Understanding the Shallow aquifers of Bengaluru

Biome Environmental Trust
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CONTENT

SUMMARY

The primary aim of this study is to highlight the neglected significance of shallow aquifers, a resource that has historical roots extending back approximately 4000 years. Shallow unconfined aquifers, accessed through open-dug wells, represent human's initial encounter with groundwater. However, the landscape of groundwater usage has been dramatically altered over recent decades, due to continuous advancements in technology and the widespread availability of electricity in rural and urban settings.

Today, wells are delving deeper and the dependability of groundwater as a resource is increasingly uncertain, notwithstanding the paradox of severe flooding in many urban areas. Climate change intensifies these issues, contributing to the growing frequency and unpredictability of extreme rainfall and drought events.

In this context, shallow unconfined aquifers could regain their prominence, serving as reliable subsurface reservoirs, a role they have consistently played over millennia. Importantly, extracting water from these sources requires substantially less energy than from alternatives such as bore wells.

These aquifers could be instrumental in addressing local water challenges as we recognize the limitations of centralized water management systems and shift towards more decentralized solutions. This is particularly relevant as water requirements, availability, and quality issues vary significantly across different regions, necessitating tailored, local strategies.

Consequently, in this document, we strive to comprehend and implement straightforward methods to gauge the potential and capability of the shallow aquifers to store and release water (their Storativity).

In the face of the critical water-related challenges that characterize the 21st century, the prioritization of understanding, estimating, and sustainably managing groundwater resources emerges as a pressing requirement. This is pivotal to guarantee water security and sustainability for our future generations.

INTRODUCTION

GROUNDWATER

Pertaining to the world's utilizable freshwater supply, a substantial fraction, close to 97 percent, is found in the form of groundwater.

In Asia, most areas of India, northern Sri Lanka, Pakistan's regions of Punjab and Sind, and the North China Plain emerge as significant locales wherein groundwater assumes a unique and steadily escalating relevance in bolstering a vibrant smallholder peasant farming system. It's noteworthy that while the majority of global groundwater usage is directed towards urban and industrial purposes, in South Asia, the usage is predominantly agricultural. This key role of groundwater in the agricultural economies of South Asia is clearly illustrated through statistics from the two most populous nations in the region.

In India, There's been a marked expansion in groundwater irrigation in since the 1970s, approximately 60% of the irrigated area is facilitated by groundwater wells. Furthermore, groundwater sources cater to approximately 85% of the drinking water supply in rural areas.

The southern part of peninsular India includes parts of Karnataka, Tamil Nadu Telangana, and Andhra Pradesh, where due to inherent characteristics of crystalline aquifers, the groundwater availability is naturally low.

The recent Groundwater Resources Assessment of India 2022 revealed that in Karnataka, a staggering 85% of groundwater extraction is employed for irrigation, underscoring the reliance on groundwater for ensuring food security.

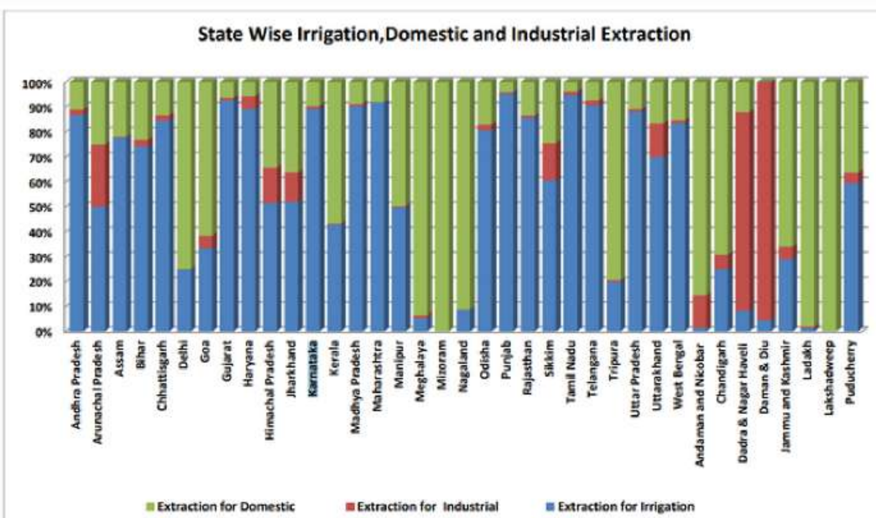

Image:Shows state wise use of Groundwater extraction for irrigation, dometic purposes and Industries

Furthermore, the Dynamic Groundwater Resources Assessment of India 2022 classified Bengaluru as a region with over-exploitation of groundwater. Therefore, gaining a comprehensive understanding of the unconfined and confined aquifers is paramount. Equitable and sustainable groundwater management in Bengaluru necessitates consideration of considerable spatial socio-hydrological heterogeneity.

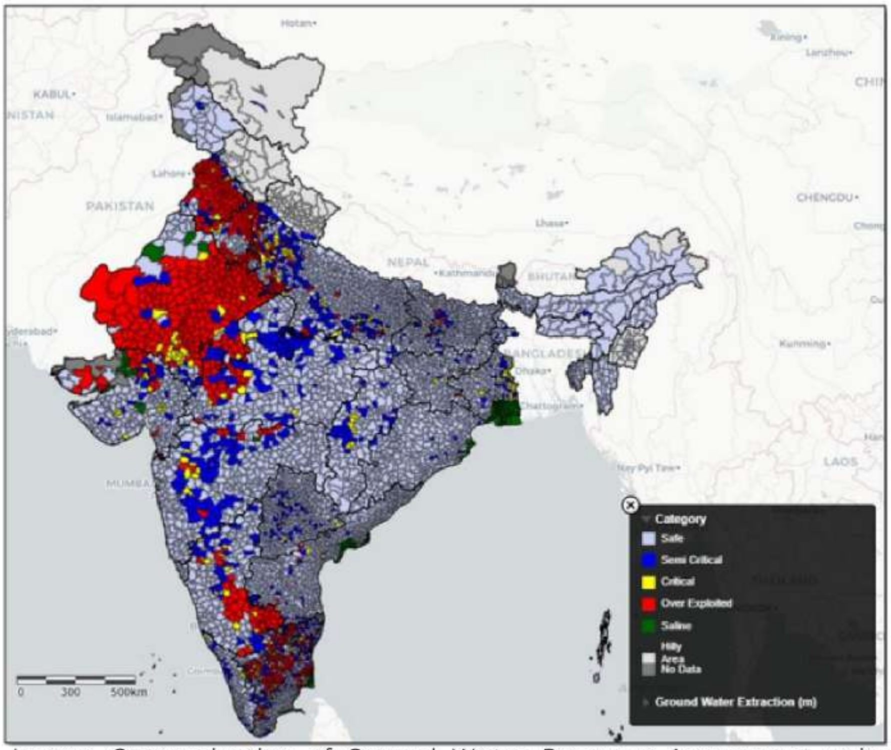

Image: Categorization of Ground Water Resource Assessment units across India, 2020

SHALLOW UNCONFINED AQUIFERS

Shallow unconfined aquifers hold immense significance in both local and global hydrological cycles and water management strategies

- **Water Supply:** Shallow unconfined aquifers serve as critical sources of potable water. Their proximity to the surface makes them easily accessible, most importantly requiring less energy and infrastructure to extract water compared to deeper aquifers.
- **Agriculture:** A healthy saturated unconfined aquifer keeps the soil and ground moistened which helps greatly for irrigation.
- **Ecological Impact:** Shallow unconfined aquifers play a crucial role in maintaining ecosystem health. They often feed local stream sas baseflow, wetlands, and lakes, providing essential habitats for various plant and animal species.
- **Buffer Against Drought:** During times of drought, shallow aquifers can serve as underground reservoirs. They can store water during periods of heavy rainfall, avoiding excess runoff, and flooding and simultaneously making water available during drier periods.
- **Waste Treatment:** These aquifers can also provide natural filtration and purification of contaminants, acting as a form of waste treatment. Water percolating down through the soil can be naturally cleaned as contaminants are filtered out.

It's important to note that the characteristics that make shallow unconfined aquifers valuable also make them vulnerable. Their connection with the surface means they are more susceptible to pollution and over-extraction, which can lead to issues like aquifer depletion and groundwater contamination. Therefore, understanding and managing these aquifers sustainably is of paramount importance.

The properties and behavior of a region's aquifer systems are intricately tied to an array of interconnected environmental and geographical factors. These include the region's underlying geology, the features and processes of its geomorphology, the patterns and intensity of its rainfall, the characteristics of its watersheds, and the overarching context of its climate. Each of these factors plays a distinct role in shaping the structure, functionality, and resilience of the aquifer systems, highlighting the need for a holistic understanding of these elements when studying groundwater resources.

AN INTRODUCTION TO SPATIAL EXTENT, CLIMATE VARIABILITY, GEOLOGICAL FEATURES, AND AQUIFER SYSTEMS OF BENGALURU

THE SPATIAL EXTENT OF BENGALURU

The Bengaluru Urban district spans approximately 2,196 square kilometers. Situated between latitudes 12°48' and 13°9'N, and longitudes 77°27' and 77°47'. Itis divided into five administrative taluks: Bengaluru North, Bengaluru East, Bengaluru South, Yelahanka, and Anekal. The city rests at a core altitude of 920 meters above mean sea level. The general topography of Bengaluru is undulating with a central ridge that runs NNE-SSW. A significant feature of Bengaluru is the way the undulating topography was used to create tanks(lakes) which acted as rain water harvesting structures and was the primary source of water for the city.

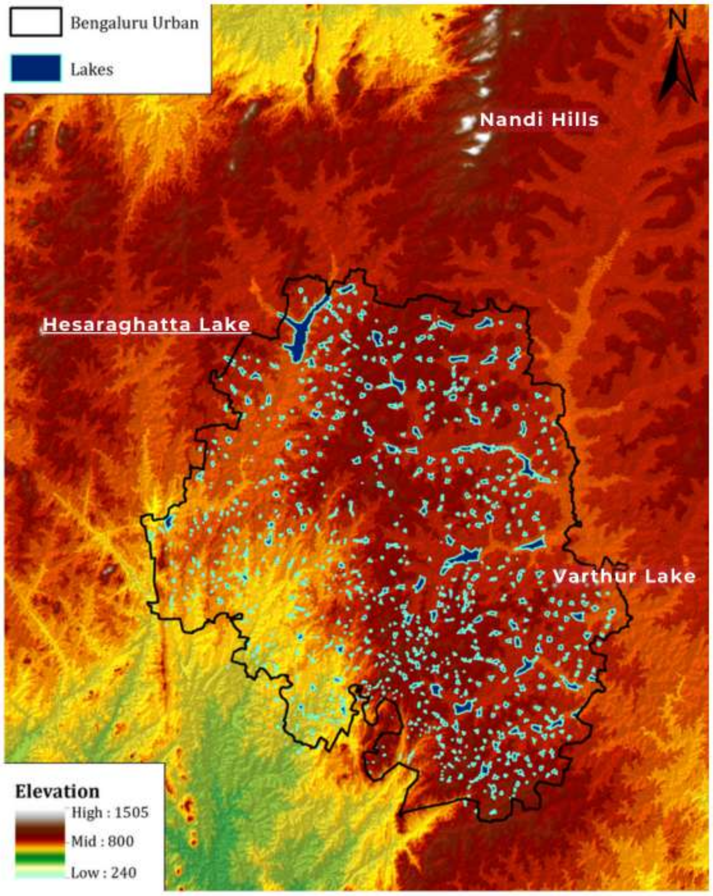

Image: Map of Bengaluru Urban district, Topography of the region and lakes.

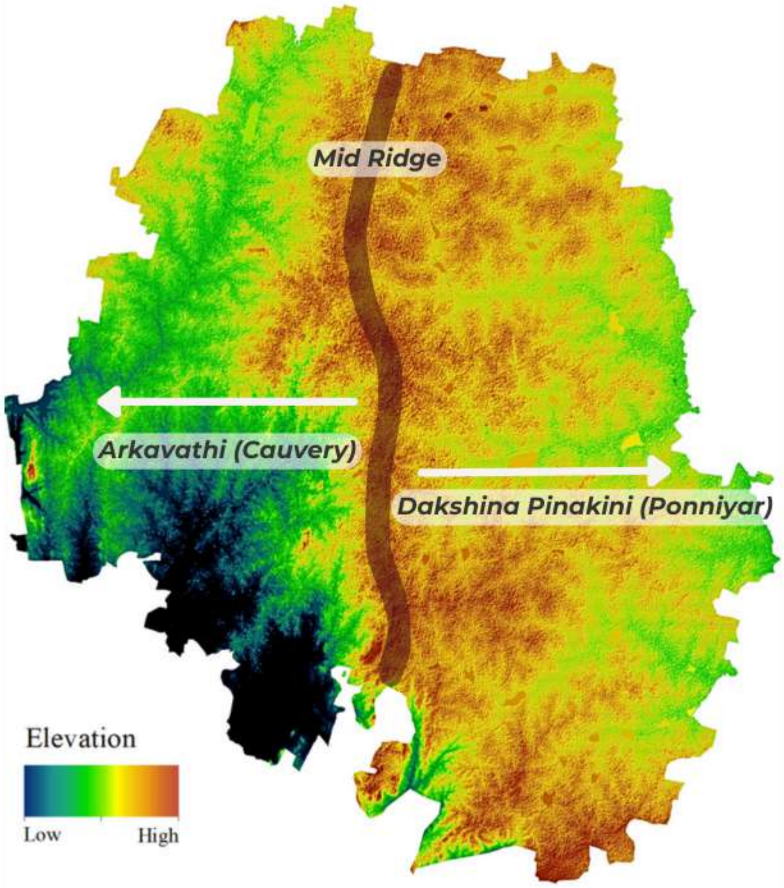

Image: Watershed Map of Bengaluru Urban district, and the midridge that divides the two watersheds.

WATERSHEDS OF BENGALURU

The district is perched on a geological divide running approximately north-south, which separates the westward-draining Arkavathi(Cauvery) watershed from the eastward Dakshina Pinakini (Ponnaiyar) watershed. The geological features of the city are significantly influenced by the watershed characteristics of the watersheds respectively. The former exhibits NNE-SSW and ENE-WSW oriented lineaments, while the latter aligns along NW-SE and WSW-ENE fractures.

SOIL TYPE IN BENGALURU

The region has a predominant mix of red laterite and alluvial soils.

GEOLOGY OF BENGALURU

The primary geological characteristics of the study region can be attributed to the Gneissic complex or Gneissic granulite, extensively interspersed with greenstone and related supracrustal belts. These geological features are estimated to have developed between 3.4 to 3 billion years ago, resulting in a broad group of grey gneisses that are often referred to as the older gneiss complex. Acting as the foundation for a wide belt of schists, these gneisses represent an integral part of the area's geological landscape. Towards the eastern portion of the region, a younger group of gneissic rocks, predominantly of granodioritic and granitic composition, can be found. These rocks are indicative of the reworking of an older crust, with significant infusions of newer granite material, leading to their designation as the younger gneiss complex.

AQUIFER SYSTEM IN BENGALURU

Geologically, Bangalore is underpinned by Precambrian granite and gneiss that has weathered to a maximum depth of 60 meters, with the surface overlaid by red loamy and gravelly soils. The city's aquifer system, as found in the larger Bengaluru urban district, is a composite of this shallow weathered zone and the deep-seated hard rock system beneath it.

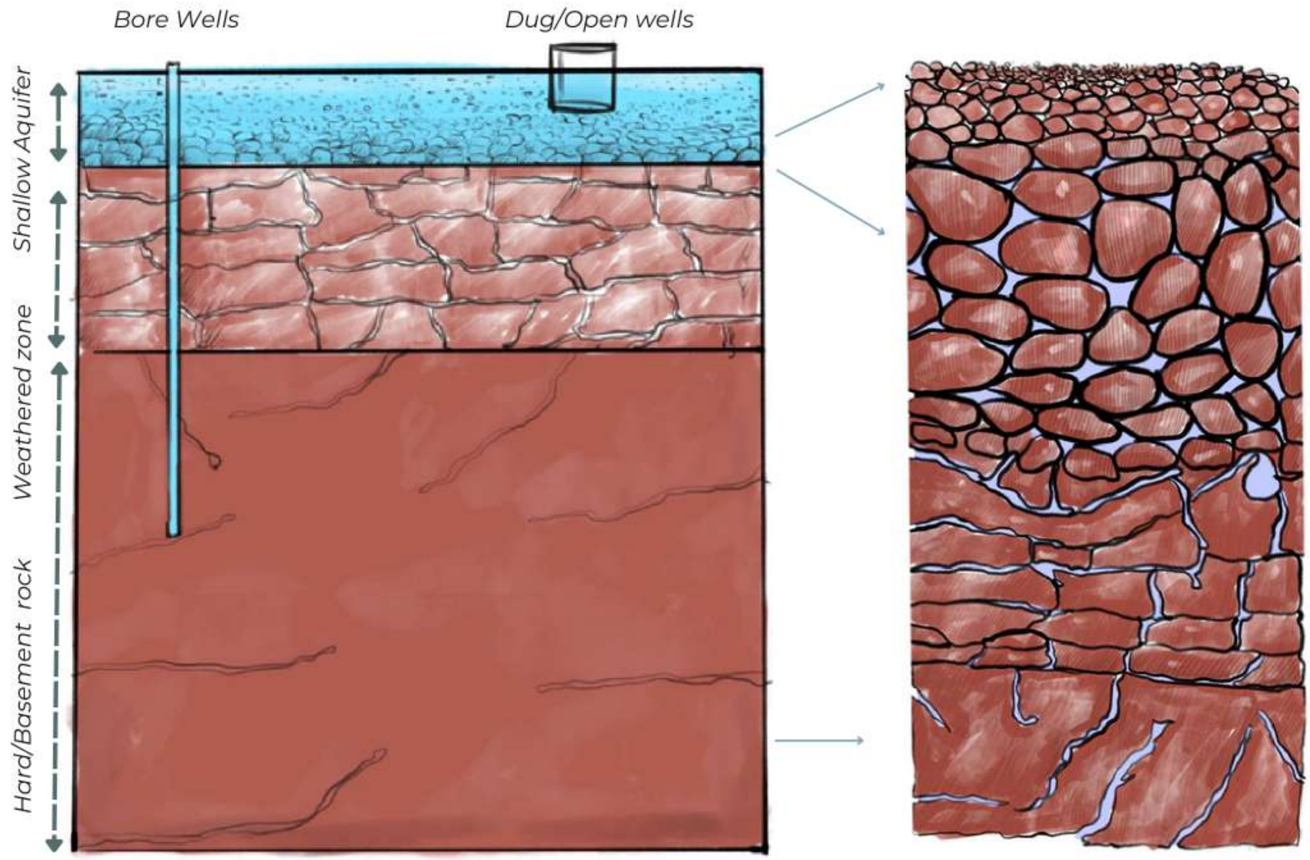

Image: Schematic diagram showing the aquifer system in Bengaluru and their zoomed in view on the right

These hard-rock aquifers exhibit distinct properties, including low hydraulic conductivity (10–65 m2/d), specific yield (0.005–0.01), and significant lateral heterogeneity. Typically, the yields of bore-wells in this region range from 0.8 to 5 liters per second. Maréchal, Dewandel, and Subrahmanyam (2004) provide a representative profile of the weathering in the area. The resultant saprolite or regolith is a clay-rich material formed from the extensive in-situ decomposition of bedrock, with a thickness reaching several tens of meters. This saprolite layer may exhibit high porosity, depending on the parent rock's lithology, and generally possesses low conductivity.

Recharge to this aquifer system primarily occurs via the shallow weathered zone, from where a portion of the water percolates further into the deeper fractured rock aquifer. Although these two components might seem like separate entities due to their distinct characteristics, they function interdependently in the larger picture. While the saturated saprolite acts as a storage unit, the fissured layer effectively transmits the stored water, thereby collaboratively serving as a global composite aquifer.

CLIMATE AND RAINFALL IN BENGALURU

In terms of climate, Bangalore resides within a region categorized as 'tropical savannah (Aw)' according to the Köppen–Geiger classification system. The city's rainfall distribution is considerably seasonal, with majority of the total rainfall occurs between May and August.

Some highlights from the report *Climate change scenario in Karnataka* by the Karnataka State Natural Disaster Monitoring Centre (KSNDMC) is summarized below.

- Bengaluru's rainfall patterns have been changing, with a 13% increase in average annual rainfall in Bengaluru Urban district from 1960-1990 to 1991-2017.
- High variability in the amount of rainfall across years, with 25% of the years showing a deviation from normal rainfall, and the highest variability occurring in July.
- Dry spells, defined as three or more consecutive weeks with less than 50% of normal rainfall, increased during the period 1991-2017, affecting soil moisture and groundwater levels.
- Bengaluru has experienced increased flooding due to heavy rainfall, with low-income families particularly affected due to intense damage or even loss of homes. Public infrastructure like stormwater drains has also been damaged.
- Flooding has become common due to increased rainfall intensity, decreased open spaces, and ineffective stormwater drains.
- The runoff coefficient has increased due to urbanization, contributing to frequent urban flooding along with increased rainfall intensity.
- Rainfall pattern varies within the city, with greater variability seen in recent years

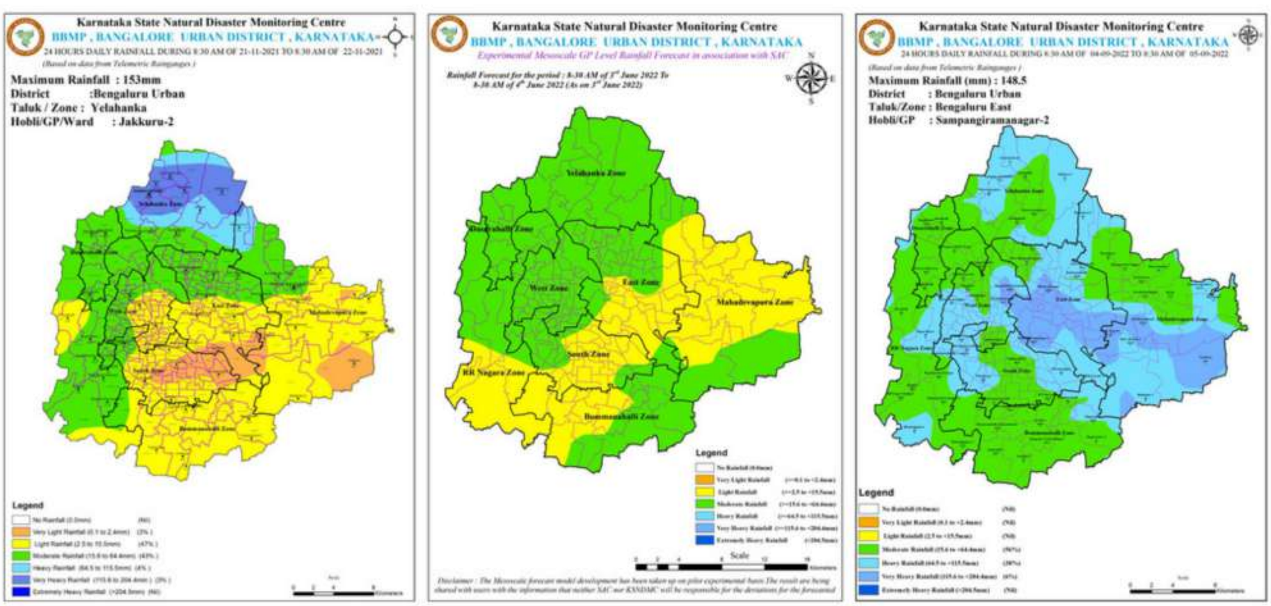

Image: KSNDMC maps showing Rainfall variability within the city Nov 2021, June 2022, Sep 2022

In the context of future rainfall projections for Karnataka and the Bengaluru district, it is anticipated that rainfall will exhibit an upward trend. Historical rainfall data spanning the past century corroborates this increasing pattern. Consequently, given the significant variability and unpredictability of both temporal and spatial rainfall distribution, there exists a compelling imperative to conduct comprehensive, localized investigations and mapping of shallow aquifers. This necessity arises from several key considerations:

1. Shallow aquifers can exhibit remarkably hyperlocal characteristics, necessitating a granular examination to understand their specific attributes and behaviours.

2. Shallow aquifers serve a crucial role as buffer zones and subterranean water reservoirs, particularly during periods of reduced precipitation and drier climatic conditions. Their capacity to store water becomes pivotal in ensuring a sustainable water supply.

3. The water table and recharge dynamics of shallow aquifers are intricately linked to rainfall patterns. As such, understanding these relationships is of paramount importance since variations in rainfall directly impact the fluctuation of water levels and recharge processes within these shallow aquifers.

RAIN WATER HARVESTING A SOLUTION AND A LAW

- Bangalore, with its unique characteristics, presents an optimal environment for the implementation of rainwater harvesting systems. Currently, approximately 40% of Bangalore relies on groundwater as a primary water source, a resource under severe threat due to uncontrolled extraction and excessive drilling. Consequently, the city is grappling with escalating water issues, driven by depleting water sources and escalating demand. In addition to these challenges, urban flooding incidents are on the rise.
- Rainwater harvesting emerges as a promising solution to mitigate these issues. Bangalore's climatic conditions make it an ideal candidate for such systems. The city receives an average annual rainfall of 970mm, distributed over 8 months and spanning 59 rainy days. Notably, as construction occurs on land, the surface run-off of rainwater escalates significantly, from 15% prior to construction to 90% post-construction. Simultaneously, evapotranspiration decreases from 75% pre-construction to a mere 5%, resulting in a considerable surplus of water.

This surplus rainwater can serve two essential purposes: it can be utilized directly or contribute to the replenishment of groundwater reserves, a critical aspect for sustainable water management. Furthermore, it is crucial to note that implementing rainwater harvesting systems in Bangalore is not merely a choice but a legal requirement, emphasizing the urgency and significance of this sustainable water management approach.

RAINWATER HARVESTING BY-LAWS:

Obligation to provide rainwater harvesting structure :

- Every owner or occupier of a building having a site area of 2400 square feet and above or every owner who proposes to construct a building on a site area of 1200 square feet and above shall provide for a rainwater harvesting structure.

MINIMUM REQUIREMENT

- Rainwater storage or Ground recharge of a minimum of 60 litres per square meter of roof area and a minimum of 30 litres per square meter of paved open space provision shall be made.
- The open well / recharge well of a depth of 3 meters (minimum) and diameter of 0.9 meter (minimum) without filling in the well (like aggregates, jelly, sand etc.) provision shall be made.

PENALTIES IMPOSED BY BWSSB FOR NON COMPLIANCE

Penalties introduced for residential and non residential defaulters.

- **Residential buildings:** additional charges of 25% of total water and sanitary charges will be levied for first 3 months and thereafter 50% of total water and sanitary charges till the RWH is provided.

- **Non residential buildings:** additional charges of 50% of total water and sanitary charges for first 3 months and thereafter additional charges of 100% of total water and sanitary charges till the RWH is provided.

OBJECTIVE

The primary objective of this technical paper is to ascertain the storativity of a shallow, unconfined aquifer using two distinct methodologies.

- The first approach necessitates the execution of field measurements, specifically incorporating a pump test along with monitoring water draw-down data over a stipulated period of time. This data acquisition process facilitates the direct calculation of aquifer storativity.

- In contrast, the second method leverages existing secondary literature to obtain the specific yield of the aquifer. This method is viable given that, in the context of a shallow unconfined aquifer, the specific yield is essentially identical to the storativity. Therefore, a comprehensive understanding of storativity can be garnered by adopting these two parallel strategies, thereby providing valuable insights into the hydraulic characteristics of the aquifer under study.

METHODOLOGY

The calculation of storativity requires field measurements. Below are the general steps you could follow to estimate the storativity of an unconfined aquifer:

- The storativity of an unconfined shallow (water table) aquifer is essentially its specific yield. It represents the amount of water an aquifer releases from or takes into storage.
- Perform a Pumping Test: In order to estimate the storativity, conduct a pumping test. This involves pumping water from a well in the aquifer at a constant rate and measuring the change in water level (drawdown) in one or more observation wells over a certain period of time.
- Collect and Record Data: Record the change in water level over time for all observation wells. The distance between the pumping well and the observation wells is also needed.
- Determine the Slope of the Line: Plot the drawdown versus the log of time since pumping started on a semi-log graph The slope of the straight-line portion of the graph represents the transmissivity (T) of the aquifer, which is the rate at which water is transmitted through a unit width of the aquifer under a unit hydraulic gradient.

Transmissivity T = 2.303*Q/4 π Δs	Where, T = Transmissivity Q =Average discharge (cu meters/day) Δs = slope
Storativity S= 2.25*T t/r2	Where, S= Storativity T= Transmissivity t=Time r= distance of observation well from pumping well

To calculate the storativity of an unconfined aquifer using already derived specific yield, area, and depth

- Specific Yield: The specific yield (Sy) is a dimensionless ratio that represents the ratio of the volume of water that the soil or rock will yield by gravity to its own volume. This parameter is derived from field tests or taken from the literature for similar materials.

- Aquifer Area: Measure or estimate the area (A) of the aquifer in question. This is the plan view surface area of the aquifer, expressed in square units (such as square meters or square feet).

- Aquifer Depth: Measure or estimate the thickness or depth (b) of the saturated portion of the aquifer. This should be a measurement from the water table to the base of the aquifer, expressed in linear units (such as meters or feet).

In an unconfined aquifer, the storativity (S) is approximately equal to the specific yield. Thus, S storativity = Specific yield (Sy).

Thus,

Amount of water shallow aquifer can store and release =
Shallow Aquifer area * Shallow Aquifer Depth * Shallow aquifer's Specific Yield

CASE STUDY

Understanding the shallow unconfined aquifer system in Devanahalli TMC and estimating the water holding and yielding capacity of the shallow aquifer.

OVERVIEW OF DEVANAHALLI TMC

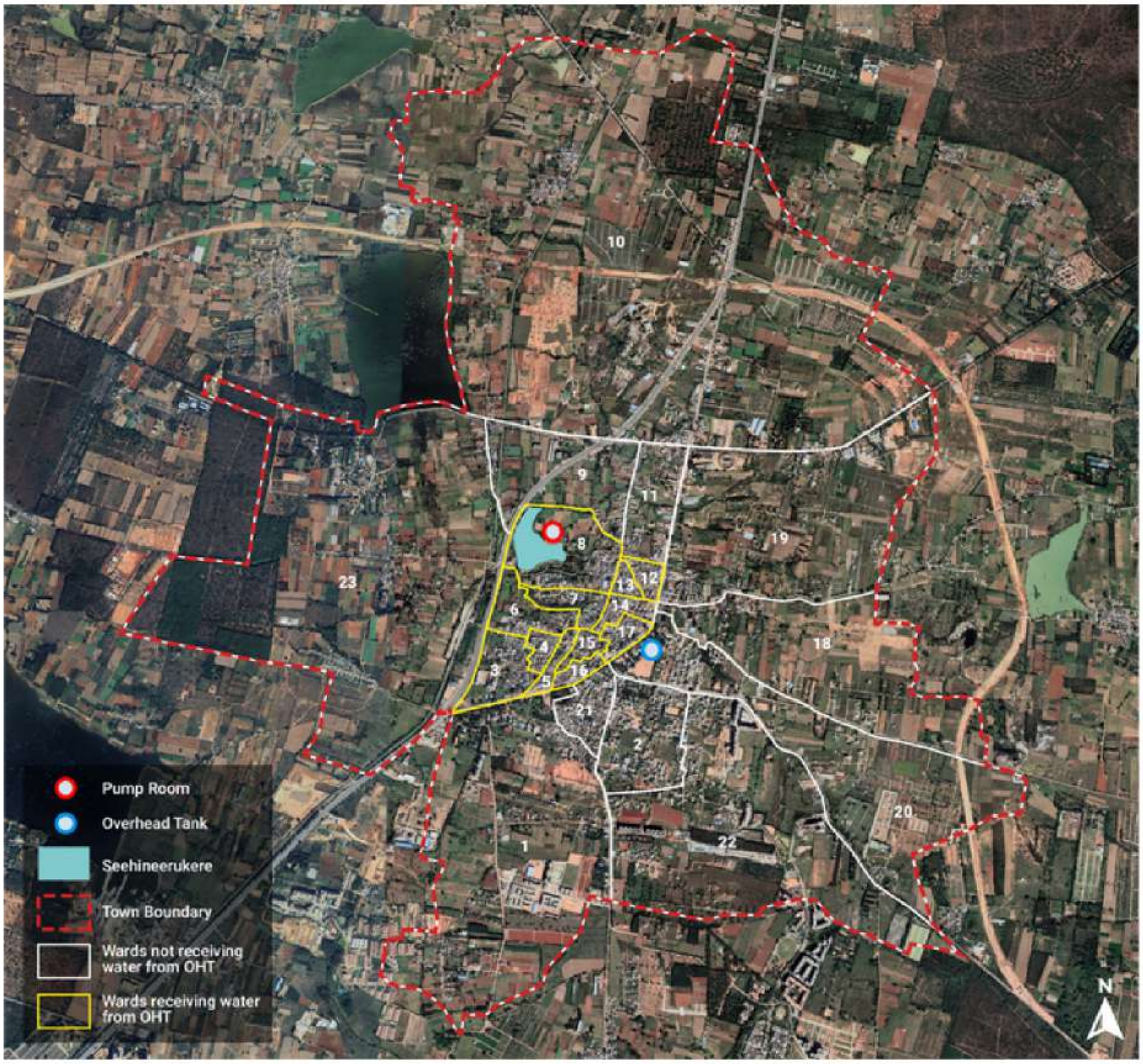

Image: Map showing the study area Devanahalli TMC region, Seehineer Kere (Devanahalli lake))

Data of the Town	Area in Sq m	Remarks/ Notes
Total Area of TMC	16672948	CGWB and Report & Satellite data
Total Urbanized area in TMC	2616800	Satellite Data
No of lakes in TMC	1	Devanahalli/Seehineer Kere

SOIL TYPE

Sandy clay and Clay

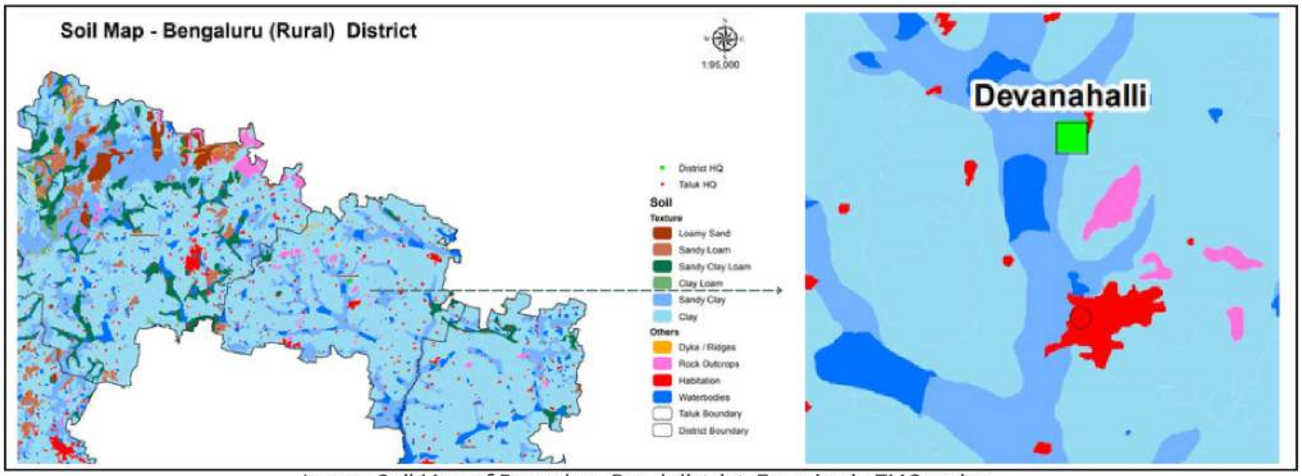

Image: Soil Map of Bengaluru Rural district, Zooming in TMC region

GEOMORPHOLOGY MAP

Valley floor

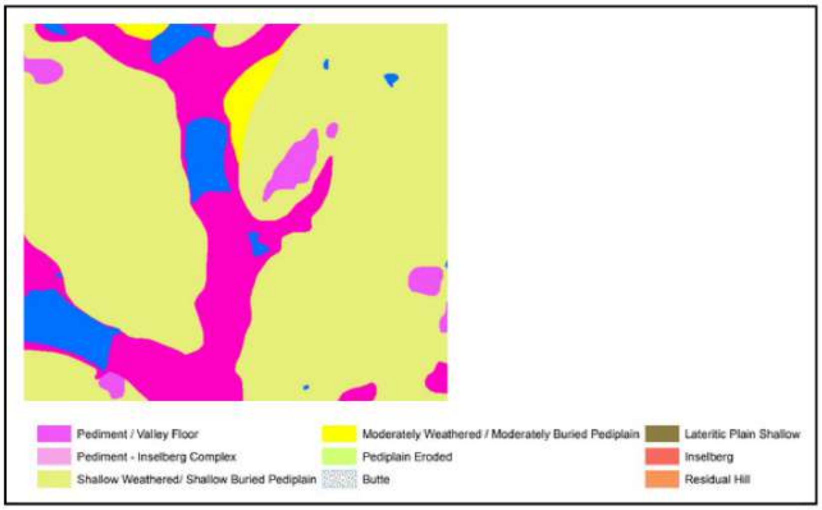

Image: Geomorphology Map of Devanahalli TMC region

AQUIFER PROPERTIES

Aquifers	Weathered Zone (Aq.-I)
Prominent Lithology	Weathered gneisses and laterite
Thickness range (mbgl)	30
Depth range of occurrence of fractures (mbgl)	-
Range of yield potential (lps)	Mostly Dry
Specific Yield	2%
T (m^2/day)	-
Quality Suitability for Irrigation	Yes
Suitability for Domestic purposes	Yes
Remarks	Over exploited

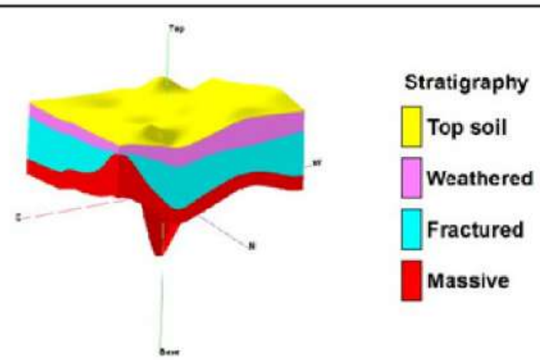

Image: 3D subsurface profile of Devanahalli Taluk)

MONTHLY RAINFALL

Month	Rainfall in mm	Rainfall in MLM
January	1	14.05
February	4	56.22
March	15	210.84
April	38	534.13
May	82	1152.60
June	76	1068.26
July	90	1265.05
August	116	1630.51
September	165	2319.26
October	156	2192.75
November	48	674.69
December	12	168.67

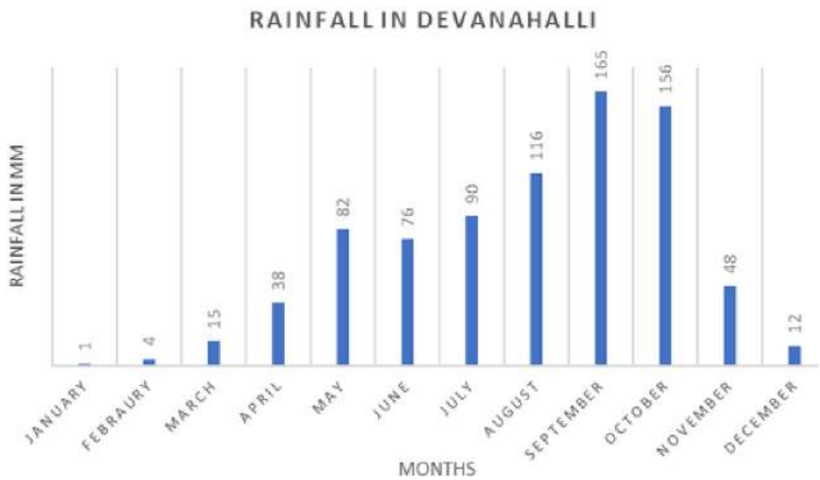

Image: Graph representing monthly rainfall in Devanahalli in 2020

The rainfall data suggests a marked seasonal variation in the precipitation patterns in Devanahalli Taluk. This pattern can be divided into three main periods.

- The dry season (January to March), pre-monsoon season (April to June), and the monsoon season (July to October), followed by a post-monsoon period (November and December).
- Dry Season: The year begins with the lowest rainfall. This period is characterized by a low amount of rainfall, leading to arid conditions.
- Pre-Monsoon Season: The onset of April marks an increased amount of rainfall, indicating the initiation of the pre-monsoon showers.
- Monsoon Season: The monsoon season, starting in July and ending in October, sees the maximum amount of rainfall for the year.
- Post-Monsoon Period: Following the monsoon season, there is a significant drop in rainfall levels in November and December, indicating the end of the monsoon season and the return of the dry period.

UNDERSTANDING THE INPUTS, OUTPUTS AND THE SHALLOW AQUIFER OF DEVANAHALLI TMC

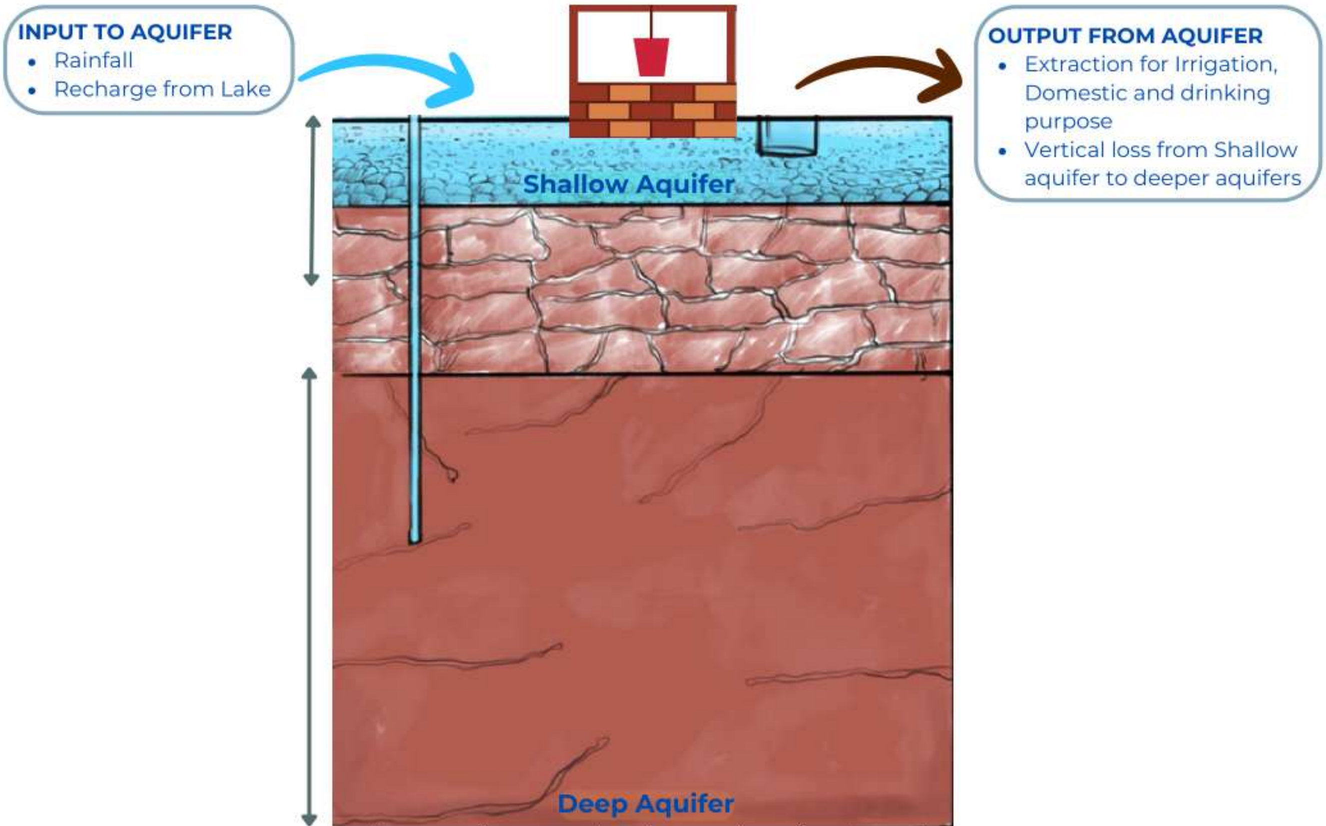

Image: diagram showing various inputs and outputs to the shallow aquifer for devanahalli

VARIOUS INPUTS AND OUTPUTS TO THE SHALLOW AQUIFER

Factors affecting Aquifer capacity	Value	Units	Remarks/References
Area under natural recharge	14.05614	sq km	Excluding urbanized area, rock outcrop
Avg thickness of shallow aquifer	30	m	CGWB Report & field data
Natural Recharge	56.21	mm	7% of rainfall
Leakage from Sewage pipes	0		No sewage system in the TMC
Artificial recharge by Recharge wells	0		No recharge wells in the TMC
Recharge by lakes	5	mm/sq m/day	Assuming lakes recharge 5mm/sq m/day
Area of lake	54262.71	sq m	Satellite data
Recharge from lake	8.139407	MLM	Field data
Loss to deeper aquifer	7.41667	MLM	GSI Report for Bengaluru
Water extracted from open wells	5.688	MLM	Field data
Number of open wells	15		Field data
Water extracted from open wells	10,000	L	
Total water extracted per day	1,50,000	L	
Water extracted per month	4.5	MLM	
Water extracted from all open wells	10.19	MLM	Field data
Water extracted from filter borewell	1.188	MLM	Field data

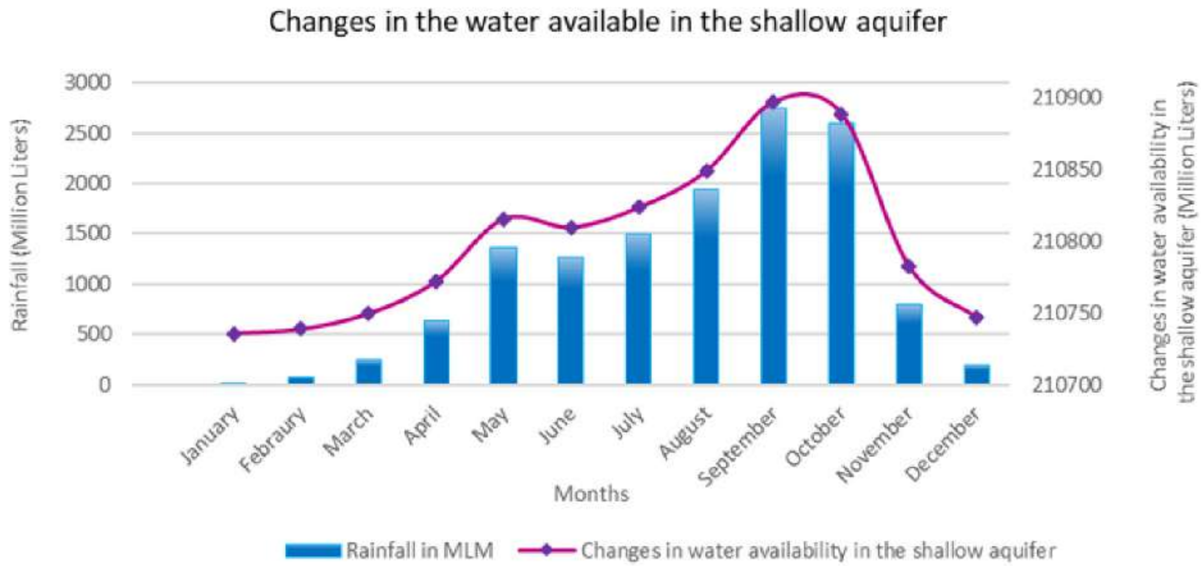

Image: Graph represents initial results of the model, showing monthly rainfall and the changes in the availability of water in the shallow aquifer

A theoretical model is used for a year-long dataset to understand the factors influencing the availability of groundwater in shallow aquifers. The model takes into account various factors that recharge the shallow aquifer such as rainfall, lakes, leakages from freshwater or sewage pipelines and discharges such as groundwater extraction, and vertical loss to deeper aquifers.

- The graph represents the changes in the shallow aquifer over a year. It experiences the highest influx during the monsoon season (July to October) with September. and lowest during the dry season (January to March and November to December) leading to a decrease in the water available in the aquifer.
- Sustainable Usage of the Aquifer: Sustainable usage of the aquifer involves maintaining a balance between the aquifer's recharge and depletion. A sustainable approach would necessitate managing outputs by limiting the extraction during drier months, utilizing water-saving technologies.
- Artificial Recharge Potential: It is evident from the graph that there is a substantial amount of rainfall available for recharge, particularly during the monsoon season. Implementing artificial recharge structures during these peak months could significantly enhance the water availability in aquifer.
- In conclusion, the data model provides valuable insights into the operation of the shallow aquifer over a year. It indicates a clear need for the implementation of sustainable management practices and the potential benefits of artificial recharge structures.

The model needs further refinement by adding variables, such as changes in rainfall patterns due to climate change, population growth and consequent water demand, and the potential for integrating alternative water sources.

WATER DEPTH LEVEL OF OPEN WELLS IN DEVANAHALLI TMC

Sl No	Wells	Latitude	Longitude	Measured Depth in m	Elevation of Well (amsl) in m	Reduced water level
1	WELL 1	13°15'34.67"N	77°42'22.42"E	2.3	923	920.7
2	WELL 2	13°15'31.20"N	77°42'41.62"E	5.5	928	922.5
3	WELL 3	13°15'25.28"N	77°42'49.72"E	3.9	921	917.1
4	WELL 4	13°15'28.14"N	77°42'50.49"E	3.5	922	918.5
5	WELL 5	13°15'16.37"N	77°42'29.34"E	4.1	921	916.9
6	6 (open well)	13°15'6.42"N	77°42'36.03"E	4	918	914
7	7 (tottilu baavi)	13°15'5.35"N	77°42'37.83"E	2	917	915
8	WELL 8	13°15'3.75"N	77°42'38.84"E	3.1	918	914.9
9	WELL 9	13°15'1.93"N	77°42'37.96"E	1.4	921	919.6
10	WELL 10	13°15'12.42"N	77°42'35.23"E	3.3	916	912.7
11	WELL 11	13°15'10.32"N	77°42'33.45"E	2.7	917	914.3
12	WELL 12	13°14'13.64"N	77°41'53.81"E	4.9	910	905.1
13	WELL 13	13°14'13.38"N	77°41'56.68"E	5.2	910	904.8

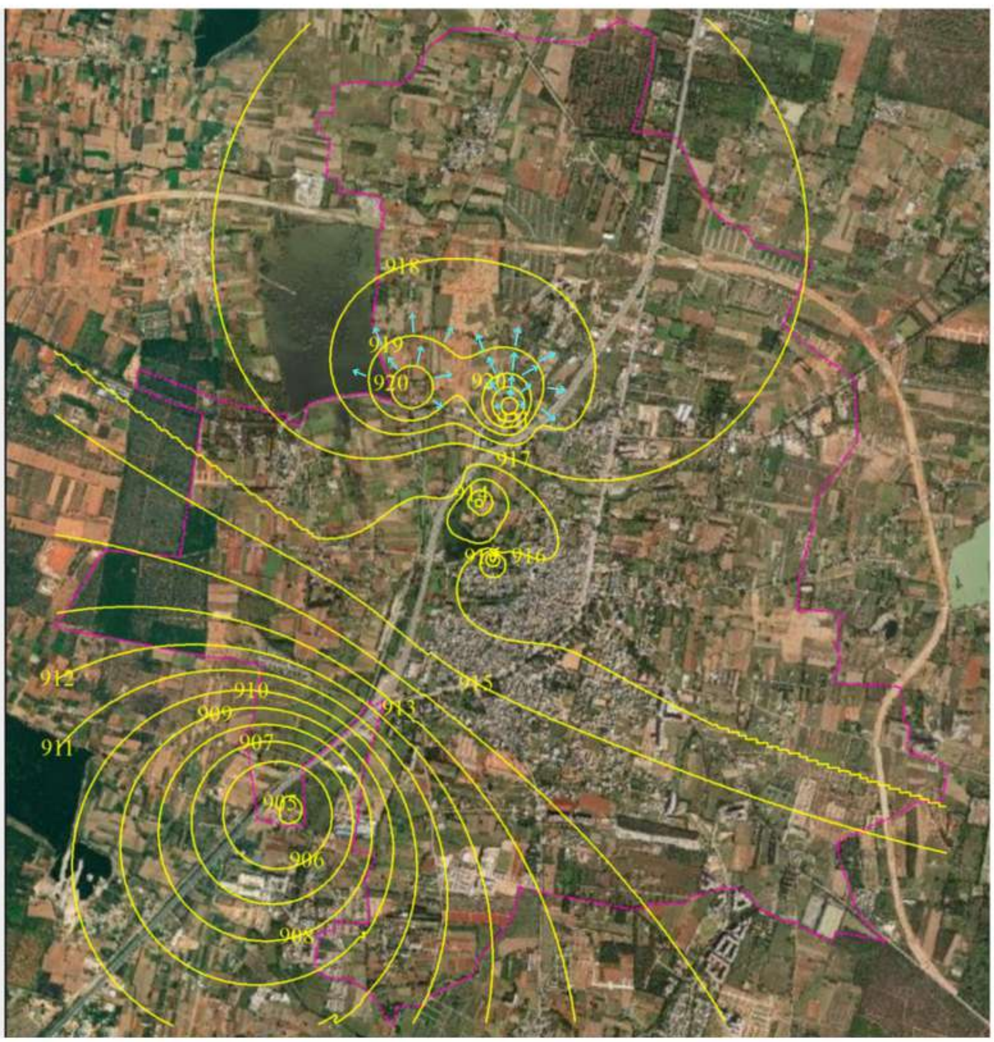

Image: water table contour map created using water level depth data obtained from 15 wells in the Devanahalli TMC.

The provided diagram represents a contour map detailing the depth levels of water within a prominent area in the Devanahalli TMC. The information utilized to construct this map was sourced directly from field data. The recorded water level depths for 15 separate wells were incorporated, all of which were measured during the pre-monsoon season. Examination of the map reveals the location of the Devanahalli Lake within the region's recharge zone, which plays a significant role in replenishing the area's shallow aquifer. Additionally, the map features directional arrows indicating the flow pattern of the region's groundwater.

Further field data is essential to enhance the precision of this map. To comprehensively portray the groundwater situation and accurately identify the recharge and discharge areas of the region, we need to account for seasonal fluctuations in water level depths from an expanded set of wells. This more robust data collection will contribute to refining the representation and understanding of the groundwater dynamics in this area.

SUCCESSFUL INITIATIVES AND THE IMPERATIVE FOR FURTHER RESEARCH IN BENGALURU URBAN DISTRICT

1. Open Well behind Sonnappanahalli GHPS, Hunasamaranahalli TMC
2. Open Well near Aviation College, Hunasamaranahalli TMC
3. Open wells near Kaikondrahalli Lake, Sarjapura Road

1. OPEN WELL BEHIND SONNAPPANAHALLI GHPS, HUNASAMARANAHALLI TMC YELAHANKA TALUK

In November 2022, a team of traditional well diggers from the Mannu Vaddar community rejuvenated this old well located in Hunasamaranahalli TMC, Yelahanka Taluk. This open well, at 13.155361, 77.617972, draws from a shallow aquifer and was previously inoperative for a decade. Prior to its dormancy, it catered to the community's domestic water needs.

Image: Location map of Open Well (Sonnappanahalli GHPS)

Following its restoration, the adjacent community began tapping into this source once more for domestic purposes. Over four days, the team removed debris, desilted the well and made several enhancements. A new pulley system was put in place and adjustments were made to the existing grill, all designed to promote manual water withdrawal.

An interesting turn of events occurred when the TMC suggested introducing a pump to integrate the well with the larger water supply framework of the city. The community, grounded in principles of sustainability and responsibility, turned down the offer. They recognized the potential of a pump leading to water over-extraction and chose manual withdrawal as a conscious step toward measured usage.

Image: Open well before and after rejuvination

This commendable initiative was a part of the 'Million Wells for Bengaluru' campaign, a movement geared towards raising groundwater awareness, emphasizing the importance of recharge wells, and spotlighting the value of open wells.

2. OPEN WELL NEAR AVIATION COLLEGE, HUNASAMARANAHALLI TMC YELAHANKA TALUK

In November 2022, a rejuvenation effort was undertaken for a 75-year-old open Well located at 13.157278, 77.624528. Spearheaded by traditional Well diggers from the Mannu Vaddar community, the project spanned three weeks, during which water was pumped out, extensive vegetation removed, and the well desilted. For enhanced safety and to thwart potential waste disposal, a protective grill was installed. Historically, this open well (24-foot diameter and depth of 65 feet) primarily facilitated irrigation.

Image: Location map of Open Well (Aviation College)

To monitor water consumption, meters were affixed to the pipelines linked to the open well. Presently, the Town Municipal Council taps into this shallow aquifer to channel approximately 200,000 litres of water daily to the municipal wards of Shaktinagar, Muneshwar camp, and Sonnappanahalli.

Additionally, distinct pipelines distribute water to a college, a hotel, and two apartment complexes in proximity to the well.

Open Well after Rejuvenation

Open Well before Rejuvenation

A salient aspect of this endeavour is the significant volume of water extracted daily. Hence, gaining insights into the shallow aquifer, along with the recharge and discharge zones, is imperative. This knowledge will guide the community in establishing sustainable dependencies on this well.

3. OPEN WELLS NEAR KAIKONDRAHALLI LAKE, SARJAPURA ROAD

Located off Sarjapura Road, Bengaluru - Kaikondrahalli Lake covers approximately 48 acres. A concerted rejuvenation effort took place between 2010-2011, facilitated by a community-municipal partnership. Notably, before these efforts, open wells and borewells within a 300m radius of the lake had largely been rendered barren. However, the subsequent Participatory Groundwater Management project period revealed transformative effects on groundwater management, predominantly impacting the shallow aquifer system.

Kaikondrahalli Lake's rejuvenation provides compelling insights into the essential role lakes play in recharging shallow aquifers. It delineates the tangible benefits of understanding and harnessing the potential of local and regional shallow aquifers.

Such initiatives not only fortify sustainable water management practices but also diminish challenges associated with water sourcing, water charges and quality. Further research and mapping of these shallow aquifers are imperative to tap into their expansive benefits fully.

CASE STUDIES HIGHLIGHTING AQUIFER REVITALIZATION:

Image: Location map of Open Wells near Kaikondrahalli Lake

1.Renuka School's Success in Tapping Shallow Aquifers

- **Background:** Renuka School, near the lake, had a barren borewell in 2011, resulting in a reliance on external tanker water.
- **Intervention:** The lake rejuvenation incentivized the school to introduce rainwater harvesting, further augmenting the groundwater recharge process.
- **Outcome:** Two shallow open wells have since been established, cumulatively supplying over 1000 litres daily—adequate to address the school's non-potable water demands. Continuous assessments depict a steady improvement in the water quality from these wells.

2.EDGE Apartments and Shallow Aquifer Reliance

- **Background:** Approximately 200m from the lake, the EDGE residential enclave encompasses around 50 homes. An adjacent neglected open well piqued the interest of the community.
- **Intervention:** The well underwent a desilting process, revealing water at a mere 15-foot depth. Inspired by this promising discovery, a new open well, spanning 6 feet in diameter and 30 feet in depth, was constructed.
- **Outcome:** Both wells now cater to the enclave's domestic water needs. Continuous replenishment ensures the sustainability of this groundwater source, reinforcing the advantages of shallow aquifers.

3.Community-driven Revival of Local Wells

- **Background:** In the vicinity of the lake, an individual residence and a tennis court each had a deteriorating open well.
- **Intervention:** With the lake's rejuvenation, both wells underwent desilting, enhancing their synergy with the lake's water levels. Surface runoff techniques were also incorporated for consistent recharge.
- **Outcome:** The resultant revived wells now fulfil specific water requirements, underscoring the potential of the lake- shallow aquifer nexus.

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