Groundwater Management in India

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

Uttar Pradesh State Report

December 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. Deepak Sharma
Md. Hidayatullah Azmi

Published by: Rajiv Gandhi Institute for Contemporary Studies, New Delhi

Groundwater Management in India

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

Uttar Pradesh State Report

December 2022

Rajiv Gandhi Institute for Contemporary Studies (RGICS)
Rajiv Gandhi Foundation
Jawahar Bhawan, New Delhi 110 001

Contents

Availability, utilisation and locally appropriate solutions for sustainable, equitable and efficient use of groundwater

Uttar Pradesh State Report

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.

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.

---

[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 Uttar Pradesh state report

2.1 Context and key features

The State of Uttar Pradesh forms a part of vast Gangetic Alluvial Plain covering an area of 2,40,928 Sq. Km (7.3% of total land of India) and it extends from latitude 23052'15'': 30025'05"N and longitude 77005'36": 84038'10"E. It is bounded by Uttarakhand on the NW, Nepal on the NE, Bihar on the East, Madhya Pradesh in the South, and Haryana, Delhi and Rajasthan in the West. Uttar Pradesh (UP) is spread over in 18 divisions, 75 districts, 822 blocks, 915 urban bodies, 13 Municipal corporations, 226 municipal boards, and 59163 Gram Sabhas.

Uttar Pradesh is the most populous State in India, accounting for 16.16 per cent of total population. The state is the most populous in the country with a population density of 649 persons per sq. km and a high rate of population growth (26%).The food production in UP is commensurate with the self-sufficiency of the country. Uttar Pradesh is primarily an agrarian economy with it being the largest producer of food grains and known as the food basket of India. South-easterly sloping, flat terrain with a gentle variable land slope, steeper in western part and flat in eastern.

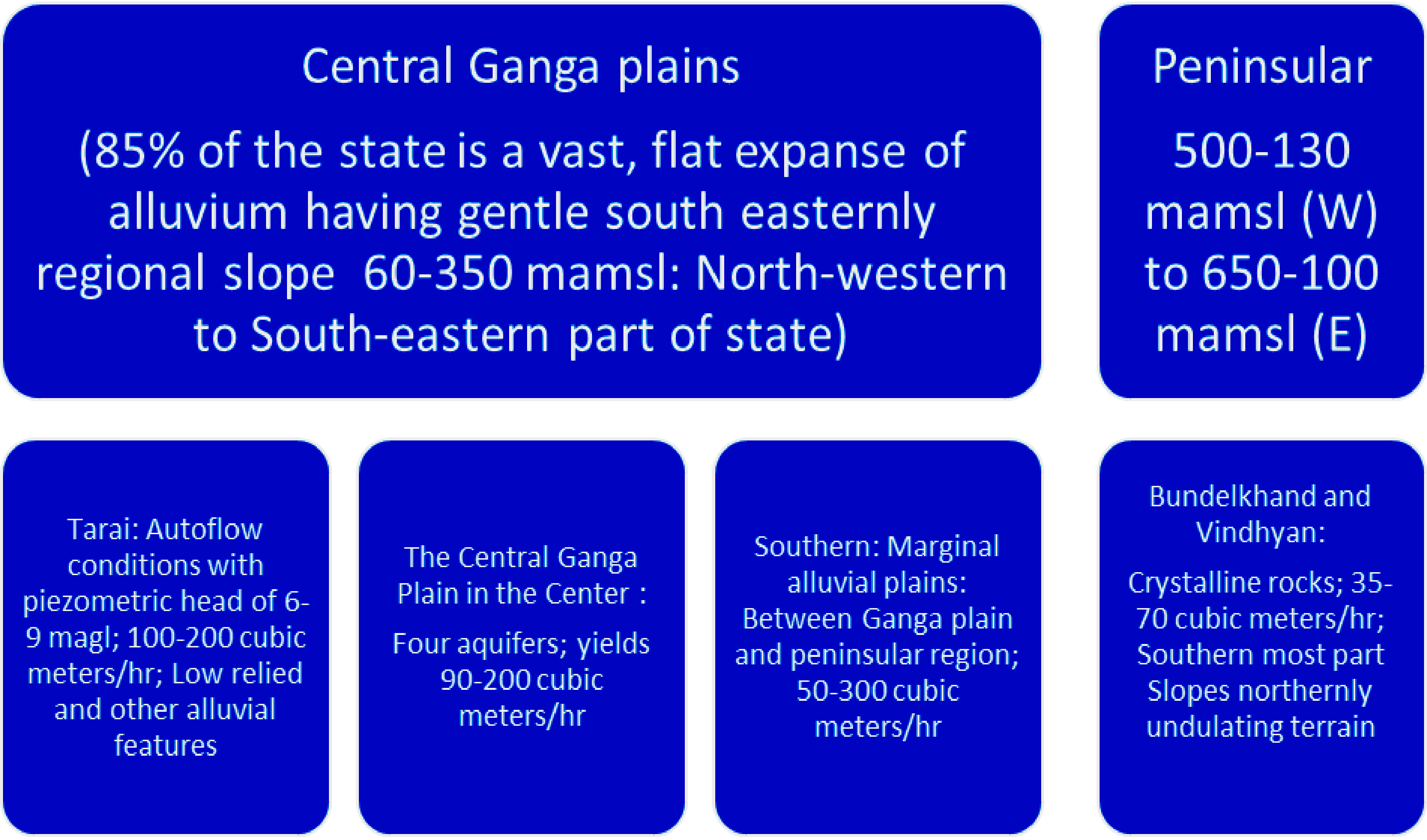
Uttar Pradesh has four distinct geographical regions namely the Western, Eastern, Central and Bundelkhand Regions having distinct hydro-geological, climatic, agronomic, and socio-economic conditions. Water availability and its management completely differ across these regions underlining the need for region specific strategies and institutional strengthening at the State, regional and local level, major river basins are Yamuna, Ganga, Ramganga, Rapti, Ghaghra, Gandak, Gomti and Sone.

It falls within the climatic zones Sub-humid to tropical climate with three distinct seasons- summer, monsoon, and winter. With the groundwater presence the state can be grouped in two regions

a)The largest groundwater repository in the country is the Central Ganga Plain with 85% region under it, unconsolidated alluvium sediment of quarter age overlying the Precambrian basement. This alluvium is a rich reservoir of groundwater, with four aquifer zones and extremely varying. The shallow one is highly exploited

b)Remaining 15% area under Bundelkhand plateau with Bijawar and Vindhyan group.

The present physiography and landforms are greatly determined by geological formations and structures and is the product of the past fluvial cycle of deposition from the Himalayan rivers. The State forms a part of Ganga basin. The master drainage of the state is river Ganga and its tributaries. The Ramganga, Ghaghra and Gomti are the main left bank tributaries, while the Yamuna is the main right bank tributary. All these rivers except Gomti originate from Himalayan ranges and are snow fed. Initially the rivers flow southward in the north-western part of the State, then turn south eastward and finally leave the State in an easterly direction.

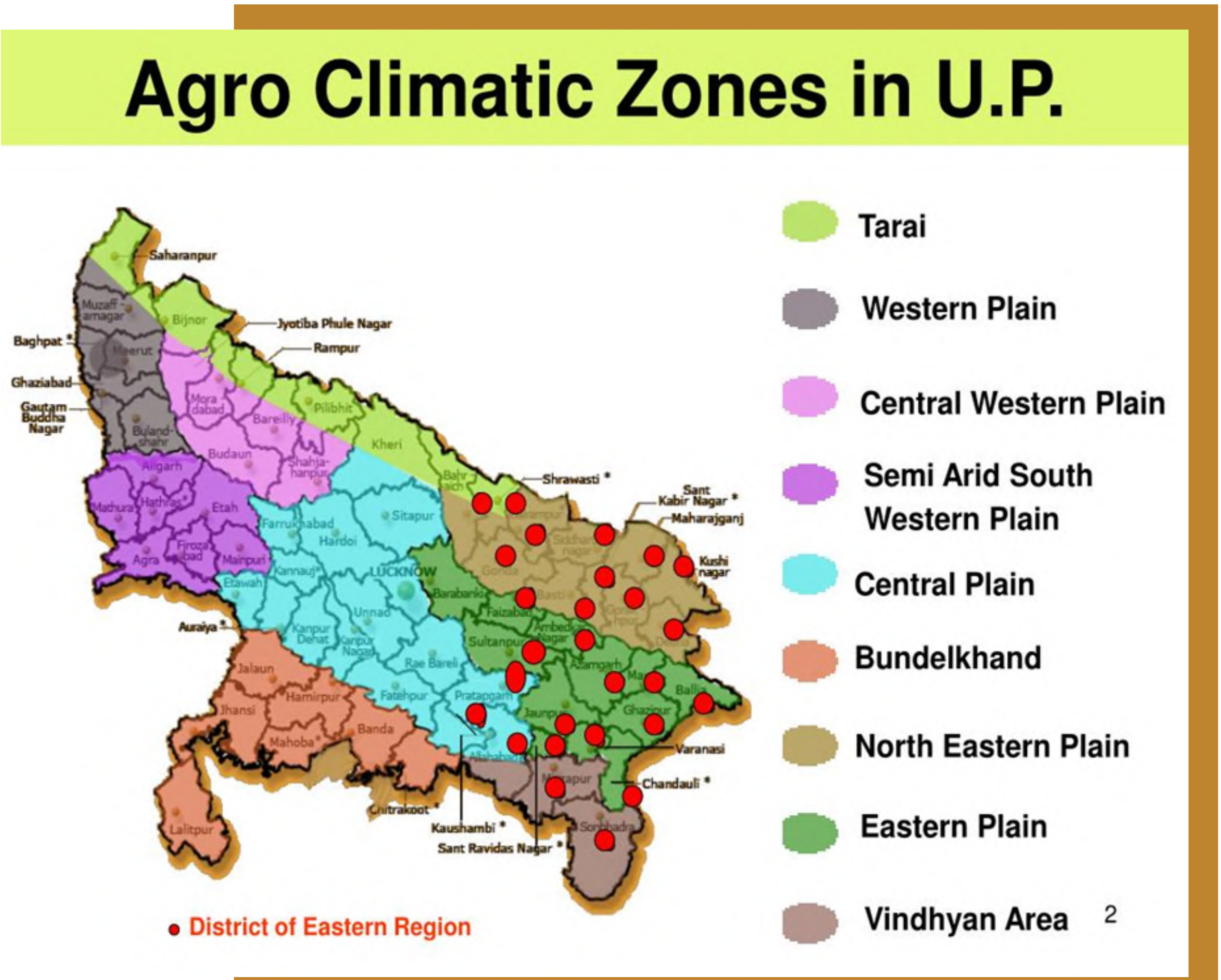


Physiographic divisions of Uttar-Pradesh

The State experiences a sub-humid and tropical climate with three distinct seasons' summer, monsoon and winter. The intervening periods are transitional period based on IMD long term normal data. The summer is hot and dry with maximum daily temperature ranging between 38°C to 43°C. The humidity during this season is lowest ranging between 30% to 53% at 08.30 hrs and 18% to 42% at 17.30 hrs.

Uttar Pradesh has nine agro-climatic regions, eight major river basins, and diversified hydrogeological setup mostly dominated by alluvial aquifers of the Gangetic plain and discontinuous aquifer system of Bundelkhand and Vindhyan. Uttar Pradesh is an agrarian state, where ground water resource has attained a prominent position as prime source of irrigation.

Climatically, the year in Uttar Pradesh can be divided into three major conventional seasons with two sub seasons in cold-weather Season. Summer seasons ends by May and transition period starts. The rainy season commences by late June when south western monsoon sets in over the State. The humidity gradually increases and reaches above 80%. August is the peak rainy season. The bulk of annual rainfall about 85% occurs during monsoon period (June to September). The monsoon starts retreating from the State in late September or early October. Then commences another transitional period followed by winter from late November till February. January is the coldest month of the period. Another transitional period follows between winter and summer.



Physiographic divisions of Uttar-Pradesh

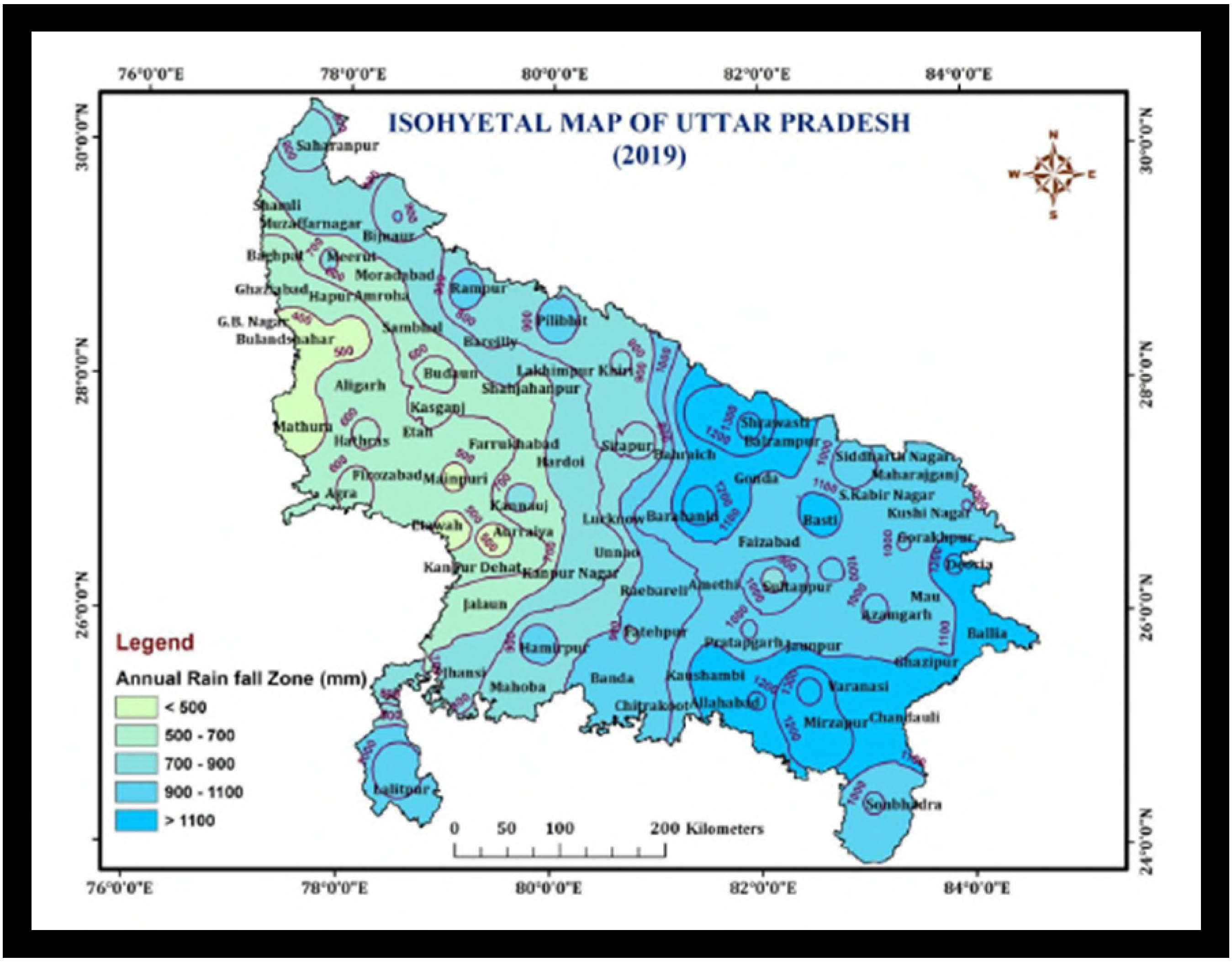
2.1.1 Temperature

There is large variation in temperature both in time and space. The lowest temperature is observed during January when night temperature ranges between 2°C and 6°C, over the state. With the start of summer, the temperature starts rising with maximum during May when the mercury may touch 45°C in central and eastern parts of the State. Gradually with the beginning of rainy season the temperature drops which again shows a mild rising trend during the intervening period before winter (October, November). The wind speed varies between 8-10 km/hr during summer season and 4-6 km/hr during winter and rainy seasons. The wind is mainly south westerly during summer and south easterly during winter.

The Normal annual potential Evapotranspiration of Uttar Pradesh is 1491.5 mm. The Normal annual potential Evapotranspiration of East Uttar Pradesh is 1484.0 mm and of West Uttar Pradesh is 1499.0 mm. The monthly normal potential Evapotranspiration is high in hot months and low in winter months. Normal potential Evapotranspiration is highest in the month of May with value of 217.8 mm fallowed by June with value of 201.6 mm. The normal potential Evapotranspiration is lowest in the month of December with value of 50.7 mm fallowed by January with value of 55.6 mm.

2.1.2 Rainfall

The rainfall is variable over the State ranging from maximum 1358.92 to minimum of381.96 mm at Sant Ravi das Nagar and Gautam Budh Nagar district respectively. The normal rainfall of the State is 955 mm and the average annual rainfall for the year 2019 is868. 45mm.The amount of average monsoonal rainfall of 761.15mm received during 2019 is less than 9.0 % from the average normal monsoonal rainfall. Drought analysis has been carried out for all the based on annual rainfall received during the 2019. It was observed that 04 districts fall under scanty rain fall category and another 23 and 39 districts under deficit and normal category respectively.

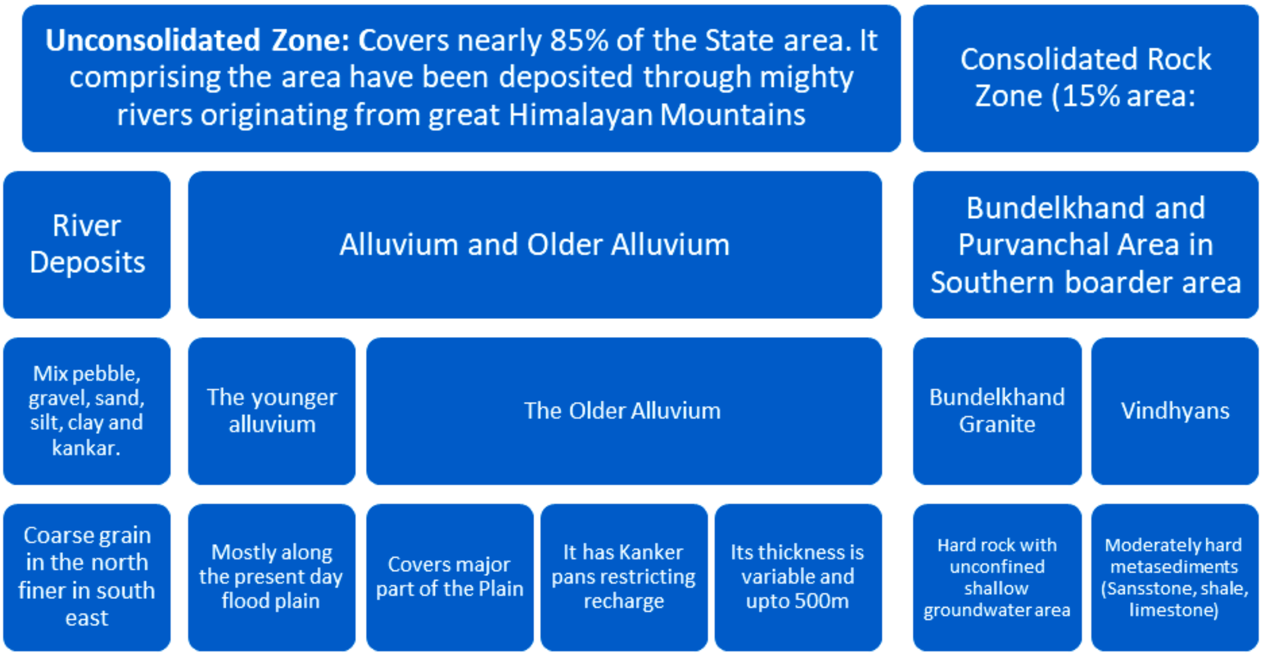


Rainfall Pattern of the state

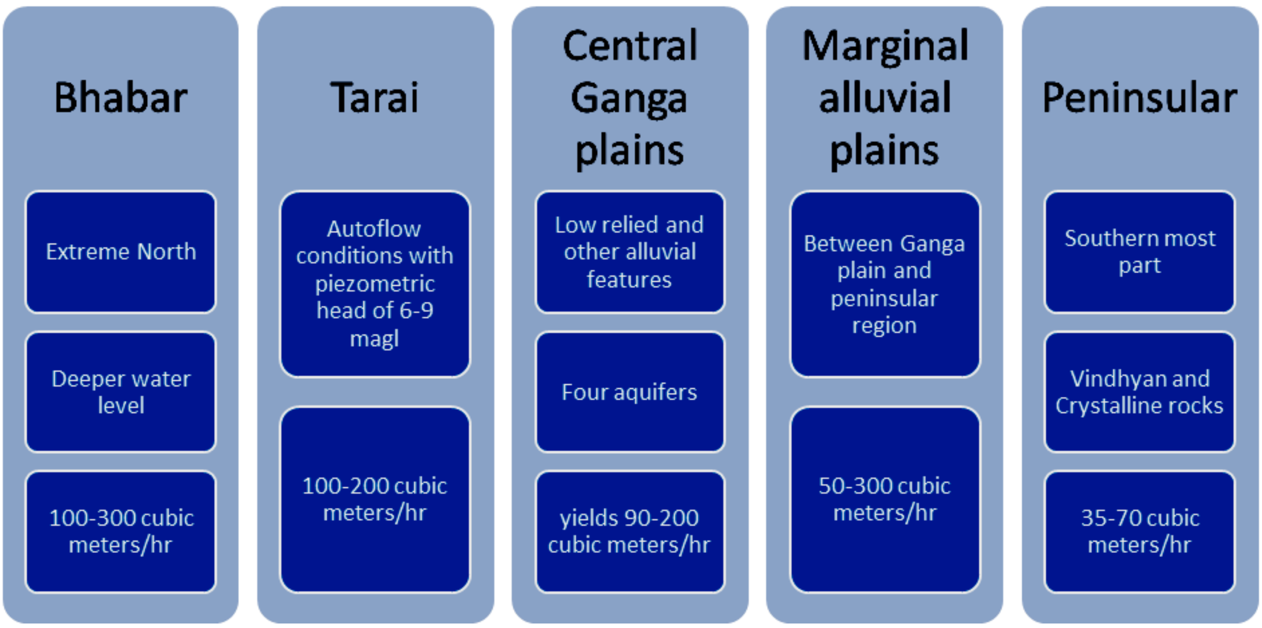
The State of Uttar Pradesh comprises an area of about 2,40,928 sq. km and forms one of the largest states in the country and is characterized by rock formations ranging in age from the Archean (the Bundelkhand Granitic gneisses) to the Recent (the Ganga alluvium). The Indo-Gangetic alluvial plain covers about 2/3rd area of the state in the north. This plain is practically devoid of valuable mineral resource. The southern hills comprising Bundelkhand granite and Vindhyan sandstone plateau. The hills and plateau bordering the southern margin of the state covers about 51,393 sq. km. area, comprises the hard rock in which the mineral deposits of the state are located. This area forms the northern part of the peninsular India.

2.1.3 Geo-Hydrology

The geology and structure of the formations existing in an area control occurrence and movement of ground water. The geomorphic conditions also have a great impact on groundwater scenario. The larger part of the State is underlain by fluvial sediments laid down in the fore deep between Plateau region in south and Himalayas in north during the Quaternary period by the Indus-Ganga system of drainage over the Precambrian topography existing during geological past. These deposits owe their origin to riverine activity. The southern part of the State has entirely different geological conditions being underlain by Precambrian formations under a thin alluvial cover. Broadly, the State can be divided into two hydro-geological units.



Aquifer Type giving break-up

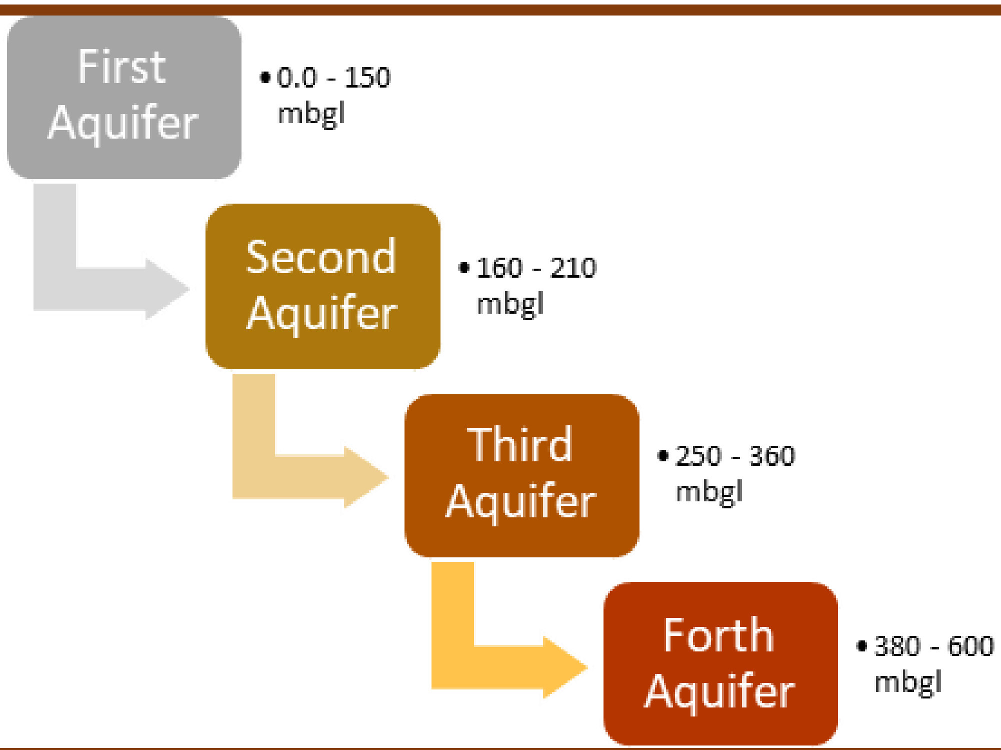


Different regions and their groundwater situation

2.1.4 Unconsolidated regions

The Ganga plain which dominates the landscape and nearly covers three fourth of the geographical area of the State, lies between the rocky Himalayan belt in the north and the southern hilly tract comprised of mainly Pre-Cambrian rocks. Flexing of the Indian lithosphere in response to the compressive forces due to collision and thrust fold loading produced the Ganga Plain foreland basin. It is filled with recent alluvial sediments which is at places more than 1,000 m. thick and amalgam of sand, silt, clay in varying proportions. Below unconsolidated alluvium occurs the semi-consolidated Upper Siwalik formation.

The Shallower basement occurs in isolated areas which are known as "Basement highs." This unconsolidated zone is porous and permeable with primary intergranular porosity and has good ground water potential. The sub-surface correlation of formations in the state has shown presence of several aquifers down to a depth of 750 m below the ground. These aquifers mainly encountered in Central Ganga Plain have been grouped based on lithological characters as well as based on interpretation of electrical logs of Boreholes drilled as shown.



Vertical variation of Aquifers

The upper part of first aquifer down to 50 mbgl is the main source of drinking water through hand pumps and dug wells and is unconfined in nature. The first aquifer which is under unconfined to semi-confined conditions is the most potential aquifer group which is the main source of groundwater in the State extensively exploited through private as well as Government tube wells to meet the drinking water and irrigation needs. The deeper aquifers are confined in nature being exploited to a very limited extent. The yield of second aquifer is limited while the third aquifer is potential.

2.1.5 Consolidated zone

The Fissured formations, as hydrogeological unit, occupy only 15 % area of the state and can be broadly classified into two units: Consolidated sedimentary rocks, and Igneous. The Bundelkhand Vindhyan plateau region is underlain by variety of Precambrian formations, mostly granite and granite gneisses, Vindhyan sandstone, limestone and shale, under a thin alluvial cover or without alluvial cover. As such these formations are hard and compact and devoid of any primary porosity. The ground water in these formations occurs in the secondary porosity of these formations.

The secondary porosity has developed due to cracks and fractures which are open at the surface and tighten at depth. The ground water occurs under unconfined or water level conditions in these formations. The alluvial sediments of moderate depth along the river courses and in valleys form potential groundwater repositories. The weathered mantle over the entire unit also forms potential aquifers. These aquifers are being monitored mostly through open wells over the area.

The groundwater storage is largely controlled by the prevailing hydro-geological and geomorphic conditions. Besides, magnitude of input (recharge) to the ground water system and output (discharge) from it also influences the status of ground water regime.

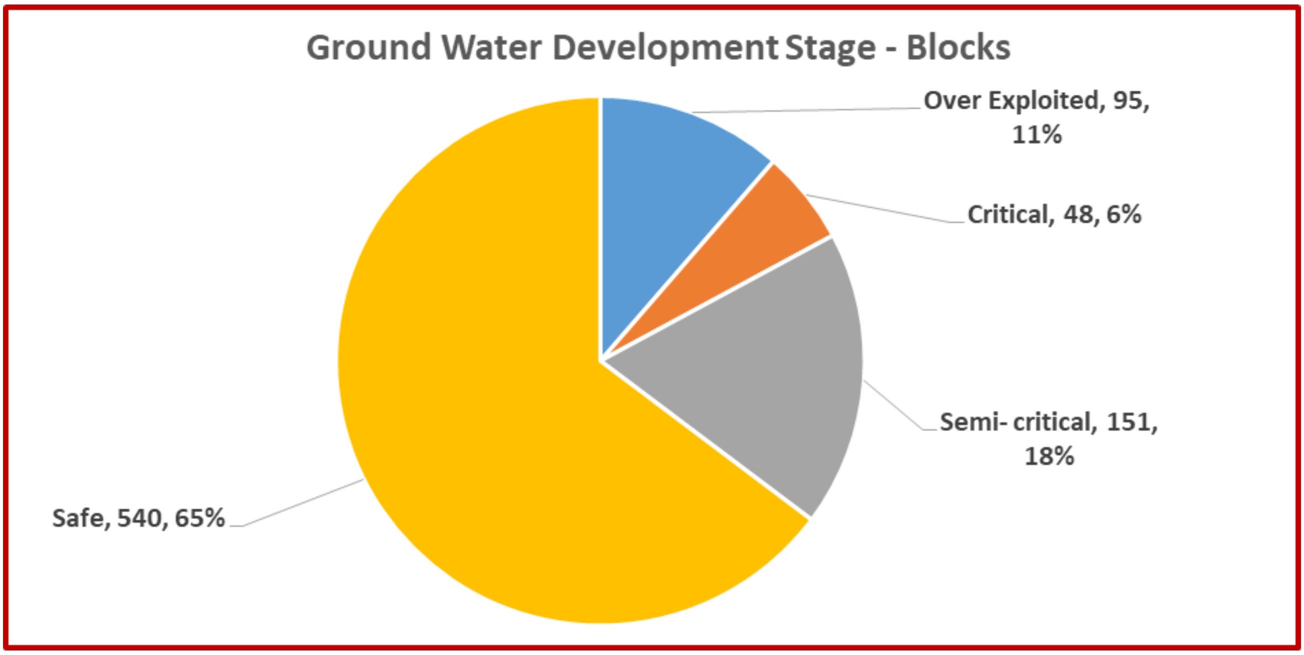
In the State of Uttar Pradesh hydrogeological as well as the geomorphological conditions are highly variable as evident from earlier chapters. The chief source of recharge to storage is rainfall which is highly variable over space and time. The main source of discharge is ground water abstraction which is also varying and growing exponentially. The regions having ground water as the main source for irrigation always remain under heavy stress. The imbalance between the recharge and discharge expresses itself in terms of variations in the ground water level. Thus, the water level is a very important parameter for ground water studies.

2.2 Ground water availability and utilization

The ground water monitoring is being carried out through a network of observation wells- the National Hydrograph Network Stations (NHS). The National Hydrograph Network set-up is a system of spatially distributed observation points at which periodic monitoring of ground water and regime behaviour. The major portion of Uttar Pradesh is covered by Ganga-Basin. The state is known for having the richest repository of ground water resource as it comprises the largest aquifer systems in the world. The significance of the ground water resource can be judged by the fact that 75% of the irrigated agriculture is mainly dependent on ground water resources. The ground water availability in UP is estimated at 56.93 MAF. Allowing for other uses ground water useable for irrigation is about 48.42 MAF, of which 36.82 MAF is already being utilized.

Annual Replenishable Ground Water Resource: 76.35 BCM
Net Available Ground Water Availability: 70.18 BCM
Annual Ground Water Draft : 48.78 BCM
Stage of Groundwater Development: 70 %
Reserved for Drinking: 8.52 BCM

Further, 80-90% of the drinking water and about 85% of all the industrial needs are fulfilled by ground water. In agriculture, industrial and urban areas after the decade of 70's, unprecedented development/withdrawal of groundwater has been witnessed. While agricultural productivity has increased because of groundwater based irrigation, the contribution of this resource is also the maximum in fulfilling the water demand for drinking water and industrial sectors.



Groundwater Development Stage Graph

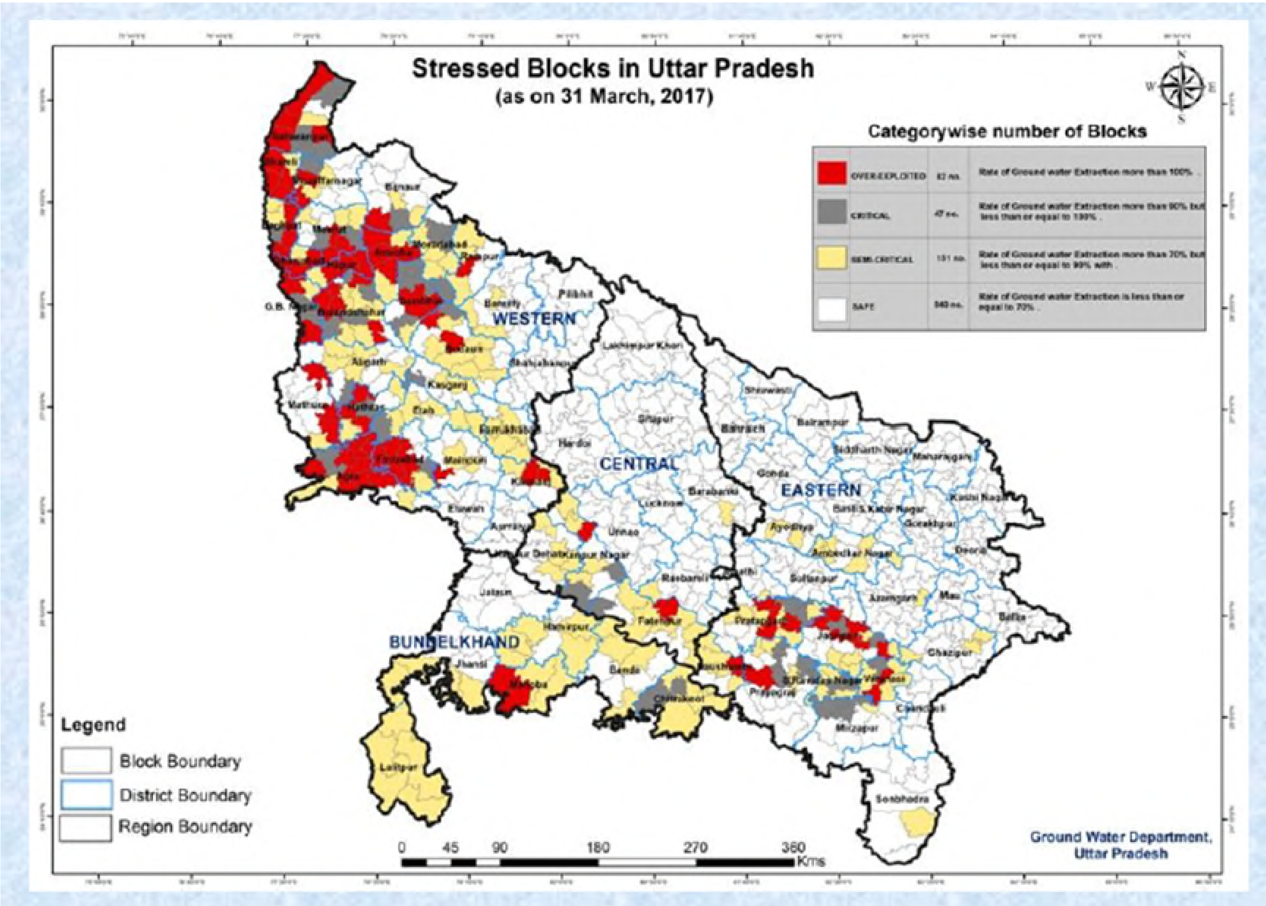
But due to its unplanned and unlimited exploitation, adverse effects are also being noticed which mainly include problems like water-level decline, reduced availability of groundwater, failure of tube-wells, ground-water pollution, etc. As a (2) result, and as a matter of concern, marked shortage is observed in ground-water resource availability in many parts of the state both in urban and rural areas.

2.2.1 Extent of groundwater extraction

Uttar Pradesh is the largest extractor of groundwater in India accounting for 18.4% of the total national and 4.5% of the total global groundwater extraction. The per capita groundwater extraction in UP is 224.97cum compared to a national average of 182.86 cum and a global average of 125.89 cum. In result 138 development blocks are in overexploited, critical, or semi-critical stage. A rapid growth in the demand for water due to population growth, urbanization and changing lifestyles pose serious challenges to water security in the State. There is wide temporal and spatial variation in the availability of water, which may increase substantially due to climate changes, causing more water crisis and incidences of water related disasters, i.e., floods, increased erosion, and increased frequency of droughts, etc.

The inadequate management of water resources has also led to a critical situation in dry rain fed areas like the Bundelkhand and Vindhya region. Access to safe water for drinking and other domestic requirements continues to be a problem in many districts. Groundwater is exploited inequitably and without any consideration to its sustainability thereby leading to its over-exploitation.

As per NITI Ayog, report; Uttar Pradesh also ranks negatively in all major domains about performance indicators for water sector development including- Groundwater Source Augmentation (-1.51), Watershed Development – Supply Side Management (-3.21), Demand Side Management Participatory Irrigation Practices (-0.01), Demand Side Management Sustainable on-farm Water Use Practices (-0.88) and Rural Drinking Water (-0.53).



In the State, ground water resources are mainly used in water-based schemes- - Irrigation -70%; Drinking Water-80 %; Industrial sector- 85%. Growing dependency on ground water resources can be assessed by the fact that the rate of ground water development/ exploitation assessed as 54.31% in the year 2000, has increased to 72.16% in the year 2009.

To meet this high irrigational requirement, ground water contributes to about 71% of the irrigation needs of the State. The indiscriminate development of ground water has resulted in depletion of groundwater storage and lowering of water level in certain areas on one hand.

On other side the surface water development in areas having shallow water level has resulted in water logging and soil salinization. All these negative impacts on the resource give rise to the need for regular and continuous monitoring of the ground water regime. The monitoring data forms the base of management practices. To manage the water resources and plan development on scientific lines a data base needs to be generated. In view of relative importance of this valuable resource it becomes imperative to adopt sound and scientific management of groundwater resources.

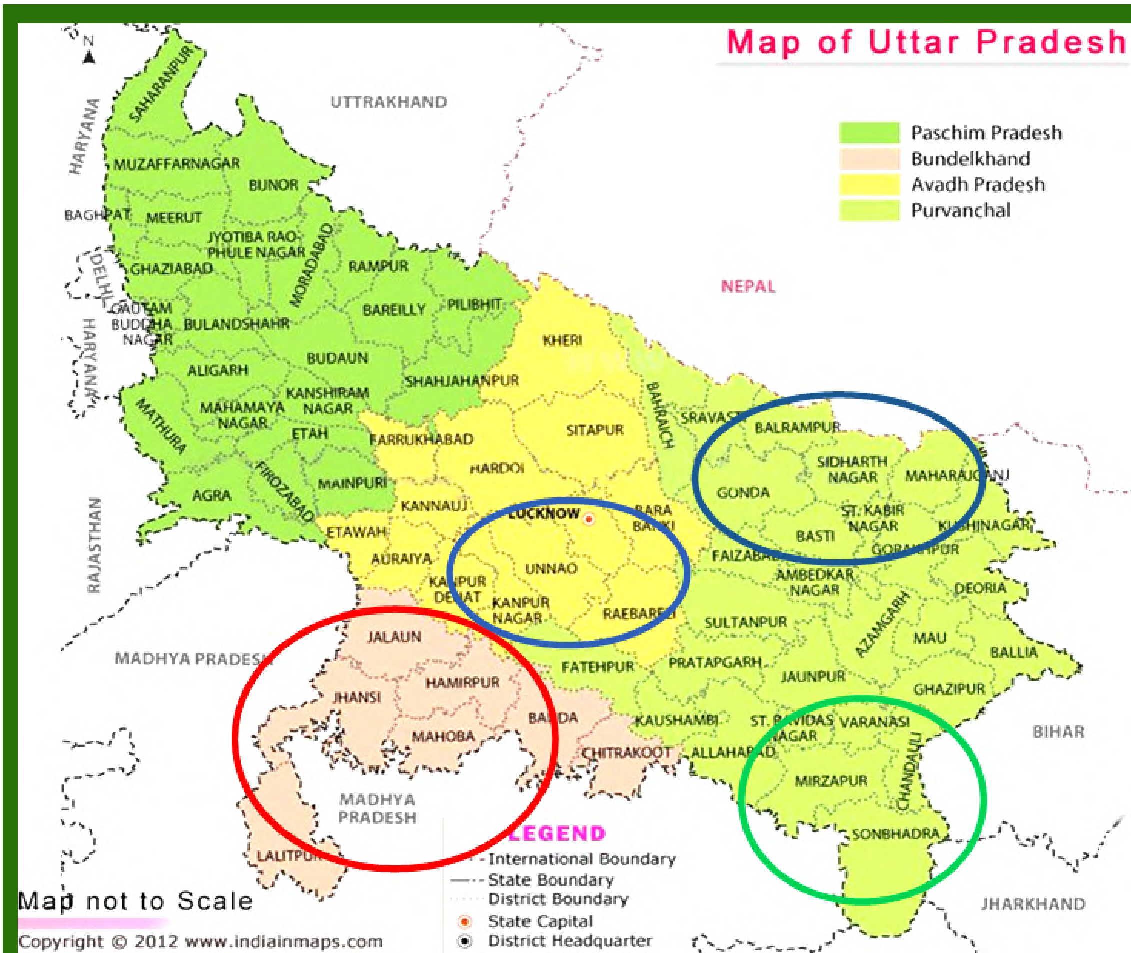
2.3 Groundwater policies and governance in the State

Major Policies and Legislations Governing Ground Water Resources in Uttar Pradesh	
Uttar Pradesh State Water Policy, 2010	• There shall be constituted a Gram Panchayat Ground Water Sub-Committee in every Gram Panchayat, which shall be the lowest public unit in rural areas within a block to protect and manage ground water resources under this Act. • There shall be constituted a Block Panchayat Ground Water Management Committee, which shall be a public unit at block level for overall management of ground water. • There shall be constituted a Municipal Water Management Committee, which shall be the lowest public unit for managing water in urban areas in an integrated manner. • There shall be constituted a District Ground Water Management Council, which shall be an overall unit for management of ground water resources at district level. • Formation of state ground water management and regulatory authority
Ground Water (Management and Regulation) Act, 2019 and Rules, 2020	• Constitution of Uttar Pradesh Ground Water Management and Regulatory Authority in the chairmanship of chief secretary • Constitution of ground water subcommittee at panchayat level • Constitution of ground water management committee at block panchayat level and at the level of municipal body. • Constitution of ground water management council at district level. • The authority has power notify areas for management and regulation of ground water resources. • Registration of existing commercial, industrial, infrastructural and bulk users of Ground Water. • Preparation and implementation of Ground Water Security Plans in notified areas • Grant of Authorisation for Ground Water abstraction in Non-notified Areas
The Uttar Pradesh Participatory Irrigation Management Act, 2009 And Rules 2010	• Empowers water users' association (WUA) to manage and maintain the irrigation system given in its charge, and to do all things necessary, proper or expedient for the safety and security of the Government property under its control and management provided that no water users. • For the purpose of supply of bulk water to the water users' associations and related issues, the distributary level water users' association shall enter into an agreement with the Irrigation Department • Every water users' association shall prepare its crop plan according to its Water budgeting water budget taking into account conjunctive use of surface and ground water well before the crop season and accordingly plan a preliminary irrigation programme, in consultation with the competent canal officer

2.4 Locally appropriate solutions for groundwater management

Even though there are many technicalities involved, groundwater development is a 'People's programme', and the actions of state of Uttar Pradesh proves that. Traditional systems of community, actions of CSOs, and even government run program in the state are focused on education and involvement of people on conjunctive use. Focuses is on involvement in overall management of water following IWRM including development, conservation, protection, and augmentation will be the prime requisite to protect resource against quality degradation and guarantee quality assurance. Mass awareness programmes aimed at educating the users regarding the adverse effects of over-exploitation of ground water on its quality and quantity, economic and efficient use of water, voluntary regulation of abstraction, etc. will ensure utilisation of the resource at optimal levels

In Uttar Pradesh, a lot more be done for community participation and creating public awareness in the field of groundwater conservation and management. The experience of water conservation in Jakhni village, water campaign in Banda district, on farm harvesting in Andhao village, Baberu and successful concept of Jal Chaupal should be scaled up and restructured with more innovative project designs for implementation in the field. Bhujal Seán is already in place in all the districts of the state along with various social groups like Pani Panchayat, Jal Saheli, WUA. These groups should be integrated and assigned with the responsibility of taking up different awareness campaigns at the local level.



Map showing regions where local actions were explored

2.4.1 Efficient water management in Tannery

India is the second largest exporter of leather garments, third largest exporter of Saddlery and Harness and fourth largest exporter of Leather Goods in the world. Some of the major production centres for footwear, leather and leather products in India are located in; Uttar Pradesh – Kanpur, Unnao, Agra, Noida and Saharanpur. With over 2000 tanneries in India of which nearly 20% located in Central Ganga Plain of Uttar Pradesh. During leather processing, the hides and skin undergoes a series of pre-tanning, tanning and post-tanning operations.

Water is an input material used in large quantities most if not all the processes of tanning and finishing of the animal skins and hides. The quantity of water used in processing a kg of hide/skin is about 40–45 litres from raw to finish consumes 30 billion litres water in India. The water use in tanneries results in two high demand and pollution load. The industry mostly depend on groundwater utilization, thus is of major concern for study also.

Quantity of Water for different processes in Tanning[4]

S.no.	Tanning Processes	Water Consumed
1	Raw to finish	40 - 45 l/kg of raw weight
2	Raw to E.I.	25 - 30 l/kg of raw weight
3	E.I. to finish	50 - 60 l/kg of E.I. weight
4	Raw to wet blue	25 - 30 l/kg of raw weight
5	Wet blue to finish	20 - 25 l/kg of wet blue weight
6	Crust to finish	10 - 15 l/kg of crust weight

Minimization of water use and reuse applications within industry has recently gained importance within the context of water conservation efforts. King's International is a Government of India Recognised Export House, which Manufacturer-exporter of Saddlery and Harness goods for 25 years. It is an ISO 9002 certified company for Quality Management System, which is ISO 14001 accredited company for Environmental Management System. It is also OHSAS 18001 certified company for Occupational Health and Safety Management System. The company applies state-of-the-art-technology tannery deploying eco-friendly tanning process.

A modern, purpose-built, mechanized Saddlery/Belt making facility. The Company has applied a computer managed system of water management in different processes particularly in drumming. It has reduced its consumption of water to 18 litres in processing a kg of hide/skin as against the government approved norms of 30–35 litres, which is almost half. Thus, exploring the potential of such system to reduce consumption of water in tannery industry can be a milestone for groundwater management in the country.

4 https://www.eolss.net/sample-chapters/c07/E6-144-16.pdf

2.4.2 Talab rejuvenation (Western Uttar Pradesh)

PANI (People's Action for National Integration) is implementing the Hindustan Unilever Foundation funded program 'Water for Public good', under implementation in cluster of selected villages in 10 districts of Eastern Uttar Pradesh. 10 grass root NGO sub-partners of PANI are involved for ground implementation of project with the prime goals to improve water productivity through improvement of various water management practices.

The programme collaborated with the Gram Panchayat and utilised the provision of MNREGA (Mahatma Gandhi National Rural Employment Guarantee Act) to renovate the existing ponds by the convergence of public funds.MNREGA provision is optimized to renovate and maintain water bodies. While the provision allows for infrastructural support of the water bodies, the community is sensitized towards collective monitoring of water consumption. Subsequent demands as per the situation of the water needs are raised by the community thus creating a viable and sustainable model of water management. Innovation was felt to create an environment for the community to understand and initiate into the process.

For this, exposure visits were conducted where in the Gram Pradhan (head of village council) and selected influential and active farmers from 2 selected location of the project area were invited to witness demonstration models set up in Gujarat; Implementation A methodical and step by step process was adopted keeping the priority as orientation, sensitization, and mobilization of the community towards importance of ponds, ground water recharge and collective management of water resources.

2.4.3 Watershed and groundwater

Limited groundwater movements characterize the Indian peninsula's hard-rock regions except for localized secondary openings. In such a region's groundwater occurrence is mainly within the shallow aquifer zone with a depth of less than 50 to 150 m below ground level. In Uttar Pradesh southern districts bordering Madhya-Pradesh are covered by hard rocks that are mostly sedimentary origin rocks of Vindhyan Formation.

Ground water movement among these rocks are restricted to fractured and weathered zones, but some parts of districts of Sonbhadra, Mirzapur, Chitrakoot, Banda, Mahoba, Lalitpur, and Jhansi obtain water supplies from surface water bodies and surrounding area's groundwater stored in these rocks. It is especially true for large rural tracts that obtain water for agriculture and domestic supplies entirely from the groundwater stored in these rocks. There are ephemeral rivers in these areas originating in uplands of Madhya-Pradesh emptying in Yamuna and Ganga. Major rivers passing through this area are Ken, Betwa, groundwater plays an essential role in the district's farmers' economy.

Watershed is a natural hydrologic land, where flow of rainwater is controlled by the existing drainage network and geomorphic features. Every watershed behaves differently to flow of the rainwater, being dependant on the drainage and its hydrologic characteristics, largely controlled by geomorphology of the area. The geomorphology, in conjunction with geological setting, is characterised by various fluvial and denudational landforms, which comprise recharge and non-recharge areas.

The understanding of watershed geomorphology and based on this, the derived water conservation measures, if suitably implemented, would prove to be a potential technological intervention for complex terrain of Bundelkhand and Vindhyan. Watershed geomorphology-based approach in such rocky terrain would certainly achieve desired results.

In these aquifers, groundwater occurs under an un-confined condition in the weathered mantle cover and semi-confined to a confined state in underlying fissured, fractured, and jointed hard rock. The volume of groundwater stored under semi-confined conditions within the hard rock body is much lower than the overlying phreatic aquifer, which is often much more significant.

Hydraulically connected fissures and fractures underlying weathered mantle cover generally serves as a permeable conduit feeding the deeper wells. In unconfined aquifer conditions, groundwater flow rarely occurs across the topographical water divides. Thus, each basin or sub-basin can be treated as a separate hydrogeological unit for planning the development of dynamic groundwater resources.

The project interventions of decentralized water harvesting in the form of small masonry check-dams, earthen-nala bund, dry-stone pond, and recharge-pits have provided scope for enhancing the poor's resilience and marginal community in the area by increasing the water holding capacity of the watershed.

Most wells are shallow (depth range 5-10 meters) located along/near the secondary and primary stream. It indicates that there is scope for extending the depth of such shallow pits to 10-12 meters depth to tap additional fractures and create scope for socially just utilization of groundwater to benefit the wider community. The frequency of right fractures and, in-turn potential to get a higher discharge in deeper zones is remote. Though some families have tried to create borewells to the range of 120-150 meters in recent years, their yields are limited to help domestic supply and support small kitchen gardens mainly.

In the watershed's upper reaches, some additional water-harvesting sites can extend the period of water availability in shallow wells and can impact small and marginal farmers' overall livelihoods. In this highly undulating terrain, agriculture fields are highly vulnerable because of exposure to extreme precipitation events. Interventions like FB, GP, CCB, and CSB can further help in capturing eroded soil in-situ. Still, they may take many years thus to address this vulnerability and build faster resilience approaches like step-cultivation, agro-forestry, sloping agriculture land technologies, etc. are useful.

Shallow wells that are typically tapping dynamic groundwater within the depth range of zero to ten meters below ground level can be further developed into good wells reaching up-to 10-12 meters. They tap base flow to help farmers for life-saving irrigation to Kharif crops during the year of low rainfall. It also gives some additional shallow wells to provide supplementary watering for Rabi crops to improve water-use efficiency in the watershed.

2.4.4 Haveli system

In the Bundelkhand region of Uttar Pradesh the slopes moderate and valleys are wide with think zone of weathered and fractured granite and sandstones of Vindhyan rock system. In such region ICRISAT along with a few civil societies worked in revival of the Haveli System.

The approach is somewhat like that of small-scale water harvesting following the principles of ridge to valley. Upper reaches are treated using soil and water conservation measures of trenching, bunding, gully-plug, loose stone check dam, etc. They are further supported with masonry check dam and earthen ponds. Such structure created in upper parts of the area along with the stream flow diversion to optimize application of water for agriculture purpose.

International Crop Research Institute for the Semi-Arid Tropics-ICRISAT was actively involved in revival of the haveli system of rainwater harvesting as one of the age-old practices in central India and were the lifelines of the region, supporting the need for freshwater for agriculture and domestic sector.

Arial View of Haveli System in Bundelkhand

The Haveli system, practiced over the past 200 years in the region, involves draining of water from 10-100-ha catchment area and its harvesting in downstream field by constructing earthen embankments across the slope; about 2-10 ha land is allowed to be submerged during monsoon. The harvested water is drained out by mid-October and farmers can cultivate their land using residual soil moisture.

The system shown above is from village Poora-Birdha, Lalitpur district, where runoff generated from hillocks was guided through field drainage channels to the haveli system. A 3-kilometer-long diversion drain was excavated, and the drainage network was widened.

In addition, this channel was also treated by constructing masonry plugs (also called nala plugs in parlance) at suitable intervals to harvest additional freshwater besides facilitating draining of the runoff to the downstream area. Altogether, 1.5 lakhs cubic meter storage capacity was created in Poora-Birdha village which is harvesting about 6 to 8 lakhs cubic meter freshwater per year.

As a result, the water levels in wells increases post monsoon by 2-5 m compared to baseline and remain increased for additional two to three months. This system offers potential to transform a prosperous landscape with adequate water availability. With realization of improved surface and groundwater availability, several tribal farmers who used to migrate to urban areas have come back. ICRISAT indicated that thousands of such havelis are lying defunct in the region and their renovation can lead to better water conservation and improved crop productivity in a cost-effective way.

Compared to check dams, havelis come with numerous benefits. Renovating a *haveli* is 10 times cheaper, the water storage capacity is on an average 20 times more and the productivity of crops grown on the silt-rich soil of the drained reservoir during the postrainy (*rabi*) season is higher. ICRISAT shared their observations from a study in one of our CSR Supported watershed projects in Jhansi district.

The *havelis* built centuries ago were designed in topographical sequence such that the runoff generated is harvested in a cascading manner from upstream to downstream (Prakash et al., 1998; Shah et al., 2003). The haveli acted as a reservoir during monsoon and as cultivable land post-monsoon. Provision was made to drain out impounded water during September /October to help farmers start preparing their land for rabi cultivation. Productivity of the haveli fields is relatively higher as it holds more residual moisture, humus, and nutrients as it also harvests silt and organic matter from the upstream fields.

It is important to note that check dams are built across village streams belonging to public/government land. Since havelis are generally located on land owned by farmers/community, their rejuvenation/repair will need community agreement. The community is aware about defunct havelis, their history and potential benefits. Incentivizing the communities to arrive at a consensus, sensitizing policy makers, identifying suitable technical expertise and capacity building are necessary to scale up haveli renovation/repair on a large scale.

The zone of influence of havelis from groundwater recharge can be much larger compared to check dams making them a preferred option of rainwater harvesting. There is a strong need to articulate the cost and benefit aspects of haveli structures in a simple and effective way to help policy makers make a right choice when it comes to large-scale investments in drought-proofing measures.

2.4.5 Judicious use of water through sensitization

The Gangetic plains, which is a fertile plain, chiefly an agrarian zone with high population density and low per capita farmland holding, resulting into a mounting pressure on natural resources, including water. A water intensive cropping pattern has evolved and adopted by farming community in the region over decades of research and introduction of improved high yielding crops and varieties, to meet the food demand and economic wellbeing of farming households. Since availability of water is plenty and energy is not a limiting factor, with no cost attached to water as it is, the use of water in agriculture and for day-to-day domestic course and agriculture irrigation is more than liberal and with almost no recycling of waste / used water.

Overall, the sensitivity of community towards water uses and water productivity across the plains is very low. With strong belief of individual ownership on ground water, it is considered as a commodity, which is free of cost and never lasting resource, promoting indiscriminate and mindless application of water, especially in agriculture. It is also traded among community as irrigation water selling by 'haves' to 'have-nots' is common.

People's Action for National Integration – 'PANI', is a social development organization working in underdeveloped regions of Uttar Pradesh in India over 32 years to create positive and enduring change in lives of communities living in abject poverty and undue inequality. HUF and PANI (People's Action for National Integration) have initiated a program on **'Water for Public Good'** which involves sub-partners of PANI for ground implementation of project in 10 districts of Eastern Uttar Pradesh.

The prime goals to improve water productivity and alleviating poverty of 26500 small and marginal farming household by promoting water efficient and sustainable agriculture practices amongst farming community. This project has been appropriately designed to layer the water component over agro based livelihood.

Changing the Crops and earning more

Meena Devi from Maholi cultivated Paddy, Wheat, and Sugarcane on her 2.5-acre field from the past few years. Last year she cultivated paddy and wheat on 0.5-acre field, investing Rs.8200.00 and managed 1.9 tons of crop production (A profit of Rs.26600.00). This involved 52.5 hours of irrigation through 10 HP pump set which bore at a depth of 100 fit and valve depth at 10 fits. Thus after 2 crop cultivation and heavy cost labour and water investment her net profit in a year was Rs.18400.00.

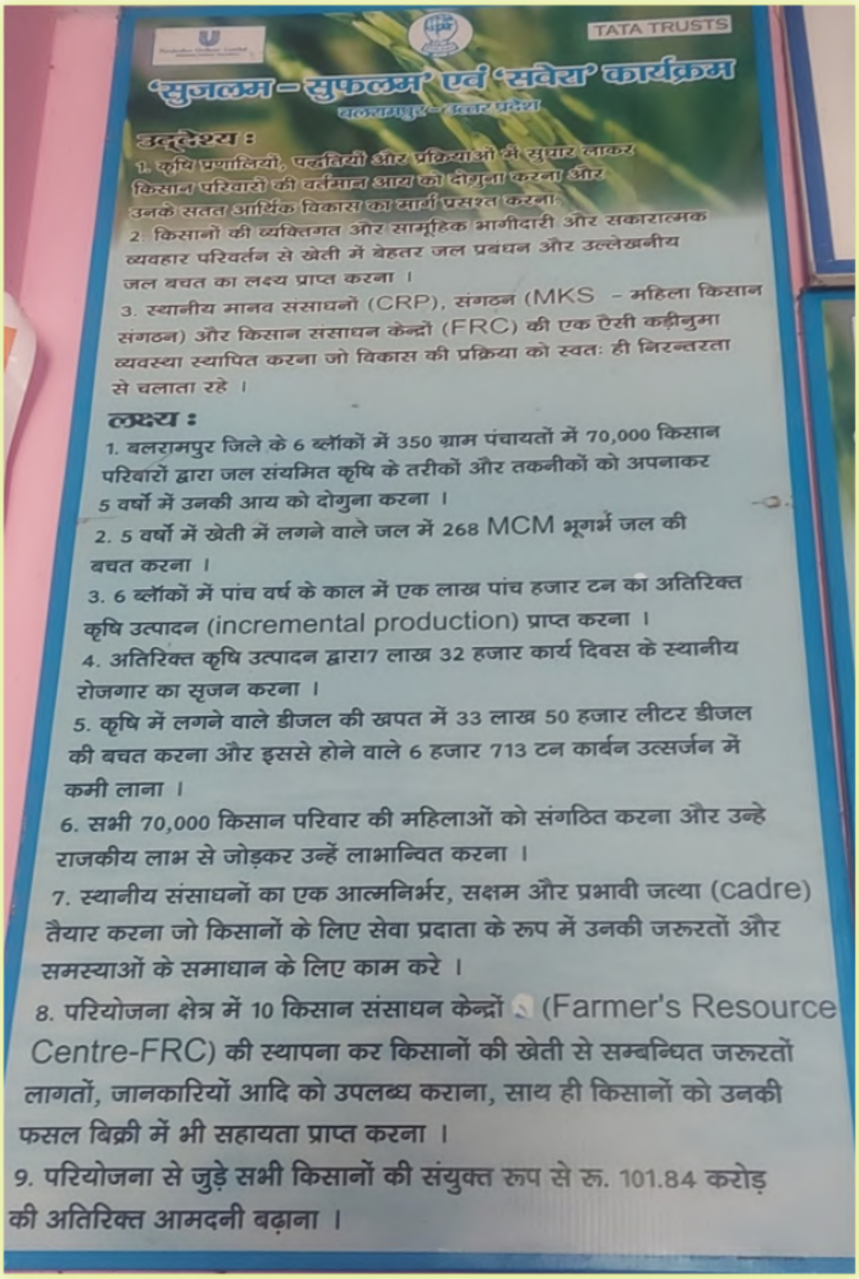
As a result of the intervention, this year, she decided to cultivate Pigeon pea with intensification technique. With an investment of Rs.4775.00, she harvested 0.6 tons of production and a total profit of Rs.48000.00. Irrigation employed only 5.5 hours with same pump and bore, thus increasing her net profit to Rs.43225.00. In comparison from paddy-wheat, she got additional profit of Rs.24825.00 and saved 47 hours irrigation.

In the beginning of the intervention for sensitizing the community towards prudent usage of water, it was gathered that not only was the knowledge base and awareness on water conservation very limited, but the subject understanding was also extremely erratic. It was thus decided to create a common baseline- a collectivization of the targeted farmer groups so that the planned mediations could be exercised effectively. It was understood that creating an understanding of water conservation would be legible if broken down into usage categories- water for domestic usage, drinking water and water used for agricultural practices. Use of alternative farming techniques (like drip irrigation or bed sowing) to facilitate lesser water Involvement of several stakeholders across verticals is encouraged and facilitated to facilitate knowledge, resources, and technology to create an actionable impact in the intervention.

Apart from existing bodies of support, it was also envisaged to build capacity and leadership within the community by installing Community Resource Persons (CRPs), lead farmers as well as Bare Foot experts to initiate and encourage community level activities. Although a relatively new intervention that may not necessarily be perceived as an urgent need by the community.

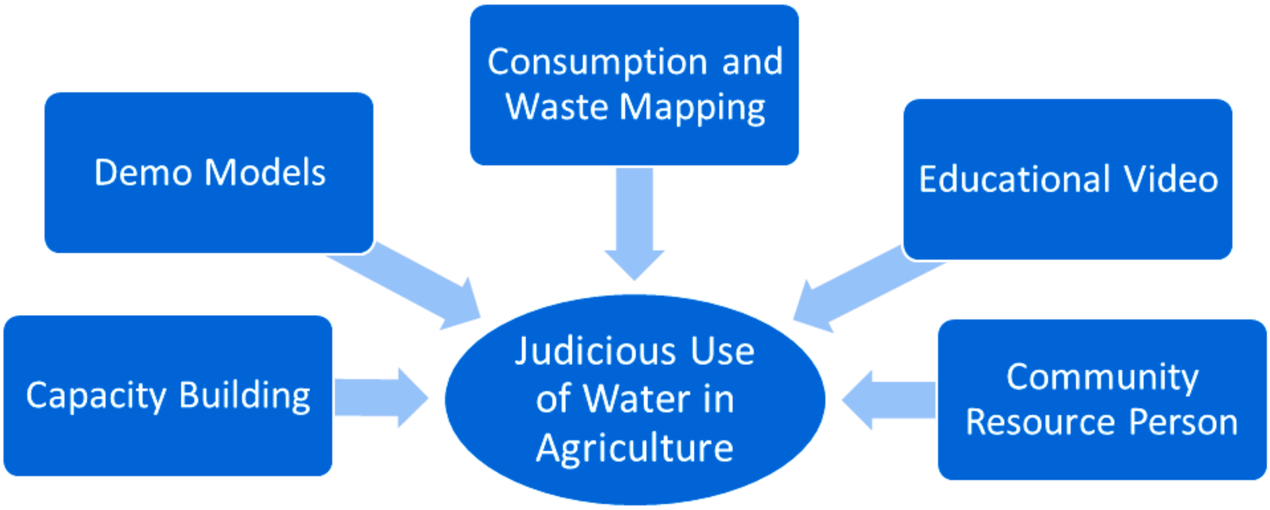
The community has started taking collective action due to several interventions of advocacy, knowledge enhancement and capacity building as group activities. Instances where water conservation was brought up as agenda in group meetings has risen considerably (1176 in a month).

Over 10,000 persons have started some form of practice for judicious use of water Ø 0.09 MCM water has been recycled because of the intervention Ø 8.62 MCM of water has been saved due to various judicious practices water sources have been initiated and more than 2000 community members have become actively involved in water monitoring.



The intervention has led to savings in irrigation cost (tube-well operating cost- by fuelled engines) Amidst the 120 Gram Panchayats of intervention, a total of over 57 thousand hours' worth of tube well operation have been reduced. This invariably led to lesser labour and fuel cost for operation.

The community has started talking about water as critical natural resource, sharing responsibility, and encouraging co-participation. Water monitoring for over 200 open wells indicated a positive change with regards to increased level.



Interventions within the Package of "Judicious use of water in Agriculture"

2.5 Challenges and Concerns

For a subject that has not been engaged in extensively in the chosen districts of Uttar Pradesh, the intervention has brought new learnings and challenges with it. The most evident point of concern has been that so far, need for water conservation has never been experienced as a subject of attention.

No appreciable control has been exercised on water consumption and its wastage has been completely ignored in all dimensions. The base of knowledge and awareness for water conservation lacking, understanding and acceptance of the idea of using less water is hard to digest for the community that has been showing evident reluctance in laconic (optimal) irrigation for the fear of crop loss.

The interventions are primarily based on collective efforts, political, social, and economic divide in the community has been creating a hindrance in the process of collectivization. It has also been noted that the community is reluctant in cultivating certain suggested cropping systems for the fear of crop damage by wild animals like blue bull. Apart from these, capacity building of the resource persons **(CRPs and Barefoot Experts)** within the community itself have been helpful.

Groundwater depletion has emerged as a policy concern both at national and state level, which needs to be addressed through an integrated and holistic approach. The resource management in Uttar Pradesh poses both quantitative and qualitative challenges, which requires efficient policy interventions for restoration of aquifers to achieve balance between extraction, utilisation, and replenishment of groundwater sources. The document presents an overview of groundwater resources in Uttar Pradesh. It shares that the issues of ground water in the state are quite diversified and therefore, the attempt has been made to cover aspects including availability and changing pattern, growing groundwater stresses, quality scenario, and management concerns.

Different policy initiatives and government decisions have been discussed at large. Local actions of community, civil-society, and government programs are discussed for resolving various issues pertaining to all groundwater users.

A road map by combining and integrating various activities would, therefore, be required for a holistic and sustainable solution to gradually overcome differential groundwater crisis in different regions in the state. There is an urgent need for coordinated efforts from various Central and State agencies, social service and non-governmental organisations, academic institutions, and the stakeholders for successfully implementing the much-needed strategies. Community involvement and people participation should be envisaged on priority and conducting round the year public awareness programmes for creating sensitization amongst the people and stakeholders at large would be greatly helpful in translating groundwater plans on the ground.

3 Lessons from the fieldwork in Uttar Pradesh – 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 Uttar Pradesh.

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

Uttar Pradesh has four distinct geographical regions namely the Western, Eastern, Central and Bundelkhand Regions having distinct hydro-geological, climatic, agronomic, and socio-economic conditions. Water availability and its management completely differ across these regions.

The geology and structure of the formations existing in an area control occurrence and movement of ground water. The geomorphic conditions also have a great impact on groundwater scenario.

The larger part of the State is underlain by fluvial sediments laid down in the fore deep between Plateau region in south and Himalayas in north during the Quaternary period by the Indus-Ganga system of drainage over the Precambrian topography existing during geological past. These deposits owe their origin to riverine activity. The southern part of the State has entirely different geological conditions being underlain by Precambrian formations under a thin alluvial cover.

Given this highly diverse physiography, hydrology and hydrogeology besides varying rainfall patterns, the regional potential of groundwater recharge and withdrawal is also highly uneven. In such conditions, locally appropriate approaches for groundwater recharge and withdrawal is important.

3.2 The efficacy of participatory data collection

Traditional systems of community, actions of CSOs, and even government run program in the state are focused on education and involvement of people on conjunctive use. Focuses is on involvement in overall management of water following IWRM including development, conservation, protection, and augmentation will be the prime requisite to protect resource against quality degradation and guarantee quality assurance. Mass awareness programmes aimed at educating the users regarding the adverse effects of over-exploitation of ground water on its quality and quantity, economic and efficient use of water, voluntary regulation of abstraction, etc. will ensure utilisation of the resource at optimal levels.

In Uttar Pradesh, a lot more be done for community participation and creating public awareness in the field of groundwater conservation and management. The experience of water conservation in Jakhni village, water campaign in Banda district, on farm harvesting in Andhao village, Baberu and successful concept of Jal Chaupal should be scaled up and restructured with more innovative project designs for implementation in the field.

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. Uttar Pradesh has adopted state water policy in 2010 and also enacted the Uttar Pradesh Participatory Irrigation Management Act in 2009. The state policy on water provides decentralized and participatory processes for the management of ground water resources. In doing so, the state policy provide for constitution of ground water management committees at village, block, district and state level. Moreover the participatory irrigation management Act, 2009 provides for constitution of Water Users Association (WUA) to decentralize the irrigation system in the state.

Uttar Pradesh has recently enacted the Ground Water (Management and Regulation) Act, 2019 to give effect to the state water policy adopted by the state in 2010. This legislation provides for the constitution of Ground Water Management and Regulation Authority at the state level chaired by the Chief Secretary. It also provides for constitution of groundwater management committees and councils are Panchayat, block and district level.

People working on ground for the effective management of groundwater require acquiring knowledge on all policies in order to utilize them for better management of the ground water resources. Using MGNREGA and other related schemes of the state and central government by people with the help of PANI NGO in eastern Uttar Pradesh is remarkable example of effective utilization of policies.

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. However, Uttar Pradesh has not yet updated its state policy on water. Policy gaps arising in the field must be communicated the policy makers.

3.5 Planning for balancing demand with supply

The major portion of Uttar Pradesh is covered by Ganga-Basin. The state is known for having the richest repository of ground water resource as it comprises the largest aquifer systems in the world. The significance of the ground water resource can be judged by the fact that 75% of the irrigated agriculture is mainly dependent on ground water resources. The ground water availability in UP is estimated at 56.93 MAF. Allowing for other uses ground water useable for irrigation is about 48.42 MAF, of which 36.82 MAF is already being utilized.

However, Uttar Pradesh is the largest extractor of groundwater in India accounting for 18.4% of the total national and 4.5% of the total global groundwater extraction. The per capita groundwater extraction in UP is 224.97cum compared to a national average of 182.86 cum and a global average of 125.89 cum. In result 138 development blocks are in overexploited, critical, or semi-critical stage. A rapid growth in the demand for water due to population growth, urbanization and changing lifestyles pose serious challenges to water security in the State.

There is wide temporal and spatial variation in the availability of water, which may increase substantially due to climate changes, causing more water crisis and incidences of water related disasters, i.e., floods, increased erosion, and increased frequency of droughts, etc. The inadequate management of water resources has also led to a critical situation in dry rain fed areas like the Bundelkhand and Vindhya region.

Access to safe water for drinking and other domestic requirements continues to be a problem in many districts. Groundwater is exploited inequitably and without any consideration to its sustainability thereby leading to its over-exploitation. The gap in demand and supply of the groundwater is increasing exponentially. The urgent need is to balance this gap both by enhancing recharge capacities and rationalizing demand.

3.6 Enhancing supply by groundwater conservation and recharge

This study has documented few successful examples of ground water conservation to enhance supply of ground water. These examples have used various methods such as watershed development, rejuvenation of traditional water resources, technological advancement, innovation in cropping and irrigation, water budgeting and public education. For example manufacturer and exporter of Saddlery and harness goods-King's International based in Kanpur has reduced its water demand for leather tanning from 35L of water for one kilogram of hid/skin to just 18 litre of water.

The revival of Haveli system in Lalitpur district of Uttar Pradesh by International Crop Research Institute for the Semi-Arid Tropics-ICRISAT has also augmented a huge amount of water by revival of Poora-Birdha haveli in the district. A 3-kilometer-long diversion drain was excavated, and the drainage network was widened.

In addition, this channel was also treated by constructing masonry plugs (also called *nala plugs* in parlance) at suitable intervals to harvest additional freshwater besides facilitating draining of the runoff to the downstream area. Altogether, 1.5 lakhs cubic meter storage capacity was created in Poora-Birdha village which is harvesting about 6 to 8 lakhs cubic meter freshwater per year. As a result, the water levels in wells increases post monsoon by 2-5 m compared to baseline and remain increased for additional two to three months.

Source: CGIAR

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 results 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.

4 References

1. http://cgwb.gov.in/Master%20Plan%20to%20GW%20Recharge%202020.pdf
2. Groundwater_Policy_and_Regulatory_Mechanism_in_Uttar_Pradesh.pdf
3. https://www.indiawaterportal.org/articles/water-all
4. https://www.gaonconnection.com/desh/flood-in-ghaghra-destruction-of-houses-and-land-in-many-villages-due-to-flood-villagers-in-panic-due-to-rise-and-fall-in-water-level-49729?infinitescroll=1
5. Groundwater scenario in district Banda 2017-18; Mathura.
6. CGWB: Ground Water Scenario of Uttar Pradesh
7. Saline water zones of Mathura (Unpublished report – AFPRO)
8. Uttar Pradesh State Water Policy 2020
9. Groundwater Policy and Regulatory Mechanism in Uttar Pradesh
10. Uttar Pradesh Development Report

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

RAJIV GANDHI
INSTITUTE FOR CONTEMPORARY STUDIES

Visit us at- www.rgics.org | |