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Study on Scarcity and Remediation of Ground Water Recharge in Patna Region.

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ABSTRACT
Ground water is the water that seeps through rocks and soil and is stored below the ground. The rocks in which ground water is stored are called aquifers. Water moves through these rocks because they have large connected spaces that make them permeable. The depth from the surface at which ground water is found is called the water table. The water table can be as shallow as a foot below the ground or it can be a few hundred meters deep. Heavy rains can cause the water table to rise and conversely, continuous extraction of ground water can cause the level to fall. In summers, the Patna and other cities of Bihar become parched and drought prone. With increasing population in urban and rural areas with its proportional demand for ground water is also increasing resulting in depletion at exponential rate. As in such, cities have limited supply of safe drinking water.

KEYWORDS- Groundwater, Aquifer, Water table, Water extraction, Patna district, Water level Depletion

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I. INTRODUCTION

Bihar is one the state of India which is facing severe water crisis, being the necessity of human survival, due to over-exploitation, over-usage, mismanagement and unregulated use of groundwater resource. Groundwater is the main source of drinking water and it constitutes more than 80 per cent of drinking source in rural Bihar. The other sources of drinking water are from surface water, well, pond and from natural sources (lakes, rivers etc.)

India is rich in both surface water and groundwater resources. India has total annual replenishable groundwater resources of 433 billion cubic meters (BCM), net annual groundwater availability of 399 BCM, and annual ground water draft for irrigation, domestic and industry is around 233 BCM, and stage of groundwater development is around 58 percent. Annual precipitation (includes snowfall) in India is 4000 cubic kilometers while average annual availability of water resources is around 1869 cubic kilometers. Per capita water availability is 1820 cubic meters (Ministry of Water Resources, 2010). Estimated utilized water resources is 1122 cubic kilometers in which surface water resources share is 690 cubic kilometers and groundwater resource share is 431 cubic kilometers.

Groundwater resources are abundant in Bihar. In Bihar, annual renewable groundwater resources, net annual groundwater availability and annual groundwater draft are 29, 27.42 and 10.77 BCM. Groundwater development in Bihar is 39% and annual rainfall (mm) is 1232. Per capita water availability is decreasing in both Bihar and India. In 2001, the per capita availability of water (in cu. M) for Bihar and India was 1950 and 1816. In 2011, it declined to 1545 and 1200 (in cu. M). Uncontrolled population growths, increased dependence on groundwater (85 percent), extraction of groundwater for irrigation, and deforestation have resulted in declining groundwater availability. This leads to overall water quality problems. But the water shortage has been increasing for years. This is due to uncontrolled growth of population, expansion of irrigation channels and development activities.

Table 1: Projected water demand in India (by different uses)

Sl no.	Sector	Water demand in Km3(BCM)								
		Standing Sub-committee of Ministry of Water Resources			NCIWRD					
		2010	2025	2050	2010		2025		2050	
					Low	High	Low	High	Low	High
1	Irrigation	688	910	1072	543	547	561	611	628	807
2	Drinking Water	56	73	102	42	43	55	62	90	111
3	Industry	12	23	63	37	37	67	67	81	81
4	Energy	5	15	130	18	19	31	33	63	70
5	Other	52	72	80	54	54	70	70	111	111
Total		813	1093	1447	694	710	784	843	973	1180

The first section deals with the basics of water cycle and aquifers where we get the information to start the process of suggestion and where to apply that. Second section deals with issues and challenges related to groundwater. Third section defines the process of groundwater through wetlands etc., and at last the fourth section defines the possible solutions to overcome the confrontation with groundwater challenge.

Figure: 1 Kankarbagh area during Monsoon in 2019

1.1 Aquifer- is a geological structure layer of water retaining permeable rocks or porous strata, rock fracture or unconsolidated materials that contains and transmit groundwater. Groundwater can be found at nearly every point near the earth subsurface, in which water can flow directly between surface and saturated zone of aquifer, then aquifer is termed as unconfined aquifer in which deeper parts are more saturated because of downward flow of water due to gravitational force. The upper level of this saturated layer of unconfined aquifer is termed as phreatic surfaces. Below the water table where all pores are saturated with water is known as phreatic zone. In these zones, types of aquifers based on porosity and permeability are as follows-

1. Substrate with low porosity that permits limited flow water is known as an aquitard.
2. Substrate with porosity which is so low that it seems impermeable to groundwater is known as aquiclude.

Based on confinement-when an aquifer is confined by bottom layer only is called unconfined aquifer whereas the aquifer in which confinement is on both side and the water is held under pressure then it is termed as confined aquifer.

1.2 Water cycle- is a cyclic process in which water circulates in 3 phases i.e. solid, liquid and gas and in various degrees of motion. Evaporation of water from water bodies, formation of clouds and their movements, rain and snow fall, stream creation and ground water are the examples of this cyclic movement which wholly creates the Hydrologic cycle or water cycle.

In this paper, our aspect is around ground water and its recharging facility, which generally make up about twenty percent of fresh water source or around 0.65% of worlds water. Its storage is generally equal to the total amount of fresh water available in the form of snow and glaciers. This makes this an important resource that acts as natural storage which can compensate for the shortages during the times of drought or for general purpose of utilization. Ground water can also be termed as natural long term storage reservoirs.

II. ISSUES RELATED TO GROUND WATER

2.1 Overdraft – Groundwater is one of the abundant resources. However due to its over usage, over draft causes major problems to humans and also to the environment. In this issue its major problem is lowering of water table beyond the reach of existing wells. Due to this well are further drilled deeper to reach the groundwater which even sometimes reaches upto hundreds of feet in extensive drilling of wells and tube wells.

2.2 Subsidence-occurs when too much water is pumped out from underground resulting in deflating of surface and thus leads to collapsing of ground.

2.3 Pollution- Ground water pollution is majorly from improper disposal of wastes on land. These polluted water causes difficulty in treatment, than pollution in rivers and lakes. Major sources include industrial and household wastes, chemicals, by-products of landfills, industrial waste lagoons, process waste water from mines, oil storage tanks and pipelines, etc. These are characterized by soil sampling and groundwater testing near the source of pollution for determines the extent of contaminations and aid for remediation process. Preventing groundwater pollution near potential sources such as landfills requires lining the bottom of a landfill with watertight materials, collecting any leachate with drains, and keeping rainwater off any potential contaminants, along with regular monitoring of nearby groundwater to verify that contaminants have not leaked into the groundwater.

2.4 Arsenic and fluoride- Around 40 per cent of the districts in Bihar reported that they had found arsenic in groundwater. It covers more than 67 blocks from 15 districts and more than 1600 habitats across the state, where arsenic contamination in groundwater exceeds the Bureau of Indian Standard (BIS) limits of 50 billion parts (ppb) and more. If we consider the WHO limits of 10 ppb, the coverage area is much higher and the population at risk of arsenic risk is higher than the BIS standard threshold as per WHO Report.

2.5 Agricultural Crop Pricing and Water Intensive Crops- Over the past four decades, 84% of the total irrigation sector has been using mostly groundwater. The main cause of high exploitation is the demand for groundwater for agriculture. In addition to this, in many areas, decision making such as crop type and crop intensity, differs from groundwater availability.

2.6 Energy Subsidies and Ground Water Extraction- The method of providing electricity subsidies to agriculture has played a major role in the decline of water levels in India. In 2009, 89% of all groundwater collected was for irrigation, and 11% for domestic and industrial purposes. Since energy is a major component of groundwater extraction, the availability of cheap / subsidized electricity in many states contributes to the greater extraction of this resource.

The challenge is to find a balance between the needs of farmers and the need to ensure sustainable use of ground water. In this regard, the National Water Policy, 2012 recommends that the over extraction of ground water should be minimized by regulating the use of electricity for its extraction. Separate electric feeders for pumping ground water for agricultural use could address the issue. The Commission on Price Policy for Kharif Crops (2015-16) has recommended rationed water use in agriculture by fixing quantitative ceilings on per hectare use of both water and electricity. Also, if farmers are able to use water or electricity less than the ceilings fixed for them, they should be rewarded by cash incentives equivalent to unused units of water/power at the rates of their domestic resource costs according to Niti Aayog/National water policy.

2.7 Inadequate Regulation of Ground Water Law -The government has always stated that ground water needs to be managed as a community resource. However, under Section 7 (g) of the

Easement Act, 1882, every owner of land has the right to collect and dispose of all water under the ground and on its surface. The legal consequence of this law is that the land owner may dig wells in his land, and obtain water at his discretion and discretion. In addition, landowners are not legally responsible for any damage to water resources resulting from excessive extraction. Lack of control over this resource has worsened the situation and made private ownership of ground water common in most urban and rural areas according to CGWB Report.

The CGWB identifies highly exploited and critical areas in the states. However, the Board does not have the authority to stop the extraction of groundwater in such areas and can only notify owners. Additionally, because there are a small number of small customers, it can be very difficult for the board to detect and penalize offenders.

2.8 Local Management Of Ground Water – The idea of local water user is successful in very few areas for managing the water resources.

1. Determining the relationship between surface hydrological units such as watershed or river basins, and hydrological units below the ground such as aquifers,
2. Identification of ground water recharges areas,
3. Maintaining ground water balance at the level of the village or the watershed, and

Creating regulatory options at the community level such as panchayat. Examples of activities that could be regulated at the local level include drilling depth, distance between wells, cropping patterns to ensure sustainability of aquifers and participatory ground water management.

III. PROCESS

Groundwater is naturally recharged by rain and snow melt and to some extent by surface water as rivers and lakes. Recharge is somewhat hindered by human activities, including paving, development or logging. These activities cause soil loss, resulting in reduced water infiltration, improved surface runoff and recharge. Artificial groundwater recharge is very important in India, especially in Bihar, where farmers are pumping ground water to reduce groundwater resources.

In 2007, on the recommendations of the International Water Management Institute, the Indian government allocated 1,800 crore (equivalent to US$590 million in 2018) to fund dug-well recharge projects (a dug-well is a wide, shallow well, often lined with concrete) in 100 districts within seven states where water stored in hard-rock aquifers had been over-exploited. Another environmental issue is the disposal of waste through the water flux such as dairy farms, industrial, and urban runoff.

3.1 Wetlands- The wetlands help to maintain the water level and controls the hydraulic head. The range of groundwater recharge of the wetland depends on the soil, vegetation, site, volume ratio and water table gradient. Groundwater recharge occurs mainly through mineral soils found in the margins of marshlands. The ground beneath most wetlands is relatively impassable. The high perimeter of the volume ratio, such as small marshes, means the surface area where water penetrates into the groundwater to recharge local groundwater resources. Researchers have found groundwater recharge in up to 20% of the wetlands each season.

3.2 Depression-Focused Recharge - If water falls on a farm that does not exceed the soil field capacity, marginal water will flow into the groundwater. If water flows downstream instead, the field capacity exceeds in form of concentrated water in a small area, resulting in groundwater to recharge. With Relative relation, the runoff area will be large, greater focus on infiltration will be. The recurrence of selective deposition of groundwater into the surface is a recurrent process of groundwater that falls relatively uniformly in an area. In such cases water tables rises.

IV. SUGGESTIONS AND RECOMMENDATIONS-

Suggestions on Bihar state Water policy-Therefore, the study team includes the following recommendations in this report.

1. Government needs to undertake massive programs to educate the general public, students, local level executives and other stakeholders on climate change at the state's block and panchayat level.
2. Irrigation Flood and drought management policies should be reviewed along with current irrigation and flood management projects to take care of the effects of climate change, such as increased precipitation by flooding. The Department of Water Resources, other institutions, must place greater emphasis on strengthening and creating appropriate facilities for studies and research on the hydrological, hydro-metrological and geomorphologic aspects of climate change.
3. Existing system requires modification of study courses, creation of new material and programs, as well as diploma and degrees of postgraduates.
4. Greater emphasis should be placed on afforestation and other water conservation practices. Where commercially viable, wetlands for seafood and aquaculture should be conserved and developed.

Remediation on the basis of Regions selected in Patna-

1.Urban Area (Kankarbagh, Patna): Following are remedy for urban areas of patna which yearly faces the problem of flooding during monsoon and depleting level of water table during summers.

Figure 2: Kankarbagh Area, Permeable pavement.

Permeable concrete pavements- Use of permeable concrete is capable of capturing storm water and recharging groundwater, and also reduction of storm water runoff which enables it as important role for previous concrete. It can be seen from the experimental results that the increase in the total aggregate / cement ratio decreases the compressive strength and the tensile strength of the concrete which makes it difficult for using it on highways which heavy loads. Permeable concrete has many environmental benefits due to its low cost, which, if used in Patna's context, proves to be very beneficial for addressing the environmental issues and water logging problem that is a major problem in Bihar.

Rain water Harvesting- is a process of accumulation and storing of rain water for its reusing it again rather than allowing for runoff. Rainwater can be collected from rivers or roofs, and in many places, the water collected is redirected to a deep pit (well, shaft, or borehole), aquifer, a reservoir with percolation, or collected from dew or fog with nets or other tools. . Its uses include water for gardens, livestock, irrigation, domestic use with proper treatment, etc. The harvested water can also be used as drinking water, longer-term storage, and for other purposes such as groundwater recharge. Rainwater harvesting is one of the simplest and oldest methods of self-supply of water for households usually financed by the user. These basic techniques have

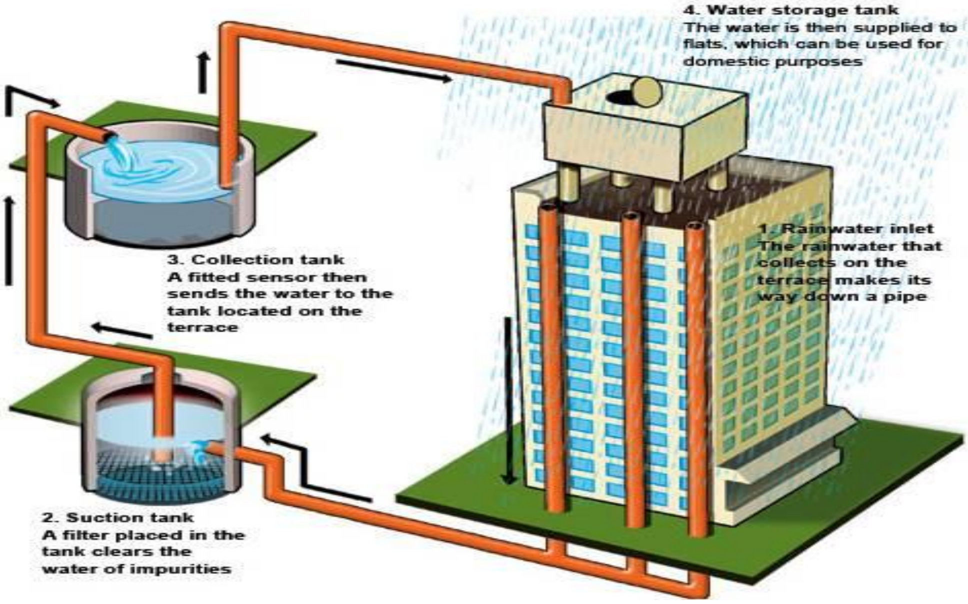

Figure 3: Roof Top Harvesting

been successfully applied in many different ways by the people in different parts of the country depending upon the local climate, type of soils and rocks both above and below the land surface and the nature of land forms. This method is environment-friendly and can be easily adopted by the villagers themselves at affordable costs.

2. Semi-Urban Area (Danapur, Patna): Following remedy for this region are as follows-

Roof Top Harvesting-This system is useful mainly for drinking water purposes. In this system, rain water falling on roofs of houses and other buildings is collected through a system of pipes and semi-circular channels of galvanized iron or PVC and is stored in tanks suitably located on the ground or underground. The system is in practice at the individual household level in danapur areas with average rainfall and also in some semi-arid areas which are more prone to water exploitation .

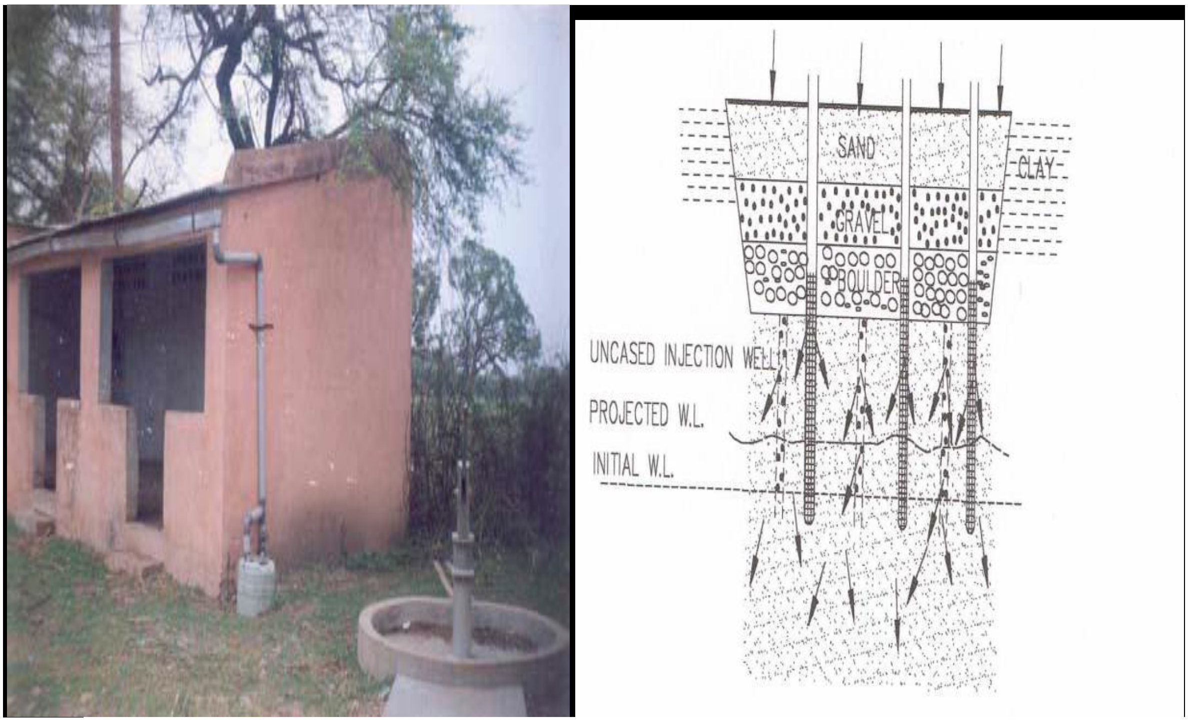

Figure 3: Roof Top Harvesting, Injection Well

Subsurface ground water recharge well- Recharge or injection wells are groundwater recharge methods that are used to divert water into deep-water bearing areas. Recharge wells can be installed using aquifer cover material. If the material is not uniform, a screen may be placed in the well in the injection area. Recharge wells are suitable only for areas where there is no thickened layer between the soil surface and the reservoir. They are also useful in areas where land is scarce (large areas are required for surface groundwater penetration). Relatively high recharge rates can be achieved with this method. The effectiveness of discharge into an aquifer will depend entirely on the quality and quantity of the water to be infiltrated, local environmental conditions (e.g. hydraulic conductivity, nutrient assimilation capacity of the receiving soil body) and legal regulations. Dense urban and industrial concentrations may render subsurface recharge wells to inject surface water into the aquifers more interesting according to UNEP 1998 report. Cultural considerations and socio-economic concerns often influence the recharge method and choice of site. Land availability, adjacent land use, public attitudes and legal requirements generally play a role in defining the acceptability of artificial recharge in a particular setting. In urban areas, land use and adjacent costs and utilization limits, injection wells, shafts or small pits require high-control water supply and small land use for large-scale and surface-wide recharge systems. Surface recharge facilities typically require protective property boundaries, regular maintenance and consistent monitoring.

3. Rural Areas (Bihta, Patna): Proposed remedy for rural areas of Patna region are as follows-

Ponds- This is the most common method of collecting and storing rainwater in ponds or Tanks. Most ponds have their own fishing grounds, which provide the required amount of water to the surrounding area of Bihta during the rainy season. To provide enough water and they are diverted through open channels to fill ponds from nearby streams. Water in some places is used to fill ponds from irrigation canals. Ponds have different shapes and sizes depending on the nature of the landscape, Availability of land and water needs of rural people.

Figure 4: Pond Area

Ditch and Furrow Method- Irregular topography, shallow, flat bottom and adjacent pits or Furrows provide a maximum water contact area for recharging water from the source stream or drain. This technique requires less soil preparation than recharge basins and is less sensitive than silting.

Check Dams- These are masonry structures built across small streams for Surface storage and also benefits to ground water recharge. The design of these Structures are done taking into consideration the volume of water that can be stored in the stream channel upstream, the surplus flood discharge that must be evacuated safely, stability of the structure against various forces and the likely ground water recharge.

Percolation Tank- These are built mainly to store monsoon runoff over a large area for ground water recharge. Moderate to high porosity of soil and underlying rocky strata is the main criteria for the choice of percolation tanks. Ponding is achieved in much the same way as is done in case of check dams except that the height of the bund is low but the length is large. The main aim is of filling the pond as many times as possible during the rainy season in such a way that most of the water impounded during one spell of rain percolates into the ground before the next spell starts.

Figure 4: Percolation Tank

Induced recharge- It is an indirect method of artificial recharge involving pumping from aquifer, hydraulically connected with surface water, to induce recharge to the ground water reservoir. In such methods, there is actually no artificial build up of ground water storage but only passage of surface water to the pump through an aquifer. The greatest advantage of this method is that under favorable situations the quality of surface water generally improves due to its path through the aquifer material before it is discharged from the pumping well.

Tanka/ Kund/ Kundi- Generally this method is adopted in Rajasthan side for meeting their water demand but this structure can also provide better storage facility in Bihta region as well. Rajasthan people build unique underground structures of various shapes and sizes to collect rain water for drinking purposes. These structures called Tankas, Kunds or Kundis are constructed in a variety of places like court yards, in front of houses and temples, in open agricultural fields, barren lands etc. These are built both for individual households as well as for village communities using locally available materials. Just before the on-set of the monsoon, the catchment area of the Tanka is cleaned up to remove all possible pollutants, and human activity and grazing of cattle in the area is prohibited. These structures provide enough drinking water to tide over the water scarcity during the summer months. In many cases the stored water lasts for the whole year. These simple traditional water harvesting structures are useful even during years of below-normal rainfall.

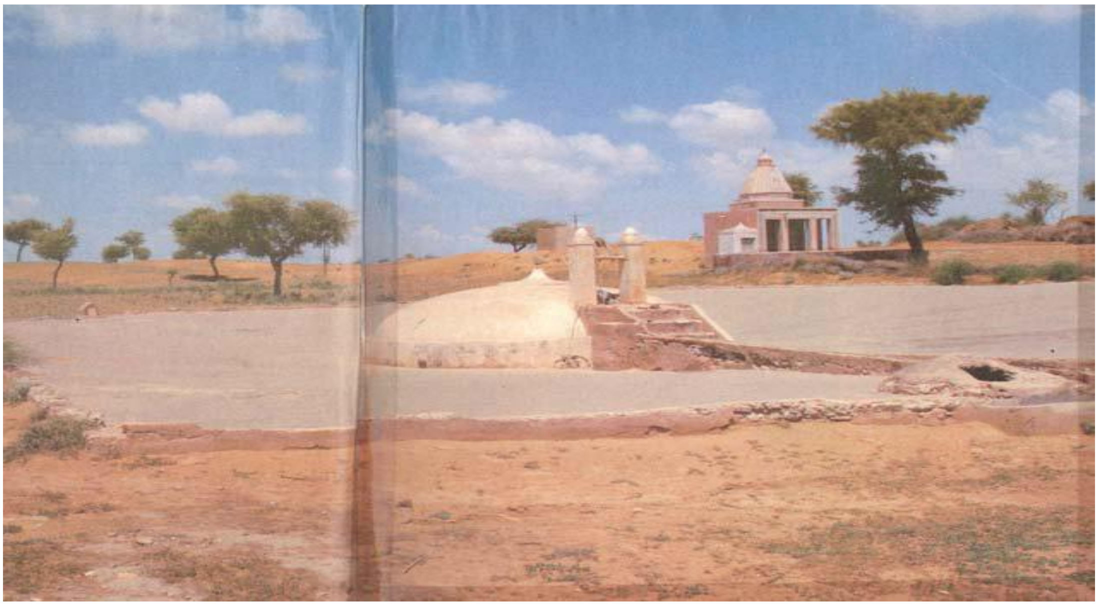

Figure 4: Tanki/Kund in Rajashthan

V. CONCLUSION

Bihar is one of the developing states in India whose economy is mainly based upon Agriculture and farming related works. It is also least developed states in terms of per capita income and human development index. But over the past few decades, the increased exploitation of groundwater resources for irrigation and drinking water and the rapid rise in industrialization and urbanization have increased water level pollution. Groundwater levels are decreasing in many areas due to mismanagement leading to contamination problems also. The basic human need is to get safe and clean drinking water along with sanitation. They are basically linked to the health and well being of the people. The more and more people are facing scarcity of clean water day by day as there is no alternative of groundwater. From this report, the main aim of our study team is to acknowledge the issues and problem of ground water in Patna region which affects its population. Our team has suggested some remedy for this current alarming issue from all around India, with techniques and methods being currently in use in some way or the other for providing solutions to this issue and to overcome this challenge.

REFERENCE

[1]. A book of “estimating ground water recharge” by R.W. Healy.
[2]. A book of “aquifer storage recovery” by R. David G. Pyne.
[3]. A book of “engineering hydrology” by K. Subramanya.
[4]. Composite Water Management Index, June 2018, NITI Aayog.
[5]. Ground Water Information Booklet Patna District, Bihar State.
[6]. Manual on Artificial Recharge of Ground Water 1994. Technical Series – M, No. 3, Central Ground Water Board, Faridabad, March 1994.
[7]. Government of India (2006). Dynamic groundwater resources of India as on March 2004. New Delhi Ministry of Water Resources, Government of India. pp (187).
[8]. Government of India (2007). Report of the expert group on “Groundwater management and ownership” submitted to Planning Commission, September 2007. Government of India, Planning Commission, Yojana Bhavan, Parliamentary Street, New Delhi. Pages 61.
[9]. Barun Kumar Thakur and Vijaya Gupta 2015.Groundwater Arsenic Contamination in Bihar: Causes, Issues and Challenges.
[10]. National Drinking Water Mission and Department of Rural Development 1989. Rain Water Harvesting, Government of India, New Delhi
[11]. Debu Mukherjee on a review on artificial groundwater recharge in India, SSRG International Journal of Civil Engineering Volume-3 issue 1 January 2016.
[12]. O’Hare, M.P., Fairchild, D.M., Hajali, P.A., Canter, L.W. 1986. Artificial Recharge of Ground Water. 5.Proceedings of the Second International Symposium on Artificial Recharge of GroundWater.
[13]. Chatterjee, R. and Purohit, R.R. (2009). Estimation of replenishable ground water resources of India and their status of utilization. Current-Science. 96(12): 1581-1591.
[14]. Chatterjee, R., Gupta, B.K., Mohiddin, S.K., Singh, P.N., Shekhar, S. and Purohit, R. (2009). Dynamic ground water resource of national capital territory, Delhi assessment, development and management options. EnvironmentalEarth-Sciences. 59(3): 669-686.
[15]. Mane, M.S., Singh, D.K., Bhattacharya, A.K. and Singh, A.K. (2008). Assessment of ground water potential for irrigation. International-Journal-of-AgriculturalEngineering. 1(2): 74-80.
[16]. Bhawna Sharma, Nihar Jungle, Nidhi Bhatt and David M. Dror on Can climate change cause ground water scarcity? An estimate for Bihar,
[17]. AnandTularam on Long term consequences of groundwater pumping, Journal 1998.
[18]. AbhinavGarg and Gaurav Sharma on Conservation of Groundwater by Artificial Recharge, Journal 2001.
[19]. Amit Kumar, ShikhaAnand, Manish Kumar and Ravish Chandra on Groundwater Assessment: A Case Study in Patna and Gaya District of Bihar, India.
[20]. Shreekant P. Pathak and Twinkle Singh on an Analysis on Groundwater Recharge by Mathematical Model in Inclined Porous Media.
[21]. http://megphed.gov.in/RWHManual.html
[22]. http://www.theconstructioncivil.com/02/ground-water-recharge.html
[23]. http://www.cee.vt.edu/programareas/environmental/teach/gwprimer/recharge/recharge.html
[24]. http://www.internationaljournalssrg.org
[25]. https://www.google.com/search?q=groundwater+recharge&source=lnms.html