Groundwater Management in India

A multi-state field study of availability, utilisation and locally appropriate solutions for sustainable, equitable and efficient use of groundwater

Assam State Report

November 2022

RAJIV GANDHI
INSTITUTE FOR CONTEMPORARY STUDIES

Concept and Overall Guidance:
Mr. Vijay Mahajan, Director
Rajiv Gandhi Institute for Contemporary Studies, New Delhi

Review and Editing:
Mr. Jeet Singh, Fellow, RGICS

Research Team:
Mr. Bitupan Gogoi, SeSTA
Mr. Mahnur Ali, SeSTA

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Rajiv Gandhi Foundation
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1 Executive summary

1.1 Groundwater scenario in India

Over the last few decades our dependence on ground water has increased tremendously. It has become a major source of water for domestic and agricultural use in India. According to an estimate the ground water resource meets 80% of our water demand. Agriculture is a major consumer of the ground water; it supplies nearly 60% of water demand of the agriculture sector. Worryingly, since the 1990s the area under canal and tank irrigation has observed absolute decrease in India, whereas, ground water fed agricultural area has increased in these years. The convenience and efficient last mile connectivity of ground water resources encouraged many farmers in this country to switch from canal/tank irrigation to the tube well/bore well.

A committee constituted by the government of India to review water governance in the country led by Dr. Mihir Shah in his report in 2016 observed that the public finance on water resources after independence largely focused on surface water.[1] Huge amount was invested on creating surface water infrastructure. The ground water resource remains neglected despite it is replacing surface water from agriculture to domestic use in the last some decades. Individuals invested hugely in ground water infrastructure especially after the green revolution as it was easier and efficient in terms of available for the end use. The technological advancement and availability & affordability of power also helped individual investors (largely farmers) to create groundwater structures. Currently there are around 30 million groundwater structures in this country.

For the purpose of ground water extraction, enough knowledge and data is available. The problem is with lack of data on aquifer management. Being a large country, the geological and hydrological characteristics of the landmass varies from region to region. It further creates complexity to understand sub-surface characteristics pertinent to water seepage, storage and water movement. The CGWB has categorized 14 different aquifer settings in India. Major aquifers include Alluvial, Laterite, Sand stone, shale aquifer, Lime stone aquifer, Basalt aquifers and Crystalline aquifers. According to a classification of geohydrologist Dr. Kulkarni, Crystalline and Alluvial aquifers comprise 59% of the total aquifer area in the country. The mountain and volcanic system of aquifers accounts for 16% of the total area each. These complex aquifer systems require detailed mapping and study for better management of ground water.

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1 https://www.indiawaterportal.org/sites/default/files/iwp2/report_on_restructuring_cwc_cgwb.pdf

1.2 Groundwater policy gaps

The increasing unsustainable extraction of groundwater is a serious issue that has now turned into a water crisis in many parts of the country. In the states like Punjab, Rajasthan, Haryana, Delhi, Madhya Pradesh, parts of Uttar Pradesh and Tamil Nadu have started withdrawing more water from sub surface than available for usage. This gap in demand and supply is continuously increasing as there is no aquifer management system in the place. The numbers of critical and over exploited units are on rise. This invited crisis due to mismanagement of natural wealth has serious social, economic and ecological consequences. There are many reasons behind this problem and these problems have been discussed a number of times.

Ground water extraction is largely unregulated. The only law that loosely governs this precious resource in India is the Indian Easement Act, 1882. This law gives all rights to land owners to extract the ground water. In other words it excludes land less people from access and use of groundwater. This law does not control or regulate water extraction and its usage by the land owner. To strengthen the regulatory mechanisms, the central government has so far issued four versions of model law to be adopted by state governments. The first model bill was released in 1992 and the latest bill was released in 2017.

Yet not all states have converted the model Bill into state legislation. Andhra Pradesh, Assam, Goa, Bihar, Delhi, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Lakshadweep, Puducherry and West Bengal have adopted the older version of model bill, but in most cases the attempt is half hearted.[2] Moreover experts believe that the model Bill must also move from command and control mode to participatory mode to ensure full participation of people.

The unavailability of data and knowledge on aquifer systems is another big problem in developing better management plans for the ground water. The CGWB collects data from selected wells four times a year to monitor ground water development. The sample size for this yearly exercise is so low that nothing can be argued conclusively based on collected information. There is a long pending demand of mapping aquifers in this country for better management plan. The CGWB has been attempting to map aquifers for all districts in the country. This data and mapping of aquifers would definitely improve our ability to manage groundwater better.

The absence of an integrated approach of ground water recharge and extraction is completely missing in India. There have been some attempts through government and non-government agencies to integrate both of these aspects, but this idea is still not part of national or state level management plans. The absence of regulations and public finance for the management of ground water further discourages any national or state level plans for ground water resource management.

In the past the CGWB attempted to design a national level master plan for artificial recharge of aquifers in 2002 and 2013. The board has now revised this master plan in 2021. According to this master plan, nearly 1.41 crore artificial recharge structures are needed across the country. The type of structures recommended for states and districts varies depending on their geological and hydrological features. The plan is expected to be financed by ongoing projects such as MGNREGA and Watershed Management. The implementation of the master plans requires investment of Rs. 1.33 lakh crore.[3]

Involvement of people in planning and execution of activities related to artificial recharge and ground water extraction has not been seriously promoted at the policy level. However, we have numerous small examples across the country to show that if people are involved aquifers can be managed sustainably and benefits can be shared equitably.

1.3 The multi-state study

There have been some attempts in various states commissioned by nongovernmental organizations to empower farmers with knowledge and capacity to help them to make the right agricultural decisions and choices. Many of these serious attempts helped in yielding good results as well. On the other hand there are numerous examples where projects related to artificial recharge were carried out successfully both by the government and non-government agencies. Some states also tried to regulate groundwater resources. All these actions by different organizations generated huge knowledge and experiences to vet success and failure of each type of programs. These small scale and localized solutions for ground water management are effective in terms of striking a balance between water supply and demand.

Learning from these models can help improving ground water regulations in different states. Therefore this study was commissioned by Rajiv Gandhi Institute for Contemporary Studies (RGICS) in 2021 in ten different states namely Punjab, Rajasthan, Gujarat, Uttar Pradesh, West Bengal, Assam, Madhya Pradesh, Maharashtra, Telangana and Tamil Nadu. Main objectives of the study were as follows:

- To develop an overview of the hydro-geological characterises of different states/regions and the extent of ground water extraction.
- To document and assess the regulatory framework in different states for the management of ground water resources.
- To assess the ability of localized solutions for management of ground water resources to strike a balance between demand and supply of groundwater.
- To draw policy lessons from successful localized solutions for ground water resource management

Groundwater experts and NGOs specialized in groundwater management in different states helped us to implement this project. This is a qualitative research project which involved methods like field work, stakeholder consultation and secondary data analysis. This state report gives an overview of the context and main natural features- geographical, geological, hydrological and hydrogeological- which impacts that status of groundwater in the state. Then it deals with the human interventions – in terms of demand and utilisation, the major policies, laws and regulations, programs, schemes and institutions pertinent to groundwater in the study state.

The main incremental contribution is in the section on lessons from locally appropriate solutions for sustainable groundwater management.We have given summaries of case studies from different location in the study state documenting such locally appropriate solutions.

Finally we summarise the main lessons from the study in a section titled the eightfold path.

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[2] https://scroll.in/article/929433/as-the-water-crisis-deepens-can-india-afford-to-leave-groundwater-unregulated

[3] http://cgwb.gov.in/Whatisnew/2021-06-30-Final-Approved%20Master%20Plan%202020-00002.pdf

2 Assam state report

2.1 Context and key features

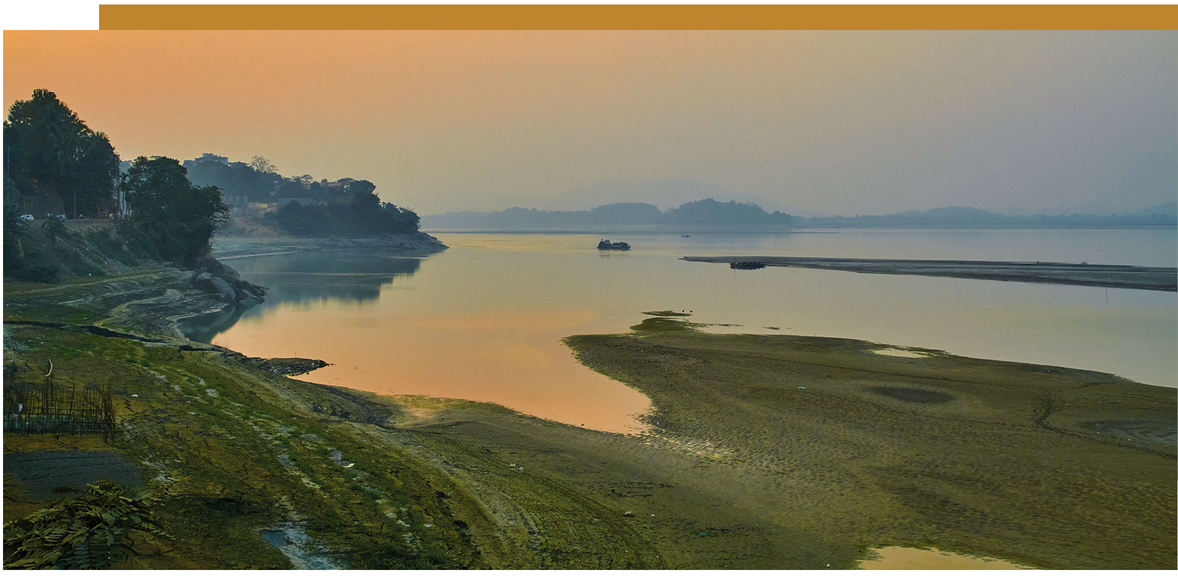
Assam state is in the north-eastern region of India. The state lies between 890 46′ – 960 01′ E longitude and 240 03′ – 270 58′ N latitude and covers an area of 78,438 km^2. The state is bounded in the north by Bhutan and Arunachal Pradesh, in the east by Arunachal Pradesh, Nagaland and Manipur, in the south by Meghalaya and Mizoram and in the west by West Bengal, Tripura and Bangladesh. The state can be divided into three principal geographical regions:

1. Brahmaputra Valley region in the foothills of the Himalayas in northern part of the state.
2. Barak Valley in the southern part.
3. Mikir (KarbiAnglong) and Cachar hills that divide the two valleys region.

Assam has mostly plain areas of low elevation, a large number of rivers and hills of low elevation in Karbi Anglong, North Cachar Hills and Cachar districts in the southern region. The peak height of hill in the state is about 1850 metres above mean sea level in North Cachar Hills district.

Due to heavy rainfall in Eastern Himalayan and other watersheds of the north-eastern part of India, Assam has extensive rivers system consisting of Brahmaputra, Barak and other main rivers like Burhidihing, Danshiri, Subansiri, Kopili, Dihang, Disang, Dikhou, Lohit, Puthimari, Kalang, Manas, Jinjiram, Dikrang, Kulsi, Janji, Aai, Nonoi, Gangadhar, Dhanshiri, Ronganadi, Krishna, Kushiara etc.

All the rivers in Assam are liable to floods, mainly because they receive heavy rainfall within a short time in the state and its neighborhood (Himalaya) where water runs very fast into Assam which has mostly low elevation. These rivers are in their early stage of maturity and are very active agents of erosion. The river water collects a tremendous amount of silt and other debris from the hilly terrains and raises the level of the riverbeds. Therefore, it becomes impossible for the main channel to cope with the vast volumes of water received during the rains so that over flow water creates the floods in adjacent areas of the rivers.



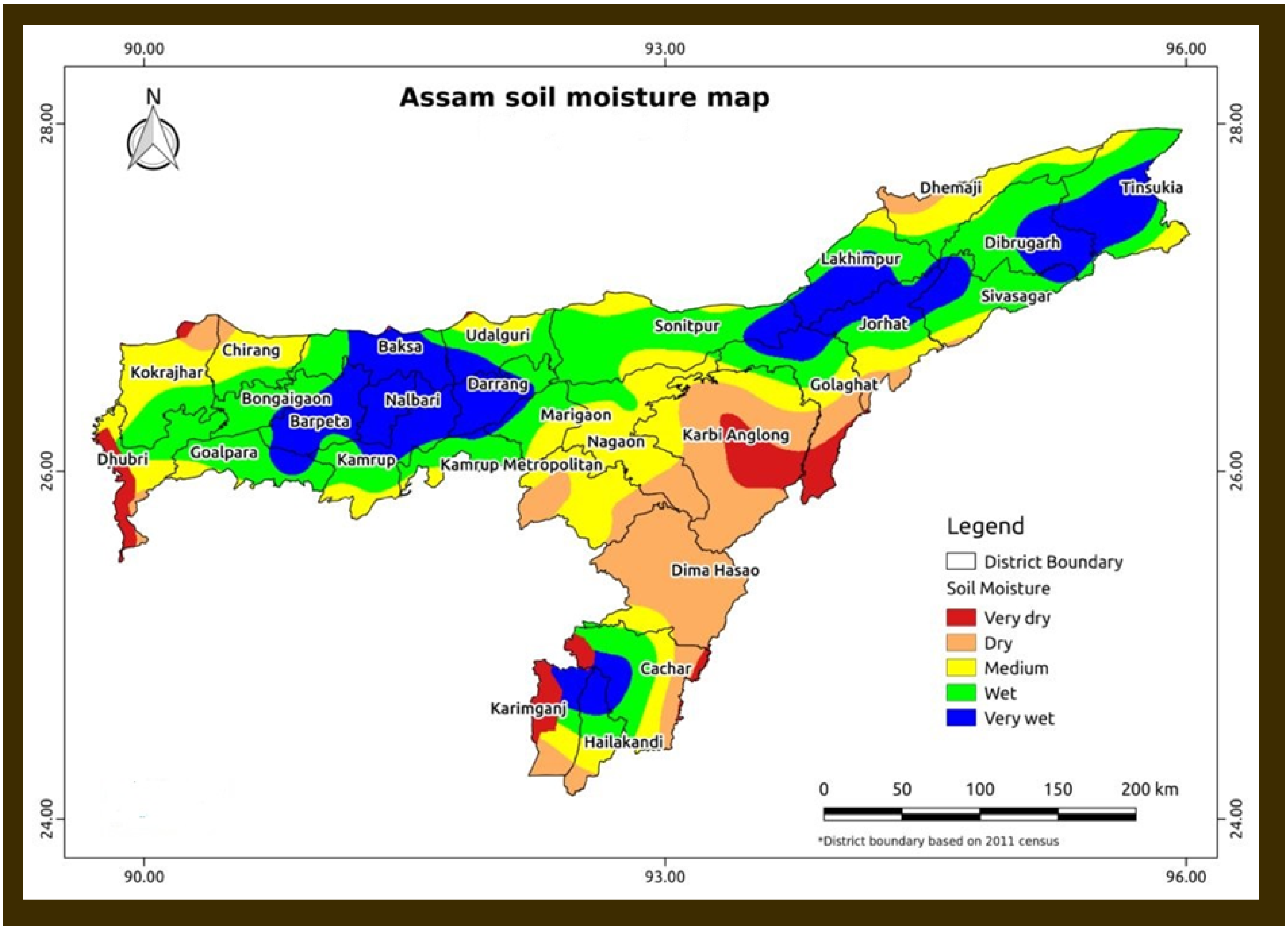
Area (Sq.km)	78,438
Physiography	• Brahmaputra Valley • The Central Assam Ranges • Barak Valley
Drainage	**Brahmaputra Basin with sub basin of** Subansiri, Jia Bharali, Badeng-Pubnoi, Dhansiri, Manas, Champamati Kalang. **Meghna Basin with sub basin of Barak river**
Rainfall	2262.95 mm with 144 rainy days
Total Districts / Blocks	28 districts / 219 Blocks
No.of sub units	28 districts, 219 blocks, 2620 panchayats, 26586 villages
Land Use/Land Cover(km^2)	Agricultural land(41323.21), Built up(3357.94), Forest(19173.69), Grassland & Grazing land (2533.40), Shifting cultivation(99.63), Wastelands(5479.36), Water bodies (6946.91)

Hydro geologically the state can be divided into three units namely consolidated formation, semi consolidated formation and unconsolidated formation. More than 75% of the state is underlain by unconsolidated formation comprising of clay, silt, sand, gravel, pebble and boulders. The Bhabar belt is about 11 to 15 km wide; the tube wells yield 27 to 59 m3/hr in this zone. The Tarai zone follows immediately down slope of the Bhabar zone where the yield of the wells ranges between 80-240 m3/hr. The flood plains follow the Tarai in Brahmaputra valley where the shallow tube wells yield between 20-50 m3/hr and deep tube wells between 150-240 m3/hr. In the semi consolidated formations of Cachar district, the yield of the tube well ranges between 50 to 100 m3/hr.

Dynamic Ground Water Resources	
Annual Replenishable Ground water Resource	27.23 BCM
Net Annual Ground Water Availability	24.89 BCM
Annual Ground Water Draft	5.44 BCM
Stage of Ground Water Development	22%
Ground Water Development & Management	
Over Exploited	NIL
Critical	NIL
Semi-critical	NIL
Artificial Recharge to Ground Water (AR)	Feasible AR structures: 250 Check Dams, 500 weirs, 1000 Gabion structures, 250 development of springs 600 RWH in Urban Areas
Ground Water Quality Problems	
Contaminants	Districts affected (in part)
Fluoride (>1.5 mg/l)	Goalpapra, Kamrup, Karbi Anglong, Nagaon,
Iron (>1.0 mg/l)	Cachar, Darrang, Dhemaji, Dhubri, Goalpapra, Golaghat, Hailakandi, Jorhat, Kamrup, Karbi Anglong, Karimganj, Kokrajhar, Lakhimpur, Morigaon, Nagaon, Nalbari, Sibsagar, Sonitpur
Arsenic (>0.05 mg/l)	Dhemaji

Source: CGWB

2.2 Groundwater availability and utilization:



Source: CGWB

The State is underlain mainly by unconsolidated Quaternary formation in Brahmaputra valley and potential aquifers lie at shallow as well as deeper zone. The semi-consolidated Tertiary formations are found to occur in the southern part of Karbi Anglong, Cachar, Karimganj and Hailakandi districts and in Upper Assam covering southern fringe of Dibrugarh, Tinsukia, Sibsagar, Jorhat and Golaghat districts. The consolidated Precambrian rocks occur mainly in N.C. Hills, Karbi-Anglong, Kamrup, Goalpara, Dhubri, and Nagaon. Ground water resources have been assessed by CGWB district-wise due to paucity of block wise data.

The Total Annual Groundwater Recharge of the State has been estimated as 27.05 bcm and annual extractable groundwater resources is 21.97 bcm. The Current Annual Ground Water Extraction for all uses is 2.58 bcm and Stage of Ground Water Extraction is 11.73 %. All the 28 assessment units have been categorized as 'Safe' and there is no saline area in the state. According to the CGWB data, as compared to 2017 assessment, the Total Annual Ground Water Recharge for the State has decreased from 28.67 bcm in 2017 to 27.05 bcm in 2020, Annual Extractable Ground Water Resources decreased from 24.26 bcm in 2017 to 21.97 bcm in 2020 and Total Ground Water Extraction decreased from 2.73 bcm in 2017 to 2.58 bcm in 2020. These changes can be attributed due to refinement of data. The stage of Ground Water Extraction increases from 11.25 % to 11.73 % due to decrease in annual extractable resource (CGWB).

The Total Annual Groundwater Recharge of the State has been estimated as 27.05 bcm and annual extractable groundwater resources is 21.97 bcm. The Current Annual Ground Water Extraction for all uses is 2.58 bcm and Stage of Ground Water Extraction is 11.73 %. All the 28 assessment units have been categorized as 'Safe' and there is no saline area in the state. According to the CGWB data, as compared to 2017 assessment, the Total Annual Ground Water Recharge for the State has decreased from 28.67 bcm in 2017 to 27.05 bcm in 2020, Annual Extractable Ground Water Resources decreased from 24.26 bcm in 2017 to 21.97 bcm in 2020 and Total Ground Water Extraction decreased from 2.73 bcm in 2017 to 2.58 bcm in 2020. These changes can be attributed due to refinement of data. The stage of Ground Water Extraction increases from 11.25 % to 11.73 % due to decrease in annual extractable resource (CGWB).

The Directorate of Geology and Mining, Assam set up a Ground water Cell in the year 1967 to explore and exploit the ground water resources on scientific line. It has carried out systematic hydro geological survey in some parts of the State for study of ground water condition and feasibility of development of ground water through deep and shallow tube wells. The Department, so far, has covered 50,000 sq km. areas by hydro geological studies with about 200 numbers of exploratory wells in different parts of the State and out of these 120 numbers have been converted to production well. The Directorate is collecting scientific hydro geological data and maintaining periodic water level in most parts of the State. These data are essential in proper exploration and exploitation of ground water for future use.

The quality of ground water is safe for drinking, industrial and agricultural purposes. The pH value ranges from 7.5 to 9.0. All parameters are within the permissible limit except iron, fluoride and arsenic. Fluoride is present only in deeper aquifer.

Dynamic Groundwater Resource in Assam, 2020

(Figures in billion cubic meters)

Ground Water Recharge				Total Annual GW recharge	Total Annual Natural discharge	Annual Extractabl GW
Monsoon Season		Non- monsoon Season				
From rainfall	From other	From rainfall	From other sources			
17.92	0.96	7.64	0.53	27.05	5.09	21.97

Water Resource Allocation in Assam, 2020

(Figures in billion cubic meters)

Current Groundwater Extraction			
Irrigation	Industrial	Domestic	Total
0.01	0.60	2.58	0.66

Total usable groundwater storage in India reveals high rates of depletion of groundwater storage in north-east India (Assam), despite an increase in rainfall. Researchers warn of impending droughts and famines in flood-prone Assam linked to the overexploitation of usable groundwater stock by pumping for irrigation. The status of the stock of groundwater available for extraction across the country revealed that Assam has lost the maximum amount of usable groundwater stock (between 2003 to 2015) in India. Assam lost two percent of the groundwater stock (up to a maximum aquifer depth of 300 meters) that could have been used. The zones that exhibited maximum depletion of groundwater spanned across located in the Brahmaputra basins that have water-bearing, highly fertile alluvial formations lending themselves to groundwater withdrawal for agriculture. In eastern India, we have seen a major shift in the last 10 years in terms of enhanced irrigation potential of areas.

A study conducted by IIT Kharagpur observed that Assam which had two crops a year, we are seeing three to four crops annually now. Water intensive crops such as rice, wheat, sugarcane, fruits and vegetables, cotton and soybean, take up the majority of the cropped area. The groundwater depletion in north India is the result of intensive pumping, long-term decline in precipitation, and decline in low-intensity rainy days. "The net irrigated area (using tube wells) jumped from 9,000 hectares to 74,000 hectares in the state".[4] But the excess water from the rainfall and floods does not get translated into groundwater because of the geology and the physics. The study reveals that the "sponge soaks up a lot of water but on subsequent use, it won't take up any more water despite the fact that there is space inside. Once the top layer gets saturated, water does not trickle down to the subsurface for storage even though there is capacity for storage." Assam and parts of east India are already saddled with problems of arsenic contamination of groundwater.

Source: Scroll.in

[4] https://india.mongabay.com/2019/03/usable-groundwater-depleting-in-assam-despite-increasing-rainfall-finds-a-study/

2.3 Groundwater policies and governance in the State

Major Policies and Legislations Governing Ground Water Resources in Assam	
The Assam Embankment and Drainage Act, 1953	• The Act provide for better provision for the construction, removal and upkeep of embankments and for the drainage and improvements of lands in Assam. • Empower government for Construction, removal or alterations of embankments or removal of obstructions
The Assam Embankment and Drainage Validation Act, 1960	• The Act provide for levy water rate, betterment cess or premium on land improved by embankment and drainage scheme executed by the state government.
The Assam Ground Water Control and Regulation Act, 2012	• Provides for constitution of state ground water authority and zonal ground water authorities. • Authority has power to notify area for control or regulation of ground water development • The authority regulates extraction of ground water in notified areas • Registration of ground water users and drilling agencies with the authority is mandatory.
The Assam Irrigation Act, 1983	• Plan, construct and monitor irrigation scheme • Develop scheme for distribution of water for irrigation from irrigation projects • Provides power to irrigation officer of a command area to determination of crops to be grown on lands in any particular year based on availability of water for irrigation • the State Government shall be entitled to levy a separate charge for such water and the State Government may prescribe the rates at which such water-rates shall be levied
The Assam Irrigation Water Users Act, 2004	• Delineate every command area under each irrigation scheme on hydraulic basis • Provides for constitution of water users' association in each water users' area • WUA are empowered to develop water bandi for each irrigation season and develop maintenance plan of the irrigation scheme.

2.4 Locally appropriate solutions for groundwater management

2.4.1 Case Study 1 - Rain Water Harvesting Model

This is a study of a village called Khungtaibari of Thuribari VCDC of Borobazar block of Chirang District of Assam. The village falls almost in the centre of the VCDC as it is surrounded by the other villages of the VCDC. To its west is the Ulubari village, Dauraibari and Kashibari village is in the east direction of the village and Fulkumari village to its South. The village is at a distance of 8 kms from the Manas National Park.

The whole village comprises of Boro community. The people of the village came from different places and settled down in the village by cutting down forest. People are in the village from last 70 to 80 years. The population of the village in approximately 500 and number of households are around 80 only. The main occupation of the village is agriculture. Apart from that there are also daily wage earners and few service men in defence. Apart from that some also goes to different places like Bangalore, Delhi, Kerala etc. to work in various companies as labor.

In the year 2008, the people from the village thought of harvesting the rain water in the village as that point of time the irrigation facility was not up to the mark as per the expectation of the villagers for the paddy cultivation. So for that they thought of harvesting rain water on a large scale.

For that they approached the VCDC for any help through any Government scheme, if any structure can be created with the help from VCDC. After a discussion with the PRI's, they concluded to create the structure through MGNREGA in a participatory approach where every villagers will work to construct the rain water harvesting tank in a land of 18 bighas (14400 sq.ft per bigha). In the initial days everyone participated to create the structure under MGNREGS. After a certain period of time due to irregularity in timely wage payment, people from the villages stopped working to create the structure. Also since the monsoon was approaching and they had very less time in their hands the work could not get completed. The structure got created but up to a depth of 2 to 3 feet at the corners and 4 to 5 feet in the middle of the structure.

Source: Research Gate

The villagers thought of digging the structure more in the coming years. Now for that they thought of some alternative ways. They started contacting contractors who takes contract of building roads as soil is required for construction of roads initially. The contractors digged the structure in the middle of it up to a depth of 10 feet. The contractors took soil from the structure and the villagers earn money from it. After that they formed a committee and termed it as *"Awaisiri Afat"*. The committee was formed with the villagers of the village in order to look after the maintenance of the structure and money they earn from the structure to be kept with the committee.

As the settlement grew with the time, people started constructing houses in the villages. So in order to construct the houses, people started digging small ponds near their settlement areas for earth filling and land leveling from the soil which they get by excavating the soil from the pond. As they don't have enough money to purchase soil from others for earth filling and land leveling of their settlement areas. So slowly every household started having a small pond. Now in the present date they do fish rearing in their respective ponds too which got constructed while building their houses. The ponds also harvest water now a days from which household utilizations are also met as the water don't get dried up completely from the ponds. Some families also do fish rearing in their respective ponds for household consumption and also as a source of income.

For some years the villagers did irrigation of their lands with the help of the lake. Also it acted as a saviour to the village during the floods. As water comes in terms of flood from Bhutan and destroys their paddy fields. Because of the huge catchment area, the rain water harvesting tank holds a huge capacity to catch huge amount of water in the structure during the floods. It provided a great relief to the nearby paddy fields of the catchment during the floods.In order to earn income from the structure, the villagers started fish rearing activity in the catchment in the year 2012. They started the fish rearing activity on a participatory approach. In the first phase every household contributed some amount of money to purchase the fish fingerlings.

Later when the fish grew, on a participatory approach villagers do fish rearing. Some amount of fish gets equally distributed to every household and the remaining fish they sell. The amount of money they earn by selling the fish is kept by the committee. The money that the committee possesses is utilized for various purposes such as for organizing cultural nights in the village, giving loans to the residents of the village in need etc. They have also formed a library in the village so that any educated youth can access the library and read books available in it.

With many catchment areas of water, the villagers don't feel the scarcity of water in their village. Moreover, it has been observed that, with the construction of different rain water harvesting tanks (the lake and the ponds in households), the level of water never went down and there are only two dug wells in the village as the villagers don't have to do the boring since the level of water never goes down. Whereas, villagers recalls that the groundwater level used to go down significantly post monsoon before construction of all these water bodies in the village. At that moment of time the villagers have to go to Dhola river to bring water for their household consumption which flows near to the village.

<u>Impact</u>

1. It has been observed that the level of water has risen of the nearby areas of the catchment. Initially the level of water was 40 to 50 feet and in today's date the level of water is 10 to 12 feet in the village. Whereas, other villages in the radius of 7-8 kilometres from this village, the groundwater level is at 60 to 70 feet.
2. Irrigation facility has improved as water is available now at 10 to 12 feet which has now led to increase in the production of crops.
3. Water remains available in the catchment throughout the year for irrigation purposes
4. Protection from floods up to a great extent in the village because of the catchment treatment and artificial water structures.

2.4.2 Case Study 2- Dugwells and change in farming pattern

A study conducted in a village called 2 no. Chikajhora of Bishnupur VCDC. In the era of 90's, the village suffered from drought with very less rainfall. The households who stay on the upland of the village suffered majorly. So in order to mitigate the required amount of water in the various places of the village, pucca dug wells were constructed by the VCDC (Village Council Development Committee) of the village. In the initial year, one well was constructed for 15 families. The families used the water for various purposes like drinking, washing clothes and utensils, taking bath etc. The 15 families got fully dependent on the well constructed for them. Seeing the benefit of the well, the other villagers demanded well for them too.

In total 90 families stay on the upland part of the village. So within a span of almost 6 years a total of 6 dug wells the VCDC constructed for them. The dug wells were constructed very uniformly. One dug well in between 15 families. It was a relief for the villagers as the access to water got easier for them. They can now easily avail water. As earlier they have to go different places in search of water.

Now after almost a span of 30 to 40 years, the level of water has gone down. As the consumption of water has increased with the increase in population. Though the households are same but the number of members in the households has increased. The level of water which was easily available in a depth of 30 to 40 feet is now available at 60 to 70 feet which shows depletion in the level of Ground water. The time when wells got dried up people again dug more the wells so that water availability remains. The wells get dried up before the monsoon even though it has reached to 60 to 70 feet.

Image: Source and Usage of Ground Water

In the early days, people used to grow paddy in their agricultural lands as a major crop. From the initial days, people were fully dependent on the rain water for cultivation of crops. Since last 20 years, people have changed their cropping pattern. The villagers have stopped growing paddy in the villages due to scarcity of rain water as they do not get the amount of rain sometimes that is required for production of crops which turns into loss of the villagers. Also the elephants destroy their crops and also eat the paddy in the agricultural lands.

They have now started growing vegetables like Chilly, Bitter Gourd, Brinjal, Ridge Gourd, Cucumber etc. which can be grown in the rainy season. These are the plants which require water and the villagers depend on the rain water. For this they don't depend much on the ground water as the rain water meets the requirement. The amount of grain they require they get it from PDS and during the shortage they purchase it from the market by the money they earn by selling vegetables. Also they have started growing Areca nut Plantations in large scale. They give the plantations in lease for a period of time to the people of the local by areas who sells beetle nut to the other places of the state and also outside the state. This has also become a source of income of the villagers from which they earn every year.

With the growing population, the use of water has increased. So now just 6 wells is not serving the purpose. The village has got now 7 bore wells too to meet the demand of water with the increase in population. With no other support from the Government, people have started constructing bore wells, as no other option is left out with them as the level of water is decreasing day by day.

3. Lessons from the fieldwork in Assam – The eightfold path

This is a multi-state study of locally appropriate solutions of groundwater management to draw policy lessons from them. In each state, we found exceptional work at micro level ensuring sustainable, efficient and equitable management of groundwater resources. Based on our findings from ten different states, we have developed eight principles which can guide our policy formulation and actions on ground. This section attempts to describe this eightfold path in the context of Assam.

3.1 Need for a new approach to achieve sustainable, equitable, efficient use

Assam has mostly plain areas of low elevation, a large number of rivers and hills of low elevation in Karbi Anglong, North Cachar Hills and Cachar districts in the southern region. Assam has extensive rivers system consisting of Brahmaputra, Barak and other main rivers. All the rivers in Assam are liable to floods, mainly because they receive heavy rainfall within a short time in the state and its neighbourhood (Himalaya) where water runs very fast into Assam which has mostly low elevation.

Hydro geologically the state can be divided into three units namely consolidated formation, semi consolidated formation and unconsolidated formation. More than 75% of the state is underlain by unconsolidated formation comprising of clay, silt, sand, gravel, pebble and boulders. The Bhabar belt is about 11 to 15 km wide; the tube wells yield 27 to 59 m3/hr in this zone. The Tarai zone follows immediately down slope of the Bhabar zone where the yield of the wells ranges between 80-240 m3/hr.

Hydrological and hydro-geologically, Assam is a very diverse state in the North Eastern part of India. While, most of its river overflows during monsoon, a large part of the state faces water crisis during summer. Geological formations across the state further diversify groundwater aquifers leading to huge variations in the availability of water. In such conditions, locally appropriate approaches for groundwater recharge and withdrawal is important.

3.2 The efficacy of participatory data collection

The Directorate of Geology and Mining, Assam set up a Ground water Cell in the year 1967 to explore and exploit the ground water resources on scientific line. It has carried out systematic hydro geological survey in some parts of the State for study of ground water condition and feasibility of development of ground water through deep and shallow tube wells. The Department, so far, has covered 50,000 sq km. areas by hydro geological studies with about 200 numbers of exploratory wells in different parts of the State and out of these 120 numbers have been converted to production well.

While there are mechanisms put in place to collect scientific data related to groundwater resources, these have not changed the management of groundwater at the local level. People who are the end users of the water resources need to be incorporated as main stakeholders in the process of data collection. Involving community members in the process of data collection not only ensure better quality of the data but also motivate people in general to innovate sustainable methods of groundwater management.

3.3 Understanding the prevailing policy framework and using it beneficially

Policies have a crucial role in regulating and managing natural resources to ensure sustainable usage and equitable distribution of benefits. Assam has developed a very comprehensive policy framework for the management of water resources. It has the Assam Embankment and Drainage Act, 1953 that provides for the construction, removal and upkeep of embankments and for the drainage and improvements of lands in Assam. Moreover, the Assam Embankment and Drainage Validation Act enacted in 1960 further strengthen the previous law by providing mechanism for levy water rate, betterment cess or premium on land improved by embankment and drainage scheme executed by the state government.

In terms of management of groundwater resources in the state, Assam has enacted the Assam Ground Water Control and Regulation Act in 2012 to regulate extraction of groundwater in the state. The state groundwater authority constituted under this law has power to notify rules for the regulation of groundwater extraction. In order to induct people in the system of water governance, the state had enacted the Assam Irrigation Water Users Act in 2004. This legislation provides for constitution of water users associations for the management of water for irrigation. The state has a very elaborate policy framework for the management of groundwater resources. It is important for the institutions and public to make better use of these policies. For example in the Khungtaibari village in Barobazar villagers used MGNREGA effectively to develop rainwater harvesting structure to augment supply of water.

3.4 Whistleblowing in the face of non-Implementation of laws and regulations

Once the community is involved with collecting the data and understands the prevailing policy, laws and regulations, it can become a watchdog against any violations. Moreover, demands can be raised for more appropriate laws and policies. Like in many other parts of the country, concerned individuals and institutions have been raising voices against non-implementation of existing laws in the state. India has updated its national water policy in 2012 that has set new priorities. Assam has yet to notify its water policy based on new national framework. Concerted efforts and voices from people would strengthen policy discourse leading to better management of groundwater resources in the state.

3.5 Planning for balancing demand with supply

The Total Annual Groundwater Recharge of the State has been estimated as 27.05 bcm and Annual Extractable Groundwater Resources is 21.97 bcm. The Current Annual Ground Water Extraction for all uses is 2.58 bcm and Stage of Ground Water Extraction is 11.73 %. As compared to 2017 assessment, the Total Annual Ground Water Recharge for the State has decreased from 28.67 bcm in 2017 to 27.05 bcm in 2020, Annual Extractable Ground Water Resources decreased from 24.26 bcm in 2017 to 21.97 bcm in 2020.

While the groundwater development in Assam is in the safe category, there is still need to work on supply and demand of water resources as the erratic weather conditions and long spells of hot weathers do creates water scarcity in the state. The state also struggles with flooding specially in the monsoon. Experiments in Khungtaibari and Chikajhora villages shows that how a single intervention of wells and lakes can leads to multiple benefits such as yearlong supply of water, flood control and increase in crop yield.

3.6 Enhancing supply by groundwater conservation and recharge

Khungtaibari village of Thuribari Village Council Development Committee (VCDC) in 2008 planned to develop a lake to address two problem, decrease in water availability in summer and excessive water in winter leading to flooding. With the help of VCDC a large lake was constructed under the MGNREGA scheme to harvest rain water. In the initial days everyone from village participated to construct the structure under MGNREGS. After a certain period of time due to irregularity in timely wage payment, people from the villages stopped working to create the structure. Also since the monsoon was approaching and they had very less time in their hands the work could not get completed. The structure got created but up to a depth of 2 to 3 feet at the corners and 4 to 5 feet in the middle of the structure.

The villagers thought of digging the structure more in the coming years. Now for that they thought of some alternative ways. They started contacting contractors who takes contract of building roads as soil is required for construction of roads initially. The contractors digged the structure in the middle of it up to a depth of 10 feet. This lake has helped in increasing the groundwater level, as other dug wells in the village are filled with water throughout the year. The increased availability of water has helped people to venture in new livelihood options such as fishery, duck and harvesting extra crop as more water is available for irrigation.

3.7 Rationalising demand for water by rationalising prices for crops and energy

India has 18% of world population, having 4% of world's fresh water, out of which 80% is used in agriculture. India receives an average of 4,000 billion cubic meters of precipitation every year. However, only 48% of it is used in India's surface and groundwater bodies. A dearth of storage procedure, lack of adequate infrastructure, inappropriate water management has created a situation where only 18-20% of the water is actually used. India's annual rainfall is around 1183 mm, out of which 75% is received in a short span of four months during monsoon (July to September). This result in run offs during monsoon and calls for irrigation investments for the rest of the year.

Examples documented in this report shows that wherever the supply of the water has increased due to locally appropriate solutions, the agricultural productivity has also increased. In many cases farmers have started harvesting two crops in a year. Such developments are really good, but it is necessary to rationalize demand to ensure sustainability of demand and supply of water. Moreover, pricing of energy and water is an important factor to ensure sustainability.

3.8 Building capacity of the community for the above functions is a must

It is very clear that the 'one size fits all' approach is not going to solve the problem of groundwater. Every step from groundwater recharge to the utilization of water has deep social, economic, geological, hydro geological and geo morphological underpinning. Therefore, it is necessary to understand physical and social sciences in each region to experiment locally appropriate solutions for groundwater management. Moreover, this exercise cannot be done without building capacities of the community. It is worth mentioning here that all successful interventions documented in this study have attempted to develop the capacity of people.

Rajiv Gandhi Institute for Contemporary Studies
Jawahar Bhawan, Dr Rajendra Prasad Road,
New Delhi 110 001 India
T- 011 2331 2456, 2375 5117 / 118

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