhealthy people along the Sonar river

Total Surveyed People	Healthy people	Unhealthy people	Respiratory diseases	Stomach diseases	Miscellaneous diseases
			Upstream		
597	479	118	32	23	63
Percentage	80.23%	19.76%	27.12%	19.49%	53.39%
			Midstream		
671	534	137	37	44	56
Percentage	79.58%	20.41%	27.00%	32.11%	40.87%
			Down stream		
849	683	166	50	69	47
Percentage	80.44%	19.55%	30.12%	41.56%	28.31%

FIG. 1 SHOWING CATEGORIES OF DISEASES IN % OF TOTAL SURVEYED PEOPLE ALONG SONAR RIVER

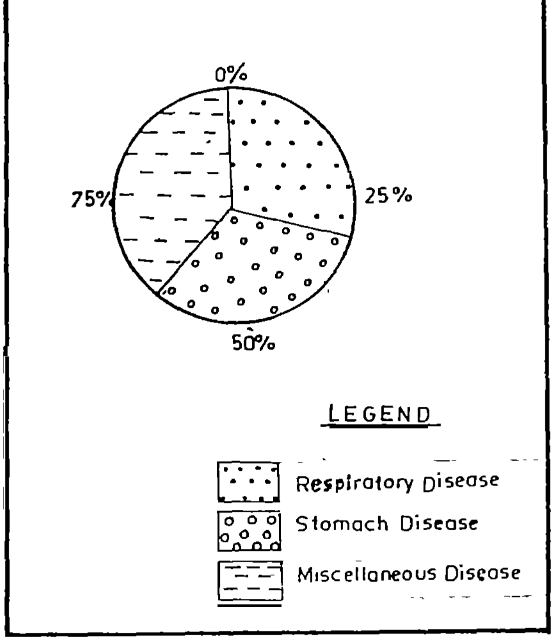
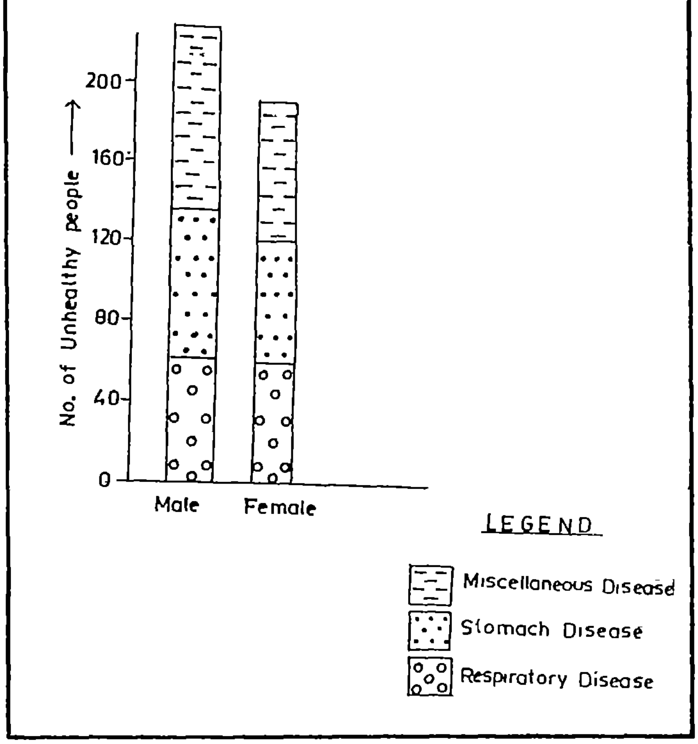


FIG. 2 BAR DIAGRAM REPRESENTING THE UNHEALTHY PEOPLE AMONG MALE AND FEMALE



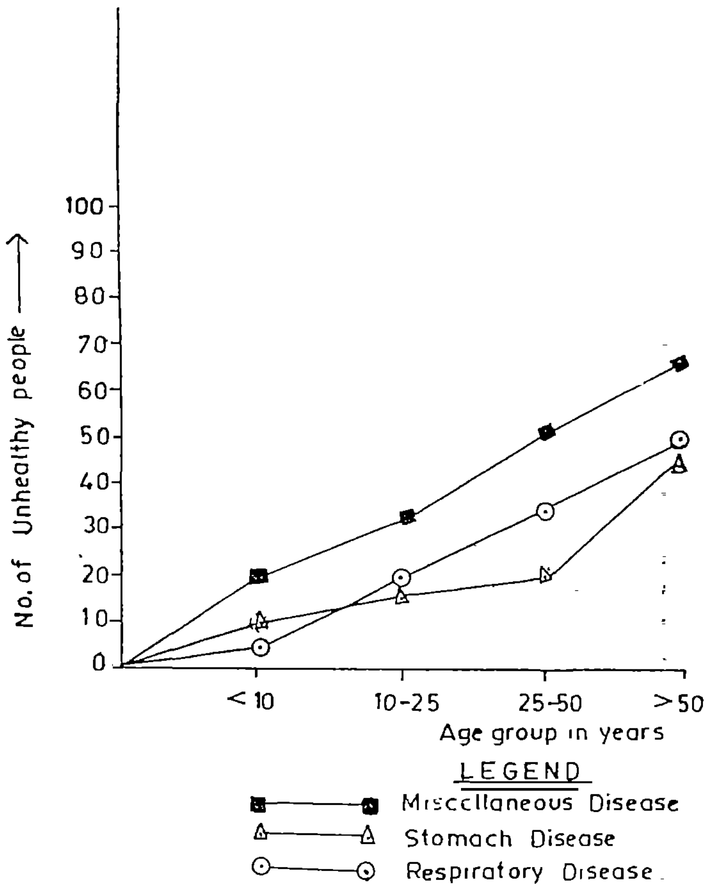


FIG. 3 SHOWING NUMBER OF UNHEALTHY PEOPLE AGAINST AGE GROUP ALONG SONAR RIVER

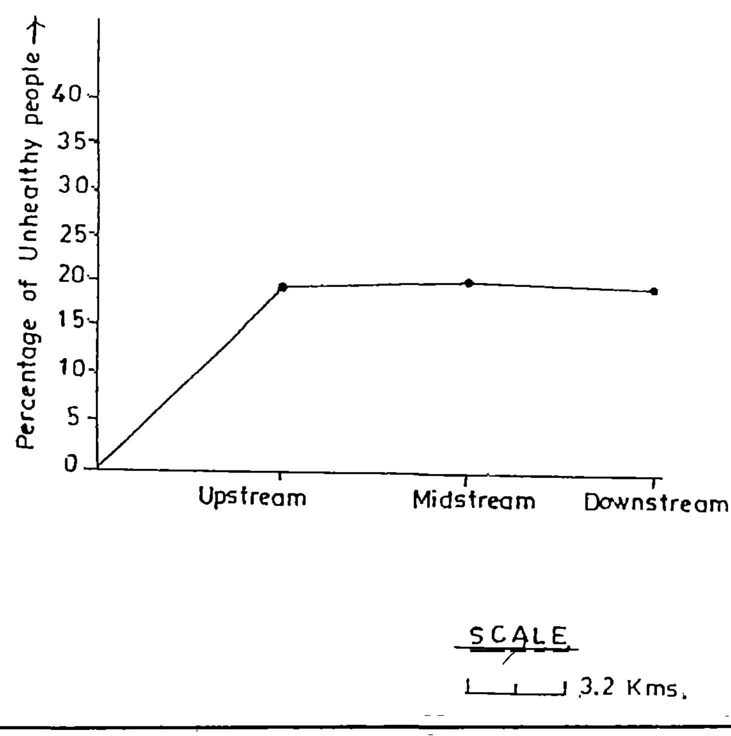
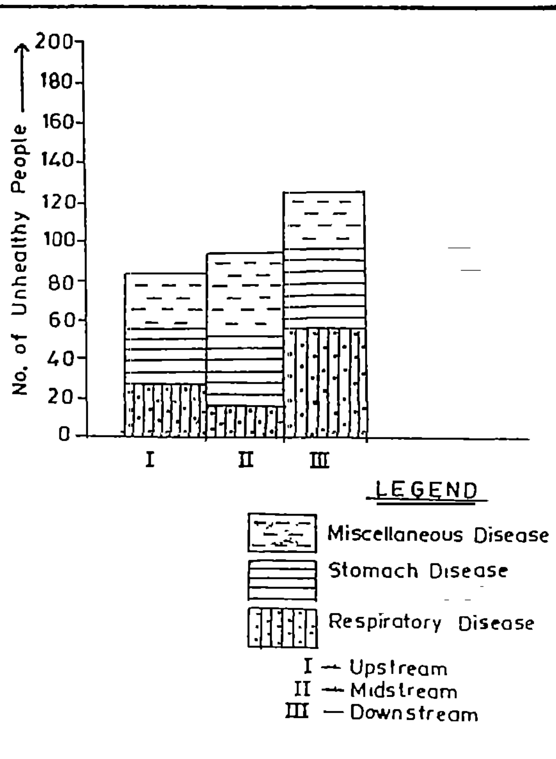


FIG. 4 SHOWING THE PLOT OF UNHEALTHY PEOPLE (%) AGAINST UPSTREAM, MIDSTREAM, AND DOWN STREAM ALONG SONAR RIVER

FIG. 5 SHOWING NUMBER OF UNHEALTHY PEOPLE OF THREE DISEASES PLOTED AGAINST UPSTREAM, MID-STREAM AND DOWNSTREAM ALONG SONAR RIVER



The increase in the frequency of stomach disease from upstream to downstream may probably be due to pollution of midstream water by sewage and municipal drainage due to animals and man made activities causing stomach diseases by pathogenic and colliform bacteria.

The environmental health hazard studies carried out indicate that there are three categories of diseases i.e. respiratory, stomach and miscellaneous among the people living in 15 villages located along the bank of Sonar. Stomach diseases is relatively less in comparison to miscellaneous disease. Regardless of whether the people are living upstream, midstream and downstream, most of the healthy people suffer from miscellaneous diseases. However, the high incidence of miscellaneous disease is in upstream followed by maximum incidence towards the downstream side. This may be due to high Ca and Mg and total hardness content in the river water.

(b) Impact of cement factory on environment

On the downstream side of the Sonar river 18 km. SSE of Damoh at the Narsingarh town, Diamond Cement Factory owned by Birlas is situated. The cement factory gets its supply of cement grade limestone from the quarry situated along the bank of Sonar river, adjacent to the cement factory. The total lease area comprise 17 sq.km. Owing to the cement factory, a township has come into existence with a population of approximately 5000 people. The raw materials used in the cement factory is cement grade limestone, clay and gypsum. The factory has a rotary reverberatory kiln in which cement clinkers are fired and later crushed to manufacture the cement.

Manufacturing of cement by the dry processes does not generate any liquid effluents. The air pollutant of environmental concern is only the fine suspended particulate matter emitted during almost each and every stages of the manufacturing process from the quarrying of raw materials to the packing and despatch of the finished cement. Some gaseous air pollutants are also released primarily in the kiln stack gases and these include significant quantities of CO_2 from the break up of carbonate during calcination, along with CO_2, CO and small amount of SO_2 and NOx produced from the combustion of the coal fuel. However, due to the highly alkaline conditions prevailing in the kiln and the alkaline nature of the fine particulates suspended in kiln-gases SO_2 and

NOx react and combine with the CaO and MgO leaving only very small quantities of these in gaseous form, too small to be of concern. In plants having electro-static precipitator (ESP) installations to de-dust the kiln gases, CO is kept at low levels (normally below 0.2% and in no case to exceed 0.8%) to protect the ESP installation from possible explosion. CO at these concentrations, emitted from high stacks of over 60m.height (73 in case of Diamond Cement factory) is not likely to be of environmental concern. And of course, CO_2 though released in extremely large quantities cannot be considered an air-pollutant in a rural area with no other significant industrial source of CO_2 and agricultural and pasture land all around, for which CO_2 shall provide the essential plant food. This discussion shall concentrate on suspended particulate matter (SPM) as the only air pollutant of concern.

The factory does exert certain impact, on the surrounding environment, with results in principally air pollution and subordinately water pollution. Crushing of limestone, roasting of clinker and powdering of clinkers produces enormous amount of dust of particulate, ranging in size from 0.001 micron to 10 milimicrons resulting in particulate fall in and around the cement factory as well as the surrounding villages Depending upon the direction of wind, the particulate are carried along with it. The wind direction has not been monitored systematically, except in the month of April and June, during which the direction was southward and SSE respectively.

The dust and particulate produced in cement factory rises to the atmosphere, and comes to the earth as particulate fall and settle on the ground soil, water bodies, plants and cultural objects. The particutate deposited on the soil through the medium of water enters or permeates the soil cracks and thereby enhancing the alkalinity of the soil, and reducing the permeability of the soil during rainy season causing surface water, contributing to floods for the river.

Cement dust deposited on the leaves exerts its pressure due to the weight of lime particulate, whereby the photosynthetic process of the plant is reduced, resulting in the change of colour (yellow colour instead of green colour).

The impact of cement factory on the cultural environment that is people, in limited sense, is dust pollution whereby, people suffer from respiratory diseases.

A health survey around the cement Factory and colony has been conducted. A total number of 542 people

Table 4 : Health survey around Diamond Cement Factory

Total Surveyed People	Healthy people	Unhealthy people	Respiratory diseases	Stomach diseases	Miscellaneous diseases
542	405	137	36	45	56
Percentage	74.72%	25.27%	26.27%	32.84%	40.87%

data on the basis of age group

Age group	Respiratory disease	Stomach disease	Miscellaneous disease	Male	Female	Total
<10	5	8	10			
10-25	14	17	21	79	58	137
>25	17	20	25			
	Total unhealthy male 207			Total unhealthy female 162		

Disease	Male	Percentage	Female	Percentage
Respiratory	67	32.36%	36	22.22%
Stomach	54	26.08%	65	40.12%
Miscellaneous	86	41.54%	61	37.65%

between the age group of (10, 10-25, >25 years. comprising male and female has been surveyed and presented in table 4. From this table, it is clear that out of 542 people surveyed, 137 are unhealthy contributing 25.27%, of which respiratory diseases 26.27%, stomach diseases 32.84% and miscellaneous diseases 40.87% were recorded respectively. Among the people affected, male is more affected than female. People in the age group of >25 years seem to be more affected in comparison to age group of 10-25 and <10 year.

(c) Impact of Mining on environment

Cement grade limestone occurs in the downstream of the river sonar at Narsingarh. The limestone belongs to lower Bhander formation of the upper Vindhyan. The limestone is overlain by Bhander sandstone and underlain by Ganurgarh shales. The topography of the limestone quarries is mostly even, but nevertheless, undulating and ravine topography is seen in the north-west region. The rocks dip N.5° to N.6° but at some places the dip is N10° to N15°. The grade of the limestone varies between 45% to 51% (CaO), and is mostly found in the river valley area. The total reserve is estimated to be 40 M.T. The extracted tonnage is 17 M.T., owing to thick overburden as well as low grade of the limestone.

The limestone quarries are operated by open-cast mining method and the material transported by haulage, dumpers, tippers, as well as manually. The impacts of the limestone mining on the downstream of the Sonar river are as follows :

Land Degradation

Owing to limestone quarry, 17 sq.kms. of area has been affected. The quarrying operation,excavate large volumes of overburden, which is dumped along the river bank creating ugly scenery. Besides this, limestone is also quarried in the river channel bed, whereby a large pit is created in the river as a consequence of which the natural river drainage course is changed The quarrying has disturbed the topography and agricultural fields and nearly 60% of agriculture land is disturbed, subordinately quarrying activities has affected the surrounding forest, creating erosion of soil in the area.

Air pollution

Owing to the blasting operation, loading operation, drilling operation, running of trucks & dumpers, hauling of limestone, crushing and scraping operation, air pollution has resulted which seems to be a major problem in the area. The exhaust of the diesel operated vehicles also has caused a major pollution. This air pollution has caused a major environmental health hazard among people working in the quarrries as well as living around the quarries namely "Pathesis" and respiratory disease due to dust (lime dust). The blasting operation carried in the limestone quarries by the use of nitroglycerine explosive, by the wedge and fan cut methods also produce huge amount of dust, which spreads into the atmosphere along the direction of the wind and settles on the soil and plants.

Water pollution

The quarring operation has resulted in huge quantity of overburden which is dumped along the bank of the river. This has polluted river water by sediments, silt and fine particulates. These sediments are further carried to downstream during the flood. Lime dust render the river waters more alkaline, and more hard resulting in stomach diseases.

Further, the playing of diesel operated dumpers and trucks in the quarry area, sheds Lead in an organic form (Tetraethyl, Tetramethyl), which is soluble in water, and moves 1 to 2 km on either side of the road along which the heavy vehicles move, resulting in "Lead poisoning".

Sound pollution

The surrounding of the quarry and cement factory is affected by noise pollution due to factory machines and quarry operations, blasting, etc., which exceeds the levels of 80 to 90dB, much more than the permissible limits of 45dB.

Socio-Economic Impact

Socio-economic impact is a consequences of limestone quarries. Diamond cement factory which has resulted in the township of Narsingarh with a population of about 5000 raised the living condition of the people.

Remedial measures to control the Adverse Impacts of Environment

The most worrying feature of the current land-use from environmental point of view is the complete absence of the forests in the area. If Diamond cement factory could afforest the area aquired by it (including mining area under tree-cover) it shall be great service to the environment and ecology of the area. Reclamation has to become an integral part of the mining activities in the country. If reclamation is made a part of mining operation from the beginning, it is easier and cheaper. It involves the application of basic principle of soil and water conservation, afforestation, regeneration of greenery and pollution control. Proper planning of land reclamation has to be done before starting the mining activity (Dubey, 1992).

To establish stable communities of vegetation on the dumps, dissemination of seeds is the easiest and best method. Broadcast seeds provide even and relatively short time, which will not be achieved through transplantation techniques. The seeds of the following plant species are recommended for seeding the contoured over burden dumps in the limestone mining area : (a) Dub grass (Cynodon dactylon), (b) Marhua or finger Millet (Eleusine coracana), (c) Kaner (Nerium odorum), (d) Mehdi (Lawsonia alba), (e) Kikar or babul (Acacia arabica).

The above operation should be repeated for three consecutive years to ensure the maximum utilization of niches available in the substratum.

The only air pollutant of significance emitted by diamond cement factory is suspended particulate matter or dust from kiln-emission and various crushing and material grinding operations. The particulates emitted are mildly alkaline in nature, rich in calcium and having significant Mg and Fe, but much lower silica than road dusts. Keeping these in view, the following species are chosen to control the air pollution, Vilayati Babool (Prosopis Juliflora), Kala siris (Cassia simea), Kaner (Nerium Indica) and Subabool (Leucaena-Leucocephala), Neem (Azadirachta Indica), Karanj (Pongamia Pinnata), Guava (Psidium Guajava), Amla (Embelica officinalis), Jamun (Engenia Jambos), Tesu (butia Monosperma), Polyalthia-longifolia, Ashok (polyalthia Pendula), Eucalyphythus (Eucalypthus camellensis), Shisham (Dalbergia sisoo) and Siris (Abbizzia lebbek), etc.

According to Dubey (1992), the water pollution may be controlled by sealing of the source of mine water or not allowing the mine water to enter river, ponds or stream. Water treatment by various methods like flocculation, reduction and oxidation, etc. should be done. Regular water spraying should be done on transport roads. Water spraying arrangement can be made at the unloading hopper of crusher and spraying of water on Rotor by using dust collector and blower in the crusher.

The dust can be reduced during blasting by inserting before and after water filled plastic bags or water ampulla before and after the charges. The noise and fumes can be reduced by proper maintenance and timely overhauling of engine. The pits could be used as ponds, which in turn could act as artificial groundwater recharge areas and could also help for plantation in the surrounding area.

To protect the residents of Diamond cement colony, a strip plantation in the space between the industrial complex and residential area is also very necessary This plantation belt will serve as a buffer zone between the industrial and residential areas and help in reducing particulate and noise pollution level.

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WATERSHED MANAGEMENT FOR CONSERVATION OF RESOURCES AND ENHANCED PRODUCTIVITY IN RAINFED AREAS OF BUNDELKHAND

A CASE STUDY OF RENDHAR WATERSHED IN DISTRICT JALAUN

With about three-fourths of cultivated area as rainfed and cropping intensity of 112 percent, Bundelkhand is one of the backward regions of Uttar Pradesh. Rocky terrain, undulating topography, severe erosion, problematic soils, low fertilizer use and poor crop husbandry give rise to low productivity of crops in this zone which is perhaps the lowest in the state. With a view to demonstrate integrated watershed management technology for optimum utilization of available land, water, plant, animal and human resources a model watershed of 748 hectares was selected at village Rendhar in district Jalaun which lies in the catchment of river Pahuj, a tributory to river Yamuna. The watershed area was in a high state of degradation due to undulating topography, steep slopes and highly erodible soils giving rise to sparse vegetation and extremely low crop yields.

The watershed development and management programme was taken up during 1983-84. The programme included treatment of land with appropriate soils and water conservation measures like contour bunding, submergence bunding, gully plugging, construction of check dams and farm ponds for water harvesting and storage and land levelling and demonstration of improved crop production technology including the use of improved seed and fertilizer, timely operations and wherever necessary putting the land under alternate use like horticulture, forestry and grasses.

Through the five years from 1983-84 to 1988-89 there has been a phenomenal increase in cropping intensity and crop productivity resulting into an alround improvement in the area. The gross cultivated area which was 696 hectares during 1983-84, increased to 1088.5 ha during 1988-89 thus bringing about an increase of 56.4 per cent in cropping intensity. Likewise the productivity of crops has been increased by 300 to 600 per cent. As against the initial productivity of 4.5 q/ha of sorghum, 4.6 q/ha of pearl millet, 10 q/ha of wheat, 5.8 q/ha of lentil, 6.2 q/ha of gram, 2.6 q/ha of linseed and 2.5 q/ha of mustard, the productivity of these crops during 1988-89 has been to the tune of 22.5 q/ha sorghum, 12.5 q/ha of pearl millet, 44.1 q/ha of wheat, 18.6 q/ha of lentil, 26.0 q/ha of gram and 19 q/ha of mustard. The fertilizer use which was almost nil at the time of commencement of the programme has increased to the level of 66.5, 19.5 and 0.5 tonnes of NPK respectively during 1988-89 in the project area. The irrigated area was only 56.2 ha during 1983-84 which has increased to 610 ha during 1988-89. Above all, the rush of run off water which was threatening the existence of village Rendhar due to the 5 drains passing through the area and endangering the residential houses has been completely controlled and in this way the uncontrolled run-off water has been converted from curse to boon. The water table has gone up by 3.7 metre during the period due to run-off control and its storage in water impounding structures. The increasing recharge is being exploited for irrigation and drinking purposes According to a survey made during 1988-89 the shallow tubewells and diesel pumpsets operating in the area were 22 in addition of 27 dugwells, while during 1983-84 except 10 dugwells no tubewell or pumpset was available in the project area. Further if the number of tractors could be a sign of prosperity in the area then as against only 3 tractors available

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during 1983-84 their number increased to 35 during 1988-89. Similarly cattle population was only 614 during 1983-84 which increased to 3207 during 1988-89. In this way the watershed development programme has brought about an allround improvement in the area.

Climatologically, edaphically and socially the Bundelkhand zone is quite different from other zones of Uttar Pradesh. It is characterised by semi arid climte, undulating topography, residual soil of erodible nature, deep water strata underlain with hard impermeable rocks, poor crop husbandary including low fertilizer use and irrigation. The annual precipitation is of the order of 1014 mm which is largely concentrated from mid June to mid September. During rainy season, the residual nature of soil and rocks reduce the infiltration rate and consequently leads to high runoff. Since the irrigation facilities are available only in 30% of the cultivated area and rest of the 70% area is rainfed in this region, the only approach which can take to improvement of dry land agriculture in this zone is watershed development approach in which the rainfall received during the rainy season is conserved in soil and excess runoff is harvested, stored and recycled for life saving irrigation followed by improved crop production technology to make efficient use of the available water which include suitable crops and varieties, adequate fertilization, timely operations and wherever necessary putting the land under alternate use like dryland horticulture, afforestation and grasses.

With a view to increase productivity of eroded rainfed lands in Bundelkhand an Operational Research Project on Watershed Management was started 1n 1983-84 at village Rendhar in Jalaun District. It is situated at 20° 05' N latitude and 79° 05' E longitude and is 149 m above mean sea level. The watershed encompasses 5 villages, namely, Rendhar, Kanharpura, Chhiriya Khurd, Kunwarpura and Hasupura covering an area of 747.83 hectares. The project area was beset with problem of high erosion due to 5 *nalas* passing through the project area and collectively discharging run-off from about 3000 hectares of land with their confluence at village Rendhar. Cultivation of crops on slopy lands and humps used to accelerate the run-off and erosion. The nala and gully beds were badly infested with Kans (Sachharun spontaneum) and Patawar (Sachharum munja). The average annual rainfall of the area is 803 mm of which 84% is received during the 3 months from July to September. The potential evapotranspiration of the area is about 1720 mm.

The soils of the watershed area are alluvial ranging from silty clay to loam. They are deep and calcarious and on account of their light texture they are highly erodible. Problem of presence of calcium modules at the surface is also encountered in these soils. On the basis of land capability classification, the entire land in the project area is arable belonging to class II, III and IV and covering, respectively, 339 ha (45.3%), 199.9 ha (26.7%) and 174.3 ha (23.2%) of arable land. Accordingly the land in the project area was treated by various soil and water conservation measures namely contour bunding, submergence bunding, land levelling, gully plugging, construction of check dams and farm ponds for water harvesting and its storage. Thereafter specific crop management practices were superimposed over different category of land treated by various soil and water conservation measures. Through the five years (1983-84 to 1988-89) tremendous improvement in productivity of crops and prosperity in the area has been observed. The major gains accrued as a result of the programme are summarised in the following paragraphs :

1. Change in Land use Pattern :

There has been a phenomenal change in land use pattern in the project area after implementation of the watershed programme (Table 1).The gross cultivated area in the project was 696.1 ha during 1983-84 which has increased to 1088.55 ha during 1988-89. The area under orchards and forests has been found to increase from 17.08 ha during 1983-84 to 31.08 ha during 1988-89. About 6.10 ha of fallow and 9.60 ha of cultivable waste land have been brought under good pasture. Likewise the agro-horticulture programme which was started during 1987-88 on a piece of 2.00 ha of land has been extended to 3.4 ha during 1988-89. It is worth mentioning that the land of Nala beds which was other wise a waste land is being extensively used for cultivation of different rabi crops.

2. Physical Achievements in Land Treatment by Soil and Water Conservation Measures

Owing to 5 drains coming from Hasupura, Kanharpura, Kunwarpura and Chhiriya Khurd villages, the watershed area has 4 distinct mini-watersheds designated as Rendhar I, Rendhar II, Rendhar III A and B and Rendhar IV, having catchment area of or-

Table -1 : Change in Land use pattern in Rendhar Wastershed						
Particulars	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
1. Cultivated area (ha)	695.05	695.05	695.05	695.05	695.05	695.05
2. Gross cultivated area (ha)	696.12	699.16	890.39	937.90	1081.60	1088.55
3. Pasture (ha)	-	-	-	-	15.60	15.60
4. Agro-horticulture (ha)	-	-	-	-	2.00	3.40
5. Afforestation	17.08	17.08	17.08	17.08	24.08	31.08

der of about 200, 150, 300 and 100 ha respectively. Out of 748 ha area 739.96 ha has been treated by various soil and water conservation measures (Table - 2).

Among the various soil and water conservation measures followed in the area the impact of submergence bunding and check dams is noteworthy as they ensure a good rabi crop by increased conservation of moisure and recharge of ground water. Check dams and gully plugs help in harvest and storage of run-off water during the rainy season which is being utilized for life saving irrigation of kharif crops and presowing irrigation of rabi crops. This has also made possible the cultivation of vegetables as water is available as and when required directly from the storage structures or by tapping shallow ground water through dugwells Land levelling and smoothening has resulted in raising the productivity of crops, more specifically in case of wheat, by 100% over the unlevelled fields.

3. Improvement in Water Potential

The various land treatments employed for moisture conservation and runoff control have helped in improvement in ground water table which has risen to the extent of 3.6 m over the base year 1983-84. The rise in water table is more pronounced in the vicinity of water impounding structures. This has prompted the farmers to exploit it for irrigation, through installation of shallow tubewells and pumpsets and dug wells. The number of dugwells has increased from 10 to 27 and of shallow tubewells and pumpsets from nil to 22 during 1988-89. Since the water availability has increased tremendously, the irrigated area has also increased in the same magnitude i.e. from 56.2 ha during 1983-84 to 610 ha during 1988-89 (Table - 3).

Table 2 : Physical Achievements in Soil and Water Conservation Measures						
Particulars	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
1. Contour bunding (ha)	-	28.65	-	-	-	-
2 Submergence bunding (ha)	-	254.35	225.36	-	-	36 75
3 Levelling (ha)	-	11.93	10 09	-	-	-
4 Gully plugging and check dam (ha)	-	128.75	68 83	-	-	-
5 Water harvesting bundhies (ha)	-	12.00	15.00	-	10.00	5 00
6 Check dams for water harvesting (ha)	-	15 00	15.00	-	-	-
7. Strengthening of existing bunds (ha)	-	-	-	75.60	120.30	
8 Land smoothening (ha)	-	-	-	-	135 50	155.00
9 Vegetative bunds (ha)	-	-	-	-	12.00	48 00
10 Establishment of S.Munja on bunds	-	-	-	-	-	203.50
11. Sodding of grasses on bunds	-	-	-	-	-	27.00

Table - 3 : Improvement in Water Potential in the Project Area						
Particulars	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
1 Ground Water table (m)	10.00	9.80	9.00	8.40	7 50	6.34
2 Number of dugwells and tubewells						
i Dugwells	10 00	10.00	18 00	23.00	25.00	27.00
ii Tubewells and diesel pumpsets	-	-	2.00	2.00	16.00	22.00
3 Surface water storage						
i. Storage in farm ponds, check dams and submergence bundhies (m^3)	-	8000	30000	81500	177630	178400
4 Irrigated Area (ha)						
i. Through dugwells/boring wells and tubewells	8.00	8.00	54 40	158 40	338 00	431.60
ii Through surface sources e.g. check dams and ponds	48.26	48.26	116 91	169.45	178.00	178 40
Total	56.26	56 26	171.31	327.85	516 00	610 00

4. Increased Cropping Intensity and Introduction of New Crops and Cropping Systems :

Mono-cropping, either in kharif or rabi, was a common practice in the project area. Jowar + Arhar, Bajra + Arhar, Barley + gram, Wheat + Gram were the important cropping systems. With the availability of irrigation water and use of improved seed and fertilizer, a major area has been brought under double cropping, thereby increasing the cropping intensity from initial 100.2 per cent to 156.6 per cent during 1988-89. The data provided in Table 4 reveal that there is spurt in area under pearl millet, sorghum, wheat, mustard and lentil while the area under arhar and gram has declined. Some new crop like soybean, pea, urd, moong, potato, vegetables and rajmah have become extensively popular. Cultivation of sugarcane, berseem and groundnut have been introduced in the area.

Apart from acceptance of new crops and cropping systems the farmers have also become cautious of improved seed and fertilizer use. The important varieties of crops finding popularity among the farmers in the project area include 'Varsha' of Jowar, 'WCC 75' of Bajra, 'Bahar' and 'T 21' of Arhar, 'T 9' of Urd, 'T 44' of Moong, 'PK 237', 'Gaurav', 'Durga' of Soybeen; 'T 13' of sesame; 'WH 147' 'HD 2285', 'K 72' of wheat ' 'Varuna', 'Vardan' and 'Vaihav' of mustard; 'K 75' of lentil; 'Sweta', 'Subhra' and 'Laxmi' of linseed, 'Radhey; 'K 850' and 'K 468' of gram, 'PDR 14' of Rajmah and 'Lakhan' and 'Azad' of barley. As regards the fertilizer use the estimates show that during 1988-89 about 66.5 tonnes of nitrogen, 19.5 tonnes of phosphorus and 0.15 tonnes of potash were used as against absolutely no fertilizer use during 1983-84. The use of urea and DAP is more popular than other fertilizer.

5. Increased Productivity of Crop :

The use of improved seed, fertilizer, increased facilities of irrigation, plant protection measures and timely operations have brought about 3 to 5 fold increase in productivity of different crops over the base year 1983--84 (Table 5)

6. Increased Animal Population and Milk and Fish Production

Owing to increased availability of fodder there is spurt in animal population and more particularly the cattle population. As a result milk production has gone up from 352.7 thousand litres during 1983-84 to 1476.6 thousand litres during 1988-89 (Table 6). Likewise fish production in one of the village pond has been started from 1987-88 which is becoming an additional source of income to Gram Samaj.

7. Increase in Draft Power :

The land treatment with appropriate soil and water conservation measures superimposed with improved cultivation methods has improved production potential of land so much that there is big spurt in draft power both by bullock and tractors. The total horse

Table 4 : Area (ha) under different crops and cropping intensity						
Crop	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
Sorghum	95.00	93.6	157.7	156.7	176.7	153.25
Pearlmillet	12.2	14.0	61 1	63 0	75.0	70.00
Urd	-	-	-	10 00	14.2	45 50
Moong	-	2.5	11 5	1 50	12 0	30 00
Til	-	2 0	9 5	9.50	9.0	7 00
Soybean	-	-	-	5 00	15 0	50.00
Arhar	107.2	107.6	113.4	105 5	107.0	39.50
Ground nut	-	-	-	-	-	0.20
Paddy	-	-	-	-	-	0.75
Kodo	-	-	-	-	-	0.20
Jowar (green fodder)	-	-	-	-	-	30.00
Bajra (green fodder)	-	-	-	-	0 50	58.25
Wheat	139.7	135.4	164.0	197.9	368.1	206 40
Lentil	37.5	37.2	43.6	46.0	63.4	70 50
Gram	264.1	267.2	272.3	278.0	77.2	158.55
Linseed	4.2	4.2	13.2	15.0	5 0	9 50
Mustard	4.6	4 4	7.0	10.0	58.8	48 05
Barley	31.5	31.0	35 0	34.6	87.5	57 00
Potato	-	-	-	-	2.0	5 00
Sugarcane	-	-	-	-	1 0	1.00
Pea	-	-	-	-	4 0	49 00
Berseem (fodder)	-	-	-	-	1 0	4.00
Barley (green fodder)	-	-	-	-	-	4 00
Vegetables	-	-	-	-	4 0	14.90
Fruits/Hort	-	-	-	-	3.2	3.40
Cropping intensity (%)	100.20	100 60	128.10	135.00	155.60	156 60

power has increased from 307.8 during 1983-84 to 1658.20 during 1988-89 (Table 7).

8. Employment Generation :

The project has provided tremendous employment opportunities to the local masses. Considerable labour was employed for earth work and construction of check dams and submergence bundhies during 1983-84 to 1985-86. Further, the increased gross cultivated area and cropping intensity has also provided considerable employment opportunities, (Table 8)

9. Energy and Fuel Production :

The total fuel production in the project area has gone up from 1176.2 q in 1983-84 to 4978.5 q in 1988-89. Prior to initiation of the project the energy production was 3.94 x 10^{12} Joules which has increased the level of 1.60 x 10^{13} Joules during 1988-89, comfortably fulfilling the demand of the people in the project area (Table 9)

10. Socio-Economic Evaluation :

Socio-economic study carried out in the project area showed that per capita income has gone up to Rs. 1400.80 during 1983-89 compared with Rs. 93.50 during 1983-84 (Table 10). Out of 491 families falling below the poverty line during 1983-84, 390 families have crossed the line. Increased number of assets like tractors, tubewells/pumpsets etc. are indicative of the prosperity brought in the area by watershed management programme involving conservation of resources, higher input use and adoption of improved technology of crop production (Table - 10).

The project involved an expenditure of Rs. 22.132 lakhs. The land treatment by various mechanical measures for soil and water conservation, namely, contour bunding, submergence bunding, water storage structures, farm pond etc. super imposed with improved crop production technology has resulted in increased agricultural production including milk, sheep and goat rearing, aquaculture, poultry farming etc. The benefit cost ratio for the different years is provided in Table - 11

Table 5 : Productivity (q/ha) of different crops in the project area during 1983-84 to 1988-89						
Particulars	**1983-84**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**
A. Cereals						
Sorghum	4.50	5 5	6.8	11.6	21.82	22.5
Bajra	4.6	5.6	7 0	8 5	12.5	12.5
Wheat	10.0	10.6	18.5	23.5	35.2	41 1
Barley	6.5	8.5	17 4	23.0	33 3	36.6
B. Pulses						
Urd	-	-	-	9.5	9 5	12.5
Moong	-	2.5	3.5	7 3	7.5	10.5
Arhar	5 6	6.6	13.2	16.6	18.0	18 6
Lentil	5.8	5.6	11.2	14 9	14.8	18.6
Gram	6.2	6 5	16.5	19.7	27.5	26.1
Pea	-	-	-	-	17.0	20 5
B. Oil seeds						
Soybeen	-	-	-	13 7	14.0	15 5
Linseed	2.6	2.8	5 9	8.0	8 3	8.8
Mustard	2.5	3.5	3.6	4 6	4.7	4.6
Sesame	-	2.3	3.6	4.6	4.7	4.6
D Vegetables						
Potato	-	-	-	-	205.0	235 0
Bhindi	-	-	-	-	75.0	100.0
Brinjal	-	-	-	-	200.0	235.0
Radish	-	-	-	-	200.0	225.0
Pumpkin	-	-	-	-	210 0	215.0
Bittergaurd	-	-	-	-	80.0	82.0
Onion	-	-	-	-	215.0	220.0
Calocasia	-	-	-	-	-	220.0
Taroi	-	-	-	-	-	100.0
Carrot	-	-	-	-	-	250.0
Chillies	-	-	-	-	-	110 0
tomato	-	-	-	-	-	225.0
Rajmah	-	-	-	-	-	18.7
E. Green Fodder						
Berseem	-	-	-	-	550.0	650.0
Bajra	-	-	-	-	190 0	300.0
Jowar	-	-	-	-	-	400.0
Barley	-	-	-	-	-	500.0
F Sugarcane	-	-	-	-	-	685.0

Table 6 : Animal Population, Milk and Fish Production						
Particulars	**1983-84**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**
Animal Population						
Cows	249	256	366	395	480	506
Buffaloes	365	378	396	411	780	1531
Others	934	1158	1462	2036	3137	4618
Fodder Production						
Green fodder (q)	-	-	-	-	645.00	28010.00
Dry fodder (q)	6697.75	7291.10	14137.39	21948.95	36595 25	34070.60
Milk production (000,1)	352.71	369 99	520.41	651.74	1218.54	1476.60
Fish Production (kg)	-	-	-	-	500 00	600.00

Table 7 : Draft Power Availability in the Project Site						
Particulars	**1983-84**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**
Draft Power						
No. of Bullock pairs	338	356	405	458	746	722
No. of tractors	3	5	9	10	23	35
Total horsepower	307.8	388.6	558.0	624.8	1252.6	1658.20

Table 8 : Employment generation (man days) in the project area						
Particulars	**1983-84**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**
1. Casual employment generation for land treatment						
Men	21870	93540	81540	-	-	-
Women	-	-	-	-	-	-
Total	21870	93540	81540	-	-	-
2. Regular employment linked with increased cropped area						
Men	50257	50371	63737	67663	87766	80138
Women	2645	2650	3355	3560	4620	4215
Total	52902	53021	67092	72223	92386	84353

Table 9 : Fuel and Energy Production in Rendhar Watershed						
Particulars	**1983-84**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**
1 Fuel Production (q)	1174.2	1680.2	3139.2	3826.0	4900.8	4978.5
2 Energy production (J)	3.9×10^{12}	5.60×10^{12}	1.02×10^{13}	1.25×10^{13}	1.60×10^{13}	1.60×10^{13}

Table 10 : Socio-Economic Improvement in the Project Area						
Particulars	**1983-84**	**1984-85**	**1985-86**	**1986-87**	**1987-88**	**1988-89**
1. Per capita income (Rs.)	93.5	143.6	359.2	631.6	1080.5	1400.8
2 Families above the poverty line	62	62	77	356	422	452
3. Families below the poverty line	491	491	476	197	131	101

Table - 11 : Benefit Cost Ratio for Different Years				
S.No.	**Year**	**Ratio**		**Cummulative Benefit**
		Cost	**Benefit**	
1.	1985-86	1.00	1.00	-
2.	1986-87	1.00	1.61	2.61
3.	1987-88	1.00	2.75	5.36
4.	1988-89	1.00	3.58	8.94

WATER-LOGGING IN THE BHANDER CANAL COMMAND AREA

Introduction

The Bhander Command area falls in Datia and Bhind districts of Madhya Pradesh state and lies between N.latitudes N.26°25' and E.longitudes 78°35' and 79°10'. With the advent of intensive irrigation in the Bhander Command area from the Matatila reservoir, the water table in this area is progressively rising. It is situated in Sind and Pahuj rivers *Doab*. Physiographically, the Bhander Command area is mostly a flat terrain and has a general gentle slope towards the north-east. The entire area consists of alluvial formations with a few isolated hills of granite and quartz reefs at places. This area comes within the Sind and Pahuj sub drainage basins of the Yamuna drainage basin. The Sind and Pahuj are the main rivers of this command. The Index Map of Bhander canal system is shown in Fig. I. The climate of the Bhander command can be designated as semi-arid, characterised by extreme of temperature, variable and uncertain rainfall. The extreme climatic conditions may be attributed to its inland location, lack of vegetal cover, nature of soils and the presence of bare rocks. The winter season is normally cold while summer season is hot and dry. The rainy season is quite pleasant with sporadic greenery. It receives about 732 millimetres average annual rainfall.

SOIL

The soils of the area may be grouped into high ground and low ground soils. These soils vary from sandy loam to clays. Below these soils, a substratum consisting of yellow clay with *Kankars* also occurs at places. Saline and alkaline soils are also found in the study area.

GEOLOGY

The geology of the area is described by Heron (1922) & Saxena (1975) The regional geology of the area is shown in Fig 2 and the geological succession is as follows:

Recent	Alluvium	Sand, Silt, Gravel, Clay etc.
	Unconformity	
Pre-Cambrian	Vindhyan Super group	Shale and Sandstone
	Unconformity	
Proterozoic	Gwalior Group	Shale and Sandstone
	Unconformity	
Archaean	Bundelkhand Granitoid Complex	Granites and Gneiss

The area is mostly covered with the alluvium. The alluvial formation consists of sands, silts, clays, lens of gravel, pebbles, etc. The lithological logs of the bore holes show that the beds of sand, silts and clays become thick and thin at places with small lenses of clay in between. Some times, the lenses of clay also occur in sand beds. The borehole logs also indicates that the thickness of the alluvium increases towards the east (Fig.3) The maximum thickness of the alluvium in the study area is 82 metres. The entire study area is covered with the alluvium.

Hydrogeology

The general hydrogeology of the area is discussed by Chourasia (1984) and Jain (1990). The occurrence of the alluvial formation is similar as described by Bhatnagar etal.(1983) and Phadtare(1985) The significant hydrogeologic unit is the sand horizon (aquifer) consisting of fine to coarse-grained sand. The ground water is found in clay-kankary bed, sands and lenses of gravel and pebbles. It occurs under semi-confined to confined conditions as well as water table conditions. The movement of groundwater is towards the main river courses. The pre and post monsoon water level fluctuation in dug wells varies from 0.49 meters to 6.30 metres. Pre-monsoon depth of water table map (May 1994) is shown in Fig 4 It indicates that the central part of the area has very shallow water table in comparison to the other parts of the area. The water-logged area is found in this area. The annual groundwater recharge of the area is 0.044 million hectare meters and the annual ground water draft

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is 0.018 million hectare metres (Jain 1990). It indicates that recharge is more than the ground water resulting in the rising of water table of the area. It is the indication of the water-logging condition of the area.

Extent of Water-Logged Area

National Commission on Agriculture (1976) has defined an area to be water logged when the water table rises to an extent that the soil pores in the root zone of a crop become saturated, resulting in restriction of the normal circulation of air, decline in the level of oxyzen and increase in the level of cabon dioxide. Sharma (1979) states that a land is said to be water-logged when the soil pores within the root zone of the crops, normally grown, are effectively saturated due to lack of aeration. of the soil thus leading to reduction in the yield of the crops. According to Navalawala (1995), the problem of water logging is wide spread and exists practically all over the world and that the solution lies in taking effective preventive and remedial measures.

During the field work in the year 1994 of the Bhander command area, it is found that the farmlands of some villages are entirely water-logged and some farmlands approaching towards water logging conditions. A list of these villages is given in Table 1. The Fig 5 brings out the distribution of the water logged areas in the study area., During the field work, it is observed that mostly water logged areas are adjacent to the major or minor canal systems. The total water-logged area of the Bhander Command was 55,000 acres during the year 1994.

The actual depth of water table when it starts affecting the yield of the crop adversely may vary over a wide range from zero for rice to about 1.5 metres for other crops. But in general, in the Bhander Command the area with water table within 3 metres below the ground level have been considered prone to water-logged and those with water table within 3 to 5 metres below the ground level have been considered as critical areas wherein any additional input of water without protective measures can turn them into water-logged areas.

Types and Causes of Water-Logging

Due to the irrigation from the water of the Matatila reservoir in the Bhander Command, two types of water-logging conditions have been noted. The first type is mostly due to the irrigation water which is neither being able to drain through the soils nor getting drained as run-off into the streams and rivers. The second type is on account of general rise in the ground water level. Wherever, the first type of water-logging conditions occur, the area is found to be low ground, not only with in adequate surface drainage, but also with clay soils having poor drainage profiles.

In the Banthari water logged area, an observation auger hole was made in a field about thirty metres away from the Bhander main canal. This test indicated that the ground water occurs under a pressure of about 180 kilograms per square metre at a depth of about one metre below the clayey soil cover. In this 15.24 cms. diameter auger hole, the water level rose to a height of 22.86 centimetres. In five minutes, the ulti-

Table -1 : Water Logging in the Bhander Canal Command Area

Depth of water below ground level	Village	District
(A) Farm Lands Water Logged		
0-1 metre	Hilgawya, Machharya, Banthari, Imlaha, Manpura	Bhind
1-2 metre	Badagaon, Saigawan, Kholan, Mahabirgank, Nodhini, Ratand, Lalpura, Kunwarpura, Singpura, Sisawal	Bhind
	Ruram Ruaha, Chorni, Dhorra, Dhoori, Barchha	Datia
2-3	Tharet, Basturi, Maharajpura, Atra, Rathaoli, Merseni, Merseni Bujurg, Gandhigram, Dharampura	Datia
	Ratanpura, Raipura, Nonpura, Sijaripura, Lahar, Kataha, Machhand, Daryaopur, Noadha, Shahpura, Baripura, Banupura, Amaha	Bhind
(B). Fram Lands Approaching towards Water Logging 3-4 metre	Kasal, Belma, Kaitha	Bhind
	Nihla, Dobni	Datia

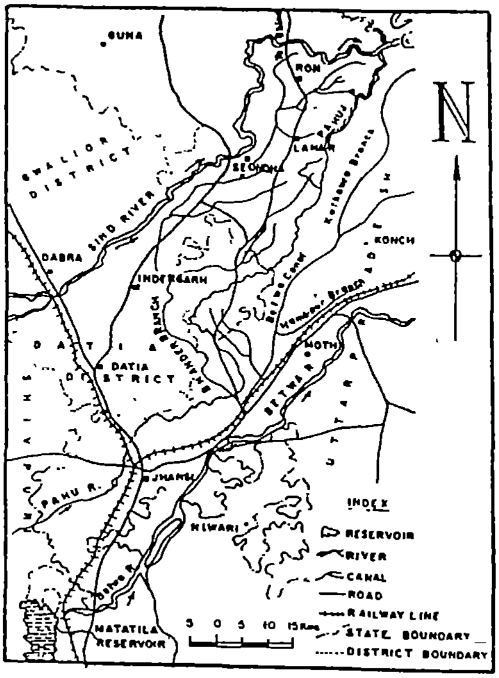

FIG. 1 LOCATION MAP OF BHANDER COMMAND AREA

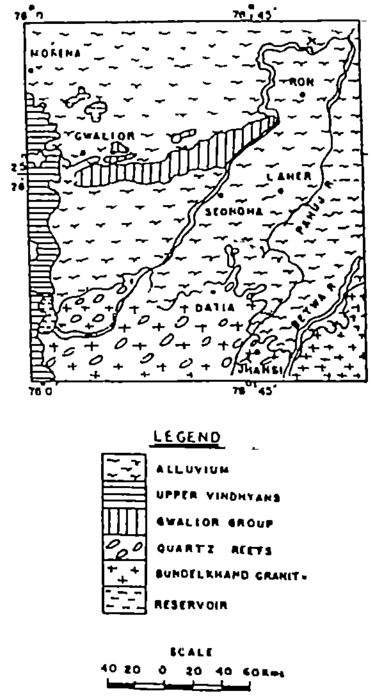

FIG. 2 REGIONAL GEOLOGY OF THE AREA

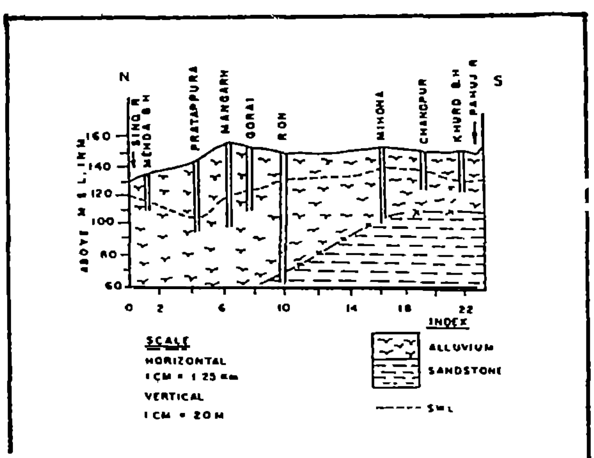

FIG. 3 GEOLOGICAL CROSS SECTION ALONG X-Y BHANDERCANAL COMMAND AREA M.P.

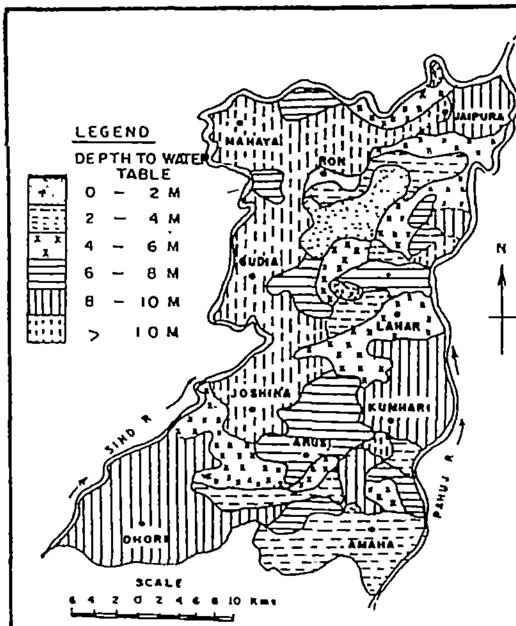

FIG. 4 PREMONSSON DEPTH TO WATER TABLE MAP (MAY 1994)

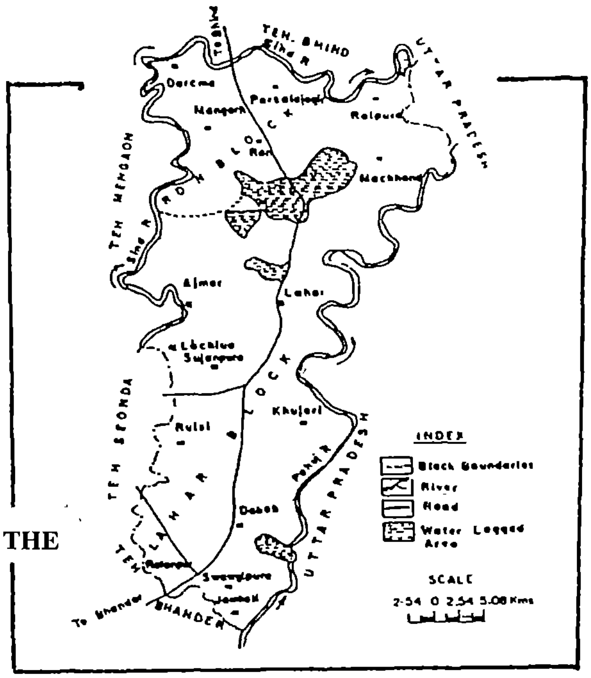

FIG. 5 WATER LOGGED AREA OF THE BHANDER COMMAND, M.P.

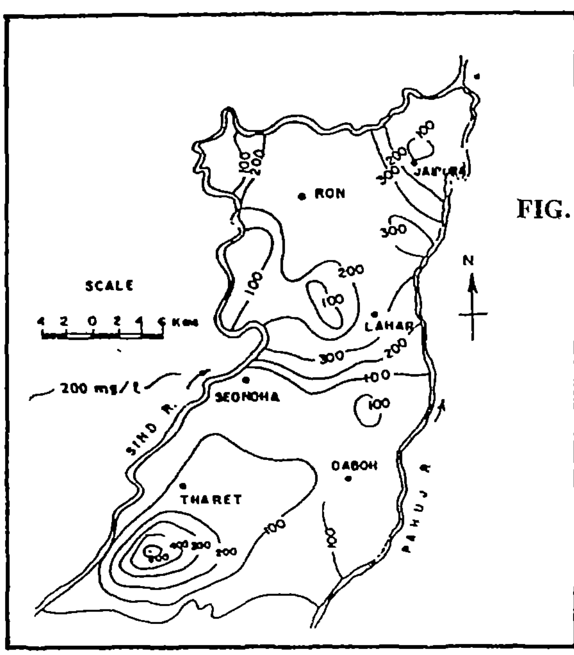

FIG. 6 ISO CHLORIDE MAP OF BHANDER CANAL COMMAND AREA, M.P.

mate static water level being 30.48 centimetres below the ground level. On account of this pressure, the capillary rise of water through the clayey soils keeps the soil moist and at the same time, does not permit the soil to dry sufficiently during summer months to produce mud cracks. The root porosity is also destroyed on account of the expansion of the soils. On account of these condition, the question of drainage of irrigation water (applied on the land through the soils) does not arise, as the soils have poor drainage profiles. In addition, the water of underlying semi-confined aquifer exerts pressure on the overlying clay horizons, making infiltration of surrface water negligible.

Water Logging in the Bhander Canal Command Area

The second type of water-logging is due to the rise in the groundwater levels. This rise is due to the improved recharge and infiltration condition as well as due to the presence of water pockets in the depressions on recharging grounds or want of surface water drainage facilities. A study of the ground water level profile starting from the Bhander main canal towards the Sind river indicates that the water levels sudddenly drop down to a depth of about 20 metres or even more, in areas immediately adjacent to the ravines. Such abrupt changes in groundwater levels may be due to (1)faulting and consequent downward displacement of the aquifer zone towards the river Sind, (2) the aquifer zone may get laterally reduced in its porosity and permeability conditions, if this is the case, the deep groundwater levels in areas adjacent to the ravines of the Sind and Pahuj rivers may represent water levels of different water bearing zones(3) the presence of deep ravines acting as groundwater trenches, and (4) due to the deterioration of the confining conditions in the aquifer zones towards the Sind and Pahuj Rivers. The best example of this is the Chakora nala which was influent before surface water irrigation from the canal. But now it becomes perennial. Out of these mentioned causes, the ravines acting as groundwater trenches appears to be the most likely cause.

The soils of the Bhander Command area have been studied to get an idea about the infiltration grounds through which the water is added to the water bearing formations. The soils of the study area may be broadly ground into high ground and low ground soils. These soils vary from sandy loam to clay. Saline/alkaline soils also noticed in a few localities of the Bhander Command area. On the whole, the soils are good and if provided with an adequate supply of irrigation water, they can be made highly productive. Below these soils occur a substratum consisting of yellow clay with kankars. The proportion of clay kankar determines the permeability of the substratum. Due to erosion, this substratum is exposed on the sides as well as on the beds of the deep ravines. But in the low ground area, it is generally capped by clay horizons of thickness range from 30 centimetres to 300 centimetres. This substratum covers a large area, and its outcrops are to be seen in the study area. Similar outcrops have also been noticed in the ravines of the sind and Pahuj rivers. This formation acts as an aquifer zone. At places where it is capped by clay, groundwater occurs under semi-pressure conditions,. Wherever, this formation is exposed on the ground surface or is overlain by soils other than the clays, groundwater occurs under water table condition., Thus, one can safely assume that most of the ground surface of the Bhander Command area acts as an average infiltrating ground for the rainfall excepting the area covered by heavy textured soils.

Prior to irrigation, on account of recharge to the groundwater from annual rainfall, the rise in the post-monsoon groundwater levels was about 3 metres from the summer static water level position. After a few years of irrigation, the static water level have risen and in some of the water-logged areas, they are just near the ground surface. Even during the summer months, the groundwater levels fluctuate very little. As a consequence, the available barren underground storage spaces of the aquifer zone are unable to accommodate a part of the annual run-in (recharge/infiltration) waters from the rainfall. This was not the case prior to irrigation. Therefore, most of the rainwater is now disposed of as run-off and as evaporation losses in the entire water-logged terrain. This has upset the natural balance between the run-off on the one hand and the run-in on the other.

The natural drainage courses like gullies, stream etc. have become inadequate for conducting the extra drainage capacities for the products of the erosion in their water draining capacities. On account of this feature, standing pools of water act either as recharge ground or as water barriers to the free flow of groundwater (effluent flow) in to the natural depressions. This leads to the rise in the static water levels of the shallow groundwater bodies.

A traverse from the town Bhander to the Sind river has revealed the fact that during the construction of canals, the thin soil cover layer above the yellowish clay-kankary water-bearing zone has been excavated at a number of places. As a consequence the canal water flowing under pressure is in direct contact with the water-bearing zone, as a result of which seepage losses occur through the floor and the sides of the canal. This results in the rise of groundwater levels. Adjacent to the canals, wherever the water-bearing zone is capped by a clay horizon, groundwater occurs under pressure. At places, the soil materials used for the construction of the canal embankments (as observed from the borrow pits), are of porous nature. The seepage losses from such sections of the canal embankments are also responsible for contributing water to the recharge areas which lie adjacent to the canals.

As already stated most of the Bhander Command area consists of moderate infiltration grounds. In addition the water-bearing zone (clay-kankary horizon), either out crops or occurs at shallow depths. Therefore, irrigation water have a wide scope to recharge the shallow groundwater bodies of the area, where extensive irrigation is being practiced. These observations bring out the fact that the problem of water-logging in the Bhander Command area can be classified into two categories namely(1) water-logging on account of seepage through the canal sides and floors, destruction of natural drainage condition, etc., and (2) water-logging due to the presence of infiltrating and recharging ground condition in the command area, occurrence of water-bearing zones at shallow depths, extensive irrigation practices, etc. The water-logging condition are very much similar as found in the Chambal area of M.P.(Chourasia, 1987).

Consequences of Water-Logging

Water-logging [illegible] affects the chemical, physical and biological properties of soils resulting in adverse growth conditions of the crops cultivated. The water from the water table rises up by capillary action and brings with its salts in solution. When the evaporation of surface water takes place, the salts are accumulated. This accumulation of salts when present in the root zone of any plant has corroding effect on the roots. Due to this, the growth of plant is checked and the productivity is also reduced. These excessive soluble salts if not removed earlier and if the soil is clayey, a base exchange reaction takes place due to which the soil become impermeable and highly unproductive.

Chemical Quality of Ground Water

The chemical quality of groundwater has been studied on the basis of chemical analysis of 65 ground water samples collected from the open wells The shallow aquifers water are generally alkaline in nature with pH ranging from 7 3 to 8.5. The total dissolved solids vary from 461 to 2345 mg/1 and the electrical conductivity ranges from 515 to 3228 micromhos/cm at 25°C. Alkalinity varies from 12 to 706 mg/1. The chloride concentration ranges from 30 to 520 mg/1. Isochloride map (Fig.6) shows that the central part and south Western part of the area has more concentration of chloride than the other parts of the area. It may be due to water-logging and evaporation processes in this area. Higher mineralization in groundwater is noticed in certain tracts or pockets often coinciding with areas of shallow water table

Remedial Measures of Water-Logging

The remedial measures suggested for the first type of water-logging are as follows·

- Lining of Canal floors and sides wherever, the yellow clay with kankar (water-bearing zone) has been exposed.
- Formation of water pools should be avoided
- Reopening of all the effective natural drainage courses such that the surface waters are conducted to their respective river systems.
- Construction of drainage channels parallel to the main canal at locations where seepage occur through the floor and the sides of the canal,
- Construction of drains to dispose-off the surface run-off of low grounds into the natural drainage courses.

The remedial measures for the second type of water-logging required the determination of the extent of individual recharge and infiltration area. Their relative recharge capacities should be evaluated on the basis of their percolation. In addition, water table and pressure-surface maps have to be prepared not only for the irrigated area but also for the area occurring on the left side of the main canal. On the basis of these data, the following preventive measures have to be taken up.

- Supply of irrigation water should be drastically curtailed in the case of farlands, where groundwater levels have reached up to one metre below the ground surface.
- On lands, where groundwater levels are more than one metre below the ground surface, irrigation water supplies should be based by taking into consideration, the soil profile, depth of profile, drainage profile and the ground slope along with the consideration of the water requirement of the crops at various stages of their growth, irrigation on the concept of "Duty of Water" should not be practiced.
- The type of crops that are to be grown, should also be based on the ground water level depths during different seasons of the year.
- Land shaping practices should be implemented and the bunds dividing them into small fields should be spaced far apart.
- Adequate provision should be made for run-off from the fields.
- Intensive exploitation of groundwater for irrigation purpose should be resorted in the command area, where canal water is not being used for irrigation. The sites for the wells should be located on the recharging grounds of the water logged areas and in the ayacut area. These wells will serve a dual purpose namely they will not only bring new area under irrigation, but they will also reduce the groundwater levels in general.
- Wherever, proper underground reservoir capacities are available for the intake of the water from the upper ground zones, inverted wells should be located specially in areas where the groundwater of the upper horizon exists under pressure.
- Wherever, serious recharging conditions occur in ponded areas adjacent to the water-logged areas, clay material have to be dumped into the pools to reduce the infiltration capacities.

Conclusion

In conclusion, it may be mentioned that the water-logging in the Bhander Command is in the initial state of its development. Preventive measures are much cheaper than the curative measures. As a first step, all the natural drainage courses should be opened up and broadened up to drain of the run-off water, and the supply of irrigation waters to the water-logged areas should be stopped. As a second step, wherever, pools of water occur, they should be drained. The third step consists of providing drainage channels parallel to the main canal on the left bank side. The fourth step consists of the use of proper agronomic provision of adequate drains to implement economical use of irrigation waters.

Water-logging and the alkalinity of the soils in the command area are intimately associated with one another. The water in the yellowish clay-kankary water-bearing zone appears to contribute to the alkalinity of the soils. The alkalinity of soils in the farmlands is more intense, where the water of the lime-kankary horizon is under pressure. The alkaline materials are more in solution towards the ground surface through the overlying soil cover, on account of pressure as well as capillary and seasonal drying action. Therefore, the prevention of water-logging helps in checking the alkalinity of the soils also.

Detailed hydrogeological surveys need to be under taken in the command area for delineating aquifers and their characteristics for proper planning of groundwater development structures and a strong data base simulation studies may also be undertaken for predicting the behaviour of groundwater regime with the additional surface water input in the command.

Acknowledgement

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REMOTE SENSING - A SOLUTION TO GROUND WATER SOURCE FINDING PROBLEMS OF BUNDELKHAND REGION

Introduction

The advent of satellite remote sensing has introduced a new dimension in the field of groundwater exploration and development. While the remotely sensed data can not be used directly to map the aquifers or groundwater conditions, it helps in drawing up suitable indirect inferences regarding the subsurface through surficial expression of the acquifer related soil rock regimen. The subsurface hydrological conditions are inferred from the identification and correlation of surface phenomenon such as geological features and structures, geomorphology, surface hydrology, soils and soil moisture, vegetation type and their distribution, land use and others which act as surface indicator of the occurrence of ground water. The use of remote sensing data as a first step helps to narrow down the target areas for further detailed exploration such as geological surveys and test drilling. This greatly reduces the cost and time in exploration of groundwater.

Application of Remote Sensing in Hard Rock Terrain-Bundelkhand region of Uttar Pradesh

Bundelkhand region of Uttar Pradesh is one of the most water starved areas of the country. Because of erratic rainfall, rocky terrain and higher runoff, the region faces acute water scarcity for most part of the region, it has traditionally been felt that the region is devoid of ground water. With the application of the techniques of remote sensing it has been possible to properly understand and evaluate the occurrence of groundwater. It has now been established that this region does hold promise for development of ground water resources. What is required is a systematic and thorough investigation approach integrating remote sensing technology with the other exploration methods. NRSA (1980) conducted a preliminary satellite remote sensing survey of the Bundelkhand and adjoining areas and recommended certain areas for detailed investigations to confirm occurrence of ground water.

Thus, realising the need for a unit responsible for taking up systematic studies for evaluation of ground water resources in the Bundelkhand regjon,the Remote Sensing Applications Centre, U.P. , established an Exploration Division at Jhansi. The division is taking up basinwise studies as well as the investigations for various users agencies for selection of suitable bore-well sites and till March, 1996 approx. 7000 sites have been recommended for further geophysical surveys on the basis of remote sensing investigations. Out of these 3700 sites were found suitable after the electrical resistivity surveys and were recommended for drilling. The information regarding drilling of many sites has since been received and approximately 89 percent have been found successful with discharge varying from 500 gallons per hour to 36,000 gallons per hour.

The major part of Bundelkhand is covered by Bundelkhand granites & gneisses, which on the south is bordered by Vindhyan sandstones, limestones and shales and on the north by the level plains of recent gangetic alluvium. The Bundelkhand granites are well traversed by the quartz reefs running in NE-SW directions and dolerite dykes generally extending in NW-SE directions. Besides these linear features, many other lineaments are observed in the granitic terrain as well as in Vindhyans. A part of Lalitpur district along river Sajnam, Shahzad and Jamni is occupied by the

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valley fills. Also few exposures of Bijawar group and Deccan Traps are observed in parts of Lalitpur district. Ground water occurs in the weathered mantle and in the joints and fractures developed in the granites, sandstones, shales and limestone due to tectonic activity. The preponderance of quartz reefs and dolerite dykes and various other lineaments in the region has direct influence on ground water occurrence and movement.

Case Histories

A few illustrative case studies of the application of remote sensing technology in groundwater targetting in the Bundelkhand region are presented herein.

1. Area Around Barata Village, Jhansi District:

A large number of geoelectrical soundings (57) were carried out at points selected on the basis of satellite and aerial remote sensing investigations in the Barata basin. Most of these sites were located within the interpreted palaeo-channels and the results obtained were found to be encouraging. Initially, one site in the vicinity of the branching abandoned channels of Betwa river near village Barata was selected and recommended. This site after the drilling has yielded a discharge of about 1400 lpm. Two more sites were subsequently drilled near villages Baragaon and Marora in the vicinity of same zone giving discharges ranging between 15,000 gph to 20,000 gph. Thus results have proved the presence of palaeo-channels which were delineated with help of satellite and aerial remote sensing techniques.

As a result of the aforesaid investigations in the basin, it has been possible to locate additional 30 tubewell sites with potential of high discharges, suitable for irrigation or town water supply mainly from palaeo-channel gravel aquifer, while 27 sites indicated low to medium discharges which could be utilised for domestic water supplies using handpumps.

Till the year 1991, Jhansi city water supply schemes could receive only 27 million litres per day (MLD) for distribution which was a meagre quantity of 87 litres per capita per day (lpcd). Nearly 86.8% of the existing water supply was depending on surface water resources. Further augmentation through surface water was not possible because of agro climatic factors.

On the basis of studies undertaken by the GED in parts of Barata basin, a well field was delineated at a distance of approx. 16 Km. from Jhansi & thus 9 MLD of additional drinking water was made available to the city in 1992 as an immediate relief.

This case history is a classic example of how the technology of remote sensing can be successfully integrated in the ground water exploration programmes specially in respect of different hard-rock areas. (Chaturvedi et al, 1983).

2. Area Around Banda City, Banda District:

The utility of identifying the palaeochannels by remote sensing inputs has again been demonstrated for delineating palaeochannels of Ken river around Banda city. If the sites for bore well are systematically selected in the vicinity, the drinking water problem of Banda city could be solved and furthermore the available groundwater in the area can be utilised for irrigation in the adjoining rural areas.

It has been possible to identify and delineate the outcrops, lineaments, meander cut offs, abandoned channels and point bar deposits (See Figure) using remote sensing data. Such investigations have been supported by adequate field checks.

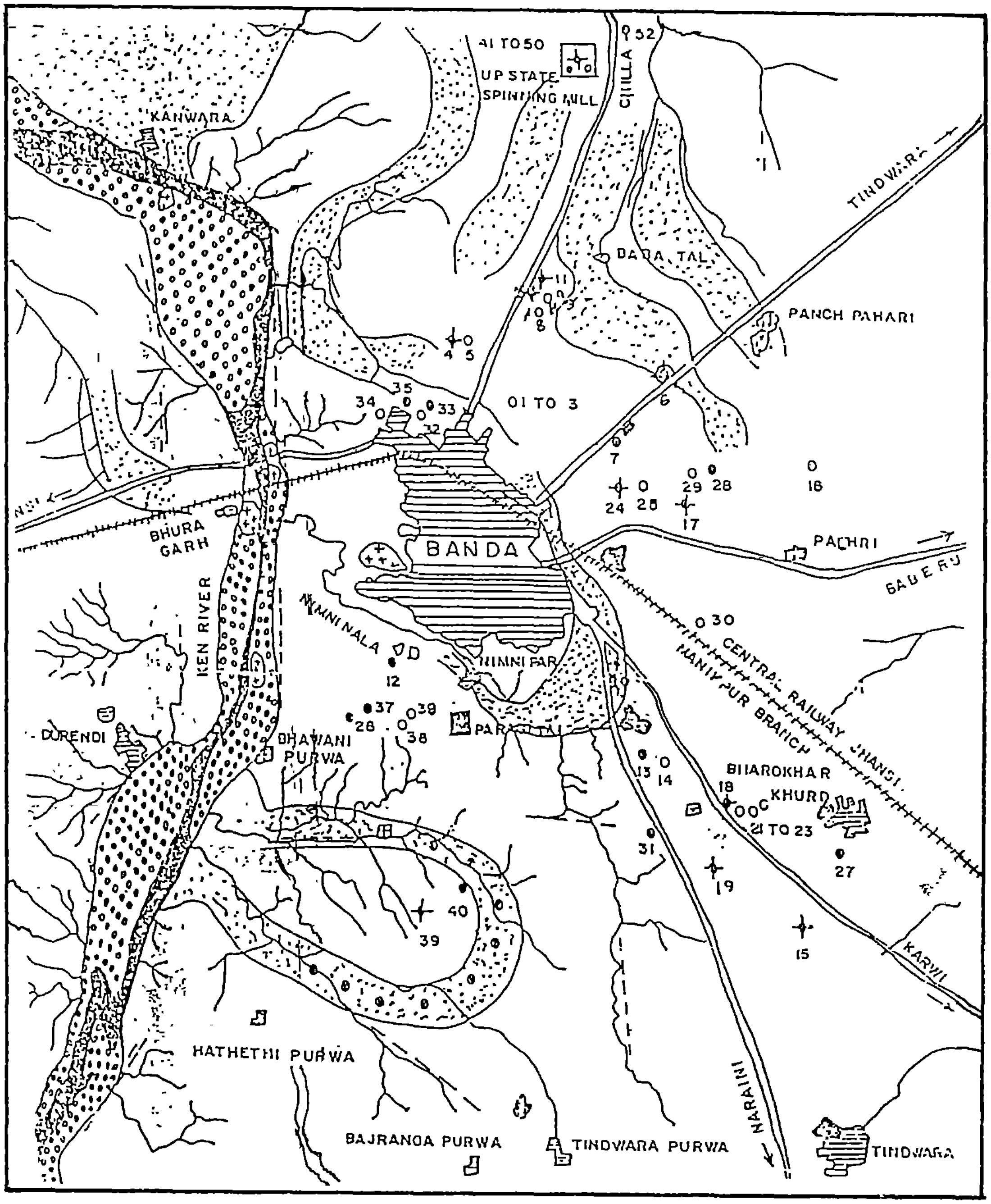
Based on these identifications and after carrying out detailed geophysical investigations, it has been possible to identify 26 sites for drilling of tube wells. Eleven of these sites have already been drilled successfully giving drill-time discharges ranging between 1500 to 20000 gph. Two sites drilled in the area proved unsuccessful.

In view of the urban sprawl & projected demand upto the year 2007, an additional quantity of approx. 14 MLD was envisaged for reorganisation of water supply scheme of Banda city. Considering the financial constraints & design aspects of the existing layout of distribution system etc, a paleochannel, identified in the immediate vicinity of Banda was recommended for additional withdrawl of groundwater by drilling a battery of tubewells. First cut results found very encouraging, , the yield of tubewells being in the range of 1500 to 3000 lpm.

It has been established that the palaeochannels of Ken river identified through remote sensing techniques hold enormous potential for groundwater exploration.

3. Balabehat area, Southern part of Lalitpur District:

Balabehat and its environs were one of the most starved areas of the southern Lalitpur district, because of erratic rainfall, plateau and highly vegetated vindhyan group of rocks and higher run off, the region



MAP SHOWING GEOLOGICAL AND GEOMORPHOLOGICAL FEATURES IN BANDA ENVIRONS.

LEGEND SCALE— 1: 50,000

SETTLEMENT
ROAD
RAILWAY LINE
DRAINAGE
WATER BODY
GRANITE
ABANDONNED CHANNEL
POINT BAR / SAND DEPOSITS
MEANDER CUTOFF
POINT SURVEYED WITH CODE No
Point Found Suitable for Drilling
POINT DRILLED SUCCESSFULLY
POINT SUGGESTED FOR GEOPHYSICAL SURVEY

faces acute water scarcity for most part of the area. It has traditionally been felt that the area is devoid of groundwater, people used to traverse long distances to fetch their drinking needs from Betwa and Saunr Nadi.

Realising this, RSAC, U.P., has carried out systematic surveys by utilising IRS and TM data of 1:50,000 scale for locating potential well sites. In this endeavour 17 handpumps sites and 7 tubewell sites were recommended for groundwater development. Among these, 12 hand pumps and 2 tubewells sites were drilled with discharges varying from 500 to 10,000 gallons per hour. Geomorphologically, the area is characterised by southern upland plateau province, which in turn characterised by flat and highly vegetated upper vindhyan group of sandstones and conglemerate rocks.The study area comprises valley fills, buried pediplains, dissected plateau and lineaments. Towards north 1.5 Km. from Balabehat, a NW-SE trending lineament was picked up from IRS satellite image. Further studies reveals, that the area is highly vegetated and topographically low and Sunar Nadi follows this lineaments. Consequently geoelectrical surveys were conducted to know the depth of fractured zone.

As a result of the aforesaid investigations in this area it has been possible to locate additional 7 tubewell sites with potential of high discharges (10,000 gph) suitable for irrigation or town water supply schemes.

This case history is a classic example of how the technology of remote sensing can be successfully integrated in the groundwater exploration programmes, specially in respect of different sedimentary rock terrain.

4. Erich Irrigrrtion Scheme, Jhansi district.

The village Erich is located about 125 Km north east of Jhansi on the bank of river Betwa. The area is poorly irrigated since water supply through canal is inadequate due to tail end and minor irrigation schemes such as dug well, tubewell, dug cum bore well are only few in the area. To augment the irrigation facility in the area State Tubewell Construction Division approached RSAC for exploring the feasibility of State Tubewell in the area since norms of discharge for success of state tubewell are very high.

The task initiated by making use of Landsat TM FCC and aerial photographs of the study area and a detailed interpreted map was prepared showing various hydrogeomorphic units. In vicinity of Erich the land is severely eroded and even ravines are formed in few areas. The feed back of previous drillings in the area further confirmed poor groundwater potential in this zone. However, a typical patch interpreted to be flood plain of Betwa river was noticed on the Landsat TM FCC in the north of eroded and ravinous lands near Erich.

Also this patch is located on the convex side of Betwa which is likely to be more potential as regards to groundwater. Further, hydrogeological data was collected in the field. The water level in the area is about 12 mbgl and feed back of strata in dug wells in the area indicated that underlying strata is intercalation of sand and clay showing various phases of deposition. Four sites were selected on the basis of landsat TM FCC interpretation and those were further investigated using electrical resistivity survey. All of them were found to be suitable and were recommended for drilling to State Tubewell Construction Division According to location wise suitability one of these site close to Erich on Erich-Dukauli road was drilled and has yielded 22,000 gallons per hour reported to be first high discharge tubewell in the area.

Conclusion

In the Bundelkhand region of Uttar Pradesh where conventional ground water targetting had not yielded satisfying results in the past, it has now been possible to use remote sensing technique for narrowing down the target areas for further ground water exploration. Some of the features identified through remote sensing technique have led to delineation of highly potential groundwater areas which have been established after drilling. This technique is now operationally integrated with the conventional field investigations including geophysical surveys for day to day work of basinwise targetting in the hard rock areas as well as for investigation for various users department. Only some of the representative case histories could be included in the text but Remote Sensing data is optimally utilised by this centre as the first step to any ground water exploration programme in the region. However, it has been found that many of the sites selected are not being drilled by the user agencies because of their location not suitable to them. Hence there is extreme need for awareness of the fact that in some cases ground water may be available in limited pockets only and one can think of location wise suitability when other alternatives exist.

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CHECKDAM CONSTRUCTION IN BUNDELKHAND AREA

Bundelkhand area of Uttar Pradesh consist of mainly 7 districts i.e. Jhansi, Lalitpur, Jalaun, Hamirpur, Mahoba, C.S. Nagar, Banda. The area lies between 78° 09' to 81° 36' East longitude and 24° 08' to 26° 25' North latitude. It consists of 47 development blocks out of which 23 are rocky. The soil cover varying from 0 meter to 100 meter with granite rock at the base. The underground water in rocky area is found only in the joints and fissures. The slope of the area is very high and topography is undulating causing the rain water to flow out of the area. The sources of irrigation are canals from storage tanks, tubewells, open wells, boring pumpsets, tanks, checkdams, ponds, lakes, shallow and deep tubewells and few artesian wells. Due to this rocky trend, the sub-surface ground water storage is very low. Most of the rain water flows down through the rivers, to main river Yamuna. During the month of September the rain water causes flood in this region. In September 1992 there was a serious flood in Banda distt. due to which great loss of life and property was caused. There is lack of water during the summer season. The water is not available for Rabi irrigation, as well as there is shortage even for drinking water during summer season. This has necessitated the construction of such projects which could store maximum rain water by surface resources. Due to this very reason, the old tanks of Bundelas and Chandelas are very popular in the area which store the rain water. These storage tanks are the back-bone of the human life. Due to passage of time, these tanks are silting resulting in less storage capacity and drying down during the drought season, due to these reasons it has been necessary to find alternative sources for storage of water. One of the means to develop in this direction was found to be the small storage check dams constructed across the *Nalas* and creation of mini reservoirs on up stream side. It has been found by the practical experience that due to these storage the open wells in the vicinity of the structures have been rejuvenated. The surface water storage is utilised for irrigation purposes with the Diesel pumping-sets owned by the farmers under Minor Irrigation Programme. There is no doubt that irrigation is one of the essential inputs in the agriculture production. Hence special emphasis is required in the region to improve the economic condition of farmers and also to meet food requirements of the area. While major and medium dams are existing in the area, they are not sufficient to meet the total demand of the area. At the same time, the major projects require lot of money. The time period for the construction of Major projects is quite long. It is better to construct these projects simultaneously with small storages structures, the average annual rainfall of Bundelkhand is 88 cms, some time it goes to 100 cms.

Problems in Checkdams :

A large number of checkdams by different agencies are under construction in Bundelkhand area for the last 10 years. We can call it as an experimental period. It has been found that large number of checkdams have been out of use due to change of course by the *Nalas*. The design also needs improvement as per the site experience. It has been found that when the course of the *Nala* is obstructed, the H.F.L. increases; due to this more area is submerged and the *Nala* course has a tendency to flow on a different course. It has also been found that the length of the checkdam constructed was kept on lower side due to which water did not find sufficient passage to pass over the checkdam. Normally submerged type of checkdams are constructed, due to this submergence there is always a possibility for cutting the banks of the checkdam. In case the maintenance work is not carried out regularly every year, the side cuttings go on increasing and causes great loss to the project and makes it out of the use. Normally no reservoir is

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being created on the up stream sides of the check dam due to which a very limited water is stored and the full benefit of the project is not taken. Normally the project is handed over after construction to the village body, it has been found that local body does not take any interest in maintenance and the whole responsibility is left over to the Govt. Deptt., who do not have sufficient funds to maintain these structures. This is proposed that at least 10% strengthening funds should be provided in the original estimate to meet the fury of the one rainy season. To allow excess water to flow during floods the side embankment should be made *Pucca* by stone pitching. In the construction of checkdam cut off walls are constructed on the up stream and down stream side. The cut off walls are normally constructed by cement concrete, it is difficult to lay down the cement concrete in the bed of *Nala* at a deeper depth for cut off wall, as the water causes problem. It is proposed to use sheet piles of G.I Sheets, plastic sheets and any other material. The experience show that the height of the checkdam should not be kept more than 2 meters in these smaller structures.

Some of the guide lines in the construction of checkdam are as under : -

a) It should not be under the submerged area of any dam.

b) The checkdam should be able to recharge the wells in the vicinity, it requires fractured rocks and permeable soils.

c) There should be sufficient land for irrigation.

d) The water storage in the up stream side of the water should normally be around one km.

e) The lift should not be more than 8 meters for irrigation of fields by pumping sets.

f) The cost of the checkdam should be reduced by construction on the rocky area.

g) To avoid silting problem, silt outlet should be provided.

h) The construction of checkdam should not take place in the initial stage of *Nala*

i) Normally there should be flowing water during December.

j) The checkdam site should be at least 100 meters away from road and rail-tracks.

k) The hydrological data such as HFL, catchment, rainfall and the survey of the area should be carried out before constructing the checkdams.

l) The checkdam should be such which creates the normal requirements of the scheme under which it is constructed.

m) An additional 40% area should be provided in the cross section of the *Nala* to allow the water to flow in addition to the area obstructed.

n) To reduce the cost of checkdam the up stream and down stream floor should be limited to the minimum.

o) Random Rubble masonary can be used on underground construction and coarse Rubble masonary on the exposed surface.

p) River training works e.g. super walls are proposed to be constructed to control the course of the *Nala*.

q) The checkdam should be visited before rains and after rains, A file of photographs be kept for records.

r) Seepage through sub-structure due to permeable soil, the seepage of water takes place causing under mining and damaging the structure. In Egypt the old Manufia regulator failed due to under mining, similarly Narora wier failed due to uplift pressure causing floor to be damaged. So the apron should be properly designed.

The cistern should be designed on the down stream side of the checkdam to avoid damage of the floor by the impact of falling water.

CHECK DAMS (WATER HARVESTING STRUCTURES)

A checkdam is a barrier built across the direction of the flow of water in a stream or *nallah* to **store** a part of the excess flow which takes place during the monsoon. The advantage of these structure is that they store surface water for use both during and after the monsoon and aid in ground water recharge of the area. This water source can also be used for pisciculture. The cost of developing assured irrigation for one heactare of land with a check dam is generally less than Rs. 10,000/- per hectare, whilst in the case of large dams & canal net work it is substantially greater. Shri B.B. Vohra, has estimated it to be close to Rs. Two lakh per hectare. Thus in our context it makes economic sense to first tap all such resources and only then think of investing into large dams and canal networks.

Check dams can be of various sizes and built with a variety of material including stone, clay and cement. Individual farmers can build small check dams of clay, whereas masonary and reinforced cement concrete structures require some degree of construction skills and monetary inputs.

Before building a check dam the following points have to be kept in mind regarding site selection:

a. The structure should be able to store a large volume of rain water.

b. It should provide a long length of stored water. Yet, care should be taken to ensure non deposition of silt in the storage.

c. There should be a high percentage of cropped area on either side of the length of stored water.

d. Risk of submergence of cropped lands during flash floods should be minimum.

e. It should have a high cost-benefit ratio.

Check dams may be categorised on the basis of the material used for their construction such as Earthen, Masonry and RCC (reinforced cement concrete) dams etc.

Earthen Check Dams.

These are also known as embankments for collection of excess rainwater in undulating areas. Some of the points to be considered during construction of these structures are:

1. Seepage has to be controlled in the area where the soils are of a light texture. The recommended measures in such cases are :

   i) Sealing of the *nallah* bed by compaction

   ii) Building of the core wall of the embankment with material like black cotton soil and boulders with cement, sand and mortar.

2. The Top/crest width of an earthern dam should not be less than 2 m to permit maintenance work;

3. Side Slopes : no specific guidelines can be given for determining the side slopes of an earthen dam. However, on the basis of experience side slopes 3 horizontal to one vertical (3;1) upstream side and 2 horizontal to one vertical (2;1) at down stream side have been found effective in resisting shear stresses, erosion of upstream slope by waves and erosion of down stream slope by wind and rain.

4. Sufficient free board must be provided while fixing the height of the dam. The minimum freeboard height should be 15% of the height of water upto HFL. The free board provides a safety factor against occurrence of increased inflow which is greater than the design flow, malfunction of spillway controls (if any), or

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settlement of the dam structure greater than anticipated in design.

5 To cater for the settlement of structure as a normal practice the earth dam height should be fixed slightly higher than the designed height.

6. While raising the structure the compaction of the soil should be carried out in layers of 20 to 30 cms thickness for better stability.

7. If the foundation in earth dam consists of coarse sands or gravel and consolidated silts or clays, the structure would have high shear strength.

8 The upstream slope of the earth dam must be protected from erosion by providing stone pitching. The individual stones must be of sufficient weight to resist displacement by wave action.

9. There must be a break in the slope at down stream side to reduce the erosion by rolling action.

Masonry Check Dams.

1. The foundation should be excavated deep enough to be safe from all subsequent scouring risks. In streams having black cotton soils in the bed, hard strata is normally reached at considerable depth. In such a situation a foundation depth of 2 m ; below the *nallah* bed is generally adequate. Two meter foundation depth is classified as shallow foundation. To achieve a firm base in shallow foundation a minimum of 20 cm thick cement concrete layer is provided for distributing the load of the structure uniformly and to counter balance the upthrust pressure. During excavation if the water is not encountered, a mix of 1:4:8 is to be used. However, if water is found, a mix of 1:2:4 with quick setting cement is to be used.

2. Larger boulders should be used in the foundation to withstand greater horizontal water pressure The boulders should be rough for obtaining good contact at joints.

3. The length of the head wall extension into the banks on either side of the stream/nallah is governed by the storage height of the dam. If the storage height is 2 m above the *nallah* bed then the extensions should be of minimum 3 m length (minimum 1.5 times of the storage heights).

4. The side walls in the structure are basically to stablize the ridges of the stream on the down stream side and also to provide strength to the head wall.

5. The structure is provided an apron at down stream side. its function is to minimise/eliminate failures due to under mining and crushing The toe wall at the end of the apron is meant to dissipate the kinetic energy gained after flowing over the apron.

6. If ridges of the stream are low on the upstream side (storage side), provision of guide walls becomes a necessity.

7. The excavated soils should be utilized for bunding the fields on the upstream side. it is a desired practice to have the entire length of the stream/nallah bounded upto the tail of the stored water. This would minimise the chances of fields getting flooded during flash floods, reduce erosion from the adjacent fields, and increase ground water charging.

Major benefits of Check dams

Some of the major benefits of checkdam constructed by using the above mentioned designs are as under :

1. Improvment in the moisture regime of the area resulting in increased biomass production.

2. Increase in ground water recharge, thus making greater water available for irrigation and household use from the farmers wells. A single crop production can easily become a two or three crop cycle per year.

3. Pisciculture is possible in some structures.

4. Availability of drinking water for animals is assured.

5. The water is available to the farmer on call viz he extracts it when he actually needs which is not the case in canal irrigation.

6. A short gestation period ; a medium structure capable of catering to 20-30 hectares can be built in two months.

7. No displacement of people.

8. Cost of construction is generally recovered in one season or at best in two due to increased agricultural production.

GROUND WATER RECHARGE TECHNIQUE*

1.0 INTRODUCTION

It has been recognized that aquifers are more than source of water but storage reservoirs that require proper management for efficient use. With respect to management, aquifers may be classified as reservoir for long-term storage artificially produced and water quality control tools through use of the filtering characteristics of aquifers especially in respect of the artificial recharge of waste water. Artificial recharge may be viewed as an augmentation of the natural movement of surface water into underground formation by some method of construction, by surface spreading of water or by artificially changing natural conditions.

The purpose of artificial recharge of groundwater has been

i) to reduce, stop or even reverse declining level of ground water.

ii) to protect underground fresh water in coastal aquifer against salt water intrusion from the ocean,

iii) to store surface water, including flood or other surface water, imported water and reclaimed waste water for future use,

iv) to improve water quality by removing suspended solids by filteration through ground, and

v) to store water to reduce cost of pumping and piping.

There are two aspects associated with assessment of artificial recharge. These are assessment of the water actually recharged and availability of the recharged water with space and time. In this report methodology has been developed to predict quantity of water recharged and to evaluate the temporal and spatial variation of the recharged water.

2.0 REVIEW

2.1. Methods of Artificial Recharge :

Artificial recharge is performed by surface spreading, subsurface injection and by induced infiltration from surface water Direct surface recharge techniques are among the simplest, oldest, and most widely applied method of artificial recharge. In these methods, water moves from land surface to the aquifer by percolating through the soil. Field studies of spreading techniques have shown that, of the many factors governing the amount of water that will enter the aquifer, the area of recharge and length of time that the water is in contact with the soil are the most important. Direct-surface methods can be grouped into several categories such as: flooding, ditch and furrow, basins, stream channel modification, and over irrigation.

2.1.1 Flooding :

Recharge by flooding can be done only on land having a 1 to 3 percent slope. The objective is to spread water over a large area in a thin film that travels slowly down hill without disturbing the soil. The water is spread over the land surface from several distribution points to obtain an even application. Embankments or ditches may bound the system to localize infiltration or to protect adjacent land. Excess water may be collected at the systems topographic low point for disposal.

The biggest problem with the flooding technique is containments. Other problems are related to large area required and evaporation. the greatest advantage of the method is the relatively low cost of construction and maintenance.

2.1.2 Ditch and Furrow Systems

In this method, a source stream provides recharge water that is passed through closely spaced, shallow,

*SOUVENIR - National Seminar "Irrigation Management Policy", Jhansi (Feb. 1993). IWRS and WRDTC (Roorkee) flat-bottomed ditches or furrows. Most ditch-and-furrows systems have one of three patterns : lateral, dendritic, or contour (see Fig.1)

Lateral Systems :

These characteristically have one or more main supply canals from which smaller ditches protrude at right angles. Gates at the head of these systems control flow rates. Furrow depth depends on topography but rarely exceeds that necessary to maintain a uniform velocity with maximum wetted surface. Most systems divert stream water into main canals, pass the water through a series of lateral furrows, and collect runoff in a canal further downslope that routes the water back to the source stream.

Dendritic Systems:

These divert flow from a main canal to a series of successively smaller ditches and gates control the flow to each series of ditches. The bifurcation of ditches continues until virtually all water has infiltrated, terminal collection ditches are optional.

Contour Systems :

These spread water through a ditch or ditches that follow the contour of the land. A switchback is made wherever the ditch approaches the limit of the spreading area. In effect, the ditch traverses the spreading area repeatedly and, at the lowest point, returns the water to the source stream.

The ditch-and-furrow system is particularly advantageous where recharge water contains high loads of suspended sediment. Generally, system flow rates are sufficient to carry a large percentage of foreign materials through the system and back into the source stream.

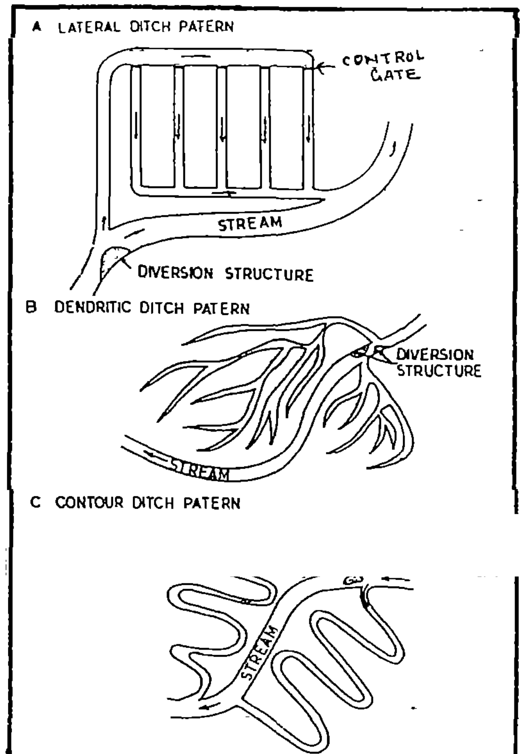

FIG. 1

2.1.3 Basins :

Basins are probably the most favoured method of recharge because they allow efficient use of space and require only simple maintenance. Basins are either excavated or are enclosed by dykes or levees. Basin geometry is flexible, allowing construction to be adapted to the terrain. Basins may be constructed individually, such as in small drainage areas to collect urban runoff, or in series for infiltration of stream or stormwater, as shown in Figure 2. Use of multiple basins for infiltration of stream water provides several advantages : the storage capability allows longer time for recharge, the upstream basins act as clarifiers for those below, and the ability to bypass the basins permits periodic maintenance (such as scrapping) to restore infiltration rates. In flat areas, basins are more costly to construct because natural landform containments cannot be used, basins in such areas are commonly long, straight, and narrow and are constructed side by side.

The advantages of basins include :

1. Expected flows can generally be accommodated by constructing basins of appropriate size.
2. Intermittent floodwater can be stored for later infiltration.
3. Clogging can be easily mitigated through basin construction techniques or operational procedures.
4. Land is used efficiently.

2.1.4 Stream Channel Modification :

Stream channel modification entails construction of check dams across stream flood plains. Above the dams, basin like impoundments enhance recharge by increasing the wetted area and driving head while

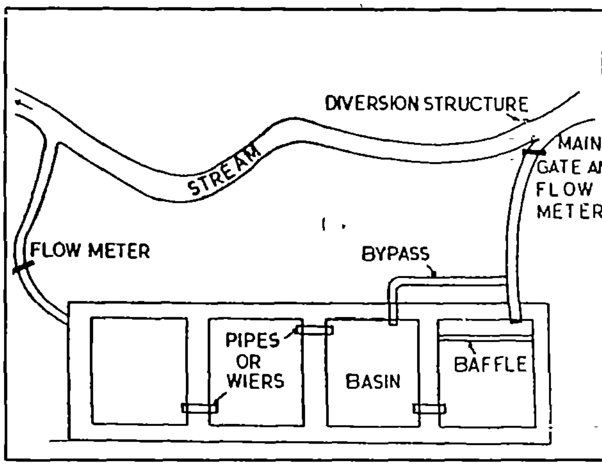

FIG. 2 A SERIES OF RECHARGE BASINS RECEIVING STREAM WATER

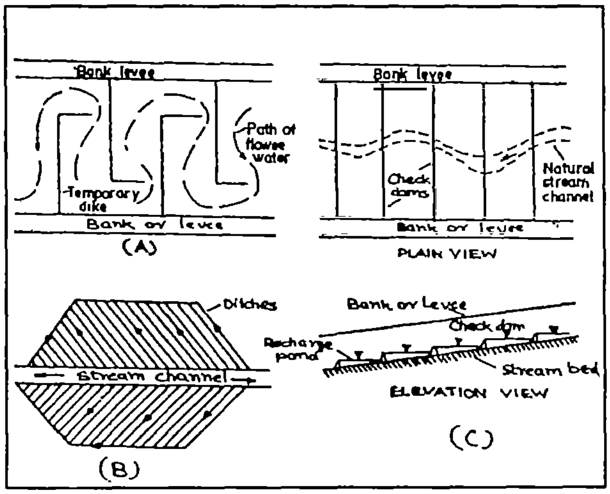

FIG. 3 RECHARAGE BY STREAM CHANNEL MODIFICATION (A) DIVERSION, (B) DITCHES, (C) CHECK DAM

detaining water for recharge, below the dams, recharge is enhanced through exposure of more than just the original stream channel to water (Fig.3) Because stream water flowing at velocities greater than the stream bed infiltration rate is essentially lost, upstream reservoirs can be constructed to dispense water in accordance with stream bed infiltration capacity.

Dredging flowing channels also increases the infiltration efficiency, and widening, leveling, increase the wetted area as well as infiltration rate.

Most stream channel modification structures are temporary and are designed to increase recharge only seasonally. Many are destroyed by floods. Nevertheless, stream channel modification is effective wherever suitable because construction costs are relatively low, maintenance is inexpensive and the procedure rarely conflicts with other land uses.

2.1.5 Overirrigation :

When irrigation water is applied during nongrowing seasons, the groundwater is artificially recharged. Methods of irrigation are similar to those of artificial recharge and include overland flow, ditch and furrow systems, sub-irrigation, flooding, and spray systems. Because overirrigation is usually created by excess surface water, one of the first four techniques described is usually employed. Implementation costs are minimum because the water distribution works have already been constructed.

2.2 Direct-Subsurface Recharge :

Direct-subsurface recharge is achieved when water is conveyed and emplaced directly into an aquifer. Direct-subsurface recharge generally is used when a semipermeable confining stratum separates the source of recharge water from the aquifer requiring replenishment techniques of direct-subsurface recharge include injection of water into (1) natural openings in aquifer. (2) pits or shafts, (3) wells (see Fig4)

In all methods of subsurface recharge, the quality of the recharge water is of primary concern because the water enters the aquifers without the filtration or oxidation that occur when water percolates through the unsaturated zone. All direct-subsurface methods of recharge use structures that occupy much less land than is required for surface methods.

2.2.1 Natural Openings :

Natural openings, such as those caused by fracturing or solution in cavernous limestones or other soluble rock, can act as a drain beneath an impounded body of water or as the extension of a pipeline delivering water to it. Depending on the source of water and size, configuration, and location of the openings, maintenance, protection, and improvement may not be necessary. Although this type of recharge system is relatively inexpensive, un-favourable terrain and geologic conditions may preclude its use.

2.2.2 Pits and Shafts :

Where a semipervious confining layer is at or near land surface, the aquifer (s) below must be recharged through deep pits or shafts penetrating that layer. Pits are variable in dimension, their depth generally is dependent on the thickness of the confining unit, the steep sides of pits minimize the opportunity for clogging, which occurs mainly at the pit bottom. Costs of construction and maintenance are high compared to surface techniques, especially if comparatively small quantities of water are to be applied. In some areas, these costs can be avoided by use of abandoned gravel pits or quarries.

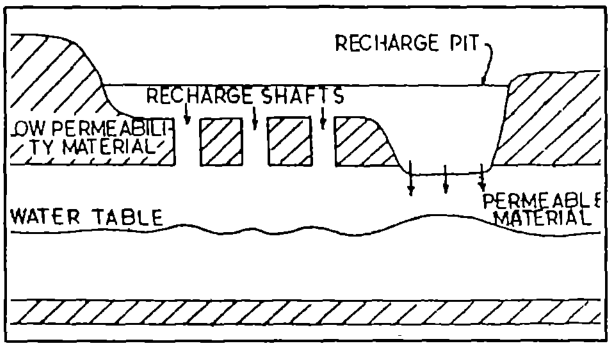

FIG. 4 RECHARGE PITS AND SHAFTS

Shafts are deeper than pits and smaller in diameter. They are either constructed by hand with draglines or are drilled or bored. They can be filled with coarse material or simply lined. As with all subsurface techniques, shaft wells and fill materials are suceptible to clogging by suspended solids or biological activity. Shafts are particularly difficult to maintain. Although similar in operation to large-diameter wells, shafts that terminate above a static water table cannot be redeveloped by pumping. Test periods and chemical treatment are generally the only means of restoring infiltration capacity and are only partly successful. Badly clogged shaft fill material must be removed and replaced with clean fill. Because of high construction and maintenance costs, pits and shafts have limited application.

2.2.3 Wells

Recharge wells, commonly called injection wells, are generally used to replenish groundwater when an aquifer is deep and separated from the surface by

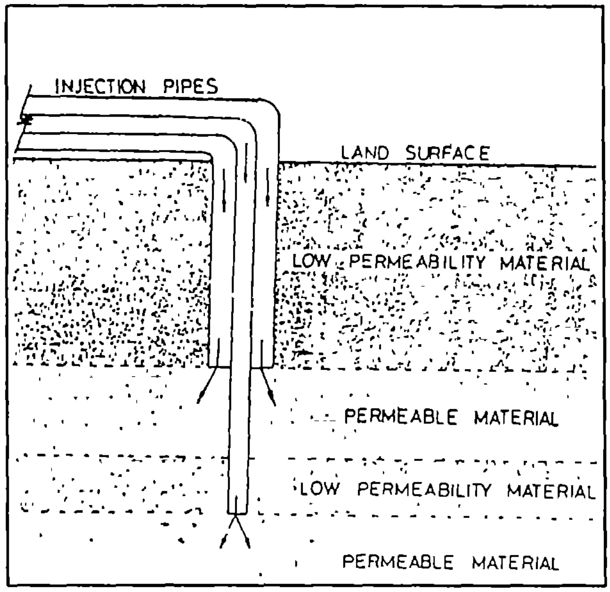

FIG. 5

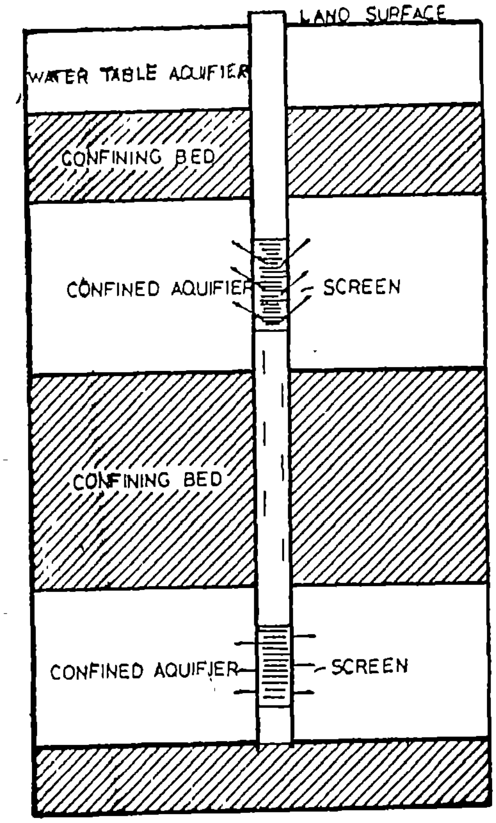

FIG. 6

materials of low permeability. If injection wells are installed in unconsolidaed material,the upper section of the well is cased and the screen is placed directly in the aquifer or surrendered by an artificial gravel pack. Typically a concrete seal is constructed at the point where the well passes into the aquifer to prevent injection pressures from forcing water upward around the casing. For a consolidated aquifer overlain by impermeable consolidated deposits, casing and screens may not be required. Wells are also used to recharge unconfined aquifers where the available land is limited. Recharge wells are not limited to replenishing just one aquifer nor does the recharge water need to be derived from surface source. Recharge wells can be constructed to supply water to two or more aquifers simultaneously (Fig.5) and where hydraulic conditions permit, can be used as passive connectors between adjacent acquifers separated impermeable material (Fig.6).

In addition to the primary purpose of replenishing potential aquifers, recharge wells have also been used to recharge groundwater used for air conditioning and to add freshwater to coastal aquifers experiencing salt-water intrusion. Injection well design depends on the recharge purpose, the amount of water to be injected and the acceptance rate of the aquifer. The latter is a function of hydraulic gradient, acquifer permeability, and length and type of screen. Because the contact area between well screen and aquifer is small, gravel packs surrounding the screen are generally used to increase the effective well diameter.

Recharge well performance can be severely hindered by the accumulation of suspended solids and biological and chemical impurities, as well as by dissolved air and gases and entrained air from turbulence. Most clogging effects can be avoided by proper treatment of the recharge water beforehand, but once it has occured correction requires various well redevelopment procedures, which include:

1. Pumping and surging the well to remove Inorganic material and loosely attached organic material.
2. Adding biocides and oxidizing agents to eliminate organic matter stemming from bacteria and their waste products.
3. Using specific chemical treatments to remove encrustation caused by chemical precipitation.

2..3 Induced Recharge:

Direct methods of artificial recharge described above involve the conveyance of surface water to some point where it enters the ground. Distinguished from these methods is the method of induced recharge, accomplished by withdrawing groundwater at a location adjacent to a river or lake so that lowering of the groundwater level will induce water to enter the ground from the surface source. The schematic cross sections of a river valley in Fig.7 show flow patterns with and without induced infiltration from a stream. On the basis of this definition, wells located directly adjacent to and fed largely by surface water serve as means of artificial recharge.

Induced infiltration where supplied by a perennial stream ensures a continuing water supply even though overdraft condition may exist in nearby areas supplied only by natural recharge. The method has proved effective in unconsolidated formations of permeable sand and gravel hydraulically connected between stream and aquifer. The amount of water Induced into the aquifer depends on the rate of pumping, permeability, type of well, distance from surface stream, and natural groundwater movement. It is important that the velocity of the surface stream be sufficient to prevent silt deposition from sealing the streambed.

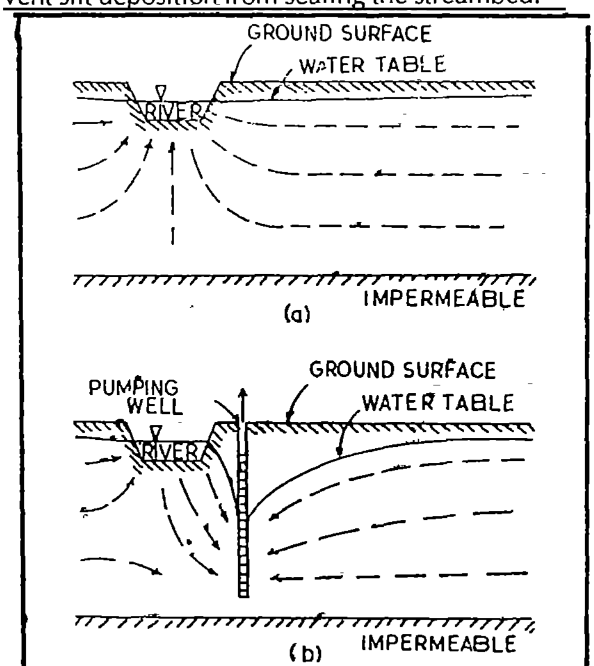

FIG. 7 INDUCED RECHARGE RESULTING FROM A WELL PUMPING NEAR A RIVER (A) NATURAL FLOW PATTERN, (B) FLOW PATTERN WITH PUMPING

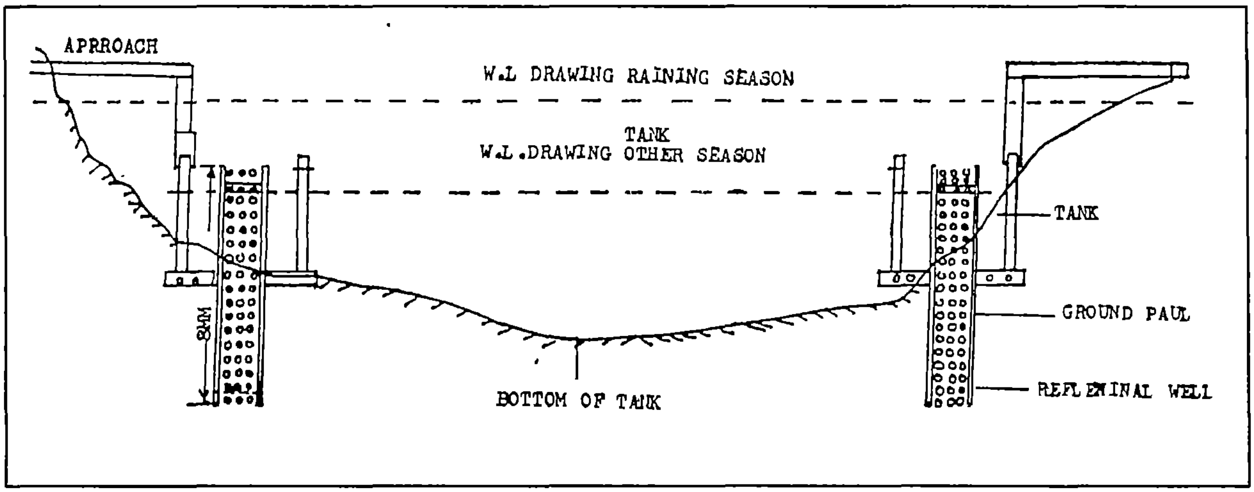

FIG. 8 PLENISHMENT WELLS IN M. NAGAR DISTRICT

Studies of water quality have shown that induced recharge can furnish water free of organic matter and pathogenic bacteria. Because surface water commonly is less mineralized than groundwater, water obtained by induced infiltration, being a mixture of two water sources, possesses a higher quality than natural groundwater.

A study of artificial recharge in California indicated that natural ground slope can serve as a convenient guide for estimating long-time rates. For alluvial soils in the slope of 0.1 to 10 percent, the long-time infiltration rate W in metres per day is given by

$$W = 0.65 + 0.56i$$

Where i is the natural ground slope in percent. Individual rates were found to vary within a factor of 2 of this estimate.

नलकूपों से नहीं बुझेगी बुंदेलखंड की प्यास

मध्य प्रदेश में बुदेलखड के नाम से जाने जाते सागर सभाग के पाच जिलों में जल–त्रासदी एक स्थायी समस्या हो गई है। साल के आठ नौ महीनो में यहां की अधिकांश आबादी का जीवनचक्र पानी जुटाने के इर्द–गिर्द घूमता रहता है। यहा की प्यास बुझाने के नाम पर बगैर सोचे–समझे रोपे गए हैंडपंपों व नलकूपो पर अभी तक चार अरब से अधिक की राशि पानी उपलब्ध कराने की विभिन्न योजनाओं मे बहाई जा चुकी हैं पर नतीजा शून्य ही रहा है। नलकूपों से यहां के कंठ तर नहीं किए जा सकते, इस आशय की सरकारी रिपोर्ट फाइलों में कहीं दबी पडी है। पारंपरिक जल स्रोत्र तालाबों से समृद्ध इस इलाके की भूगर्भ सरचना, अंदरुनी जल के दोहन के लिए प्रतिकूल है। इस तथ्य से वाकिफ होने के बावजूद सरकार धडाधड नलकूप खोदकर पैसा बर्बाद करने में व्यस्त है।

बुंदेलखण्ड की जमीन के अदरुनी हिस्से में ग्रेनाइट चट्टाने हैं, मिट्टी की तह केवल 30 से 40 फीट हे। ग्रेनाइट चट्टानों को हर संभव गहराई तक छेदा गया, लेकिन उसकी थाह नहीं मिली। साफ जाहिर है कि इस इलाके में भूगर्भ जल दोहन के नाम पर जो पानी सोखा जा रहा है, वह वास्तव में इन चट्टानों की दरारों में एकत्र बरसाती पानी मात्र है। इसी कारण यहां की जमीन, भूगर्भ जल के लिए ठीक नहीं मानी गई है। तभी तो लगाए गए आधे से अधिक हैंडपंप या ट्यूबवेल अब रीते है। वैसे भी यहां की चट्टोनो में बरसाती पानी जमा होने की क्षमता लगातार जगलों के सफाए के कारण कम होती जा रही है। सन् 1954 मे इस संभाग के 80 प्रतिशत हिस्से पर घने जंगल थे। ताज़ातरीन सर्वे के मुताबिक यह हरियाली क्षेत्र घटकर मात्र 29 प्रतिशत रह गया है। सागर जिले के कुल क्षेत्रफल का 0 5 फीसदी, दमोह मे 37 9 प्रतिशत, पन्ना में 33. 8 प्रतिशत, छतरपुर में 12.9 प्रतिशत और टीकमगढ में 10 प्रतिशत भूभाग पर जंगल है।

राष्ट्रीय मापदंड के मुताबिक किसी क्षेत्र में कुल क्षेत्रफल के कम से कम 33 फीसदी पर जंगल जरुरी है। चूंकि पेड़ मिट्टी का कटाव रोकते हैं, इससे बरसाती पानी जमीन के जरिए सोख लिया जाता है। यही पानी हैंडपंपों का मुख्य आधार होता है। जंगलों के सफाए से जमीन के ऊपर की मिट्टी की परत थोड़ी बारिश में ही बह जाती है। यह मिट्टी छोटे नदी–नालों के जरिए बह कर इलाके की बडी नदियों में जा कर उन्हे उथला बना रही है। यही कारण है कि सागर संभाग में थोड़ी बारिश मे ही नदियां उफनने लगती हैं लेकिन कुछ ही महीने बाद वहां फिर सूखी रेत दिखने लगती है। बारिश में मिट्टी बहने के बाद शेष रह गई कठोर चट्टानों से तो पानी का सोखना संभव है नहीं। यही कारण है कि औसत से अधिक बारिश होने वाले सालों में भी यहां जल सकट यथावत रहता है। सरकारी आंकड़ों के अनुसार सागर संभाग में भूगर्भ जल 9 से 10 मीटर गहराई पर है। सन् 92 मे तो अच्छी बारिश हुई फिर भी टीकमगढ़ जिले के धवारी में जल स्तर 3 25 मीटर नीचे गिर गया। ठीकमगढ़ शहर मे पचास सैंटीमीटर और छतरपुर शहर में पिछले वर्ष की तुलना में 48 सेमी जल स्तर नीचे गिर गया। सन् 91 की तुलना मे 92 वर्ष के दौरान सागर संभाग का जल स्तर औसतन एक से दो मीटर नीचे गया है। इस क्षेत्र में जल स्तर नीचे जाने की एक सीमा है। उसके आगे अभेद्य अनंत ग्रेनाइट चट्टानें हैं।

सरकारी आंकडों पर गौर करें तो वे खुद हैंडपंपों के जरिए प्यास बुझाने की कोशिश फ्लाप होने को पुख्ता करते हैं संभाग के कुल 5950 गांवों में से 5363 गांव समस्या मूलक की श्रेणी में हैं। इनमें से 605 गांवों में सरकारी तौर पर पेयजल मुहैया करवाने की अभी तक कोई व्यवस्था नहीं हुई है। अधिकतर गांव पन्ना और छतरपुर जिले के आदिवासी बहुल मजरे हैं। यहां के लोग कई–कई किलोमीटर दूर से प्राकृतिक झरनों या गंदे पानी के पोखरों के सहारे जीवन बिता रहे हैं। पिछले महीनों तक संभाग में कुल 21,934 हैंडपंप खोदे गए। सागर जिले में कुल लगाए 4527 तो उसी समय असफल हो गए। इनमें से 5152 हैंडपंपों में से 1181 असफल रहे। दमोह जिले में 4571 हैंडपंपों में से 831 असफल रहे, छतरपुर में 4128 में से 946, टीकमगढ में 3853 में से 896 और पन्ना में 4230 हैंडपंपों मे से 673 असफल हो गए।

पंकज चतुर्वेदी, नेशनल बुक ट्रस्ट, ग्रीन पार्क, नई दिल्ली

इस प्रकार कुल सफल 17,467 हैंडपंपों में से मात्र 13,863 का चालू होना प्रशासन स्वीकारता है। वैसे सरकारी आंकड़े कितने भरोसेमंद है, उसकी बानगी के लिए सागर, टीकमगढ और छतरपुर जिला मुख्यालयों पर लगे कुल हैंडपंपों के फौरी सर्वे की रिपोर्ट काफी है। इन शहरों में लगे पचास फीसदी हैंडपंप ही साल भर पानी देते हैं। इससे भी बदतर हालत आंचलिक क्षेत्रो में लगे हैंडपंपों की है। कुल हैडपंपो में से बीस फीसदी तो ऐसे हैं, जो सिर्फ बरसात के दिनों में और उसके कुछ दिन बाद तक ही पानी देते हैं। दस फीसदी पप सुबह–शाम कुछ ही देर पानी दे पाते हैं। सही मायने में पानी फेंकने वाले पंपों का प्रतिशत 40 से अधिक नहीं है। एक हैंडपंप लगाने में औसतन 20 से 25 हजार का खर्चा सरकारी रिकार्ड में किया जाता है। इस प्रकार सभाग में प्यास निराकरण के नाम पर अभी तक साढे चार अरब रुपए से अधिक की राशि लगायी जा चुकी है।

वैसे भी हैंडपप खोदने का सारा धधा अफसरों और रुतबेदार राजनेताओं के घर भरने के इरादे से ही चलता प्रतीत होता है। सरकारी रिकार्ड के मुताबिक संभाग के 168 पंप लाइन गिरने और 1150 पंप भर–पट जाने के कारण बंद पड़े है। इस प्रकार के पंप रेतीले इलाके मे है जहां पंपों के पाइप मय प्लेटफार्म के धस जाते है। ऐसे क्षेत्रों में हैडपंप लगाने के लिए 'ग्रेतिल पैक बो' नामक विशिष्ट तकनीकी अपनाई जाती है और इसी के लिए यहां टेडर भी बुलाए जाते हैं। जानकर आश्चर्य होगा कि यहां किसी भी बोरिंग ठेकेदार के पास 'ग्रेतिल पैक मशीन नहीं है। इस तरीके के लिए साधरण से पचास फीसदी अधिक दाम पर टेडर स्वीकृत होते है। मिलीभगत के चलते रेतीले इलाकों में ग्रेतिल पैक की जगह साधारण बोर कर दिया जाता है। तभी वे कुछ ही दिनों मे भर–पट जाते है।

यहां जानना जरुरी है कि हैडपंप लगवाने वाला पीएचई विभाग हर पंप लगाने से पहले इस जगह का 'सर्वे' करवाता है। इस सर्वे में कितनी गहराई पर किस मात्रा का पानी है? सब कुछ साफ–साफ आ जाता है। जियोलॉजिस्टों के मुताबिक रेसिस्टिविटी सर्वे की रिपोर्ट के झूठे होने की संभावना पांच फीसदी से भी कम होती है। यानी असफल हैडपपो की संख्या का प्रतिशत पाच से अधिक नहीं होना चाहिए। हकीकत में सर्वे किया ही नहीं जाता है। पहले गांव–मोहल्ले के नेता सरपच से पूछा जाता है कि हैंडपंप कहां लगाया जाए, फिर वहां मशीन लगा दी जाती हैं आखिर में जब ठेकेदार को पेमेंट होना होता है तब उससे एक सर्वे रिपोर्ट मंगवा कर फाइल में नत्थी कर दी जाती है।

मनमाने ढंग से लगाए जा रहे हैंडपपों के चलते यहा के सदियों पुराने कुए सूखते जा रहे है। भूगर्भ जल की रिचार्जिंग करने वाले तालाब–पोखर दिनों–दिन पुरते जा रहे है। संभाग में चार हजार से अधिक ताल–तलैया हैं जो नौवीं से ग्यारहवी सदी के बीच इलाके के शासकों ने बनवाये थे। सिर्फ टीकमगढ जिले मे एक हजार तालाब हैं। ये बेशकीमती तालाब कई सदियों से लोगो की प्यास बुझाते आ रहे थे। आधुनिकीकरण, शहरीकरण और आदमी के अतिक्रमण की मनोवृति के चलते ये जीवनदायी तालाब दिनों दिन सिमटते जा रहे हैं। इससे कुंओं का जल स्तर अचानक नीचे गिर गया है। यदि कही आसपास, एक–दो ट्यूबवेल लग गए तो फिर कुछ की तो शामत ही है। नलकूपों की मार से सूख गए कुओं की संख्या हजारों नहीं लाखों मे पहुंच गई है।

कुल मिला कर इस क्षेत्र में भूगर्भ जल दोहन हर सिरे से नुकसानदायक रहा है। एक तरफ असफल पंपों के कारण पैसा बरबाद हो रहा है साथ ही साथ करोड़ो की लागत के पारंपरिक कुएं बर्बाद होते जा रहे है। केद्र सरकार ने एक ऐसे विधेयक का मसविदा तो तैयार कर दिया है, जिसके तहत अधिसूचित इलाकों में कुआं खोदने या किसी और तरीक से जमीन का पानी निकालने के लिए लाइसेस लेना जरूरी होगा। केवल छोटे और सीमांत किसानों को निजी तौर पर पानी उपयोग के लिए इसमें छूट रहेगी। पर क्या यह विधेयक बुंदेलखंड में पानी के बिगड गए ढर्रे को फिर संवार पाएगा। यहां क्षमता से कही अधिक कुंए हैंडपंप पहले ही हैं, फिर लाइसेंस कोटा सिस्टम भ्रष्टाचार का पयार्य ही है। छोटे सीमांत किसानों के नाम पर इस अध्यादेश में खासी जगह भी रखी गई है।

बुंदेलखंड के पर्यावरण पर गंभीरता से तत्काल विचार करना जरूरी है। भूगर्भ जल के मनमाने दोहन के कारण एरिजोना में जमीन सिकुड़ने फिर अचानक फट कर दरारों में बदलने का उदाहरण इस संदर्भ में देखना काफी होगा। सागर सभाग की आबादी और बस्ती का विस्तार साल–दर–साल हो रहा है। जाहिर है कि जल की मांग भी बढ रही है। इसकी पूर्ति कि लिए भूजल दोहन के बनिस्पत पारंपरिक तरीकों को फिर अपनाना अधिक श्रेयस्कर होगा। हजारों तालाबों की मरम्मत व गहरीकरण किया जाए। यहां उपलब्ध असंख्य बरसाती नालो, छोटी नदियों पर स्टाप डेम बनाकर वहां का पानी बड़ी नदियो में जाने से रोका जाए। बुंदेलखण्ड के पथरीले पहाड़ों मे सैकडों ऐसे झरने है, जो साल भर पानी देते है। उनका सदुपयोग होना चाहिए। इन कामों पर यदि अभी तक हैंडपंपों पर खर्च बजट का आधा भी खर्चा होता तो, इस विपन्न इलाके का बाशिंदा कम से कम पेयजल संकट से तो मुक्त हो गया होता।

दरअसल जल स्रोत्रों के दोहन की मौजूदा प्रणालियो से हट

कर वास्तविकता के आधार पर जल प्रबंधन के तरीके नहीं खोजे जाएं तो बुंदेलखंड की जल समस्या हल नहीं हो सकती। यह समस्या मध्य प्रदेश के पथरीले जिलों की ही नहीं है, बल्कि इसी से लगे उत्तर प्रदेश के कई जिलों की भी है। बुंदेलखंड का इलाका भौगोलिक रुप से दो राज्यों–मध्य प्रदेश और उत्तर प्रदेश में फैला है। इसलिए आवश्यक है कि इस क्षेत्र की जल समस्या को हल करने के लिय साँझी रणनीति बनाई जाए। इस सदर्भ मे दो बातों पर ध्यान देना जरूरी है। बुंदेलखंड में भूगर्भ से पानी प्राप्त करने की संभावनाएं सीमित हैं, भले ही चट्टानों को काट कर काफी गहराई तक बोर करने की टेक्नोलॉजी इस्तेमाल की जाए। चट्टानी इलाका होने के कारण वर्षा का पानी भूमि में पर्याप्त मात्रा मे संचित नहीं रहता और अगर चट्टानों के नीचे पानी के भंडार हों भी तो उनके दोहन मे इतना खर्चा आएगा कि यह व्यावहारिक नहीं होगा। इसलिए भूगर्भ के बदले भूमि की सतह के पानी का भंडारण होना चाहिए। यानी तालाब ही इस इलाके की प्यास बुझा सकते हैं।

लेकिन दूसरी महत्वपूर्ण बात है कि तालाबों में पानी तभी पहुंचाया जा सकता है जबकि उनके आसपास पर्याप्त जल ग्रहण क्षेत्र हों । लेकिन पिछले चालीस साल मे ऐसे क्षेत्रों पर या तो गांव–कस्बे बस/गए हैं या दूसरे तरह के निर्माण हुए हैं। इसलिए तालाबो में पानी संचित करने की कोई भी योजना तभी कारगर हो सकती है जबकि जहां तक हो सके ऐसे अतिक्रमण को हटाया जाए और जहां ऐसा संभव नहीं वहां तालाब भरकर अन्य उपयुक्त स्थलों पर खोदे जाएं। मध्य प्रदेश और उत्तर प्रदेश यदि मिल कर ऐसी बड़ी योजना बनाएं तो बुंदेलखंड की त्रासदी को वरदान मे बदला जा सकता है।

बीहड़ निगल रहे हैं, बुंदेलखण्ड की उपजाऊ भूमि

मध्य प्रदेश मे बेशकीमती कृषि भूमि के बीहडों द्वारा उजाड़ने की बात आती है तो चंबल के बाद बुंदेलखण्ड क्षेत्र का नाम उभर कर आता है। अलबत्ता चंबल मे तो बीहड़ उन्मूलन के नाम पर अभी तक डेढ अरब से अधिक रुपये भी खर्च किये जा चुके हैं लेकिन बुदेलखण्ड के लिए इस बावत् सरकारी प्रयास न के बराबर हैं। जनवरी, 92 से समूचे राज्य में बीहड़ उपचार की सभी परियोजनाएं बंद हो गई है। राज्य शासन के इस रवैये का कारण केंद्र सरकार द्वारा कुछ योजनाएं बंद करना बताया जाता है। प्रदेश शासन का मानना है कि भूमि सुधार का काम इतना अधिक खर्चीला है कि इसे राज्य सरकार अपने बूते पर नहीं करा सकती।

शौर्य और वीरता के समृद्ध अतीत वाला बुदेलखंड बीते कुछ दशकों में अपराध विशेषकर दुर्दान्त दस्युओं के लिए मशहूर रहा है। डकैतों की शरणस्थली बनते यह बीहड इलाके के अधिसंख्यक लोगो के जीविकोपार्जन का जरिया खेती को खाये जा रहे है। जमीनो में दिनों दिन गहरी हो रही यह दरारें यहां के बाशिदों की तकदीर पर दरारे पैदा करती जा रही हैं। मध्य प्रदेश के बुदेलखण्ड क्षेत्र में सागर संभाग के सभी पांच जिले और ग्वालियर संभाग का दतिया ज़िला आता है। समूचे पठारी इलाके में बडी नदिया तो गिनी चुनी हैं लेकिन उनकी सहायक नदियां व बरसाती नालों का जाल सा बिछा है। इन्हीं के तेज बहाव से बेशकीमती जमीन साल दर साल घटती जा रही है। इलाके के दतिया, टीकमगढ़, छतरपुर, पन्ना जिले में चिकनी काली और लाल हल्की मिट्टी पाई जाती है। दमोह व सागर जिलों मे काली मिट्टी है। यह मिट्टी, खेती के लिहाज से उपजाऊ है लेकिन पानी की धार मे बडी तेजी से बहती है।

तेज बहाव में बीहड़ों की उत्पत्ति

जब जमीन पर पेड पौधे घटते है, तब बरसात का पानी उस पर सीधे आ गिरता है, इससे धरती की ऊपरी सतह (टाप स्वाईल) बह जाती है। जमीन असमतल हो जाती है और पानी को जहां भी जगह मिलती है, वहीं तेज बहाव से जाता है। पहले छोटी नाली बनती है, फिर यही गहरे दर्रे मे बदल जाती है, यहीं से बीहड़ों की उत्पत्ति होती है। बीहड़ उन गहरी घाटियों के कारण बनते हैं जहां के दर्रों से पानी समानांतर दिशा में गहरे कछार की ओर बढता है और आसपास की ऊंची जमीन से काफी नीची गहराई मे बह रही नदी में मिलता है। कछार की मिट्टी के कारण ऊंची जमीन की मिट्टी खिसकने की समस्या खड़ी होती है। नदी अपने कछार में गहरी–गहरी नालियां बना देती है। पानी के इस अनियंत्रित बहाव के चलते नदी तटों पर बीहड़ बन जाते हैं। एक बार छोटी सी खोह बन जाने पर हर बारिश उसे और गहरा व चौड़ा कर देती है। बारिश में नदियों का बहाव तेज होने के कारण उसके किनारे तेजी से कटते हैं, वहीं दर्रों में बाढ का पानी भरने पर किनारे टूट जाते हैं।

बुंदेलखंड, गंगा–यमुना जल क्षेत्र के तहत् आता है। यहा की मुख्य नदियां बीला, तरेन, धसान, सुनार, केन, पहुज, श्यामरी, व्यारमा, जामनी और सिंध है। यहां का कुल क्षेत्रफल 4025.8 हेक्टेयर है। सन् 1979 मे मध्य प्रदेश के मुख्य वन संरक्षक जे डी. शर्मा ने एक रपट में बताया था कि राज्य की 6 83 लाख हेक्टेयर भूमि बीहड़ बन चुकी है, जिसका 21 फीसदी बुन्देलखण्ड में था। ताजा–तरीन अनुमानों के मुताबिक बुंदेलखंड में मौजूदा 1 43 लाख हेक्टेयर जमीन को बीहड़ निगल चुका है। यहां जमीन का कटाव सालाना 0.12 फीसदी की दर से हो रहा है। जाहिर है कि आने वाले 200 सालो में यहां के अधिकतर खेत उजड़कर बीहड़ बन जाएंगे। इलाके में गहरे बीहड, छतरपुर और दतिया जिलों में पाए जाते हैं।

छतरपुर में गंभीर संकट

केन और धसान नदियों की सीमा के बीच बसे छतरपुर मे बीहड़ संकट गंभीर मोड़ ले चुका है। इनकी सहायक नदियों उर्मिल, श्यामरी, केन आदि अधिक जमीन फाड रही है। यहां की 42 हजार हेक्टेयर से अधिक भूमि बीहड में परिणत हो चुकी है। इसमें तीस हजार हेक्टेयर पर अत्यन्त गहरे खोह हैं।

पकज चतुर्वेदी, नेशनल बुक ट्रस्ट, ग्रीन पार्क, नई दिल्ली

1971 में यहां चालीस हजार हेक्टेयर पर बीहड़ था, 1985 मे 41 और 1992 में 42 हजार हेक्टेयर पर इसका विस्तार हो चुका है।

दतिया जिले की 25 हजार हेक्टेयर भूमि पर 1971 में बीहड़ थे, आज यह बढ कर 28 हजार हेक्टेयर हो गया है। दमोह मे 25 हजार हेक्टेयर का बीहड लगभग स्थिर है। पन्ना जिले की बीस हजार हेक्टेयर जमीन इसकी शिकार है। टीकमगढ में मात्र पांच हजार हेक्टेयर भूमि प्रभावित है, दमोह, पन्ना, टीकमगढ मे इनके विस्तार की रफ्तार भी लगभग नहीं के बराबर है।

सरकारी सर्वेक्षण विभिन्न जिलो में गहरे और मध्यम आकार के बीहडों के बारे में इस प्रकार बताते हैं सागर (21000 हेक्टेयर), दमोह (15000 हे) पन्ना (1000 हे), टीकमगढ़ (1000 हे), छतरपुर (30,000 हें.) दतिया (15,000 हे.), इस गहरे बीहड़ों की चपेट में पन्ना जिले के 78 गांव, छतरपुर के 177 गांव, दमोह जिले के 96 और दतिया के 31 गांव हैं। यहां बीहड का औसत ढाल 0 5 से एक प्रतिशत और कहीं–कहीं उथली बीहड़ का ढाल पांच प्रतिशत तक है।

सर्वाधिक बीहडग्रस्त छतरपुर जिले में टेबललेड का ढलान 0. 5 से पांच प्रतिशत है जबकि बीहड का ढाल तीन से दस प्रतिशत व कुछ जगह इससे भी अधिक है। छतरपुर, पौगांव और विजावर अनुविभागीय क्षेत्र, मूलरुप से धसान व केन नदी से प्रभावित है। इनकी सहायक सेलाब, बन्ने, श्यामरी, बरार, बसरिया, जमुनिया नाला आदि के किनारे बसे 57 गाव पूरी तरह उजड चुके है। इनमें 3780 हेक्टेयर पर बहुत गहरे और 9550 हेक्टेयर पर उथले बीहड़ हैं। इससे बीहड प्रभावित गांव शिकारपुरा, लक्ष्मणपुरा, सुकवा, पुतरया, धरमपुरा, रैदासपुरा, टिकरी लहर, प्रतापपुरा, बक्सरेई सिंगरामपुरा, नारायणपुरा आदि हैं। लोडी अनुविभागीय क्षेत्र में केन नदी ने भूमि चौपट की है। यहां की मिट्टी सरध्र व हल्की है, सो यहां के 64 गाव बुरी तरह बीहड़ त्रासदी भुगत रहे हैं इनमें दो हजार हेक्टेयर गहरे, उथले और तेईस सौ हेक्टेयर मध्यम बीहड हैं। इनकी सहायक नदी केन के मुहाने पर बसे 61 गांवों में से 34 इस विपदा को झेल रहे हैं। यहा उथले और गहरे दर्रों का क्षेत्रफल क्रमश 2500 हे और दो हजार हेक्टेयर आंका गया है। 13 गांव तो आने वाले एक दशक के भीतर ही बर्बाद हो जाएंगे। पंचमपुरा मे 236 हे. पिढार में 134, मडकर में 165, पडवार में 378, बरुआ में 144, परेई में 791, ठकुर्रा में 205, मवई घाट में 305, अजीतपुरा में 114, गौहानी में 270, गोयरा में 552, रामपुर घाट में 82 और हाजीपुरा की 116 हेक्टेयर उपजाऊ भूमि पर लाइलाज गहरे बीहड़ बन गए हैं। बछौन, जमुइया, बजारी, बसिया, भूरापूरवा, रेवना, अभऊ आदि के बीहड भी खतरनाक होते जा रहे हैं। ऊपर लिखे सभी गांव उत्तर प्रदेश के बांदा जिले से सटे हैं ये सभी डकैतो का चारागाह माने जाते हैं। खेती, बीहडों को भेंट होने के बाद यहा का आदमी मजबूरीवश अपराध की ओर बढता है। यह सर्वविदित है कि लौंडी इलाके मे मात्र 500 रु में हत्या करने के लिए तैयार होने वाले युवक घर–घर में मिल जाएंगे। जिले के डकैतों की शरणस्थली बनाने वाले बीहडों के उद्धार का जिम्मा रखने वाले भूसर्वेक्षण विभाग का कहना है कि सन् 1988–89 में बिजावर क्षेत्र के आठ गांवों के बीहड उन्मूलन को शुरु किया गया था। यहां के देवरी, बसरोई, ऐरारा, धरमपुरा, बेदपुरा और खैरकला के छोटे बीहडों को बुल्डोजर से समतल किया गया फिर यहां पैराफिट बनाई गई। यह काम जनवरी 92 से सरकारी सहायता न मिलने के कारण बंद हो गया है, उधर उपरोक्त गांवों के गहरे बीहड़ बरकरार थे जो इस बार तेज बारिश में और चौडे हो गए है।

अन्य क्षेत्रों में बीहड़ों की संख्या

दतिया जिले में सिंध नदी के किनारे बसे सात गावों की हदें बीहडो के कारण दिनों–दिन सिमटती जा रही है। लांच गांव का रकबा 149 हेक्टेयर है। यहां डेढ़ मीटर गहराई के 57, डेढ़ से पांच मीटर के 44 और पांच मीटर से अधिक 55 बीहड हैं। 288 हेक्टेयर के कुलैथ गांव में 195 बीहड डेढ मीटर तक गहरे, पांच मीटर तक और उससे भी गहरे बीहडों की संख्या क्रमशः 60 और 53 है। अंडोरा में इनकी संख्या 112 से अधिक है, इनमें 51 पांच मीटर से भी अधिक गहराई के है। झांसी–ग्वालियर राजमार्ग पर एक जगह है गोराघाट। यहां से भीतर की तरफ इंदरगढ़ रोड है। इसी के लगभग समानांतर सिंध नदी बहती है। इसके किनारे बसा गांव सुनारी, गोराघाट से पाच किलामीटर पर है। 168 हे. वाले इस गांव में डेढ मीटर तक के 45, पांच मीटर तक के 46 और इससे भी गहरे 36 दर्रे हैं। उसके बाद आता है 317 हे. का गांव भरसूला । यहां कुल 322 बीहड हैं। जिनमें 46 पांच मीटर से भी ज्यादा गहरे हैं। फिर आता है उचाढ़। यहां की दो हजार से अधिक आबादी, पानी के लिए पूरी तरह सिंध नदी पर ही आश्रित हैं, जबकि नदी के किनारे सालों–साल कट कर गांव की तरफ बढ़ रहे हैं। 47 हे. वाले इस गांव में 52 गहरे बीहड़ है तिलैथा में 52 गहरे बीहड़ हैं। तिलैथा के 266 हे. रकबे का अधिकतर भाग अब जमीन कटाव का शिकार है। यहां 300 से अधिक दर्रे हैं। इनमें 46 पांच मी से भी अधिक गहरे हैं।

सरकारी योजना का अभाव

1977–78 में मध्य प्रदेश सरकार ने बीहड़ सुधार और ऊंचाई वाले भूमि के संरक्षण की एक योजना केंद्र सरकार को भेजी

थी। इसमें छतरपुर और दतिया जिलो को भी शामिल किया गया था। यह योजना दिल्ली के फाइल बीहड़ों में कहीं लोप हो गई। 1979 में एक बार फिर कुछ योजना बनी और ठप हो गई। इसके बाद 20 नवम्बर, 1984 को दस्यु समस्या पर विचार के लिए दिल्ली में आयोजित एक उच्चस्तरीय बैठक में बीहड इलाको के समतलीकरण, वायुयान से बीज छिड़काव कर वृक्षारोपण सरीखे कई प्रस्ताव स्वीकृत किए गए। पर वे सभी महज कागजो पर ही रह गए। मध्य प्रदेश सरकार ने 1986 में बुदेलखण्ड विकास प्राधिकरण गठित किया था। प्राधिकरण में बीहड़ समस्या पर पहली बार गंभीरता से विचार हुआ। जब तक इसके निराकरण का मसौदा तैयार हुआ, खर्चे का बजट तय हुआ, तब तक राज्य में भा.ज.पा सत्ता में आ गई। नई सरकार ने आते ही इस प्राधिकरण को समाप्त कर दिया। इसी के साथ बुंदेलखण्ड की बीहड उन्मूलन योजना भी एक सपना बन कर रह गयी। क्षेत्र मे 88–89 से शुरु किए गए भूमि सुधार कार्यक्रम जनवरी में बंद कर दिए गए हैं। इस अवधि में सुधार तो दूर ठीक तरीके से सर्वे तक नहीं हो पाया।

मेंडबंदी आवश्यक

बुंदेलखण्ड मे बीहड रोकने के लिए तत्काल ही 4000 हेक्टेयर भूमि पर मेडबंदी करना अत्याधिक आवश्यक है, ताकि बीहड विस्तार रोका जा सके। इस मेंड का आधार 6 50 मीटर चौडा ऊपरी सिरा आधा मीटर चौडा और इसकी उंचाई डेढ़ मीटर होनी चाहिये। इस पेराफिटबड (मेड) के बाहरी तरफ दस से पद्रह मीटर दूरी तक बबूल, शीशम सरीखे बृक्षों को पास–पास घना उगाना होगा। जल निकासी का उचित प्रबध, नहरों में रिसाव की रोकथाम भी खेतों को बीहड से बचाने के लिए जरूरी है। नए बीहड बनने से रोकने में पेडों की अहम भूमिका है क्योंकि वृक्ष बारिश से टाप स्वाइल का नुकसान होने से बचाते हैं। साथ ही पानी के साथ मिट्टी के बहाव पर भी नियंत्रण रखते हैं। वृक्षारोपण के लिए हवाई जहाज से बीज छिडकाव, मुरैना जिले के अलावा राजस्थान व गुजरात में भी काफी सुखद परिणाम रहा है। 1980–81 के दौरान मुरैना और भिंड जिले में बीज व उर्वरक छिड़काव पर कोई 881 रु. प्रति हेक्टेयर का खर्चा आया था। आज यह राशि 1400 रु हो गई है। बुंदेलखण्ड की बारह हजार हेक्टेयर भूमि पर यदि घने वन हो जाएं तो नए बीहड बनने पूरी तरह बंद हो जाएंगे।

बुंदेलखण्ड, उद्योगहीन विपन्न क्षेत्र है। बीहड की चपेट में खेत उजड़ने पर यहा के आदमी कुंठित हैं, कामकाज की तलाश मे लोग या तो दिल्ली–पंजाब भाग रहे हैं या फिर कानून तोड़ने में व्यस्त हो गए हैं। बीहड उन्मूलन के कार्यक्रम में आम आदमी की भागीदारी बढ़ा कर इस विपदा से तो निबटा ही जा सकता है साथ ही रोजगार के अवसर भी पैदा किए जा सकते हैं। कम गहरे बीहड़ों को समतल करने वालों को उस भूमि का का मालिकाना हक देने, वृक्षारोपण के लाभ उस उगाने वाले को मिलने सरीखी योजनाओं के जरिए बीहड उन्मूलन के प्रति आम आदमी को सहजता से प्रभावित किया जा सकेगा।

कभी यहां लहलहाते खेत थे। बीहडों की चपेट में उपजाऊ भूमि ।

COMMON FLORA OF BUNDELKHAND*

Local names	Botanical name	Local names	Botanical name
Aak	*Calotropis gigantia*	Ber (beri)	*Zizuphus mauritiana*
Aal	*Morina tinctoria*	Bhander (pindaloo)	*Randia uliginosa*
Aam	*Mangifera Indica*	Bheri (chila, meri)	*Casearia tomentosa*
Addhi (padal)	*Stereospernum*	Bansha	*Albizzia odoratissima*
suaveoens			
Achar (chiraunji)	*Buchanania latifolia*	Bhurkul	Nymenodictyon
Ajvai (kamnip)	*Ficus refusa*	excelsum	
Akala	*Alangium salvifaliu m*	Bilayati siras	*Cassia siamea*
Amaltas (kirwara)	*Cassia fistula*	Bharrati	*Gymnosporia spinosa*
Anjana(arua, arra, maharuk)	*Ailanthus excelsa*	Bilsena	
Aonla (amla)	*Embelica officinalis*	Baikal	*Gymnsopria montana*
Arjun (koha)	*Terminalia arjuna*	Butea	
Asna (thrha)	*Terminalia alata*	Bassia	
Adusa (basook)	*Adhatoda Vasica*	Borga	*Kydia calcina*
Ail	*Mimora Himalayana*	Bhilawa	*Semecarpus*
Airwan	*Albizzia odoratissima*	*anacardium*	
Ashta	*Bahunia racemosa*	Barru	*Sorghum halepense*
Ainthi(marorphal)	*Helictres isora*	Beli	*Hesperethusa*
Ased	*Salanum verbscifolium*	*crenulata*	
Avaram	*Cassia auriculata*	Bhatkataiya	*Solanum indicum*
Amarbel (akasbel)	*Cuscutar efflexa*	Bilaikand (Korikand)	*Urginea indica*
Adrak	*zinziber officinale*	Badrasin	*Butea superba*
Akalkara	*Anacyclus pyrethrum*	Babaiya tulsi	*Ocimum basilicum*
Al	*Moninda citifalia*	Bhurbhusi	*Eragrastis tanakla*
Alsi	*Linum usitatissimum*	Ban-tulsi	*Eranthemum*
Amrud	*Psidium pyriferum*	*pulechellum*	
Anjir-baghi	*Ficus Carica*	Bajra	*Penicillaria spicata*
Anjir saharai	*Ficus caricoides*	Bakayan	*Melia composita*
Aphim	*Papaver album*	Banoa	*Rhus cotirius*
Arand	*Ricinus communis*	Bandaul	*Luffa Acutangula*
Arand kharbuza	*Carica papaya*	Bathuwa	*Chenopodium album*
Asgand	*Withania somnifera*	Benaula (cotten seeds)	*Gossypium herbaceum*
Anar	*Punica granatum*	Bhang (hemp)	*Cannabis Sativa*
Akashneem	*Millingtonia hertorsia*	Bhanphuli	*Corchorus olitoria*
Anantmul	*Hemidesmus Indicus*	Bhauta	*Solanum*
		ranthocarpum	
Bans	*Dendrocalamus*	Bhindi	*Hibiscus esculentus*
Strictus		Braham Dandi	*Sarcostemma*
Bija (bjahara, bijaisar)	*Pterocarpus marsu-*	*brevistigma*	
pium		Beir	*Zezyphus jujuka*
Bel	*Aegle marmelos*	Benani	
Babul	*Acacia Arabica*	Brodhi	*Themedo quadrivalvis*
Bahera	*Terminalia belerica*	Bhanjura, Bhanjuri (see Pipatwan)	
Ban masooria	*Anrtideema diandrun*	Bherra	*Chloroxylon swietercia*
Barbeda (bhaunti)	*Krioleana hookeriaba*	Banrahar	*Flemingia semialata*
Bargad	*Ficus bengalensis*	Bhunsi dhavae	*woodfordia fruticosa*

Local names	Botanical name	Local names	Botanical name
Bankapas	*Thespesia Lampas*	Dhatura - Safed	*Datura alba*
Bel Plas	*Buitea superba*	Dhatura - siyah	*Datura metal*
Badi Kail	*Diconthium caricesum*	Dhudhi Badi	*WrighTea rothji*
Bargee	*Aristida adscensionis*	Dhunia	*Panicum*
Badaber	*Ischaemum rugosum*	*frumentaceum*	
Bhanjura	*Aplucda mutica*	Dudhi Choti	*Wrightia tindoria*
		Donda	*Dichanthium*
Chil	*Acacia Donoldi*	*annulatum*	
Chheola, Dhak, Palas	*Butea moriosperma*	Domosal	*Miliusa velutina*
Chakunda	*Cassia tore*	Dekamal	*Gardemia resinfera*
Chheonkara, Chenkur	*Prasopis spicigera*	Dudh-bel	*Vallaris salanaces*
Chilla - see Bheri			
Chiral	*Noloptelea integrifolia*	Erma	*See chichua*
Chiro	*Noloptelea*	Erony	*Zizyphus oenoplia*
lowcopeloea		Ehikua	*Chrysopo gon*
Chamroil		*montanus*	
Chichwa	*Chrysepogon*	Eucalyptus	*Eucalyptus hybird*
montharius			
Chhind		Fluggia	
Chilati	*Acacia caisia*	Fulkat	*Gymnema sylverstre*
Capparis (karil)	*(See Karil)*	Fulli	Apluda aritata
Chakori	*Securinega virora*		
Chharenhta	*Cocculus hirsutus*	Galgal, Gogel	*Cochlospermum*
Chameli	*Jasminum grandi*	*gossypium*	
florum		Gurer, Modhi Gunher	*Thermedia*
Chanchara		*quadrivaluis*	
Choulai	*Amaranthus blitum*	Gangarua	*Antropogon pumilus*
Chiraunji (see Achar)		Ganja (Preparation of hemp)	*cannabis sativa*
Chirchira	*Achyranthes aspera*	Genda	*Togetes erecta*
Chitraka	*Plymbago europea*	Ghamoi	
Chuka	*Rumex vesicarius*	Ghi Kuar	*Aloe perfoliata*
Chilbil, cirol	*Haloptelea integrifalia*	Ghumra	*Mallyugo cerviana*
Chhota Parwi	*Artistida hystrix*	Ghunchhi	*Abrus precatorius*
Chikna, chikua	*Chrysopogon fulvus*	Gurch	*Tinospora cordifalia*
Chichura	*Eragrostis tenell*	Ghont	*Zizyphus xxlopyrus*
Chinchwa	*Albizzia odoratissima*	Gunja, Gunj, Ratti	*Abrus precatorius*
Chilauti	*Mimisa hamata*	Gurja	*Lanmed*
Chota kail	*Bothriochloa pertusa*	*coromandelicus*	
Chinkara Indian	*Gazzelle - gazell*	Gabdi, Gongal	*Cochlospermumn*
		religiosus	
Dhamin, Dhaman	*Grewia tiliaefalia*	Ghanta	*Schrebera*
Dhovin	*Dolbergia*	*sweitenoldes*	
panichulata		Goolar	*Ficus glomerata*
Duddhi	*Halarrhena*	Gulbhair	*Althea officinalis*
antidyssentrica		Gumchi, Gonchi	*Eulatia trignicata*
Dhaora	*Anogeirrus acuminata*	Gonal	
Datranga	*Ehretia leavis*	Guner	*Anthistiria sacudems*
Dhama		Ghivpatti	*Desmodium*
Dhawai	*Woodfordin fruiticosa*	*pulchellum*	
Dhaura, Dhau, Dawa, Dhaora	*Anogeissus latifolia*	Gokhru	*Echinops echinatus*
Dispyris		Gurshkari	*Grewia hirsuta*
Doob	*Cynodon dactylon*	Gaaj, Gulhari	*Milletia auriculate*
Deona	*Artemisia indica*	Gurich	*Tinospora malabarica*
Dhak	*Butea frondosa*	Gumar	
Dhaniya	*Coriandrum sativa*	Gamhar	*Gmelina orgorea*

Local names	Botanical name
Ghura	*Anogeissus acuminata*
Ghavaye	*Woodfordia floribunda*
Gokhura	*Tribullus terristria*
Ghout	*Zyzyphus xylophrus*
Gurbel	*Themeda caudata*
Gokhhuru (chhota)	*Acanthosperum*
Gokhhuru	xanthium strumarium
Gangeruwa	*Grewia florescens*
Gumar	*Careya arborea*
Gulmohar	*Declonix regia*
Godbu	
Holdu	*Adina cordifolia*
Hurnghhi	*Ichnocarpus frutiscens*
Harua	*Erythrina suberosa*
Har, Harra	*Terminalia chebula*
Harjor	*Vitis quodranaguluris*
Hulhur or hurhur	*Cleome pentaphylla*
Hingata, Ingua	*Balanites aegyptiaca*
Hingol	*Balanites aegvoties*
Hingot	*Balanites roxhurighi*
Harshingar	*Nyctanther arbortristis*
Harwa	*Erythrina variegata*
Haldi	*Curcuma longa,*
Costus speciosus	
Haruwa	*Kydia calycina*
Imli	*Tamarindus indica*
Ingua (see Hingota)	
Inni	*Clerodendron*
phlomidis	
Indarjau	*Wrightea tinctoria*
Indrayan	*Cucumis*
pseudocolocynthis	
Indrajat	*Patalidium barleriodes*
Indrajau	*Halarrhena*
antidysenterica	
Indrapuspika	*Glarisoa superba*
Jaman	*Syzigium cumini*
Jilbil	
Janglipiyaz	*Urginea indica*
Jharberi	*zizyphus nummularia*
Jhau	*Tamarix troupii*
Jamalgota	*Crodon tiglium*
Jangli gobhi	*Emilia sonchifolia*
Jawar	*Sorghum vulgare*
Jamrosi	*Elacodendron*
glaucum	
Jangli Angur	*Vitis linnaci*
Kaddu, Kumhra	*Cucurbita pepo*
Kag Changi	*Vernomia cinerea*
Kaitha	*Feronia elephantum*
Kakri	*Cucumis pubercens*

Local names	Botanical name
Kanguni	*Setaria italica*
Kaner	*Nerium odorum*
Kanwal gata (stalk)	*Nelumbium*
speciosum	
Karela (gourd)	*Momerdica charantia*
Kasni	*Cichorium intybus*
Kasaundi	*Cassia sophera*
Kat Karanja	*Coesalpinia bonduc*
Kautha, Khair	*Acacia catechu*
Kela	*Musa sapientum*
Keora	*Pundanus*
Odoratissimus	
Khaskhas	*Anatherium*
muricatum	
Khirni, Khini	*Mimusops kanki*
Khira	*Cucumis sativus*
Khurpha	*Portulaca sativa*
Koilar, Koilara	*Bauhinia variegata*
Kukraundha	*Blumea aurita*
Kanju (see chilbil)	
Kutira, Kumhi	*Cochlaspermum*
gossypium	
Kaima, Pholdu	*Mitragyna parviflora*
Kaith	*Feronia limonia*
Kali keekar	*Acacia farnesicera*
Kamela, Rchini	*Mallotus phillipensis*
Kanji, Karanje	Pongamia pinnata
Kari	*Miliusa tomamtoso*
Kasai, Khaja	*Bridelio retusa*
Katai, Kattaiya, Kanker,	*Flacourtia Indica*
Kath (see Jamun)	
Kath bar	*Ficus tomentosa*
Khamhar (see Gamhar)	
Khinni,	*Manilbara hexandra*
Khujha, Khujja	*Ixora arborea*
Kullu, Karar, Kardhai Kulloo	*Sterculia orens*
Koinini	*Careya anbores*
Kusum	*schlerchera, trijuga*
Kala siris	*Albizzia lebbels*
Kabai	*Flacourtia ramonkhi*
Karil	*Capparis ophylla*
Kewanch	*Mucuna prurita*
Kusha	*Desmostachya pinnata*
Karaunda	*Cassis spianrum*
Kuns, Kans	*Saccharum*
spontaneum	
Kewati	*Ventilago calycnlate*
Kardhai, Pendula	*Anogeissus pendula*
Kumbi, Mubhar	*Careya arborea*
Kein	
Kanghi	*Abuliton asiaticum*
Kalam, Kaim	*Mitragyana parvifolia*
Karmata, Kalla	*Dillenia pentagyna*
Kaankar	*Flacourtia Indica*
Koha, Kohu (see Arjun)	

Local names	Botanical name	Local names	Botanical name
Kodar		*foenumgraecum*	
Katai		Moli, Muli (radish)	*Raphanus sativus*
Kush	*Eragrostis*	Meza	
cynosuroides		Modhi (see Gurer)	
Kail	*Andropogon annulatus*	Moonj	*Erianthus munj*
Khajur	*Phypix sylvestris*	Marorphal (see Ainthi)	
Kachar		Musalband	*Dioscorea pentaphylla*
Khas	*Vetiveria zigenioides*	Mahul	*Bauhinia Vahlii*
Kusul	*Helicteris isora*	Marbel	*Dicanthium annulatam*
Kalla	*Dillenia pentagyna*	Musyal	Iseilema
Kali musli	*Curculigo exchiodes*	anthephoroides	
Katang or Bumbu	*Bambusa bambos*	Nagar motha	*cyperrus longus*
Keoti	*Ventilago*	Narangi (orange)	*citrus aurantium*
madraspatana		Nibu (Lemon)	*Citrus lemon*
Khakhaudan	*Celastrus paniculata*	Nil (indigo)	*Indigofera tinctoria*
Kumudnee	*Nymphaea stellata*	Nim, Neem	*Azadirachta Indica*
Kamal	*Nelumbo nucifera*	Nagdu, Samari, Shiwari, Nirgundi	*Vitex negundo*
Kachnar	*Baselaphur*	Neel	*Indigofera hirsuta*
tragocamelus		Nag bel	*Crypotolepis*
Kadlay	*Desmodium triflorum*	*buchanani*	
Ksuhrunt	*Flemingis strolchifera*	Nasbel	*Butea parviflora*
Kukurbicha	*Grewia polyayama*	Parvi	*Heteropogon -*
Lendia	*Logerstromia pariflora*	*contorturs*	
Lokhandi	*Lxora arborea*	Pakar	*Ficus infactoria*
Lompo, Parba, Lumpa	*Heteropagon*	Papar	*Gardenia latifolia*
contorisis		Putjeev	*Putranjiva roxburghii*
Lantana	*Lantana camara*	Panibel	*Cissus repanda*
Lasoda	*cardia dicatosa*	Phang	*Rivea*
Labhera	*cordia myxa*	*hypocrateriformis*	
Lahsan (garlic)	*Allium sativum*	Puraina	*Cissampelor pareira*
Lal Mirchi (red paper)	*Capsicum fastigiatum*	Pilur	*Salvadora deoides*
Lauki	*Layenaria vulgaris*	Panwar	*Cussia tora*
Maniphali, mainphal	*Rendia durometorum*	Phaldu (Kaima)	*Mitragyna parviflora*
Malkangn, Malkangni	*Calastrus paniculata*	Palash	*Butea monosperma*
Maurain	*Bauhinia vahlai*	Padal	*Stereospernum*
Mahua	*Madhuca Indica*	*suaveoens*	
Mamri Mamar	*Elaeodendron*	Pipal	*Ficus religiosa*
glaucum		Pan	*Piper betel*
Mayuriangha, Sauna	*Oroxylum Indicum*	Pathar Chata Safed & *Pathar Chata Surkh*	Boerhevia
Mothi	*Eriolaena hookerjana*	*diffusa*	
Markarar	*Gardenia turgida*	Patpapra	*Fumaria paruiflora*
Musel, Musyal, Mural	*Iscilema laxum*	Phalsa	*Grewia asiatica*
Medhsing	*Dalichandrone falcata*	Piyaz (onions)	*Allium cepa*
Makoy, Makor	*Zizphn oenoplia*	Pudina (mint)	*Mentha viridis*
Mango (see Aam)		Puller	
Mubhar (See Kumbi)		Parwa (see Lumpa)	
Munga	*Moringa*	Phaleria, Sanyar	*Bothriochloa pertusa*
	pterygospermia	Pipatwan, Bhanjura, Bhanj	*Apluda mutica*
Moyan	*Lannea grandia*	Panjra	*Erythrina suberosa*
Mokha	*Nathusia switenioides*	Padar	*Stereospermum*
Makoi	*Solanum incertum*	*Suaveilens*	
Mautha	*Cyperus rotundus*	Propis	*Propis juliflora*
Maulsri	*Mimusops elengi*	Reonja, Reunjha, Hewar	*Acacia leucophloea*
Mehdi	*Lawsonia ineremis*	Rati (Gunja)	*Abrus precatorius*
Methi (Fenugreek)	*Trigonella*	Ram datun	*Smilax macrophylla*

Appendix

Local names	Botanical name	Local names	Botanical name
Ratanjot	*Onosma echioides*	Sawan	*Oplismenum*
Ritha (soap nut)	*Sapindus detergents*	*frumentaceum*	
Rian		Semi	*Canavalia gladiata*
Rioni		Senua	*Cassia clongata*
Rohan	*Soymida Jebrifuga*	Singhara (water caltrops)	*Trapa bispinosa*
Raathar, Rusa	*Cymbopogon martini*	Siris Kala	*Albizza lebbek*
Roumuniya	*Lantana camara*	Soya	*Peucedanum*
Saijana	*Moringa aleifera*	*graveolens*	
Sindhu	*Euphorbia nivulia*	Sudarshan	*Crinum Asiaticum*
Saphoo, Saal	*Shorea robusta*	Sodha	*Ophiorus corymbosus*
Salai, Salaie	*Baswellia serrata*	Saina	*Sehima harvosum*
Sandon tinsa	*Tugenia oojelnensis*	Sanghoor	*Bothriochloa pertusa*
Semal	*Salmalia malabarice*	Sita phal	*Anona squamosa*
Shareeja	*Annona squamosa*	Safed musli	*Choloraphytum*
Sheesham, Sissoo	*Dalbergia sissoo*	*tuberosum*	
Siharoo, Siari, Harsingar	*Nyctanthes arbortristis*	Tendu	*Diospynos*
Sirki	*Securinega virosa*	*melanoxylon*	
Sarphonka	*Tephrosia purpurea*	Teek, Sagon	*Tectona grandis*
Sain, Saj	*Terminalia tomentosa*	Thuar, Sehund	*Eupharbia nivulia*
Satan	*Alstonia scholaris*	Thinsa	*Augenia delbergioides*
Sandal wood	*Samtalum album*	Tarwar	*Cassia tora*
Send or bhampuri	*Apluda aristate*	Tamaku	*Nicotiana tabacum*
Saja	*Lagerstroemia*	Tarui	*Luffa acutangula*
parviflora		Till	*Sesamum Indicum*
Siris, Siras-Safed	*Albizzia procera*	Tulsi Safed	*Ocimum Sanctum*
Sagon, teak	*Tectoma grandis*	Tut	*Morus Indica*
Shatavari	*Asparagus racemosus*	Tara Dehai	
Sahjan	*Hyperanthera moringa*	Tindeen	
Sarson Kala (mustard)	*Brasica nigra*	Thur	*Euphorbia tirucalli*
Sarson Safed	*Brassica alba*	Tinsa	*Augeinia oojeinensis*
Satpatuja		Tor	*Borassus flabelli formis*

*Source :

1. Atkinson, 1874
2. Gazetteers of Banda (CS Nagar), Hamirpur (Mahoba), Jalaun, Jhansi (Lalitpur), Chhatarpur, Damoh, Sagar and Datia Districts (Govt. of U.P. and M.P.) published in different years
3. *Vanaushadhi Chandrodaya* (CR Bhandari) Chaukhamba Sanskrit Sansthan, Varanasi (1986)

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