HARDA DISTRICT AT A GLANCE

S. No.	ITEMS	STATISTICS	
1.	**GENERAL INFORMATION**		
	i) Geogeaphical area	2644.32 Sq.Km.	
	ii) Administrative Divisions (As on 2006) Number of Tehsils	3 (Harda, Khirkia, Timarni)	
	Number of Blocks	3 (Harda, Khirkia, Timarni)	
	Number of Panchayats	211 village Panchayats	
	Number of Villages	571	
	iii)Population (As per 2001 census)	474174 persons	
	iv)Average Annual Rainfall (mm)	1124.2 mm	
2.	**GEOMORPHOLOGY**		
	i) Major Physiographic Units	1. Satpura range and extension of Malwa Plateau in the south 2. Ridges (equivalent to Aravalli Hills) 3. Alluvial plain in the north-east and central part	
	ii) Major Drainage	Narmada river and its tributaries, namely Ganjal river, Ajnal river, Sukni nadi, Midkul nadi, Dedra nadi, Machak nadi, Syani nadi and Kalimachak river.	
3.	**LAND USE**		
	i) Forest area:	780.92 Sq. Km.	
	ii) Net area sown:	1797.87 Sq. Km.	
	iii) Cultivable area:	1845.32 Sq. Km.	
4.	**MAJOR SOIL TYPES**		
		Black soils and ferruginous red lateritic soils, Sandy clay loam, sandy loam and clay loam. (Ustocherpts/ Ustorthents/ Haplustalfs/Haplusterts as per pedological taxonomy)	
5.	**AREA UNDER PRINCIPAL CROPS**		
		Crops	**Area (In Sq.Km)**
		Wheat	1151.01
		Paddy	11.98
		Jowar	10.73
		Maize	13.97
		Other Grains	7.84
		Gram	200.87
		Tuar	25.34
		Urad	0.20

		Other Pulses	6.97
		Soyabean	1621.76
		Til	1.54
		Sugarcane	3.52
		Cotton	19.86
		Spices	6.81
		Fruits	0.43
		Vegetables	6.26
6.	**IRRIGATION BY DIFFERENT SOURCES**		
		Number of Structures	**Area (sq km)**
	Dugwells	6164	329.74
	Tube wells/Bore wells	1758	110.20
	Tanks/Ponds	1	1.57
	Canals	3	796.2
	Other Sources		164.24
	Net Irrigated Area		1394.71
	Gross Irrigated Area		1394.71
7.	**NUMBER OF GROUND WATER MONITORING WELLS OF CGWB (As on 31.3.2007)**		
	No. of Dug Wells No. of Piezometers	10 3	
8	**PREDOMINANT GEOLOGICAL FORMATIONS**		
		Archaean Granite; Porcellanite/ quartzite/ schist (equivalent to Aravallies); Deccan Trap basaltic lava flows and older dolerite dykes/ sills and Recent laterite and alluvium	
9	**HYDROGEOLOGY**		
	Major Water Bearing Formation	Alluvium, Deccan Trap and weathered granite.	
	Pre-monsoon depth to water level during 2006	3.80 to 15.37 m.bgl	
	Post-monsoon depth to water level during 2006	2.90 to 11.50 m.bgl	
	Long Term water level trend in 10 years (1997-2006) in m/yr	**Rise** 0.01 to 0.11 (Pre-monsoon) 0.01 to 0.31 (Post-Monsoon) **Fall** 0.12 to 0.30 (Pre-monsoon), 0.10 to 1.23 (Post-monsoon)	

10.	**GROUND WATER EXPLORATION BY CGWB (As on 31.3.2007)**	
	No of wells drilled (EW,OW,PZ,SH, Total)	1 exploratory well and 3 piezometers
	Depth Range (m)	32.61to 98.45 m.bgl
	Discharge (litres per second)	meagre to 10 lps.
	Storativity (S)	-
	Transmissivity (m^2 /day)	-
11.	**GROUND WATER QUALITY**	
	Presence of Chemical constituents more than permissible limit (eg EC, F, As,Fe)	High Nitrate (> 45 mg/l) recorded in 5 water samples
	Type of Water	Calcium Bicarbonate type
12	**DYNAMIC GROUND WATER RESOURCES (2004) in MCM**	
	Annual Replenishable Ground Water Resources	488.10 MCM
	Net Annual Ground Water Draft	137.22 MCM
	Projected Demand for Domestic and Industrial Uses upto 2025	13.83 MCM
	Stage of Ground Water Development	28 %
13.	**AWARENESS AND TRAINING ACTIVITY**	
	Mass Awareness Programmes Organised Date Place No. of Participants	Nil
	Water Management Training Programmes Organised Date Place No. of Participants	Nil
14.	**EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING**	
	Projects completed by CGWB (No. & Amount Spent)	Nil
	Projects under technical guidance of CGWB (Numbers)	Nil
15.	**GROUND WATER CONTROL AND REGULATION**	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Blocks notified	Nil
16.	**MAJOR GROUND WATER PROBLEMS AND ISSUES**	
		Ground water level in declining in Khirkiya block and parts of Timarni block.

INTRODUCTION

Harda district has predominantly an agricultural based economy. It is situated in the eastern part of Madhya Pradesh. Prior to 1998-99 District Harda was a part of Hoshangabad District. Harda District was created in 6th July 1998, when it was divided from Hoshangabad District. After the division of the district, the area of Harda district is 2644.32 Sq. Km. The district is bounded by Dewas and Sehore districts in the North, Hoshangabad district in the east, Betul in the south and Khandwa district in the west and south. Harda district lies between north latitudes 21^0 54' and 22^0 36' and east longitudes 76^0 46' and 77^0 30' in parts of Survey of India toposheet Nos, 55B & F. Harda is the district headquarters and Khirkiya and Timarni are some of the major towns. Harda lies on Delhi-Mumbai and Kolkata-Mumbai railway routes. State Highway No. 15, linking Bhopal to Khandwa and National Highway No.59 A, linking Indore to Betul, pass through the district. The villages in the district are approachable by fair weather motorable tract.

The district is divided into three Tehsils and three development Blocks, namely Harda Block, Timarni Block and Khirkiya Block. (Plate-I). As per 2001 census, the total population of the district is 474174 persons in 571 villages, as per 2001 census.

Drainage

The entire district is drained by Narmada River and its tributaries. Thus the area falls in the Narmada Basin. The river Narmada flows along the northern boundary of the district. The Ganjal river is the major tributary of the Narmada river and flows from south to north along the eastern boundary of Harda district before merging into the Narmada river. The other major tributary of the Narmada river draining the district are Ajnal river, Sukni nadi, Midkul nadi, Dedra nadi, Machak nadi, Syani nadi and Kalimachak river.

Irrigation

A total of 1107.18 Sq.Km. land is irrigated against agricultural area of 1747.21 Sq.Km

Table 1. : Irrigation (2005-2006)

S. No.	Sources of Irrigation		Number and Area Irrigated in Hectare
1	Canals	Number	3
		Area	796.2
2	Tubewlls	Number	1758
		Area	110.20
3	Dugwells	Number	6164
		Area	329.74
4	Tanks	Number	1
		Area	1.57
5	Other sources	Area	164.24
6	Gross area irrigated from all sources	Area in Hectare	1394.71

Cropping Pattern

District is very rich in the field of agriculture due to good sources of irrigation and fertile alluvial and black cotton soil. Wheat and gram are the main crops grown during Rabi season. Cotton, Soyabean, Mustard, Til and Groundnut are the main oilseeds produced here. The farmers have started the production of Sunflowers.

CGWB Activites

Preliminary hydrogeological studies in parts of Harda district were carried out by the erstwhile ground water wing of geological survey of India in co-ordination with the erstwhile exploratory tube wells organization from 1953 to 1963 (P.G. Adyalkar, 1975). A comprehensive hydrogeological study of the alluvial area of the district was carried out by Central Ground Water Board, during the Narmada Project period from 1971 to 1978. During the above mentioned studies, besides hydrogelogical, hydrological and hydrometeorological studies, exploratory drilling was also carried out covering the entire Narmada upland alluvial valley. Systematic hydrogeological survey has been carried out by Shri K. Srinivasan, Junior Geologist of the GSI in 1969-90, by Shri A. K. Jain, Asstt. Hydrogeologist of Central Ground Water Board in the southern part of the district in 1984-85 and by Shri S.N.Bangar, Asstt. Hydrogeologist in 1987-88. Reappraisal Hydrogeological Survey was taken up by Shri R. M. Verma, Asstt. Hydrogeologist during AAP 1991-92 to assess the scenario of ground water regime.

Rainfall & Climate

The climate of Harda district is characterized by a hot summer and general dryness except during the south west monsoon season. The year may be divided into four seasons. The cold season, December to February is followed by the hot season from March to about the middle of June. The period from the middle of June to September is the southwest monsoon season. October and November form the post monsoon period.

The normal rainfall of Harda district is 1124.2 mm. It receives maximum rainfall during southwest monsoon period. About 90.5% of the annual rainfall is received during monsoon season and only 9.5 % of the annual rainfall takes place during October to May period. The surplus water for groundwater recharge is available only during the southwest monsoon period.

The normal maximum temperature occurs during the month of May i.e. 42.1^{o}C and minimum during the month of January i.e. 11.7^{o}C. The normal annual mean maximum and minimum temperature of Harda district is 32.8^{o}C and 19.8^{o}C respectively. During the southwest monsoon season the relative humidity generally exceeds 91% (August month). Rest of the year is drier. The driest part of the year is the summer season, when relative humidity is less than 33%. April is the driest month of the year. The wind velocity is higher during the pre-monsoon period as compared to post monsoon period. The maximum wind velocity 7.7 km/hr is observed during the month of June and minimum 2.9 km/hr during the month of December. The average normal annual wind velocity of Harda district is 5.0 km/hr.

Geomorphology & Soil Types

Physiographically, the district can be divided in three major divisions:-

1. Satpura range and extension of Malwa Plateau in the south,
2. Ridges (equivalent to Aravalli Hills) in the north-west,
3. Alluvial plain in the north-east and central part

The district is bounded by Satpura ranges in south and by Narmada river in the north. The area slopes north west towards the Narmada river. The slope is generally steep at the foothills of Satpura but moderate to gentle towards Narmada river. The land surface attains a maximum altitude of 734 m above mean sea level at Kaoti (77^0 19'30": $22^0$03'00"), and minimum altitude of 240 m above mean sea level at confluence of Machak river with the Narmada ($76^0$46'50": $22^0$19'00"). A large number of north westerly flowing tributaries originating from the Satpura join the Narmada River along the left bank. The area is mainly drained by Narmada river and its tributaries - namely Ganjal river, Ajnal river, Sukni nadi, Midkul nadi, Dedra nadi, Machak nadi, Syani nadi and Kalimachak river.

Soils of the area are characterized by black grey, red and yellow colours, often mixed with red and black alluvium and ferruginous red gravel or lateritic soils. These soils are commonly known as black soils. About 15% of the area is covered by sandy loam soils immediately on the banks of rivers. Remaining part is occupied by clay loam with big pockets of sandy clay loam and sandy loam. The permeability of the soil is low when the clay contains montmorillonite. They swell intensively when wet and shrink with deep cracks when dry. Intake of water is very rapid till the cracks disappear after complete wetting. The soils have been classified as Ustocherpts/Ustorthents/ Haplustalfs/Haplusterts as per pedological taxonomy as per pedological classification.

GROUND WATER SCENARIO

HYDROGEOLOGY

Aquifer System and Aquifer Parameters

The rocks occurring in the district range in age from Palaeoproterozoic to Quaternary. About 40 % of the district, in the eastern, central and northern (adjoining the Narmada river) part, is covered with alluvium. Ground water occurs under phreatic as well as confined conditions. The water bearing properties of different hydrogeological units occurring in Harda District are described below. Hydrogeology of the district is shown in Plate-II.

Archaeans and Metamorphic rocks equivalent to Aravallis

The Archaean Group of rocks, comprising granite, phyllite, dolomite, quartzite, chert breccia etc are exposed in the north-western part and are faulted near the Narmada River. Weathered and fractured Granite forms a potential aquifer in the area.

Deccan Trap

Deccan traps, which makes for about 50% of the entire district occur as lava flows in the western and southern part of the district. The phreatic aquifer in weathered/vesicular basalt are tapped by dugwells while the deeper confined aquifers are tapped by drilling tubewells. The yield of dug wells ranges from 120 to 180 litres per minute, but in the canal command area, due to substantial recharge from canal seepage, sustains a good discharge.

Alluvium

The alluvial aquifer system in the district is highly potential. Two to three granular zones and at places more number of potential granular zones comprising of fine to medium to coarse grained sand, gravel and pebbles and laterite are encountered in alluvium. The top phreatic aquifer range in thickness from 2 to 10m and is encountered in the depth range of 4 to 20 mbgl.

It appears that all the alluvial aquifer zones constitute a single aquifer system - the unconfined aquifer and a number of deeper aquifer zones separated by thick clay zones. The deeper aquifers are of semi-confined to confined nature with varying potentiometric heads. The yield of alluvial aquifers ranges from 180 to 900 litres per minute.

GROUND WATER EXPLORATION

During Narmada Project period between 1971 to 1978 one exploratory well was drilled in the District at Timarni site and 3 Peizometers were drilled during Hydrology Project period between 1997 to 2000.

S. No	Location	Depth Drilled/ Well Completion depth (In mbgl)	Geological Formations (In mbgl)	Aquifer Zones (In mbgl)	Discharge (litres/sec)	Depth to water level (mbgl)
1	Timarni 22°23' 77°14' 55 F/3	32.61	0-28.35 Alluvium Basalt at 28.35			
2	Handia(S) 22°29'02" 76°59'10"	36.86	0-14 Alluvium Granite at 14.0	14.43-17.86 23.86-30.86	1.0	9.43
3	Harda(D) 22°20'29" 77°05'27"	57.50				10.46
4	Khirkiya(D) 22°09'45" 76°51'34"	98.45	0-0.6 Soil Basalt at 0.6	8.5-12.19		4.58

Well Design

Exploratory wells were drilled by direct rotary method in the alluvial area of the district. Since the area is highly potential, mostly 305 mm (12") or 357 (14") housing has been used to the desired depth depending upon expected discharge and draw-down vis-a-vis depth to water level. The water bearing zones were tapped by placing slotted pipe of 1/8" or 1/16" opening against these zones and the annular space was filled up by gravel of suitable size.

It has been observed that the State Govt. and the individual farmers in the district are getting the bore holes drilled by DTH rigs which is most unsuitable.Geophysical logging facilitates design the production wells properly.

In hard rocks DTH rig can be utilized. Bore hole can be left naked below the surface casing. However, in the basaltic terrain suitable assembly can be lowered to avoid collapsing of strata.

WATER LEVELS

Ground water level form a very important parameter of the ground water system. The groundwater balance expresses itself in the change in water levels; hence a continuous record is important and useful. CGWB has 10 Ground Water Hydrograph Monitoring wells and 3 Peizometers in Harda district.

Pre Monsoon Depth to Water Level (May-2006)

In general depth to water level in the area ranges from 3.80 to 15.37 m. below ground level. Shallow water level of less than 6 m has been recorded at Chhidgaon and Morgarhi. Depth to water level between 9 to 12 m. bgl. is occurring in major part of the district and recorded at Magardha, Mandla, Handia, Harda, Timarni and Mohanpur. Deep water level more than 12 m. bgl. is recorded at Chhipawad and Temagaon.

Post Monsoon Depth to Water Level (November-2006)

In general, during post-monsoon period, depth of water levels in the district ranges between 2.90 to 11.50 m. below ground level. Very shallow water level of less than 3 m is recorded in an isolated monitoring well at Chhipawad. Depth to water level between 3 to 6 m bgl. is occurring in major part of the district has been recorded at Chhidgaon and Mandla. Depth to water level between 6 to 9 m bgl. is observed at Morgarhi, Handia, Timarni, Mohanpur and Temagaon. Deepest water level of 11.5 was recorded at Harda.

CHANGE IN GROUND WATER LEVELS

Water Level Fluctuation between Pre and Post-Monsoon 2006

Slight fall in groundwater level between pre and post monsoon season was recorded at Harda and Morgarhi. Rise has been recorded in major part of district. Rise in water level ranges between 0.70 m at Chhidgaon in north-eastern part of the district and 10.73 m at Chhipawad in southwestern part of the area.

Rise in water levels of less than 2 m is observed in monitoring well at Chhidgaon. Water level rise between 2 to 4 m at Handia and Mohanpur. Rise in water levels more than 4 m is recorded in monitoring wells at Timarni, Mandla, Temagaon and Chhipawad.

Perusal of long term trend analysis indicate that there is no significant change in water levels over 10 year period. Only the Ground Water Hydrograph Monitoring well at Timarni shows declining trend during pre-monsoon as well as post monsoon period, while five Ground Water Hydrograph Monitoring wells show falling trend during pre-monsoon and rising trend during post monsoon period and three Ground Water Hydrograph Monitoring wells show rising trend during pre-monsoon and falling trend during post monsoon period, while no Ground Water Hydrograph Monitoring well of the district shows rising trend during pre-monsoon as well as post monsoon period.

During pre-monsoon period, 6 National Hydrograph Monitoring wells of the district show declining trend. Average rate of decline is ranging between 0.125 m/year at Chhidgaon to 0.3m/year at Mohanpur. 3 Ground Water Hydrograph Monitoring Wells located at Handia, Harda and Chhipawad are indicating rising trend with an average rise of water level from 0.01 m/year (at Handia) to 0.12m/year (at Chhipawad).

During post-monsoon period, the rate of decline is ranging between 0.12 m/year at Handia to 1.235 m/year at Harda.

Long term decline in water levels is perhaps due to increased dependency on ground water resources for various uses and continuous withdrawal of it at various places.

GROUND WATER RESOURCES

The groundwater resource of the District are under-developed and under-utilised. 1758 number of tubewells and 6164 number of dugwells facilitate to irrigate an area of 439.94 Sq.Km. of agricultural land as against 1797.87 Sq.Km. of net sown area in the district. Total annual replenishable groundwater resource of the district is 513.79 MCM while total groundwater draft in the district is only 137.22 MCM and after deducting unaccounted natural discharge, the net available ground water resource is 488.10 MCM. The stage of ground water development of the district is only 28.11%. Harda comes under white category from ground water development point of view. Net Groundwater Availability for future irrigation development is 344.22 MCM. There is ample scope for development of groundwater for irrigation, industrial and domestic purposes.

Table 6: Ground Water Resources of Harda district

Assessment Unit/ District	Command/ non-Command/ Block Total	Net Annual Ground water Availability	Existing Gross Ground water Draft for Irrigation	Existing Gross Ground water Draft for Domestic & Industrial water Supply	Existing Gross Ground water Draft for All uses	Allocation for domestic & industrial requirement supply upto next 25 years	Net Ground water Availability for future irrigation	Stage of Ground water Development
				(Million cubic Meter)				
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Timarni	Command	171.86	2.21	0.42	2.63	0.69	168.96	1.53
	Non-Command	85.67	31.30	1.55	32.85	2.56	51.82	38.34
	Block Total	**257.52**	**33.50**	**1.97**	**35.47**	**3.25**	**220.77**	**13.77**
Harda	Command	86.08	4.59	0.93	5.52	2.42	79.07	6.41
	Non-Command	57.36	33.60	1.86	35.46	4.84	18.93	61.82
	Block Total	**143.44**	**38.19**	**2.79**	**40.98**	**7.25**	**98.00**	**28.57**
Khirkiya	Command	0	0	0	0	0	0	0
	Non-Command	87.14	58.36	2.41	60.77	3.33	25.45	69.74
	Block Total	**87.14**	**58.36**	**2.41**	**60.77**	**3.33**	**25.45**	**69.74**
	District Total	**488.10**	**130.05**	**7.17**	**137.22**	**13.83**	**344.22**	**28.11**

GROUND WATER QUALITY

Based on Chemical analysis of water samples collected during pre-monsoon, 2006 from National Ground Water Monitoring wells, applying IS: 10500 (Drinking Water), all analyzed quality parameters viz. pH, Electrical Conductivity, Total Hardness, Alkalinity & Salinity, except Nitrate and Fluoride fall within permissible limit. In case of Nitrate, 55.55 percent samples contained Nitrate concentration exceeding 45 mg/l at Chhipawad, Temagaon, Mandla, Morgarhi and Magardha villages. High concentration of Nitrate in ground water is in general a potential indicator of agriculture or / and municipal pollution. In case of Fluoride, 11.11 percent of samples contained Fluoride concentration exceeding 1.5 mg/l (at Handia), and 77.77 percent below 0.6 mg/l. However, National Secondary Drinking Water Standards recommended by Environment Protection Agency limit Fluoride concentration to 2.0 mg/l. In ground waters Fluoride concentration exceeding 1.5 mg/l, and below 0.6 mg/l, de-fluoridation, and fluoridation up to Fluoride concentration of 1.0 mg/l is recommended respectively under strict quality control.

Based on chemical analyses of groundwater samples collected from Ground Water Monitoring Wells, chemical data of 2006, applying IS: 11624 (Irrigation Water) standard, 88.88, 100, and 55.55 percent samples fall under low category of Electrical Conductivity (< 1500 μS/cm at 25^0C), Sodium Adsorption Ratio [< 10 (millimole/litre) $^{1/2}$], and Residual Sodium Carbonate (< 1.5 milliequivalent / litre) respectively.

According to U S Salinity diagram, 44.44, 44.44, and 11.11 percent samples fall under C_2S_1, C_3S_1, and C_3S_2 category respectively, which means 88.88 percent ground waters are safe (C_2S_1 and $C_3S_{1)}$ on all soils for irrigation. 11.11 percent ground waters (C_3S_2) may be used on soils with moderate leaching.

According to Wilcox Diagram 44.44, 44.44 and 11.11 percent samples fall under excellent to good, good to permissible and permissible to doubtful categories respectively.

On the whole, groundwater is good for drinking and irrigation purposes.

GROUND WATER MANAGEMENT STRATEGY

Harda comes under safe category from ground water development point of view. Due to easy availability of surface water for irrigation, after the construction of major irrigation Tawa project (1975), the development of ground water for irrigation has been negligible in the area falling under the Tawa Command Project. The ground water development is confined only in non-command area in the district i.e. in Khirkiya block and parts of Timarni block where ground water being the main source of irrigation, ground water level is declining.

Scope of Conjunctive utilization of surface and ground water

Indira Sagar Project on Narmada river has the largest reservoir in India and second largest in Asia has been completed and a number of villages on the bank of Narmada river in Harda district will come under submergence as the water in the reservoir attains its full reservoir level.

By 2008 monsoon, Donglighat-Jhalwa village in Harda district submerged. The effect of the reservoir on groundwater levels will be seen in the coming decade and the benefits/problems will be seen then. To deal with the situation, the possibilities of conjunctive use of surface water and ground water should be considered immediately.

RECOMMENDATIONS

Based on the hydrogeological studies the following recommendations are made for proper development and utilization of the available groundwater resources and management of ground water resources.

Once the Indira Sagar reservoir attains its full reservoir level, all existing ground water structures should be put to their fullest use. All the tube wells constructed in the area should be run to their fullest capacity. This will also cause induced recharge from the reservoir to the ground water aquifers. Water from tubewells/dugwells should be used for irrigation and excess water, if any, may be put into distributaries and minors. More number of tube wells could be sunk in the demarcated productive areas and individual command per tube well can be increased for efficient and appropriate irrigation.

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