Groundwater Resource Assessment and Management Strategies with Special Reference to Madhya Pradesh

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Abstract: Unplanned rapid urban agglomeration, industrial growth combined with intensive irrigation, groundwater over-exploitation and disruption of natural groundwater recharge courses led to depletion of groundwater recharge. Consequently most of the first aquifers have either reduced their replenishing character or exhausted completely. Due to low and erratic rainfall in Madhya Pradesh, management of ground water has become the need of the hour. Sustainable development of groundwater resource has to be based on the available groundwater reserve and the knowledge of current and future demands on these reserves. Therefore groundwater assessment (GEC '97) for the entire state has been quantified for suggesting suitable management practices in the different parts of the state. However, integrated approach i.e. rainwater harvesting, water conservation measures, rejuvenation of traditional water harvesting sources combined with people participation, Water Act are some of the measures suggested for sustainable groundwater development and management in the over-exploited/critical areas.

INTRODUCTION

The state of Madhya Pradesh (M.P.) is centrally located in India covering total geographical area around 3,08,245 sq. km. It is bounded by N Latitudes 20°, 00' and 26°, 15' and East Longitude 74°, 00' to 80°, 50'. The M.P state is surrounded by five states viz., U.P. and Rajasthan in the north, Gujarat in the west, Maharashtra in the south and Chhatisgarh in the east. The state of M.P. has been divided into 48 districts and 313 blocks.

The state has heterogeneous hydrogeological characteristics and consequently groundwater potential differs from place to place. Impact of over-development of groundwater resources is noticed in western part of M.P. especially in Malwa region. In these areas depletion of water levels, drying of wells and groundwater quality deterioration are reported. For proper management of groundwater resources estimation of groundwater reserves is prerequisite. Therefore blockwise estimation of groundwater resources have been carried out using GEC'97 methodology for the entire state, so that proper management strategies could be adopted according to the groundwater availability in different parts of state.

Management of a resource means judicious use and development without causing any adverse affect/harm to the environment. The groundwater resources also need proper management very often forgotten with an excuse that former would itself handle it as per his wishes. This is far from the truth. None of the management practices is simple and mismanagement may adversely affect the aquifer/ groundwater regime.

GROUNDWATER RESOURCE ESTIMATION

It is common sense that to manage water, one must know the quantity available beforehand. Blockwise groundwater resources estimation of Madhya Pradesh state has been computed according to methodology and norms prescribed by Groundwater Estimation Committee 1977 (GEC '97). Net groundwater resources of M.P. come to 35.33 billion cubic metre (BCM). The stage of groundwater development of the state has increased from 42.39% (1998) to 48.46% (2004). This is due to increased uses of groundwater for different purposes in the state. Districtwise groundwater availability and their categorization is given in Tables 1 and 2.

Table 1. Districtwise groundwater resources and categorization

Sl. No.	*District*	*Total annual replenishable resource (ham)*	*Unaccounted natural discharge (ham)*	*Net available groundwater resources (ham)*	*Total draft (ham)*	*Existing stage of Groundwater development in %*	*Category*
1.	Anuppur	46533.99	2326.69	44207.3	3615.69	8.18	
2.	Ashoknagar	46763.9	-	44275.7	15230.42	34.4	
3.	Balaghat	117006.2	5656.56	111349.6	14651.45	13.16	
4.	Barwani	42930.43	2146.33	40784.1	26978.92	66.15	
5.	Bhind	78709.79	3935.39	74774.4	18719.7	25.03	
6.	Bhopal	34270.57	1713.55	32557	23220.98	71.32	
7.	Betul	89965.76	4498.288	85467.5	41407	48.45	
8.	Burhanpur	27051.24	1352.457	25698.8	18177.51	70.73	
9.	Chhatarpur	99840.06	4999.008	94841.1	53609.61	56.53	
10.	Chindwarwa	115958	5807.696	110150.3	55896.32	50.75	
11.	Damoh	44217.68	2210.884	42006.8	21997.4	52.37	
12.	Datia	44029.35	2201.468	41827.9	18524.55	44.29	
13.	Dewas	92702.67	4635.133	88067.5	58468.45	66.39	
14.	Dhar	110227	5523.954	104703.1	104327.5	99.64	
15.	Dindori	43362.19	2168.11	41194.1	3220.1	7.82	
16.	Guna	64382.24	3219.112	61163.1	33266.2	54.39	
17.	Gwalior	69200.83	3460	65740.8	19314.01	29.38	
18.	Harda	51379.31	2568.967	48810.3	13722	28.11	
19.	Hoshangabad	221988.9	11099.45	210889.5	28746	13.63	
20.	Indore	59897.28	2994.864	56902.4	59426.31	104.44	Over-exploited
21.	Jabalpur	53829.3	2705.957	51123.3	21474.95	42.01	
22.	Jhabua	53652.74	2682.637	50970.1	14044	27.55	
23.	Katni	59367.91	2968.396	56399.5	20628.53	36.58	
24.	Khandwa	73222	3661.636	69560.4	40875.76	58.76	

(*Contd.*)

Table 1 (*Contd.*)

25.	Khargone	73600.47	3680	69920.5	53314.7	76.25	
26.	Mandla	60149.11	3006.05	57143.1	3206	5.61	
27.	Mandsaur	74597.73	3729.887	70867.8	77573.18	109.46	Over-exploited
28.	Morena	93125.91	4656.296	88469.6	23902.63	27.02	
29.	Narsimhapur	121316.7	6065.832	115250.9	72032.11	62.5	
30.	Neemuch	38344.14	1917.244	36426.9	33407.31	91.71	
31.	Panna	51257.57	2562.879	48694.7	11907.46	24.45	
32.	Raisen	138835	6941.751	131893.3	45482.75	34.48	
33.	Raigarh	93646.56	4684.475	88962.1	69140.55	77.72	
34.	Ratlam	63598.95	3179.947	60419	70882.13	117.32	Over-exploited
35.	Rewa	53358.05	2668.882	50689.2	21197.69	41.82	
36.	Sagar	121697.2	6084.861	115612.4	53925	46.64	
37.	Satna	64712.68	3235.634	61477	42240.2	68.71	
38.	Sehore	79215.29	3960.764	75254.5	46979.75	62.43	
39.	Seoni	100968.7	5048.938	95919.8	20972.77	21.86	
40.	Shahdol	91149.2	4557.46	86591.7	5751.56	6.64	
41.	Shajapur	55239.46	2918.874	52320.6	59439.41	113.61	Over-exploited
42.	Sheopur	107832	5391.6	102440.4	19632.59	19.16	
43.	Shivpuri	104925.8	5246.29	99679.5	67998.36	68.22	
44.	Sidhi	87386.78	4370.339	83016.4	20875.03	25.15	
45.	Tikamgarh	80646.68	4032.334	76614.3	39373.15	51.39	
46.	Umaria	70635.05	3531.753	67103.3	6273.18	9.35	
47.	Ujjain	83454.13	4172.706	79281.4	86435.21	109.02	Over-exploited
48.	Vidisha	69265.92	3463.296	65802.6	30922.04	46.99	
	State Total (Ham)	3719449	186132.8	3533316.2	1712407	48.46	
	State Total (BCM)	37.18	1.86	35.33	17.12	48.46	

Table 2. Districtwise balance of ground water for future irrigation use and future irrigation potential

Sl. No.	*District*	*Net available groundwater resources (ham)*	*Current total draft for irrigation*	*Allocation for domestic and industrial use for next 25 years (up to Jan 2029) (in ham)*	*Balance of ground water for future irrigation use (in ham)*	*Future irrigation potential (in hectares)*
1.	Anuppur	44207.3	2400	2204.20	39603.10	990077.4
2.	Ashoknagar	44275.73	13887.48	1724.64	28663.60	716590.1
3.	Balaghat	111349.6	11344.2	4447.75	95557.68	2388942
4.	Barwani	40784.1	25092.8	3410.90	12280.40	307009.9
5.	Bhind	74774.4	16353.5	3973.59	54447.31	1361183
6.	Bhopal	32557.02	22514.5	1239.26	8803.26	220081.6
7.	Betul	85467.47	39089	3380.20	42998.27	1074957
8.	Burhanpur	25698.78	16777.1	1901.07	7020.62	175515.4
9.	Chhatarpur	94841.05	51100	3043.31	40697.74	1017443
10.	Chindwarwa	110150.3	52931.5	5912.76	51306.03	1282651
11.	Damoh	42006.8	20035.9	2807.75	19163.15	479078.6

(*Contd.*)

Table 2 (*Contd.*)

Sl. No.	District	Net available groundwater resources (ham)	Current total draft for irrigation	Allocation for domestic and industrial use for next 25 years (up to Jan 2029) in Ham	Balance of ground water for future irrigation use (in ham)	Future irrigation potential (in hectares)
12.	Datia	41827.88	17478.55	1891.72	22457.61	561440.2
13.	Dewas	88067.54	56172.1	3086.12	28809.32	720232.9
14.	Dhar	104703.1	101295.6	5562.33	-2154.88	-53871.96
15.	Dindori	41194.08	1765.5	3398.82	36029.76	900744
16.	Guna	61163.13	31544.8	2304.66	27313.67	682841.8
17.	Gwalior	65740.83	17077.35	2617.73	46045.75	1151144
18.	Harda	48810.34	13005	1383.03	34422.31	860557.8
19.	Hoshangabad	210889.5	27218	2009.32	181662.15	4541554
20.	Indore	56902.42	56942.6	5965.11	-6005.30	-150132.4
21.	Jabalpur	51123.34	19177.25	4570.99	27375.10	684377.6
22.	Jhabua	50970.1	11113	8275.22	31581.88	789547.1
23.	Katni	56399.51	18874.25	2190.14	35335.13	883378.2
24.	Khandwa	69560.36	38484.98	4174.71	26900.67	672516.9
25.	Khargone	69920.47	50815.2	4153.99	14951.28	373782
26.	Mandla	57143.06	1314	3213.95	52615.11	1315378
27.	Mandsaur	70867.84	75965.5	3463.24	-8560.90	-214022.4
28.	Morena	88469.61	21473.75	3857.95	63137.91	1578448
29.	Narsimapur	115250.9	69799.5	3073.47	42377.90	1059448
30.	Neemuch	36426.9	32110.5	1698.65	2617.75	65443.74
31.	Panna	48694.69	10111.08	2042.16	36541.45	913536.2
32.	Raisen	131893.3	43485.1	5480.88	82927.30	2073182
33.	Raigarh	88962.08	66584.75	4737.39	17639.95	440998.7
34.	Ratlam	60419	67780.32	3628.09	-10989.41	-274735.3
35.	Rewa	50689.17	18075.65	6868.01	25745.52	643637.9
36.	Sagar	115612.4	51040.25	4133.32	6038.80	1510970
37.	Satna	61477.05	38610.5	7509.85	15356.70	383917.5
38.	Sehore	75254.53	44843.8	2982.89	27427.84	685696
39.	Seoni	95919.76	18676.9	3739.01	73503.86	1837596
40.	Shahdol	86591.74	4038	3218.07	79335.67	1983392
41.	Shahapur	52320.59	56907.5	3577.71	-8164.62	-204115.5
42.	Sheopur	102440.4	18104.25	1910.43	82425.73	2060643
43.	Shivpuri	99679.52	65548.7	3833.01	30297.81	757445.2
44.	Sidhi	83016.44	17082.25	6387.19	59547.00	1488675
45.	Tikamgarh	76614.35	37351.27	3766.01	35497.06	887426.6
46.	Umaria	67103.3	5380.75	1556.86	60165.69	1504142
47.	Ujjain	79281.42	83932.2	3059.24	-7710.01	-192750.3
48.	Vidisha	65802.62	27726.75	4270.73	33805.15	845120.7
	State total (ham)	353316	1608433	173637.44	1751245	43781121
	State Total (BCM)	35.33	16.08	1.74	17.51	437.81

The command areas of different blocks for the entire state are classified as safe category (Groundwater development <70%). Non-command areas of 18 blocks are falling in semi-critical category (Groundwater development is 70-90%), five blocks in critical category (90%-100% Groundwater development) and 24 blocks of the state are categorized as over-exploited (Groundwater development >100%). List of these blocks are presented in Table 3 and illustrated in map (Fig. 1).

Table 3. Semi-critical, critical and over-exploited Blocks in Madhya Pradesh

Districts	*Blocks*	*Stages of groundwater development (%)*	
(A) Semi-Critical Blocks			
Barwani	1	Rajpur	76.47
Bhopal	2	Phanda	82.68
Betul	3	Amla	83.63
Burhanpur	4	Burhanpur	76.50
Chhindwara	5	Chhindwara	89.42
Dhar	6	Dharampuri	87.74
Khargone	7	Kahrgone,	83.97
	8	Maheshwar	82.91
Khandwa	9	Chhegaon Makhan	89.59
Neemuch	10	Jawad	89.23
Ratlam	11	Salina	89.13
Satna	12	Rampur Baghelan	85.86
Sehore	13	Sehore	81.32
	14	Astha	81.28
Shajapur	15	Agar	75.10
	16	Shajapur	76.11
Ujjain	17	Tarana	82.21
	18	Khachrod	86.85
(B) Critical Blocks			
Dewas	1	Dewas	95.59
	2	Sonkatch	96.81
Indore	3	Depalpur	96.43
Khargone	4	Bharwaha	94.27
Shajapur	5	Barod	93.97
(C) Over-exploited Blocks			
Barwani	1	Parsemal	126.11
Dhar	2	Badnawar	152.63
	3	Dhar	156.08
	4	Manawar	125.01
	5	Nalchha	122.01
	6	Tirla	110.85
Indore	7	Indore	136.64
	8	Sanwer	132.76
Mandsaur	9	Mandsaur	128.18
	10	Malhargarh	136.32
	11	Sitamau	113.79
Neemuch	12	Neemuch	139.40
Ratlam	13	Jarora	132.44
	14	Piploda	174.34
	15	Ratlam	111.34
	16	A lot	107.51
Shajapur	17	Kalapipal	109.48
	18	Mohan Barodiya	128.87

Districts	*Blocks*	*Stages of Groundwater development (%)*	
Ujjain	19	Nalkhedi	104.30
	20	Sujalpur	144.46
	21	Sunser	133.09
	22	Ujjain	144.38
	23	Badnagar	168.47
	24	Ghatia	100.80

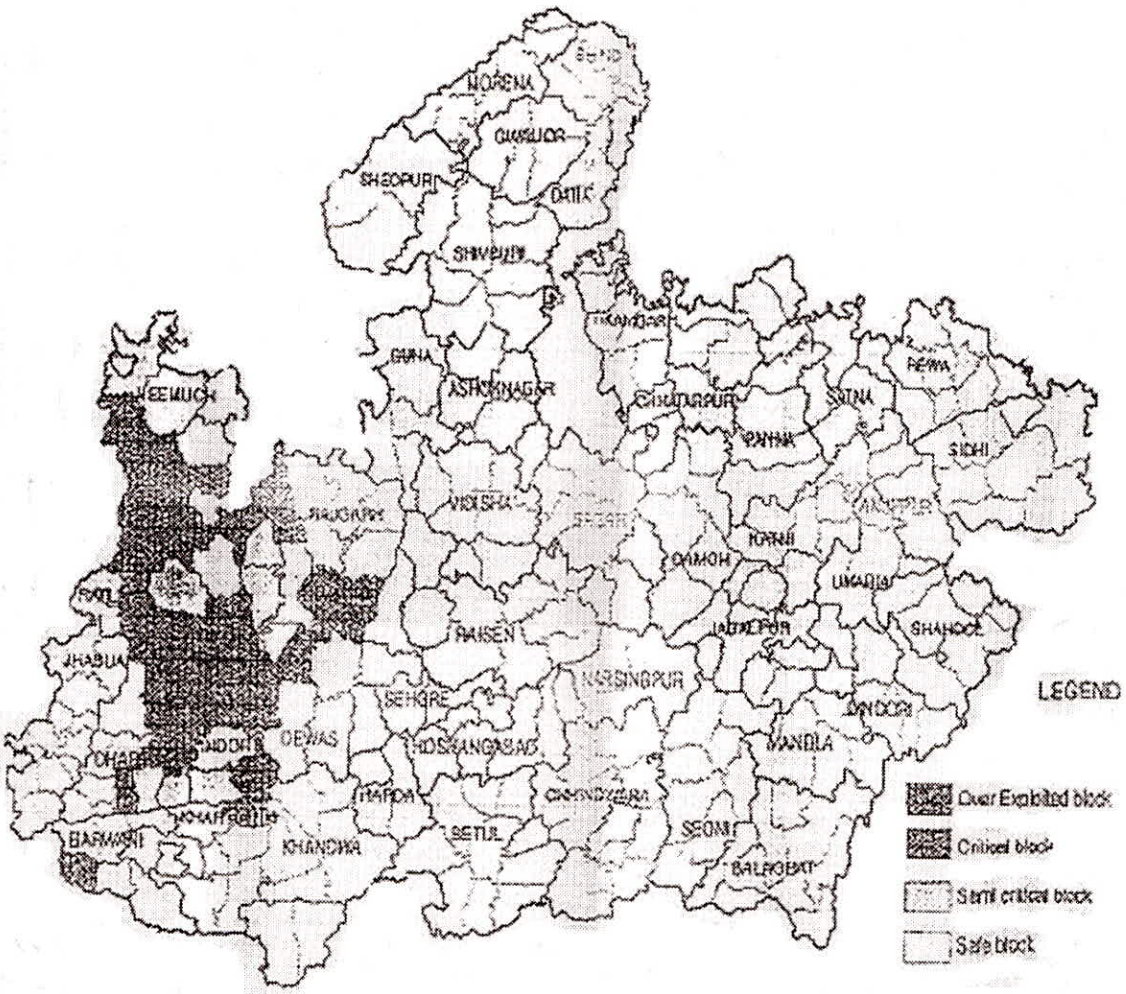

Fig. 1. Map showing districtwise groundwater development in Madhya Pradesh.

STRATEGY TO BE ADOPTED FOR GROUNDWATER MANAGEMENT

Groundwater situation in western M.P. is worst. Almost all over-exploited blocks are falling in western part of the Madhya Pradesh, which is known as "Malwa region", where groundwater draft has increased many folds during past decades. On the other hand, eastern part of M.P. is falling in safe category. In western Madhya Pradesh sustainability of groundwater resources is to be ensured by proper groundwater management strategies based on the following principles.

1. Ban on over-exploitation of groundwater (Legal aspect of GW management).
2. Pricing policy for water.
3. Restoring traditional groundwater structures like Tanks, Bowdis etc.
4. Rainwater harvesting and artificial recharge of ground water.
5. Protection of groundwater resource from pollution.
6. People's participation in groundwater management.
7. Conjunctive use of surface water and ground water.
8. Groundwater conservation.
9. Farmers training/awareness.

Ban on Over-exploitation of Groundwater — Legal Aspect

It should be mandatory to regulate groundwater withdrawal in over-exploited/critical areas. It includes

(1) Ban on construction of new wells
(2) Register all existing structures. Regulation of new power connection for pump in such areas.

The Hon'ble Supreme Court has directed in the decision of the PIL filed by the Lawyer Shri M.C. Mehta that "Central Govt. shall constitute the CGWB as authority under section 3(3) of Environment (Protection) Act 1986 in order to regulate indiscriminate boring and withdrawal of groundwater in the country." Accordingly, Govt. of India constituted CGWB as an authority under Environment (Protection) Act 1986 as appeared in the Gazette of India dated 14th Jan 1997.

In M.P. the state government after considering "Model Bill to regulate and control groundwater" circulated by MOWR, GOI in June 1996 had also drafted M.P. Bhujal (Niyanthran Avam Viniyam) Adhiniyam to regulate and control groundwater development in the state. This will help in:

- Regulating exploitation of ground water for various use can be possible.
- Withdrawal of groundwater could be judged and checked as and when required.
- Water recharge areas for urban agglomeration have to be kept reserve from other uses.
- To check on unauthorized construction at areas of GW recharge zone.

Pricing Policy for Ground Water

Water has become a scarce source as we have taken it for granted as a free nature's gift. We have not attached any 'price' for this resource, which is precious to life. We must now think to price water. The water users must pay for it. It is also true that water is our prime need. Therefore, we cannot restrict people to use it. But nevertheless proper (rational) water pricing is required for irrigation, domestic and commercial groundwater supply schemes in order to restrict wastage of precious water.

Restoring Traditional/Old Groundwater Structures

Revival of traditional water conservation structure like Nadi, village, pond, baori and dugwells should be made mandatory. Gram Panchayats may be made responsible for this work. This will improve groundwater recharge and water harvesting in rural areas.

Implementation of Artificial Recharge of Groundwater

Different types of artificial recharge methods like roof top rain water harvesting, construction of sub surface barrier, check dam, inverted wells is being constructed under various government programmes like watershed mission, Pani Roko Abhiyan, Jal Abhishake programme and also under CGWB, central sector schemes. Rooftop harvesting structure is being proposed in cities, industrial estate and township area of the district. Recharge structures have to be constructed to enhance infiltration in the water deficient areas along with all suitable natural depression to facilitate groundwater recharge.

Subsurface barrier with suitable recharge shafts and tube wells are also considered in second order and higher order streams associated with the villages of water deficiency where enough rain water is available for harvesting. Construction of recharge structures like inverted wells/shaft/tube wells in areas of anicuts and other structures to increase groundwater recharge can also be taken up.

Protection of Groundwater Resources from Pollution

The pollution of ground water is continuously increasing due to household effluents, industrial wastes, garbage dumps, biomedical wastes, pesticides and fertilizer from agricultural fields. It is a matter of very serious concern because the retrieval of aquifers, once polluted is not possible. It is suggested, therefore, that

(a) The pollution control laws should be strictly enforced so that household, industrial and bio-medical waste is properly treated and it is not discharged into streams of water or earth without careful treatment.
(b) Urban landfills/garbage dumps should have either concrete floored or sheets of impervious film be used to prevent leaching of pollutants in ground water.
(c) Groundwater recharge structures should always use filters before injecting surface water into the ground. Water should not be directly injected into a well unless it is confirmed that there is no pollutant in the water. Special care should be taken in case of water from agricultural fields so that pesticides and fertilizers do not mix with groundwater.

People's Participation of Groundwater Management

The public support is needed to implement groundwater management. Institutional frameworks that enable effective participation of local users and communities in the management process are essential. It is also suggested that in the local languages of region, seminar, posters, nukkad sabha, drama be arranged using audio-visual aids for educating the people of urban and rural areas for judicious use of ground water.

Conjunctive Use of Surface and Ground Water

In command areas during crises period ground water and surface water are used conjunctively. It is one of the water management measures. Areas in which surplus rain water is available and which can

be made available for utilization in each micro watershed can also be considered for harvesting. Water logging problem in the command area could also be reduced with this measure.

Water Conservation

This includes modern agriculture practices like dry farming, sowing of salt tolerant crops, laying efficient irrigation network by using lined distributories, sprinkler and drip irrigation. Conventional tank system of Rajasthan is most suitable method for water conservation. This system can be used to collect roof top rainwater in Malwa region, western part of the state to reduce pressure on water supplies of all major cities and towns. Crop, which requires less water, be encouraged. It should made mandatory requirement for construction of underground water-tank while approving plan for residential house as a part of water conservation plan.

Farmers' training/awareness

The farmers are not aware about many things associated with the management of water. Hence it is necessary to incorporate the basic theory regarding mode of occurrence and availability of ground water while imparting training to them. In command area development programme (CADP) much emphasis is given for proper management of water but in case of ground water, it is left to the initiatives of farmers.

RECOMMENDATIONS

For proper management of groundwater resources two-fold strategy is suggested.

1. Conservation and legal framework with people's participation to avoid over-exploitation.
2. Augmentation of groundwater resources.

Micro irrigation techniques such as, drip irrigation, sprinklers, should be used. The heavy water duty crops should be discouraged in groundwater irrigation. Conjunctive use of surfacewater and groundwater resources should be planned and exercised.

It should be made mandatory to every owner of tube well or user of ground water to resort to roof top rainwater harvesting and recharge their wells in urban areas. Similarly in the rural areas also every cultivator who owns a tube well for irrigation must recharge ground water by adopting simple groundwater recharge technique such as field bunds, field trench, farm pond or recharge pits in their fields.