CHAPTER-8

WATER RESOURCES
EVALUATION AND MANAGEMENT
WATER RESOURCES EVALUATION AND MANAGEMENT

The conjunctive use of surface and groundwater for irrigation, domestic and industrial purposes may be scientifically defined as the management of multiple water resources in a coorientated manner, such that the total yield of the system over a period of years exceeds the sum of the yields of the separate component of the system arising due to uncoordinated operation. The concept of conjunctive use is not one of providing groundwater supply as a backup for a complete surface water system or vice-versa. In fact, it is a concept in which one system complements and supplements the other to compensate the inadequacies of both.

Our new national water policy, now directs that both surface and groundwater should be viewed as an integrated resource and should be developed conjunctively in coordinated manner. Keeping this in view, present study was undertaken to suggest the best possible ways for development of water resources in command area of Sonbarsa river basin, Rajnandgaon district (C.G.)

HYDROLOGY

8.1. RAINFALL: The nearest rain gauge station of the Sonbarsa river basin catchment area is Rajnandgaon. The average (36 year) rainfall of the area is 1175 mm (Table year 1964-2001) whereas the normal rainfall is 1200 mm. During the year 1983, 1986, and 1995 the area has, received more than normal rainfall. The maximum rainfall of 1996.6 mm was observed in 1994 while the area has experienced minimum rainfall of 804.6 mm in the year 1996.

8.1.1 Surface Water: The catchment area of Sonbarsa river basin is 441.59 sq. km and the maximum water spread area is 40.89 sq. km. The catchment area of the basin falling in Rajnandgaon block is 280 sq.km. with the yield of 0.344 Mcm/sq. km with a total yield of 96 Mcm. The total water spread area of the above mentioned block is 5.23 sq. km.
8.2 THE OTHER SOURCES

8.2.1 Canal & Tanks: There are 23 tanks in the area, most of which are seasonal. The biggest one is Ruse having a command area of 35.18 sq.km. and channel length of 12.2 km. However, construction of minor distributaries is under progress. The other sources include i.e. lift from river and nalas is 3.2 sq.km can contribute to irrigate about 10% of RUSE command area.

8.2.2 Groundwater Resources: The groundwater resources of the present area are estimated following the methodology of Groundwater Estimation Committee and approved by Central Ground Water Board, North-Central Region. The data for resource estimation of groundwater of Sonbarsa River basin are estimated and also borrowed from Groundwater Recharge Project, Rajnandgaon, 1988

8.3 ANNUAL NATURAL RECHARGE: The annual recharge to groundwater body comprises mainly monsoon recharge, non-monsoon recharge, canal seepage, seepage from tanks and return flow from surface and groundwater irrigation. Their components have been calculated as hitherto mentioned. Geographical area, infiltration index and specific yields are the governing parameters to determine the availability of groundwater in an aquifer. The estimate of groundwater recharge has been done block-wise by

1. Water level fluctuation method.
2. Rainfall infiltration method.

Based on ARDC norms, groundwater recharge has been calculated assuming 3% as specific yield and 10% as infiltration index for water level fluctuation method and rainfall infiltration method respectively for hard rocks.

8.3.1 RECHARGE DURING MONSOON SEASON: Annual replenishment of groundwater during monsoon period has been worked out on the basis of following equation:

Monsoon Recharge = (S+Dw) - (Rs+Ris+Rigw)x NF(Rs+Ris)
Where

\[ S = \text{Water level fluctuation} \]
\[ Dw = \text{Draft of groundwater during monsoon.} \]
\[ Rs = \text{Recharge of canal seepage during monsoon} \]
\[ Ris = \text{Return flow from subsurface water flow from tanks/reservoir during monsoon.} \]
\[ Rigw = \text{Return flow from irrigated field during monsoon.} \]
\[ NF = \text{Normalization factor of rainfall which is calculated as,} \]
\[ \text{Normal rainfall of a year} \]
\[ \text{Average rainfall during monsoon for proceeding five years.} \]

8.3.1.1 Recharge Due to Annual Water Level Fluctuation (S) : The recharge during monsoon has been estimated on the basis of groundwater fluctuation in the phreatic aquifer. The fluctuation is calculated for 75 observation wells, located in different lithounits of Sonbarsa river basin. The value of (S) is estimated by multiplying the area with the specific yield of its hydrogeological unit and then by the average fluctuation of groundwater level that has taken place in the pre and post-monsoon period.

Table - 8.3.1.1 GROUNDWATER STORAGE IN SONBARS A RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>Area (sq.km.)</th>
<th>Average Fluctuation (m)</th>
<th>Specific yield ARDC</th>
<th>Change in Storage (Mcm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>441</td>
<td>5.2</td>
<td>0.03</td>
<td>68.79</td>
</tr>
</tbody>
</table>

\[ (d) = (axbxc) \]
8.3.1.2 Recharge Through Seepage From Canals (Rs): This recharge has been calculated on the basis of wetted perimeter wetted area of canals running deep, and seepage factor as shown in table below.

Table - 8.3.1.2 RECHARGE THROUGH SEEPAGE FROM CANALS IN SONBARSA RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>length of Canals m.</th>
<th>Average wetted Perimeter m</th>
<th>Seepage factor ham/day/10^6 sq.m. Of Weighted area</th>
<th>Seepage Mcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>12,800</td>
<td>5.00</td>
<td>20</td>
<td>1.28</td>
</tr>
</tbody>
</table>

8.3.1.3 Seepage From Tanks/Reservoirs (Ris): The existing number of tanks and ponds used for irrigation purposes have been taken into account and by assuming a percolation seepage from beneath the bed or such structure @60cm/annum/unit area of total water spread area.

Table - 8.3.1.3 SEEPAGE FROM TANK/RESERVOIRS IN SONBARSA RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>No.of Tanks</th>
<th>Total water Spread area (sq./km.)</th>
<th>Seepage factor (m/year)</th>
<th>Total seepage (Mcm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>7</td>
<td>3.6</td>
<td>0.6</td>
<td>2.16</td>
</tr>
</tbody>
</table>

8.3.1.4 Return Seepage From Irrigated Field (Figw): Application of surface water irrigation to the crops in the field area during monsoon period is basically as protective irrigation in nature. Assuming 80% efficiency of irrigation applications to the crops, the water that does not get utilized by the crops and returns to groundwater reservoir is calculated as.
Table - 8.3.1.4  RETURN SEEPAGE FROM IRRIGATED FIELD IN THE SONBARSA RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>Area Irrigated (ham)</th>
<th>Average depth of water applied (m)</th>
<th>Irrigation water applied (ham)</th>
<th>Seepage factor</th>
<th>Seepage Mcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>2510</td>
<td>0.35</td>
<td>878.5</td>
<td>0.40</td>
<td>3.51</td>
</tr>
</tbody>
</table>

8.3.1 TOTAL MONSOON RECHARGE : Various components of monsoon recharges and their respective volume have been computed and present in Table - 8.3.1.

Table - 8.3.1  TOTAL MONSOON RECHARGE OF SONBARSA RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>S</th>
<th>Dw</th>
<th>Rs.</th>
<th>Ris</th>
<th>Rigw</th>
<th>Nf</th>
<th>Monsoon Recharge Mcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>68.79</td>
<td>1.939</td>
<td>1.28</td>
<td>2.16</td>
<td>3.51</td>
<td>1.185</td>
<td>65.94</td>
</tr>
</tbody>
</table>

8.3.2 RECHARGE DURING NON MONSOON SEASON : The non monsoon rainfall in the district Rajnandgaon is about 10% of the annual rainfall. This quantity being small, the groundwater recharge during non monsoon period has been calculated on the basis of infiltration index as shown in Table 8.3.2.

Table - 8.3.2  RECHARGE DURING NON MONSOON SEASON IN SONBARSA RIVER BASIN.

<table>
<thead>
<tr>
<th>Basin Area sq.km.</th>
<th>Average Non Monsoon Rainfall (mm)</th>
<th>Infiltration Index</th>
<th>Non monsoon Recharge Mcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>441</td>
<td>118</td>
<td>.1</td>
<td>0.52</td>
</tr>
</tbody>
</table>
8.4 ANNUAL GROUNDWATER DRAFT: In the absence of detailed water use data, the annual groundwater draft has been estimated on the basis of existing structures like dug wells with mhots/persian wheel or fitted with pumps, dug cum bore wells, shallow tube wells, etc. The unit draft of groundwater caused by such structures has been assumed as @ 0.6 ham and 3.0 ham for dug wells and tube wells respectively.

Table - 8.4 ANNUAL GROUNDWATER DRAFT OF SONBARSA RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>No of Structure</th>
<th>Annual Draft</th>
<th>Total Draft</th>
<th>Net Draft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DW</td>
<td>Tw</td>
<td>Mcm</td>
<td>Dw</td>
</tr>
<tr>
<td>Sonbarsa</td>
<td>248</td>
<td>43</td>
<td>1.48</td>
<td>1.29</td>
</tr>
</tbody>
</table>

8.5 ANNUAL RECHARGE AND UTILIZABLE RESOURCES: The annual groundwater recharge is a sum of total of monsoon and non-monsoon recharge. Out of this total recharge volume 15% is separated out towards allocation for drinking and industrial requirement. Balance 85% of total recharge volume is accounted as utilizable groundwater resource (Table - 8.5).

Table - 8.5 ANNUAL RECHARGE AND UTILIZABLE RESOURCES OF SONBARSA RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>Monsoon Recharge Mcm</th>
<th>Non Monsoon Recharge Mcm</th>
<th>Total Recharge Mcm</th>
<th>Utilizable Resources Mcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>65.94</td>
<td>0.52</td>
<td>66.46</td>
<td>56.49</td>
</tr>
</tbody>
</table>
8.6 GROUNDWATER BALANCE: The groundwater balance for exploration is estimated by deducting the annual draft from net recharges pertaining to the year 1998. This balance and the stage of development are given in Table 8.6.

Table - 8.6 GROUNDWATER BALANCE OF SONBARS A RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>Utilizable Groundwater Resources Mcm</th>
<th>Groundwater Draft Mcm</th>
<th>Groundwater Balance Mcm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>56.49</td>
<td>1.939</td>
<td>54.55</td>
</tr>
</tbody>
</table>

8.7 GROUNDWATER BALANCE AND STAGE OF DEVELOPMENT: The groundwater balance for exploitation purposes is estimated by deducting the annual draft from net recharge. This balance and stage of development is given in Table - 8.7.

Table - 8.7 GROUNDWATER BALANCE AND STAGE OF DEVELOPMENT IN SONBARS A RIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>Net Recharge Mcm</th>
<th>Net Draft Mcm</th>
<th>Groundwater Balance Mcm</th>
<th>Stage of Development %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>56.49</td>
<td>1.939</td>
<td>54.55</td>
<td>3.4%</td>
</tr>
</tbody>
</table>

8.8 AVAILABILITY OF GROUNDWATER FOR DOMESTIC AND INDUSTRIAL NEEDS: Nearly 90 percent of rural and 50 percent of urban population of Rajnandgaon district depends upon groundwater resources. The Groundwater Estimation Committee constituted by the Government of India, has recommended utilisation of groundwater recharge to the extent of 15 percent to meet domestic and industrial water needs.
Table - 8.8 AVAILABILITY OF GROUNDWATER FOR DOMESTIC AND INDUSTRIAL NEEDS OF SONBARSARIVER BASIN

<table>
<thead>
<tr>
<th>Basin</th>
<th>Total Recharge</th>
<th>Annual Groundwater Recharge</th>
<th>Availability for domestic &amp; industrial needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sonbarsa</td>
<td>66.46</td>
<td>56.49</td>
<td>8.47</td>
</tr>
</tbody>
</table>

The domestic groundwater demand is mostly met by withdrawal of water from dug wells manually and from tube wells fitted with hand pumps and power pumps. Although dug wells and tube wells draw water from two different aquifer systems, heavy groundwater withdrawal is likely to establish hydraulic continuity between the two systems, especially, so when aquifers are feebly Semi confined and leaky. It can therefore be safely presumed that the groundwater withdrawal from deeper aquifers would mean the phreatic aquifers too.

8.9 WATER MANAGEMENT AND ARTIFICIAL RECHARGE: On the basis of data available and rapid appreciation of the updated information, well programmed implementation of projects for exploration, the evaluation and exploitation should commence from high potential areas as well as virgin areas. Some of the important aspects listed below are required to be considered for proper planning of surface as well as subsurface water management and development of a region.

River sections with flood and base flow:

1. Perennial rivers zone.
2. Lake in virgin tracks.
4. Water-logged areas.
5. Potential groundwater areas like canal command areas.
7. Potential moisture region.
On delineation of these zones, investigated area can be launched for harvesting, wasted flows, groundwater exploitation, utilizing conjunctive approach for greening wasted lands in regions with water potentialities. Utilization of waters and lands could be carried out by simple techniques like diversion and commissioning hydrams.

8.9.1 SURFACE WATER: The hilly tracts have an unfavorable terrain, while plains are already having sufficient water, so the operable solutions are offered herein.

8.9.1.1 Diversion of water for:
1. Storing in natural depressions.
2. Bunding in broad valleys with narrow necks.
3. Greening the region.
4. Irrigating the crops around the year.
5. Distribution of flood flows through the existing canal network.
6. Rain water and groundwater harvesting.
7. Development of grid system for distributing the excess water.
8. Improving drainage system for integrated water resources management.

8.9.1.2 Utilization of wasted flows: Unutilized flood flows and rejected recharge are wasted into big rivers and ultimately into sea. An aspect of utilization of these flows is by diversion of river flows through channels taken from higher altitudes for catering to lower tracts.

Next aspect is siting natural depressions favorable for storing and salvaging significant quantities of these flows. Selection of sites suitable for reserving huge quantities by building minor, economical structures across necks of broad valleys of stream course is another aspect. Hydraulic rams can lift the perennial flows of hilly streams.

8.9.1.3 Salvaging flood flows: Flood water could be distributed through existing canal grid into the delineated depressions.
8.1.9.4 Dams and irrigation: This approach is most essential and extension of activity is dependent upon the availability of surface waters on a large scale.

8.9.1.5 Rejected Recharge: Huge quantities of base flows of most of the river are let into big river and leading ultimately in to oceans. It is essential to organize these waters for listed reasons.
1. Base flows are available in the lean months of post-monsoon period.
2. They are major surface for greening around the year.
3. Economical means for harvesting and salvaging water resources.
4. Easily usable by simple pumps.

8.9.2 GROUNDWATER: With the advent of development there is exponential increase in demand for water. The dimensions of the demand became more and more apparent during summer, thus, need for and dependency of groundwater have been increasing from year to year. Groundwater resources being part of natural resources could be fed into canals for enlarging the command areas. Identification, delineation and development of groundwater resources from potential areas in under exploited region are also equally important. Development of well fields in shallow water table tracts not only makes available resources in good quantities but also reduces the evaporational losses and further decreases the accumulation of salt. Man-made recharge of surplus water into the ground is known as artificial recharge. Check dams, water harvesting structures, and return flow from irrigated tracts, serve this purpose to a great extend. Another important practice left untouched is recharge of flood flows through well structures.

8.9.2.1 Conventional Method of Recharging: All the means of recharge are listed for better appreciation.
1. Contour plugging and other techniques.
2. Contour hedging.
3. Check dams especially in higher grounds.
4. Percolation tanks.
5. Water spreading
6. Recharge through pits and wells.
7. Induced recharge from river flows.
8. Spreading of wasted flows on waste lands.

8.9.2.2 Non-conventional methods of recharging: There are some villages/habitations situated in unfavorable terrain where the source developed needs augmentation, but has a less scope for adoption of conventional artificial recharge structures. The non-conventional methods are discussed below have given a new dimension to recharge techniques:

1. Bore blast - technique (BBT)
2. Jack wall (JW)
3. Fracture seal cementation (FSC)
4. Trench cum Bore well (TCB)
5. Rain water recharge Bore well
6. Hydro-fracturing

The methods indicated above are situation specific. The selection of particular methodology has to be decided after detailed field investigations.

8.10 WATER MANAGEMENT AND PROPOSED WATER CONSERVATION STRUCTURES FOR SONBARSА RIVER BASIN: The Sonbarsа river basin is capable of supplying sufficient amount of water for various purposes. But water potential is intimately associated with human civilization. As long as the rate of exploitation of these resources was within the rate of recharge by natural rainfall, the hydrologic equilibrium was kept intact. When the rate of withdrawal had surpassed the natural recharge limits, the water table started receding. To cope with these situation in future in Sonbarsа catchment area, artificial recharge of groundwater was assumed to be an effective measure to overcome the situation. It is needed to increase the recharge of the area. Artificial recharge can be achieved by constructing various types of water
conservation structures and implementation of horticulture and afforestation practices.

PROPOSED WATER CONSERVATION STRUCTURES

8.10.1. CHECK DAMS/NALA BUNDING: These are nothing but the earthen embankment constructed on the nala. In such type, a series of bunds (check dams) are constructed at suitable sites to create ponds of water along the course of nala. In such structures, the height of bund is kept up to one meter with slope of 1:2 on upstream and down stream. These checks are generally constructed in a series along the nalas in such a manner that the bed level at previous check corresponds to tip level of the next check. A spillway trench on the bank is also constructed to let the excess water pass through it. To prevent erosion, the locally available grass seeds are spread over the bund. The suitable sites proposed for the Sonbarsa basin is near village Kuharjorki, Gopalpur (E) (Fig. 8.1). These are covered with laterite/alluvium underlying hard rocks i.e. limestones extending up to the depth of 40 meters and more.

8.10.2. Recharging trenches: Eastern area of the Sonbarsa basin is covered by thick soil cover. During the active monsoon period, heavy overflow is observed in certain sections of the basin. Small trenches on the banks of Sonbarsa river 2 to 3 meters in depth should be excavated across the nala. These trenches are later filled back by stones and sand. Large size stones are placed at bottom of the trench and medium and small size stones are placed in successive layers. Excessive water overflowing as run off during the rainy season can be conserved and stored for subsoil recharge through these trenches. Suitable plantation is also recommended along these riverside trenches. The suitable sites for recharging trenches in the Sonbarsa river basin are proposed near villages Chichola, Darra and Putia. The calcareous shale and laterite cover the surface and hard rock comprising limestones and sandstones extended down to 40 meters and above.

8.10.3. Underground Bhandharas: The underground bhandhara is an impervious barrier to obstruct groundwater flow below nala bed. In certain
streamlets 1 m or more than 1 m of sand layer is removed and excavation is done up to the hard strata which is later filled by the clay up to its bed level. Due to this, underground flow of water is obstructed and percolation of water in the adjoining areas increases. In Sonbarsa catchment, water mounds develop near villages Bhalukona, and Saleh bhari. The proposed sites within the vicinity of the river bed are favorable for the construction of percolation tank/Bhandara. However, due to occurrence of limestone basement in the proposed area it is essential to seal the cavernous zones, by excavation up to 2 meters and thereafter deep grouting is required.

8.10.4. Diversion Bunds: The watershed region in which water retaining capacity is upto month of December (perennial), the cement bunds of 1 m height are constructed over the stream. Water is diverted into nearby fields by providing two gates in this bund. In the Sonbarsa river basin, the proposed site for such structure is near village Dhaba, Parsada and Dendsara, where the river is approx 25 m wide with sufficient water is available up to March. It is also a suitable zone for U shaped dyke.

8.10.5 Contour Bunds: In contour bunding, series of earthen bunds are constructed at fixed contour interval to intercept flow of water and at the same time increase soil moisture storage. The hilly tracks of Sonbarsa river basin near villages Thelkadih, Basula, Deogodongar are capped by laterite with underneath compact limestone and Deodongar sandstone possessing valley slopes. Construction contour bunds in these regions will reduce the runoff and increase the amount of percolation in the investigated basin.

Apart from all these recharge structures, (Plate - 21) temporary structures can also be made during rainy season. In this type, the sand and soil are filled in across the nala. Grabean structures are also useful in some areas. In this, layers of stones are placed in an iron net. This iron net is placed across the river. It is much economical. Advantage of this structure is that as there is a gap in between the stones. It remains stable during floods and also controls the soil erosion. The favorable sites proposed for such type of
GENERALISED MAP SHOWING SUITABLE LOCATIONS OF ARTIFICIAL RECHARGE STRUCTURES IN SONBARSA BASIN
Plate 20. Abandoned mine pit being used for surface water harvesting. The jointed limestone facilitates faster recharge in Pachperi village.

Plate 21. Rectangular recharge tank under construction near village Parsoda. The thick laterite soil cover over sandstone makes a suitable water harvesting structure.
structures are near villages Karela and Panduka. Artificial recharge can be achieved through abandoned limestone quarries near villages Deodongar, Gatapar and Basula ((Plate - 20). These quarries can be used recharge basins in future.

The water conservation structures are site and location specific, Hence, general guidelines are to be modified as per the need for each such structure. Selection of particular type of structure is based on all those factors that affect runoff (rainfall and catchment characteristics), water need and economics of the system.

8.10.6 Afforestation and Horticulture: Basin under investigation generally bears scanty vegetation. However, its eastern and southern parts are occupied by protected and reserve forests. Adopting drip irrigation in farms it can increase the green cover of the area. To protect the soil erosion and increase recharge in barren areas, afforestation is very essential to opt for quick growing, moisture stress and specific species depending upon local conditions. The area bears ample scope of afforestation and horticulture, Social forestry practices are adopted especially near Anjora, Karela and Jarwahi villages. The road side plantation in a planned way will not only protect road cutting but it will decrease the soil erosion and run off wastage too. This will also act as a natural bund on a smaller scale increasing. The overall recharge of the subsurface groundwater regime.