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Drying of Aquifers: Infiltration Occuring at a Slower Rate than Extraction

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Abstract: *Aquifers that form an integral part of the water cycle are gradually being extracted to a level where no amount of recharge can restore their original capacity. As these critical water resources are situated below the surface of the earth and not visible to the common eye, their importance is not being realised. The danger that the coming days will bring to us is not striking the citizens at the moment. Water scarcity will be the primary concern no later than the coming decade. Not just a shortage of quantity but over extraction of water beyond the permissible limit also affects the water quality where a high amount of salts and minerals are flowing into our systems. This article highlights how our aquifers below the ground are drying up as their natural recharge is unable to keep up with our water demand and how this is affecting us presently, and the risks in the coming days. It also tries to pose some simple solutions to deal with this problem to some extent.*

Keywords: *Aquifers, water, recharge*

1. INTRODUCTION

With 71% of the earth's surface being covered with water, it is very contrasting and difficult to accept the fact that inspite of having an abundance spread, water is becoming an increasingly scarce resource. (Mehta, 2003)Besides its other multitudinous uses, water is required for the basic sustenance of human lives. It is not only an ecologically important resource but is also required for our day to day functioning. If not available in required quantity or quality, the entire living world can perish. However, the present times are falling prey to a situation where this primary resource is at stake. Water scarcity has become a global problem where most of the areas do not have access to optimum water resources according to their demand. Water crisis across the globe is one of the principal reasons for the misery being experienced by millions of people. It has been estimated that almost 4 billion people live in areas with severe water scarcity atleast one month a year and this is the entire population in almost 37 countries of the world and half of the population in 97 countries. (Mathews, 2016) According to a report, India is one of the worst affected countries in terms of water crisis with almost 200,000 people dying every year due to the lack of access to safe drinking water.

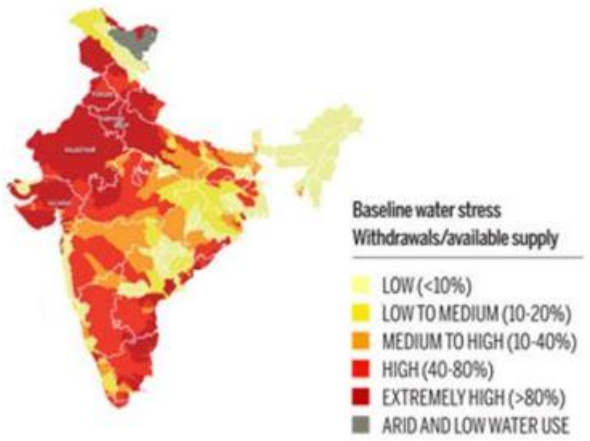

Fig1. *Baseline Water Stress, India*

Source: *World Resource Institute*

From the figure, it can be seen that more than 50% of the Indian landmass is subjected to extremely high water stress. However, the water crisis does not only imply an acute shortage or insufficiency of available water resources but the imperfect condition or state of the usable water arising from excessive pollution as well as poor institutional capacity to manage water demands. (Suparana Katyaini, 2015)

1.1. Inland Water Resources in India

Inland water resources are not just sources of water but have a huge ecological and socio-economic advantage. India accounts for about 4% of the world's total water resources. (India Water Facts, n.d.)

State wise inland water resources

Table1. *Inland Water Resources, India*

S.N	States	Rivers & Canals (Length in kms.)	Reservoirs (Ha.)	Tanks & Ponds (Ha.)	Brackish Water (Ha.)	Beels(Ha)	Oxbow Lakes(Ha)	Derelict Water (Ha)	Other than rivers and canals(Ha)	Total (Ha.)
1	Andhra Pradesh*	6960.49	170725.00	271167.00	60000.00				126000.00	627892.00
2	Arunachal Pradesh	30.00	160.00	3625.00			5.00	11864.00		15654.00
3	Assam	4820.00	2000.00	73065.00		100815.00		86204.00		262084.00
4	Bihar	3200.00	60000.00	93296.20			9000.00		133956.00	296252.20
5	Chhattisgarh	3573.00	84000.00	99400.00						183400.00
6	Delhi	150.00	4000.00	-						4000.00
7	Goa	250.00	3448.00	180.00						0.00
8	Gujarat	3865.00	347659.00	22000.00	100000.00			12000.00		481659.00
9	Haryana	5000.00	0.00	20000.00	0.00	0.00	0.00	0.00	0.00	20000.00
10	Himachal Pradesh	3000.00	43785.00	805.04	0.00	0.00	0.00	0.00	619.63	45209.67
11	Jammu & Kashmir	27781.00	11000.00	445.00			6000.00			17445.00
12	Jharkhand	1800.00	121000.00	66348.00		0.00	0.00	0.00	14450.00	201798.00
13	Karnataka	5813.00	440000.00	292332.00	10000.00	0.00	0.00	0.00	0.00	742332.00
14	Kerala	3220.00	34205.00	27625.00	240000.00	74000.00	89000.00	80000.00		544830.00
15	Madhya Pradesh	17066.00	339175.00	0.68						339175.68
16	Maharashtra	17725.00	299000.00	148406.90	17125.15	0.00	0.00	0.00	0.00	464532.05
17	Manipur	3360.00	2142.00	11442.00	0.00	24433.00	0.00	4728.00	0.00	42745.00
18	Meghalaya	3904.12	8000.00	2000.00		220.93	61.45	53.94		10336.32
19	Mizoram	1100.00	8100.00	5468.34						13568.34
20	Nagaland	1600.00	2258.00	3425.50			1700.00			7383.50
21	Odisha	24878.33	256000.00	132832.00	430000.00	180000.00				998832.00
22	Punjab	868.00	4211.73	16220.00						20431.73
23	Rajasthan	5290.00	336871.00	93909.00						430780.00
24	Sikkim	900.00	850.00	15.70		3000.00				3865.70
25	Tamil Nadu	7420.00	570000.00	258035.00	60000.00	0.00	0.00	7000.00	0.00	895035.00
26	Telangana	1808.00	167900.00	404000.00						571900.00
27	Tripura	1266.71	5000.00	17552.07	0.00	0.00	0.00	361.44	0.00	22913.51
28	Uttarakhand	2686.00	20587.00	861.15		300.00			347.89	22096.04
29	Uttar Pradesh	39542.00	147552.00	149933.76	0.00		12034.00	0.00	25351.00	334870.76
30	West Bengal	2526.00	28050.00	263372.00	210000.00	42082.00		26925.00		570429.00
31	Andaman & Nicobar		367.00	160.00	33000.00					33527.00
32	Chandigarh	2.00	0.00							0.00
33	Dadra & Nagar Haveli	54.00	5000.00							5000.00
34	Daman & Diu	12.00	0.00							0.00
35	Lakshadweep	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
36	Puducherry	25.00	1678.45	340.87	37.35			1000.00		3056.67
TOTAL		201495.65	3524724.18	2478263.21	1160162.50	424850.93	117800.45	230136.38	300724.52	8233034.17

Source: *Handbook of Fisheries Statistics, 2018, Ministry of Fisheries, Animal Husbandry & Dairying.*

The above table shows us the various types of inland water resources that are present in each state and Union Territory of the country. This data has been obtained from the Handbook of Fisheries Statistics, 2018, Ministry of Fisheries, Animal Husbandry & Dairying. The most important water resource of a place is a river which is a naturally flowing channel of water joining a sea, lake or another river. From

the data it is observed that Uttar Pradesh has the longest length (39542km) of rivers and canal systems in the country followed by Jammu and Kashmir with 27781km. Apart from rivers, tanks, ponds, reservoirs, beels, lakes are the other important storages on inland water.

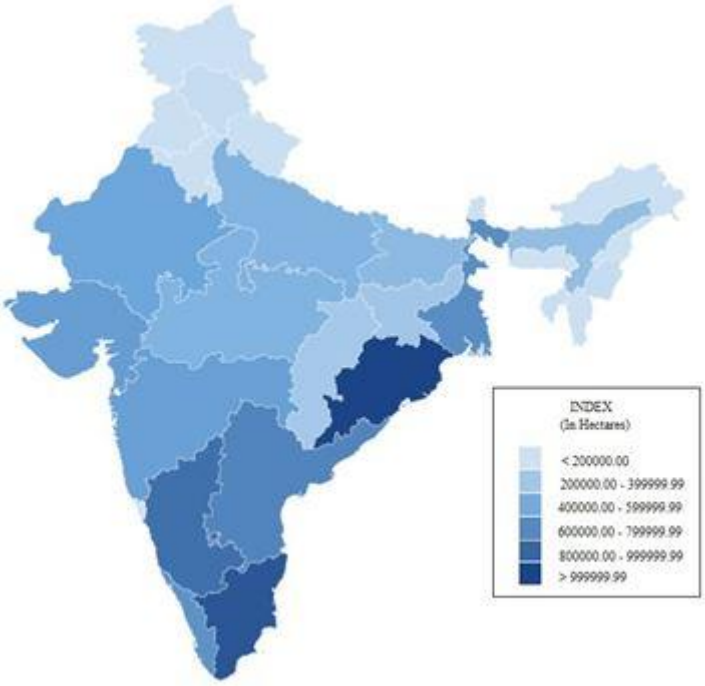

Fig2. *Choropleth Map showing inland water resources in states of India*

Source: *Created by Author*

The inland water resources are unevenly distributed in the country. Orissa, Andhra Pradesh, Karnataka, Gujarat and West Bnegal possess almost 50% of the country's inland water resources. (India Water Facts, n.d.) From the figure, it can be seen that Orissa has the largest area (in hectares) of Inland Water storage in the country followed by Tamil Nadu. The Northern and the North eastern part of the country do not have much significant inland water resources. This can be accounted to the presence of mountains which makes it difficult to construct tanks and reservoirs. (Rakesh Kumar, 2007) Also, being a mountaneous region, it does not have any significant presence of brackish water in the region.

It is also noted that the presence of river water is found in every state as it is a naturally occuring body of water. On the other hand, man-made storages such as tanks or reservoirs do not occur in certain states. They are only built in places where it is needed and convenient to construct.

Brackish water is a naturally occuring water which is slightly saline in nature and has a higher chloride content. From the data, it is observed that brackish water is more in the coastal states. Thus, it can be concluded that the areas adjacent to the seas have a higher amount of brackish water due to the mixing of fresh and saline sea water.

Ox-bow lakes are still water lakes that indiactes the remains of a meandering river. They are cut of from the main river by the deposition of sediments. The data shows that oxbow lakes are found in the states of Bihar, Kerala, Uttar pradesh. These lakes are usually found in the lower course of a river channel near a plain.

Derelict water bodies are unutilized or neglected water bodies found in a region. According to a study, such water bodies can be important grounds for fishing. (H.K. Dash, 2008) Therefore the states of Assam, Kerala and West Bengal, which have large hectares of derelict waters can be a potential ground for the development of fisheries.

An analysis of the given data can help in the assessment of the water resources available for each state. It can help in the planning of utilization of water as well as to determine the availabilty and method of irrigation. Further data on the quality of water and the level of pollution can also help us to determine the actual use the water can be put into.

2. RESEARCH OBJECTIVE

Groundwater, though not directly seen, has its impact on almost all the consequences that we undergo. It makes up for nearly 30% of the world's freshwater supply including streams, lakes, rivers as well as the snow in Polar Regions. Aquifers are an important source that ensures the supply of fresh water to the population for its use. Ranging from consumption to irrigation, this water supports almost every activity dependant on hydrological factors. Not just an ample source, groundwater is even of better quality than surface water as the flow through the rocks helps in removing a considerable amount of pollutants. However, in many areas groundwater is being associated with a direful term "overuse." The increasing demand for water is forcing people to extract more and more water from the aquifers. However, the rate of infiltration is not being able to compete with this withdrawal and gradually the freshwater resources are disappearing from beneath the ground. This slow renewal compared to its overexploitation is pushing the world towards an acute water scarcity.

With the onset of the Green Revolution in India, the significant increase in groundwater irrigation has drastically increased with almost 90 million rural households directly dependent on it. (Esha Zaveri, 2016)

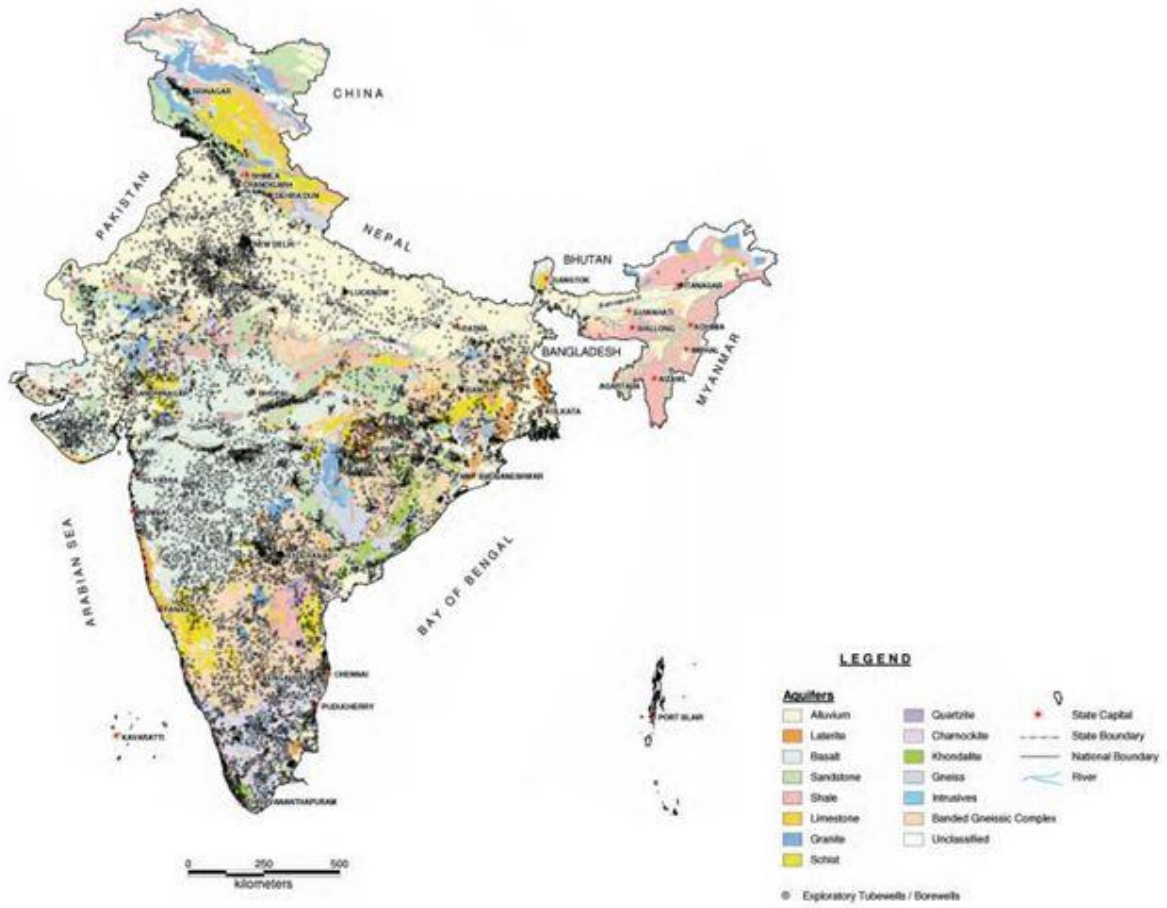

Fig3. *Groundwater Exploratory Borewells and Tubewells, India*

Source: *Aquifer Systems of India, Central Groundwater Board, Ministry of Water Resources, Government of India*

The above figure very vividly shows that India is specked with numerous exploratory wells and the Government makes sufficient efforts to understand the lithological and hydrological characteristics of this underground resource. However, despite all the current efforts, sustainable use of groundwater remains a serious concern for India's future. (Esha Zaveri, 2016) Thus, the primary objective of this research is to understand the potential causes for the heavy depletion rates which are causing groundwater crisis in India and to address the clashes between the rates of recharge and extraction.

3. CONCEPT MAP

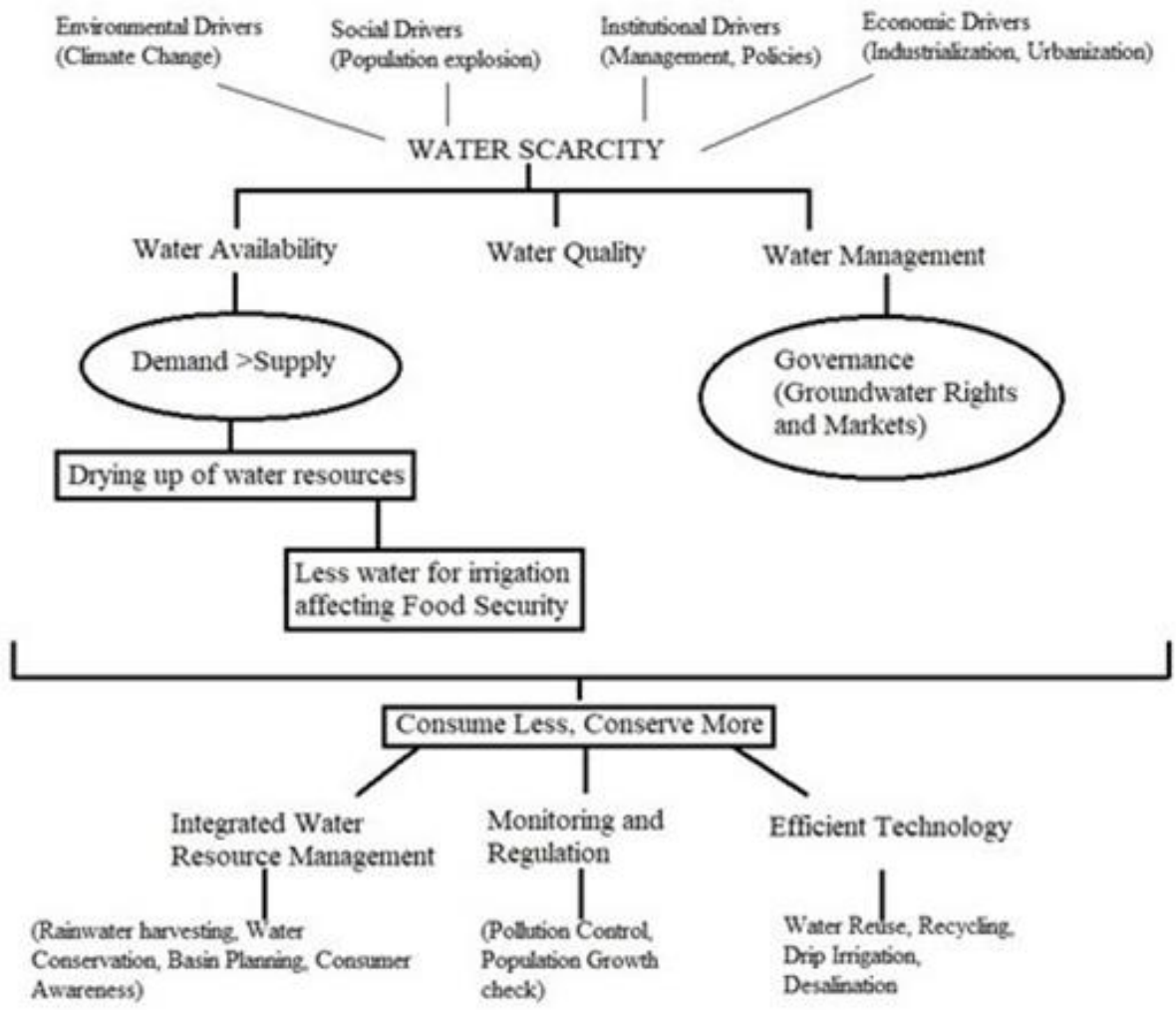

Fig4. *The main highlights of the paper*

4. WHAT IS LEADING TO GROUNDWATER SCARCITY?

Recent years have been characterised by over-dependance of people on water below the surface as most of the lakes, rivers and ponds have dried up. From ancient ages, people have developed a very casual nature to dispose their waste easily into any open waterbody. This continuous practice has also caused the surface water resources to degrade in quality to a level where it is now not suitable for human consumption and use. As groundwater is a covered resource, it has been protected from this indiscreminate waste disposal for quite some time. Thus, the surface water shortage and degrading quality have now transferred the attention of the people towards the use of groundwater. Groundwater is replenished mainly by the natural process of precipitation and infiltration and this recharge cannot be accelerated artificially. However, the rates of its extraction are growing exponentially leading to an overall decline of the water level. Such changes are more prominent in the north-western states of India where groundwater is found to be depleting at a mean rate of 4cm/year (Observed from NASA Gravity Record and Climate Experiment Satellites).

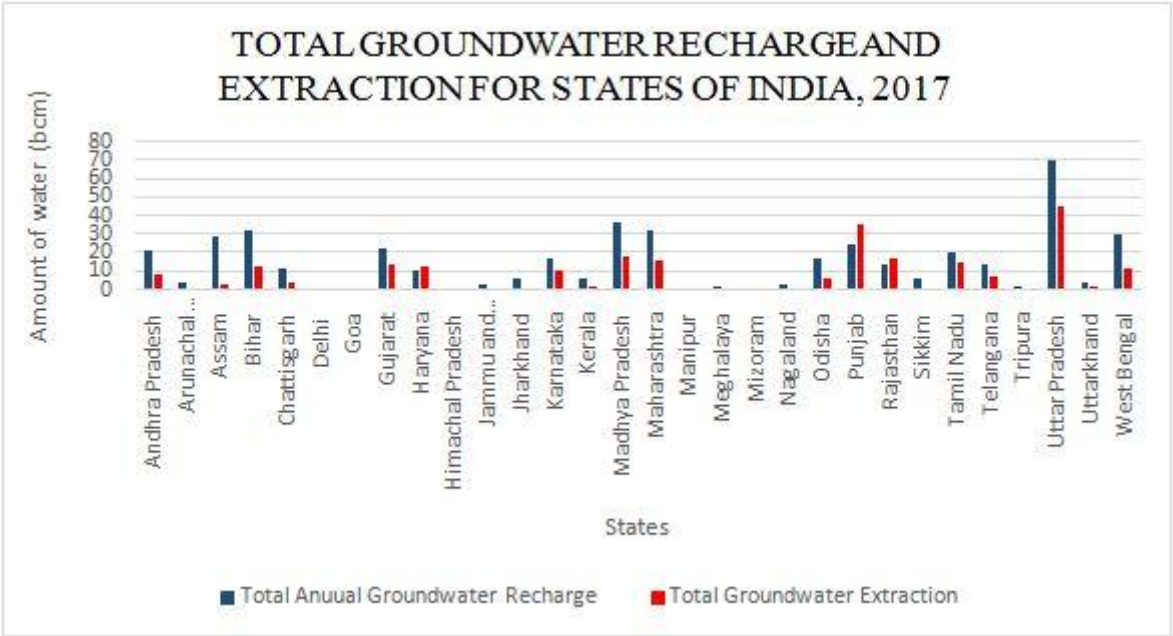

Fig5. *Recharge and extraction of Groundwater, 2017*

Source: *National Compilation on Dynamic Groundwater Resources of India, 2017, Ministry of Jal Shakti, Government of India*

The major drivers of this acute water scarcity are not only anthropological but is also caused due to various environmental, economic and institutional factors. (Matthew Rodell, 2009)

4.1. Climate Change

The gradual change of the global climate causes various uncertainties in the supply and management of water resources. Apart from the surface water bodies which are directly affected, climate change also results in the reduction of quantity and quality of groundwater. As the aquifers below the surface are recharged through precipitation and interaction with surface water bodies, the direct impact of climate change on these factors ultimately affects the groundwater. Climate change results in large-scale changes in precipitation through its influence on evaporation and transpiration. Being the primary source of groundwater recharge, changes in evaporation and transpiration will lead to an overall change in the quantity of water stored below the ground. The effects of climate change on groundwater can be assessed under the following sub-topics:

4.1.1. Soil Moisture

The gradual increase in the earth's temperature directly stimulates the soil moisture contents and its characteristics. Very high temperatures as well as frequent changes in local temperatures result in the development of cracks in the soil which directly acts on its water-holding capacity. The increased intensity and frequency of freezing also influences the soil moisture and water-holding capacity in many soils. High evaporation rates also leave the soil with huge concentrations of various salts and ions. Thus, soil being the major medium of infiltration, any changes in it will greatly affect the aquifers below the ground.

4.1.2.. Groundwater Recharge

Aquifers depend majorly on rainfall, rivers and lakes for their effective replenishment. The presence of large pores or fissures in the rocks causes quick recharge whereas slower infiltration takes place through the layers of soil lying over the aquifers. Thus, if the amount of rainfall or the duration of the monsoon season varies, the amount of recharge will also differ considerably. In many places, especially in the arid and semi-arid regions, an extreme rate of evaporation due to high temperatures even lead to the complete depletion of various shallow and unconfined aquifers. As the recharge of groundwater is largely dominated by the amount of rainfall, the change in seasonal cycles due to climate change adversely affects the amount of water in the aquifers. It has also been noted that the recharge of aquifers vary considerably over climatic zones, signifying that climatic factors play a very crucial role in the supply of water to the aquifers. (Kumar, 2012)

4.1.3. Water Quality

The impact of climate change on the quality of water stored in the aquifers is mainly observed in the coastal areas. The rise in the sea-level is a major consequence of climate change. However, as the level of the sea rises, the water often floods over the land which leads to the infiltration of this salty water into the aquifers. This alters the chemical composition of the water and also makes it unsuitable for various uses, mainly irrigation. Thus, saline intrusion into the groundwater due to sea-level rise is also a negative impact of climate change on water.

4.2. Population Explosion

The sustainable use of any ecological resource is severely constrained by the grave issue of population explosion. (Zhang Fa-Wang, 2015) As the population of the world rises, more water is required for the sustenance of lives and thus the demand for water goes on increasing. Too much pressure on the surface water resources have led people to pump out water frequently from the ground to meet their needs. This withdrawal of water from the ground is being done at a rate which is significantly higher than the rate at which the storage is refilled. As a result, the amount of water available below the ground is gradually decreasing.

Another significant effect of population explosion is the need for the production of larger quantities of crops to feed more people. This has resulted in the increase in cultivation which inturn led to a higher demand for irrigation facilities. This soaring water requirement for the purpose of irrigation has also caused over extraction of water from the aquifers below. It has been estimated from various satellite data that between the year 2002 and 2016, the groundwater in the northern and eastern states of India is undergoing severe depletion primarily due to intense extraction for crop irrigation. (Jain, 2018)

The following diagram attempts to highlight the changes in groundwater level in the 7 most populous states of India from the year 2009 to 2019.

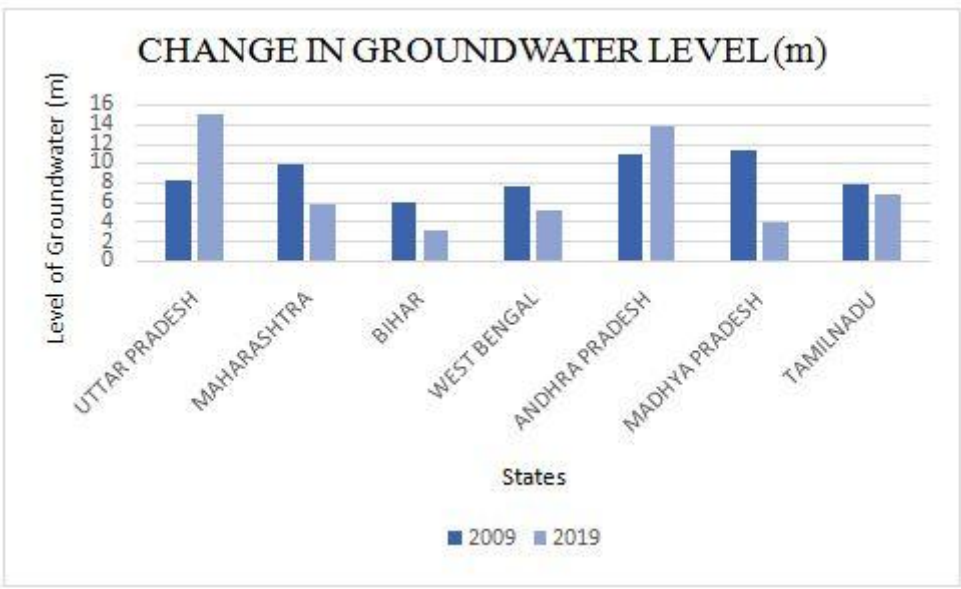

Fig6. *Decadal Change in Groundwater Level for 7 most-populous States, India*

Source: *India Water Resources Information System, Ministry of Jal Shakti, Government of India*

It can be observed that among the 7 states taken into consideration, the groundwater levels have decreased in 5 of the states over the span of 10 years. Thus, it can be said that when the population of a state is high, the pressure on the groundwater is higher and causes the level of water to decrease. Population explosions can therefore be considered a major driver of groundwater scarcity.

4.3. Inappropriate Management Policies

Groundwater being the most important water resource in India and accounting for the major supply of water for irrigation as well as domestic use requires robust and holistic management practices and

policies. However, poor control and regulation of the groundwater resources in India encourages the over extraction without any penalty. Thus, groundwater laws in the country are not adequate for addressing the issue of water conservation effectively. Unscientific methods of agriculture as well as lack of sanitation facilities specially in the rural areas lead to the contamination of groundwater. Sufficient regulation on the use of fertilisers and pesticides is also not imposed which further degrades the quality of water in the aquifers. Another major reason for the depletion of groundwater is the subsidy for electricity provided by the government a high Minimum Support Price (MSP) for agricultural produce set by the government. Such faults in the regulation mechanism accelerate the overuse and pollution of groundwater resulting in severe water scarcity throughout the country.

4.4. Industrialisation and Urbanisation

The process of economic and social development have led to the increased rates of urbanisation and industrial growth which have profound impacts on the depletion of water resources. This is noticed more in developing nations as they are often characterised by rapid and unplanned urban developments. Industries are a major pollutant of groundwater by discharging many harmful effluents into the the ground and also extract huge quantities of water from the aquifers to meet their requirements. Urbanisation has many large scale impacts on the availability of water resources and some of its main contributions to water scarcity can be discussed as follows:

- The process of urbanisation is closely associated with the expansion of cities accompanied by huge construction of buildings. This leads to less land surface availability for the penetration of water through the rocks or soil layers into the ground. Thus, the recharge of aquifers occur at a slower rate compared to a time span before urbanisation.
- Building of roads also leads to the concretisation of land which ultimately generate more amount of run off that is discharged into the surface water bodied instead of infiltrating below the ground.
- Sewage and other domestic wastes are often discharged into the groundwater leading to a deterioration in its quality.

5. The Problem of Groundwater Scarcity

The shortage of groundwater is a very serious contemporary ecological problem. This depletion of water from beneath the surface of the earth is primarily occurring due to the frequent pumping of water from the ground. It is being pumped out so rapidly that the aquifers are not getting adequate time and scope to replenish themselves. Unlike the rivers and lakes, the refilling of groundwater takes a longer time as the water has to seep through various layers of rocks or soil. As a result, the level of the water table is continuously falling. According to the World Water Development Report provided by United Nations Educational, Scientific and Cultural Organisation (UNESCO), India is considered to be the largest extractor of groundwater in the world. The country's water demand is expected to exceed its water supply by almost 200% by the year 2030. This implies a highly severe scarcity of water which can even lead to 6-7% fall in its GDP. (Groundwater Crisis in India, 2019)

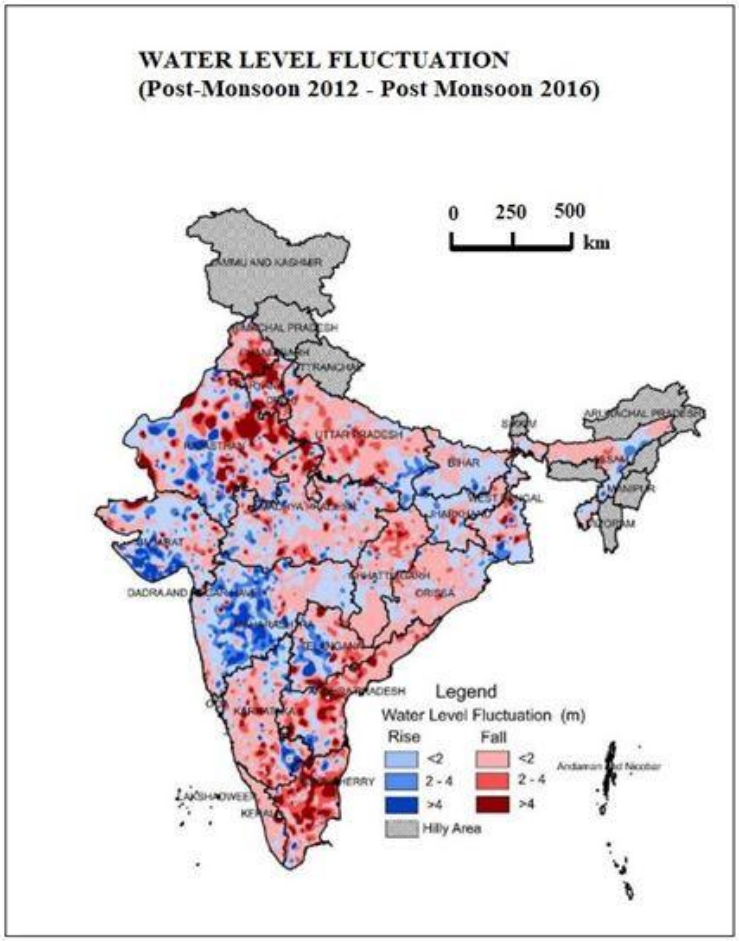

Fig7. *Water Level Fluctuation from November 2012 – November 2016*

Source: *National Compilation on Dynamic Groundwater Resources of India, 2017, Ministry of Jal Shakti, Government of India*

The shortage of groundwater is further resulting in the extraction of water from deeper into the earth's surface. This is even leading to the use and consumption of water that is severely contaminated by various elements such as arsenic and merury. A shortage in groundwater also prevents water from flowing into the surface water bodies such as lakes and ponds. As a result many water resources are becoming shallow and even drying up completely.

Over extraction of water from the aquifers is found to be mainly a consequence of the increase in water demand. The drying up of water resources in turn leads to an increase in the demand as less water is available for use. Thus, the problem of water scarcity is inevitable if the demand for water is not controlled at the very first step.

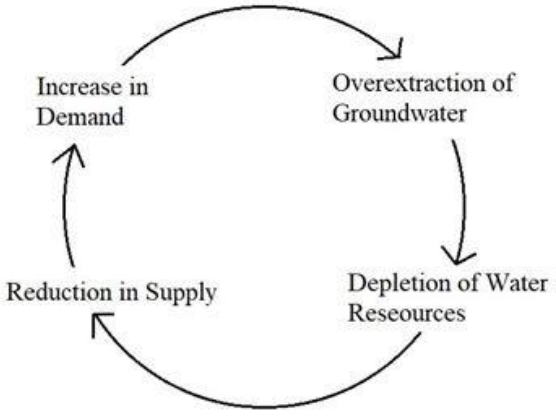

Fig8. *Unending Cycle of Water Scarcity*

The water scarcity is not just a problem of water shortage but has many other widespread effects. Continuous depletion of groundwater is also causing the extinction of many species, especially certain soil microbes. At some instances, depletion of the aquifers results in the formation of dangerous sinkholes which are very dangerous for buildings and houses. Even the base flow of major rivers such as Ganga is also reducing as a consequence of extreme groundwater use. (Abhijit Mukherjee, 2018)

Zaveri (2016), through the analysis of various agricultural data, has also laid stress on the fact that the loss of ground water is leading to a decline in water availability for irrigation, leaving a large population vulnerable to food insecurity.

6. Governance of Ground Water

Groundwater management also forms a very crucial component of water scarcity issues, apart from water availability and water quality. The overuse of aquifers due to unregulated withdrawal of groundwater has resulted in various environmental, social, economic and human health problems, especially in the developing countries of Southern Asia. This has given rise to the development of various institutional arrangements as well as groundwater rights in the market. The public-good approach towards the groundwater resources is considered as one of the primary reasons for the decrease in quality and overuse. With no private property rights over the resources, government intervention is the only possible way to mitigate the harmful effects as individuals have an exploitative attitude towards the common assets. To solve this issue, the property rights approach is considered to be an alternative. Ananda et al. (2019) has highlighted this issue as an important concept of groundwater scarcity.

The entire mechanism of groundwater management is a very complex part of the scarcity problem. The conventional water governance methods are not adequate for effective monitoring as well as understanding all the hydrological parameters involved in the process. Absence of groundwater rights is considered to be a driving factor for the indiscriminate present overuse. Property Rights can be defined as a set of specific rules or measures that specify the use of scarce resources. Thus, through the imposition of exclusive property rights, public goods can be transformed into private goods. This will also reduce the intervention of the government except in assigning such rights and determine the uses of this increasingly scarce resource. Pricing policies also enhance collective action in groundwater management and ensure judicious and sustainable use of resources.

Groundwater markets help deal with the uncertainty of groundwater supplies through rural electrification and high flat tariffs. Besides improving the resource use efficiency, it is also economically beneficial as the poor and marginalised farmers get adequate rights to use the resource and increase their productivity and income.

Thus, some changes in the existing institutional structures as well as assignment of intrinsic rights also forms an important part of the scarcity issue from the social and economic point of view.

7. The Way Forward

The over extraction of groundwater has almost become an irreversible process as it might take up to 50 years to replenish the water that is being extracted at the present rate, if no further withdrawal is done after this. Thus, our current withdrawl rates are taking us to a situation of catastrophe. This calls for immediateaction to protect this resource for our present and future use as well as to avoid the allied problems associated with its overuse. The major way out from this difficult situation is to limit our personal use at the primary level and conserve the water for the coming generations. Focus should be laid on the Sustainable Development Goals as they provide a very structured framework to deal with many ecological and social crises. (Mathews, 2016) A holistic solution framework will therefore include the following measures.

7.1. Integrated Water Resource Management

Integrated groundwater management is one of the foremost priorities of the present times that includes all the processes from its conservation to raising awareness and also effective monitoring of the implementation of various groundwater policies and measures. A very common and practical example of this is the practice of rainwater harvesting which allows the rainwater to reach the ground in a much shorter time than infiltrating naturally and also prevents it from flowing as surface run-off into other water bodies.

The catchment area for any river basin can be planned out in a scientific way which allows more water to seep below the ground. Certain traditional ecological practices also accelerate these processes considerably. The first and foremost way to deal with the problems of overuse is to raise awareness among the people and involve them in the conservation process. People should be warned about the forecasted danger of depleting aquifers so that they understand the severity of the issue and their personal damages associated with it. Involving the community or society in the management will also encourage them to conserve groundwater and prevent it from being contaminated. Before the formulation of any policies or measures ample amount of research and scientific evaluations should be done. Such research should focus on all the aspects starting from causes to regulation and include the active participation of the local communities to form an integrated approach. Decentralised water management thus needs to be improved and encouraged, especially in developing countries like India, to impart hydrological skills and knowledge from various sections of the society.

7.2. Monitoring and Regulation

The monitoring and regulation of underground water is a very complex and difficult process. However, certain basic measures can be undertaken that will help to reduce the indiscriminate extraction of water and raise the water table up to certain heights. The primary control measure to prevent overuse of aquifers is to check the population growth. This will result in a decrease in the potential demand for water. Certain restrictions on the acces of groundwater should also be imposed, specially in the areas that have extremely low water tables. Setting up of various institutions and agencies to monitor issues such as the release of industrial effluents and water logging will also ensure the protection of the quality of water in the aquifers. Reducing electricity subsidies in the rural areas is also an effective measure to control depletion as subsidised electricity enables farmers to run more pumps that draw water from below the ground.

An efficient groundwater monitoring network should also be set up as they help inform the water boards and municipality of any alarming situations and enable them to take immediate effective actions and also mitigation measures. If the government also takes up some initiatives in determining which crop is to be grown in which region according to the water availability then the water resources will be more judiciously used. Policy measurements should also be made in such a way that it encourages the farmers to ensure the recharge of groundwater from their farms and fields.

Such feasible solutions, when done at a community level by involving the local governments as well as all stakeholders of the resource, make the entire process easier and more successful.

7.3. Efficient Technology

Various technological measures can be employed to control the overuse of water from the aquifers and also enhance their replenishment. At the very first step, technological means should be used to determine and identify the groundwater recharge areas. The use of Geographical Information System and other such technology can be used in the mapping of groundwater which can help us to understand which areas need more focus. An analysis of the temporal change will also help in understanding the severity of the issue.

Artificial recharge of tubewells, recycling the water and reusing it, scientific methods of agriculture are some other ways how technology can help in the conservation of water resources. Farmers should also be encouraged to adopt micro-irrigation techniques such as drip irrigation which is very effective to ensure sustainable use of aquifers.

8. CONCLUSION

The understanding and conservation of groundwater cannot be done by using any one single approach or measure. It involves many complex phenomena and processes that need to be studied and applied in detail. Thus, the actions taken should also encompass every sphere such as community participation, legislation, technology, market forces, etc. Successful alleviation of the groundwater problem in India as well as in other nations therefore needs to find an inclusive and holistic approach.

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