FEASIBILITY OF RECHARGE SHAFTS/INJECTION WELLS FOR GROUNDWATER RECHARGE IN PATAN DISTRICT, GUJARAT, INDIA

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Abstract: *For the industrial development, agricultural & economic growth the demand of groundwater has increased in north Gujarat alluvial plain. The groundwater Draft exceeds the groundwater recharge resulting in over exploitation of groundwater aquifers. This has resulted in continuous decline in water levels and reduction in the yield of the tube wells. Due to poor rainfall reliability and recurring drought conditions, the area could never recover the deficit of water extracted from groundwater resources. The artificial recharge to groundwater can only sustain the water levels or can arrest the rapid depletion of groundwater rate. The part of Patan taluka in Gujarat, India is selected for the construction of artificial recharge structures near the large storage village ponds. It is proposed to construct artificial recharge structures in seven villages of Patan taluka near these village ponds. The recharge potential is calculated taking 40 rainy days taking average rainfall as 770mm. If the recharge shaft is connected to the ponds at a depth, it is able to utilize the storage of ponds and recharge potential can then be calculated for a period of 180 days (pre-monsoon and post-monsoon period). Thus calculating the runoff potential of seven recharge structures and considering the catchment of the area, the plan is considered feasible for recharge in seven villages of Patan Taluka.*

KEYWORDS: *groundwater, recharge, rainfall, Patan Taluka, Gujarat*

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INTRODUCTION

Many of us have an image of the world as a blue planet as 70 percent of the earth's surface is covered with water. The reality, however, is that 97 percent of the total water on earth of about 1400 Billion Cubic Meter (BCM) is saline and only 3 percent is available as fresh water. About 77 percent of this fresh water is locked up in glaciers and permanent snow and 11 percent is considered to occur at depths exceeding 800 m below the ground, which cannot be extracted economically with the technology available today. About 11 percent of the resources are available as extractable groundwater within 800 m depth and about 1 percent is available as surface water in lakes and rivers. Out of the 113,000 BCM of rain and snow received on the earth, evaporation losses account for about 72,000 BCM, leaving a balance of about 41,000 BCM, out of which about 9000-14000 BCM is considered utilizable. The annual precipitation including snowfall in India is of the order of 4000 BCM and the natural runoff in the rivers is computed to be about 1869 BCM. The utilizable surface water and replenishable groundwater resources are of the order of 690 BCM and 433 BCM respectively. Thus, the total water resources available for various uses, on an annual basis, are of the order of 1123 BCM. Although the per capita availability of water in India is about 1869 cubic meters as in 1997 against the benchmark value of 1000 Cu m signifying 'water-starved' condition, there is wide disparity in basin-wise water availability due to uneven rainfall and varying population density in the country. [3]

Groundwater plays an important role in sustaining India's economy, environment and standard of living. It is not only the main source for water supply in urban areas for domestic uses, but also is the largest and most productive source of irrigation water. Indiscriminate groundwater development has led to substantial groundwater level decline both in hard rocks and alluvial areas threatening sustainability of this resource. Long-term decline of groundwater levels is being observed in many areas, mostly in the states of Rajasthan, Gujarat, Tamil Nadu, Punjab, Delhi and Haryana. Apart from this, in most of the cities depending on groundwater for drinking water supplies, water level declines up to 30 m and more have been observed. Traditional water harvesting methods, which were in vogue in arid and semi-arid areas of the country have either been abandoned or have become defunct in most cases. There is an urgent need to revive these methods. Groundwater development, therefore, needs to be regulated and augmented through suitable measures to provide sustainability and protection. Dependence on use of groundwater for agriculture due to monsoon failures is accelerating groundwater depletion. Excessive withdrawal of groundwater is further compounding the stress on groundwater system due to free/subsidized power in some States. In order to tackle the burgeoning problem of water level decline, it is necessary to take up schemes for water conservation and artificial recharge to groundwater on priority. [3]

LITERATURE REVIEW

In order to augment the depleting groundwater resources, it is essential that the surplus monsoon runoff that flows into the sea is conserved and recharged to augment groundwater resources. Groundwater storage that could be feasible has been estimated as 214 Billion Cubic Meters (BCM) of which 160 Billion Cubic Meters is considered retrievable. The Central Groundwater Board (CGWB) has prepared the master plan for artificial recharge to groundwater for all states in the country. [5]

The preparation of master plan for artificial recharge to ground water in different states, prepared by Central Ground Water Board in 2002, aims at providing area specific artificial recharge techniques to augment the ground water reservoir based on the twin important requirements of source water availability and capability of ground water reservoir to accommodate it. The specific problems in different areas in the states like excessive ground water development resulting in ground water decline, water scarcity due to inadequate recharge in arid areas, low ground water retention in hilly areas despite substantial rainfall, urban areas with limited ground water recharge avenues and related problems of urban pollution, etc., have been considered while preparing the master plan. To fully utilize the available surplus monsoon runoff in rural areas, emphasis has been given for adoption of artificial recharge techniques based on surface spreading like percolation tanks, nala bunds, etc. and sub-surface techniques of recharge shaft, well recharge, etc. In urban areas, hilly areas and coastal regions priority has to be given to rain water conservation measures through roof top harvesting techniques etc. [4]

The Master Plan while bringing out the areas suitable for artificial recharge to ground water reservoir, prioritizes the areas wherein schemes need to be implemented as a first priority to ameliorate the water scarcity problems. The proposals and schemes recommended are not the ultimate ones but are the first stage of implementation. These need to be further extended in other areas depending on the availability of infrastructure, finances and future problems. [4]

The master plan envisaged the number of artificial recharge and water conservation structures in the country as 39 lakh at an estimated cost of Rs. 24,500 crores. [4]

The CGWB has prepared a Manual and subsequently a Guide on Artificial Recharge to Groundwater which provides guidelines on investigation techniques for selection of feasible sites, planning & design of artificial recharge structures, economic evaluation & monitoring of recharge facility. These are of immense use to States/ U.T.s in planning and implementation of artificial recharge and rain water harvesting schemes for augmentation of groundwater in various parts of the country. [5]

During the Ninth Five Year Plan, a Central Sector Scheme "Studies on Recharge of Groundwater" was undertaken by the CGWB, in which 165 artificial recharge pilot projects were implemented in 27 States/UTs in coordination with organizations of State governments & NGO / VOs, etc. with 100% central funding. Civil works were done by state implementing agencies under technical guidance of the CGWB. Efficacy of the recharge structures constructed in different hydrogeological conditions of the country was assessed through impact assessment studies taken after completion of recharge facility and has indicated rise in water levels and sustainability of dug wells/ tube-wells locally including other benefits like decrease in soil erosion and improvement in social-economic status of farmers of benefited zone due with increase in crop production. [5]

In Tenth Five Year Plan, special emphasis is given to implementation of rainwater harvesting schemes at schools for utilization of rain runoff and creation of mass awareness amongst school children. In Fresh Water Year – 2003, the Ministry of Water Resources had approved and sanctioned projects on construction of roof top rain water harvesting structures at Government buildings in the states of AP, Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Orissa, Punjab, Sikkim, Tamil Nadu and Uttar Pradesh and UT of Chandigarh under technical guidance of CGWB and funds provided under Grant-in-Aid to the concerned state Governments. Similarly, demonstrative projects of Roof top rainwater harvesting were also implemented through NGO's in 100 schools in rural area of 13 states viz Andhra Pradesh, Delhi, Gujarat, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Orissa, Rajasthan, Sikkim, Tamil Nadu, Uttaranchal and West Bengal. [5]

In 2005-2007, project on rainwater harvesting from roof tops of remote government rural schools for collection of rainwater for drinking and use in two toilets for girls in 413 schools in rural areas of 15 states were sanctioned by the Ministry of Water resources. The CGWB facilitated the work by providing technical guidance in designing, monitoring and implementation through its expert scientists. The Government released Rs.3.47 crores as Grant-in Aid to NGO's for construction of roof top rain water harvesting facilities in govt. schools under this program.

In 2006, a demonstrative scheme on "Rain Water Harvesting and Artificial Recharge to Groundwater" has been taken up at following areas:

1) Lingala, Pulivendula Vemula and Vemalli blocks in Kadapa district, Andhra Pradesh
2) Gangavalli block in Salem district, Tamil Nadu
3) Mallur Block in Kolar district, Karnataka
4) Bel watershed, Amla & Multai Blocks in Betul District, Madhya Pradesh.
5) Upper reaches of Choti kali Sindh river in parts of Sonkatch & Bagli blocks in Dewas district, Madhya Pradesh.[5]

The approved cost of projects was Rs. 5.95 crores for implementation by the departments of states under overall technical guidance of CGWB during 2006-08 with 100% funding by the Central Government. The norms adopted in implementation of National Rural Employment Guarantee Scheme (NREGS) by the Ministry of Rural Development were followed in implementation of civil works. Under this scheme, priority was given to hard rock areas having over-exploited groundwater resources. On completion of civil works of recharge facility, impact assessment studies are taken up to demonstrate the efficacy of artificial recharge and rain water harvesting as well in above mentioned sites selected on scientific basis in different hydrogeological situations. [5]

During XI Five Year Plan a provision of Rs. 100 Crores has been made for demonstration of artificial recharge and rain water harvesting techniques in Overexploited and critical areas, urban areas and areas affected by water quality. [5]

Designing of Artificial recharge and rainwater harvesting systems in different hydrogeological settings and demonstrating their efficacy will help State government to replicate the structures in similar areas. The first instalment of 70% of the approved cost of the project is released after approval of the project to the implementing agencies. The next installment of 30% of the approved cost is released on recommendation of State Level Technical Coordination Committee on physical progress and after utilization of 75% of initial funds released to the implementing agency. It is expected that artificial recharge structures constructed will additionally recharge 75 MCM surface runoff and raise the water levels by 0.5 – 5.0 m in the vicinity of the structures. This Scheme will also help in capacity building of State govt. organizations, local bodies, NGOs, VOs and stakeholders. [5]

METHODOLOGY

A pilot project to study the technical feasibility and economic aspects of artificial recharge to the depleted aquifers in the Mehsana area was taken up by Central Groundwater Board in collaboration with UNDP and Gujarat Water Resources Development Corporation (GWRDC), Govt. of Gujarat. The Project was completed between 1980 & 1984.

Both Surface spreading and injection methods were feasible in the area. The former was feasible in the recharge zone and later in the central part. The confined aquifers were recharged by injection method, whereas, the phreatic aquifers were recharged by surface methods.

In the experiment conducted using the injection wells, the waters from the phreatic aquifer below the Saraswati river were utilized. A quantity of 225 cubic meters per day was injected continuously for 250 days, through pressure injection technique. At the end of this recharge cycle, an average rise of 5 meters (m) was observed in the injection well along with a rise of 0.6-1 m in the wells 150 m away from the injection well .Since the source of water itself was an aquifer, the problems of silt and clogging were minimized. [6]

The results indicate 3.0 to 5.0 LPS recharge rate in the area. Hence, considering average recharge rate of 4.0 LPS, one recharge structure can recharge about 1, 20,000 Cubic meter of water per year.

RECHARGE CAPACITY DURING MONSOON &POST MONSOON STORAGE IN POND:

Recharge capacity of one well during monsoon (40 days period if long term storage facility is not available with the structure)

1. Considering average 4 lps intake rate of the over exploited aquifer, the capacity of recharge for monsoon considering average 40 days period it comes to 13824 kilolitres and for seven wells it will be 96768 cubic meters.

2. The location of well is near the storage in ponds generally found for monsoon and post-monsoon period up to January. Taking 180 days the recharge potential will be 62208 cubic meters.
3. If the ponds are not linked with Narmada pipe line the recharge potential will come to 435456 kilo litres.
4. The village ponds of Sankhari, Mithivavdi and Gaja village are large pond linked with Sujlam Sufalam Yojana getting water supply from Sujalalam Suflam spreading recharge canal feed from Kadana reservoir spill water and Narmada pipeline. The potential recharge will be 608832cu.m.

   If rest four villages will be linked the recharge will be 8, 40,000 cubic meters. For 25 years recharge potential will be 21000000 liters.

DESIGN OF RECHARGE STRUCTURE

A) Recharge tube well or injection well.

The water level ranges 110-120 meters in proposed project area. The aquifers below 120 meters need recharge to control the depletion rate of water level and reduction in yield. A recharge well with 150.0 meter depth is designed with following specifications recommended for the construction in seven proposed village ponds. Surface water head of 110- 120 meter is sufficient for the injection of water in to recharge tube wells.

Specifications:

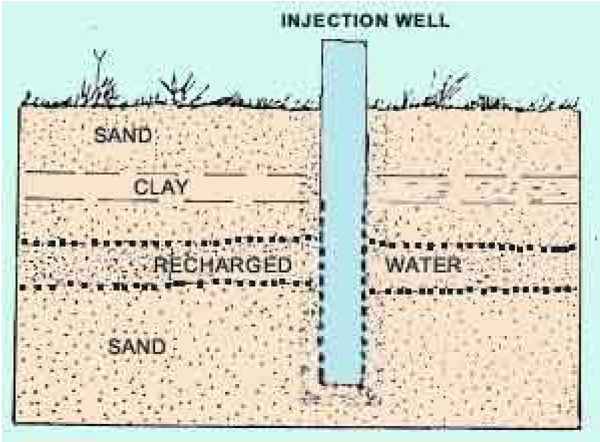
Diameter: 200 mm, Thickness: 6.0mm, Depth: 150 meter,

Expected SWL(m)-110 m,

First screen-120 m bgl,

Expected TDS-1500 ppm,

Yield-1000 lpm



Source: [6]

RESULTS

The details of village ponds are collected and are found feasible for the construction of recharge structures. For the feasibility of recharge structures following criteria are considered:

1) The storage /gross storage capacity of pond to feed the recharge structure throughout its storage period up to the month January.
2) For the generation of runoff volume the coefficient 0.90 of the precipitation is considered as practically there are no evaporation losses from the surface of reservoir during monsoon.
3) For the generation of runoff volume from catchment 0.30 coefficient is considered looking to the soil texture and type of catchment.
4) For the calculation of runoff volume, decadal average 770 mm from year 2005-2013 is considered.

Name of Village	Area Sq.meters	Depth (m)	Storage capacity (cum)	Gross storage capacity cu.m (1.5 of Storage)	RFCoefficient(Yr2005-2013)m	Direct precipitation(0.9)-90 % of water spread area	Catchment sq.m.	Runoff coefficient	Runoff volume cubic m	Total volume cubic meter (40 days of scattered rainfall)	Recharge potential at 4 LPS
Lakhdap	28531	4.5	128389.5	192585	0.77	19772	640000	0.3	147840	167612	62208
Endla	180200	3	540600	810900	0.77	124879	2566000	0.3	592746	717625	62208
Badipur-Vastrasar(Vadli)	45565	3.5	159478	239216	0.77	31577	792100	0.3	182975.1	214552	62208
Shiyol	35125	3	105375	158063	0.77	24342	722500	0.3	166897.5	191239	62208
Sankhari	39965.9	3	119898	179846.93	0.77	27696	756500	0.3	174751.5	202448	126144
Mithivavdi	96655.32	3	289966	434948.98	0.77	66982	1083300	0.3	250242.3	317224	126144
Gaja	48375	3	145125	217688	0.77	33524	825500	0.3	190690.5	224214	126144
TOTAL	**474417.22**	**23**	**1488831.5**	**2233247.91**	**0.77**	**335976**	**7385900**	**0.3**	**1706143**	**2034914.033**	**627264**

Source: Undisclosed, compiled by researcher

Where; direct precipitation (cu.m)=Area* RF Coefficient*0.9

Runoff volume (cu.m)=Catchment*RF Coefficient*Runoff Coefficient

Total Volume (cu.m)=Runoff Volume+ Direct Precipitation

Total estimated run off volume available for recharge from these 7 ponds is 2034914 cu.m. Out of this volume, proposed recharge for three ponds is 120000 cu.m (for 365 days) which are connected to Narmada canal network and for four others, which are not connected to Narmada canal network as of now, the recharge potential is 62208 cu.m per pond, considering 180 days of recharge.

Recharge shafts are to be built in the vicinity of the ponds/ lake, where pond water will be diverted at mid-level of the pond to the recharge shaft through de-silting chamber.

CONCLUSION

Looking at the available monsoon runoff potential from surface reservoir body and catchment & recharge capacity of one recharge structure construction of 7 recharge structures near 7 ponds located in Patan Taluka are feasible. An attempt is also made to work out recharge potential considering 40 rainy days (13284cu.m). Runoff volume has been calculated from the catchment & direct precipitation on pond surface with coefficient based on type of catchment.

If in future, the remaining three ponds also get connected to Sujalam Sufalam Yojana, larger amount of water will be available for recharge of water-deficient areas in Patan District.

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