Groundwater Management in India

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

Andhra Pradesh and Telangana State Report

February 2023

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

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1 Executive summary

1.1 Groundwater scenario in India

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

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

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

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

1.2 Groundwater policy gaps

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

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

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

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

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

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

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

1.3 The multi-state study

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

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

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

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

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

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

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

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

2 Andhra Pradesh and Telangana State Reports

2.1 Context and key features

Andhra Pradesh and Telangana are two south Indian states located on Deccan Plateau. Andhra Pradesh is a coastal state spread on the Eastern Ghats and Telangana is located on the north west of the Andhra Pradesh. The united Andhra Pradesh was bifurcated in 2014 to form Telangana as a separate state. Together these two states cover 2.75 lakh sq km of land on the Deccan Plateau and inhabit more than 8.45 crore population. Godavari and Krishna are respectively the second and third longest rivers of India after Ganga pass through these states. Moreover the state of Andhra Pradesh has several other smaller rivers such as Palar, Murredu, Kundu, Papagani, Nadari etc. The state of Telangana has relatively less number of rivers. Apart from two main rivers mentioned above, it has rivers such as Maner, Dindi, Taliperu, Musi etc.

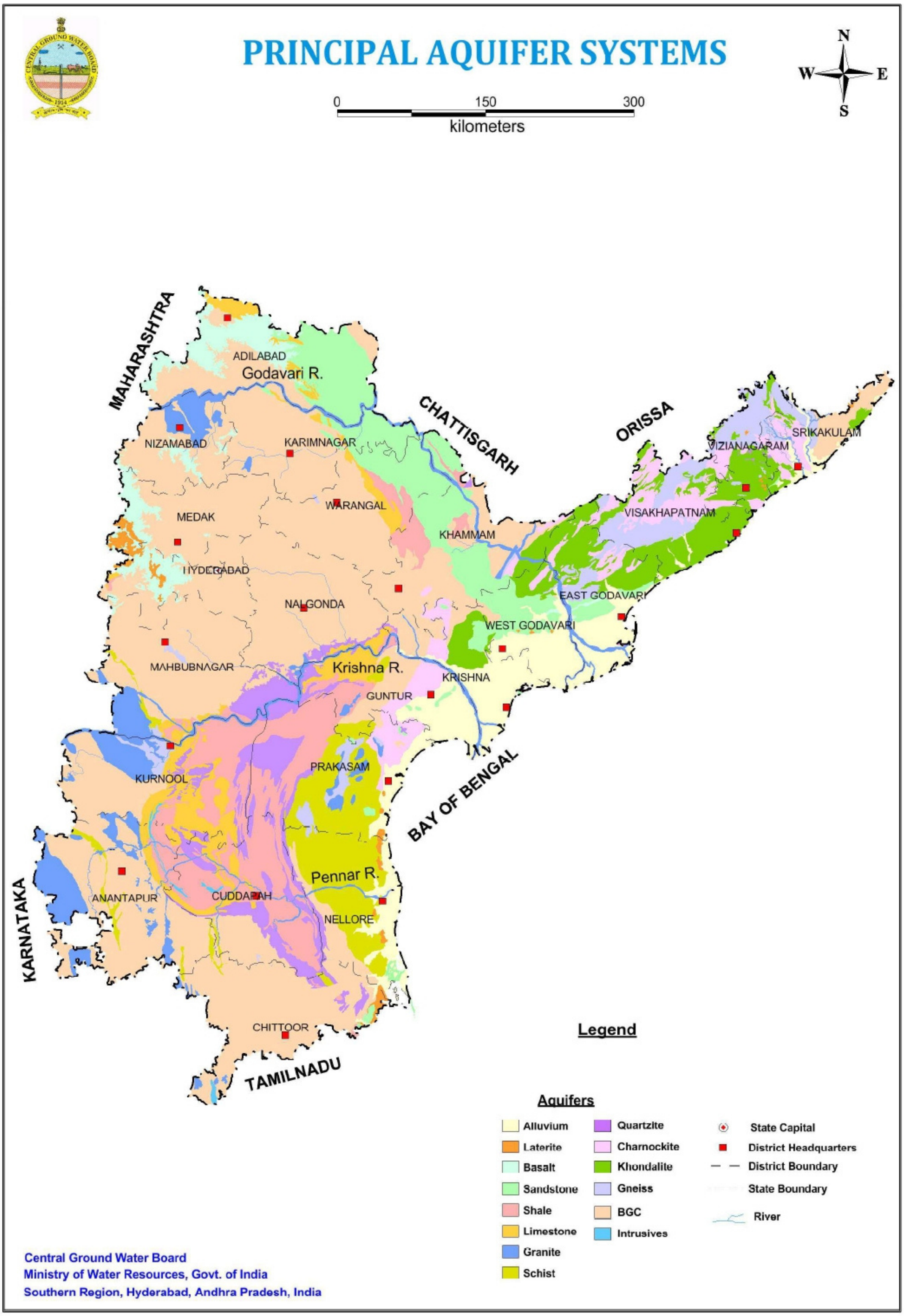
The geological formation of Andhra Pradesh ranges from most ancient landmasses to the recent landmasses. It consists of Igneous, Sedimentary and Metamorphic formation. The department of Mines and Geology of Andhra Pradesh describes the geology of the state as follows: "The Peninsular Geneissic Complex consists of an Archaean group covered by a complex group Gneisses and Schists. The Precambrian sedimentary formation of the Kadapa Super Group and Kumool Group are found in Kumool, Kadapa, Anantapur, Chittoor, Guntur, Prakasam and Krishna districts." [4]

The Telangana state is part of Southern Peninsular Shield that consists of greenstone- granite suite. The department of Mines and Geology describes the geology of the state as follows: Dharwar Craton is divided into two tectonic Blocks with reference to its North-South trend. The Western Tectonic Block (WTB) covering major areas of Karnataka with two cycles of greenstones and geosyncline piles and the Eastern Tectonic Block (ETB) relatively narrow linear greenstone belts diapiric granites and the division is with respect to the N-S trending Closepet Batholith." [5]

Source: https://cdn.telanganatoday.com/wp-content/uploads/2020/10/Groundwater.jpg

[4] Website of Department of Mines and Geology, Government of Andhra Pradesh: https://mines.ap.gov.in/miningportal/Inner/GeologyandMineralprofile.aspx, Accessed on Feb 7, 2023

[5] Geological Survey of India: Geology and Mineral Resources of Telangana, 2015, Misc Publication No 30 Part- VIII A: https://mines.telangana.gov.in/MinesAndGeology/Documents/RTI%20Circulars/Geology_Telangana_GSI%20(1).pdf



Source: http://cgwb.gov.in/AQM/AP_ATLAS.pdf

2.1.1 Geohydrology

Nearly 83% area of Telangana and Andhra Pradesh is occupied by hard rock aquifers and 17% of landmasses are composed of soft formation. The aquifer atlas of the united Andhra Pradesh published by the Central Ground Water board in 2013 has grouped rock formations of both of these states into fourteen principal aquifers system. These 14 different aquifers are Alluvium, Laterite, Basalt, Sandstone, Shale, Limestone, Granite, Schist, Quartzite, Charnockite, Khondalite, Gneiss, Banded Gneissic Complex (BGC), and Intrusives. These aquifers systems are categorised based on mineral composition, age, nature of formation and distribution.

The largest principal aquifer system is Banded Gneissic Complex (BGC) that covers nearly 43% of the total geographical area of these two states. It is followed by Shale and Sandstone; they together cover around 16% of the total landmass.[6] All of these principal aquifer systems in the region are further divided into 29 sub-groups. These groups of aquifers are important to assess characteristics of aquifers such as depth of water level, their seasonal fluctuations, decadal mean of pre monsoon, post monsoon, overburden thickness, fractured depth, granular zones and yield range.

The hard rock formation of Andhra Pradesh and Telangana is formed of consolidated formations such as Archaean, Cuddapah, Dharwars, Kurnool and Deccan Traps. On the other hand the soft rock formation of the region is formed of semi-consolidated formation like Gondwanas, Tertiaries and deposits like recent alluvium. According to the data available on the website of Central Ground Water Board, the yield of wells ranges between 2-5 cubic meter per hour in Dharwars, 10-35 cubic meter per hour in granite gneiss, khondalites and charnokites, 7-50 cubic meter per hour in Cuddapahs, 0.5-1.50 cubic meter per hour in Shales and 10-40 cubic meter per hour in Deccan traps. In the region of soft rock formations the yield varies from 12-220 cubic meter per hour in Gondwana to 15-60 cubic meter per hour in alluvial formations.[7]

Source: https://worldarchitecture.org/cdnimgfiles/extuploadc/borewell.jpg

[6] Central Ground Water Board, 2013: Aquifer Systems of Andhra Pradesh: http://cgwb.gov.in/AQM/AP_ATLAS.pdf

[7] Website of Central Ground Water Board: http://cgwb.gov.in/gw_profiles/st_ap.htm

2.1.2 Hydrology

The landmass of Andhra Pradesh and Telangana is spread over four river basins namely Godavari, Krishna, Cauvery and Mahanadi. Godavari river basin is located in the north, Mahanadi is located in the north east, Krishna in the central and Cauvery is located in the south of Andhra Pradesh. The present Andhra Pradesh is located on three major river basins and 11 medium river basins. The average annual rainfall in the state is 950mm. However, it is highly uneven across the state. In 2018 the rainfall ranges from 391 mm in Anantpur district to 1301 mm in Srikakulam district.

According to the Central Ground Water Board, the estimated sub-surface volume of aquifers in present Andhra Pradesh is 7.79 lakh MCM. Further it has been estimated that the available unsaturated volume for recharge in the state is 15,948 MCM, which can be recharged using artificial techniques. Similarly the same report estimates 1.67 lakh MCM volumes of sub-surface storage aquifers in Telangana. Further it estimates that subsurface recharge potential of 3342.82 MCM.[8]

The Telangana state is spread on two major river basins and 13 sub basins. The normal annual rainfall of the state is 909 mm. But, as in other places, the rainfall in this state is also highly uneven. In 2018, the precipitation ranged from 478 mm in Mahbubnagar district to 1215 mm in Adilabad district.

2.2 Groundwater availability and utilization

The National Water Information Centre has identified 36,733 small, medium and large surface water bodies in Andhra Pradesh and 17,088 such water bodies in Telangana that provide water for various purposes such as irrigation, drinking water and industrial use.[9] The united Andhra Pradesh is a riverine region where more than 40 small and big rivers flow. Krishna and Godavari river basins are largest river basins in this landmass that is spread over 150 lakh hectare land of Telangana and Andhra Pradesh. These two river basins provide 64 BCM for various uses.[10] From all river basins these two states receive 78.5 BCM water for utilization. Most of it is used only for irrigation.

The use of groundwater for irrigation has tremendously increased in the last three decades; it has therefore promoted unsustainable management of the groundwater resources. In Andhra Pradesh the gross irrigated land area using groundwater has increased from 5.9 lakh hectares in 1980 to 15 lakh hectare in 2012-13. It is expected to sharply increase in coverage of irrigated land in the next few years in the state. Many parts of Telangana and Andhra Pradesh receive very less rainfall, yet the whole landmass of these two states has capacity to replenish more than 35 BCM ground water. Of this, Telangana has 13.68 BCM and Andhra Pradesh has 18.88 BCM groundwater available in a year. According to the data published by the Central Ground Water Board on its website, the groundwater development in Telangana is 55% and 37% in Andhra Pradesh.

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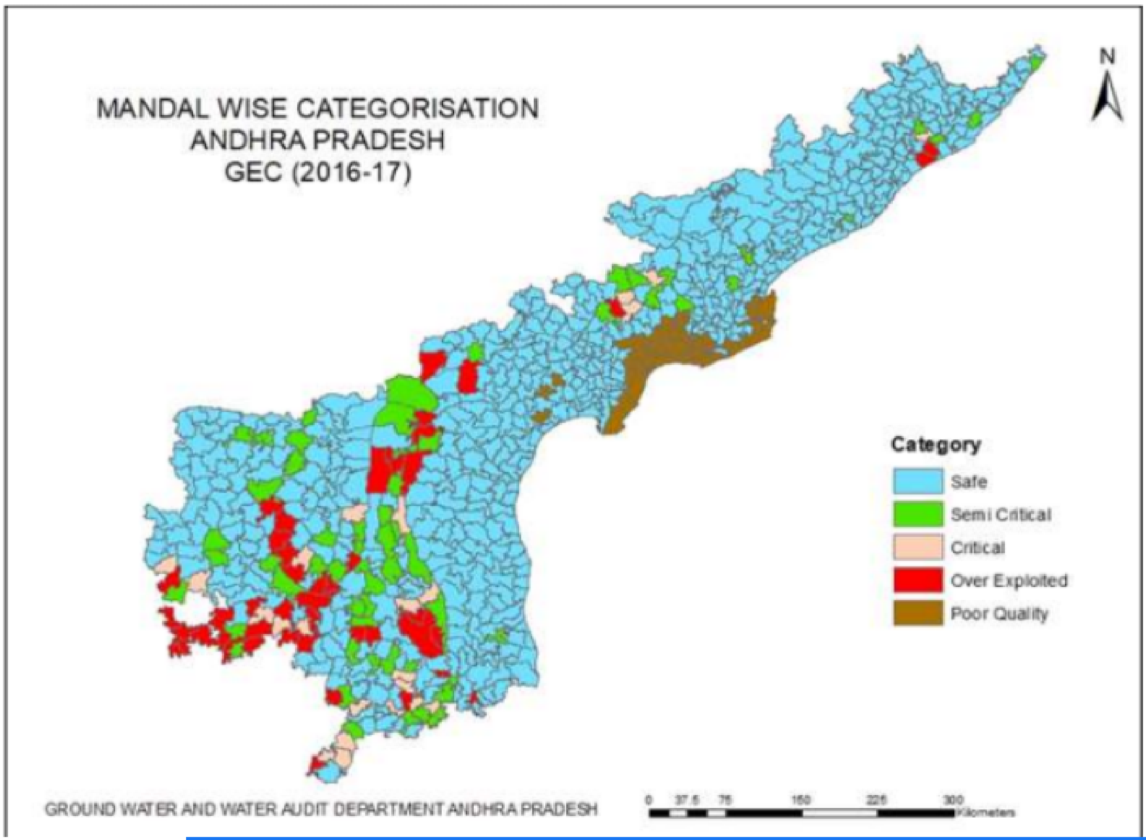
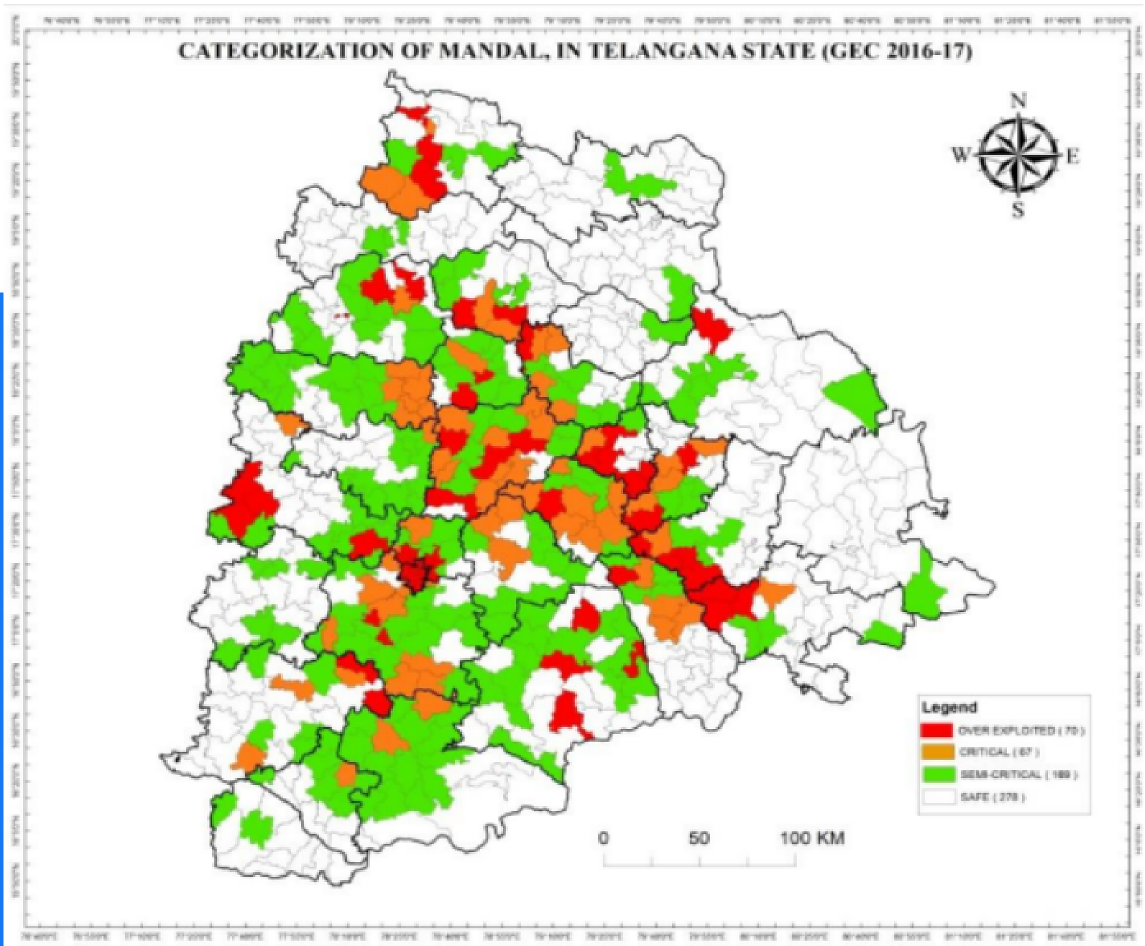
[8] Central Ground Water Board, 2021, Master Plan for Artificial Recharge to Groundwater in India- 2020, Accessed from: http://cgwb.gov.in/documents/Master%20Plan%202020-00002.pdf

[9] Website of India Water Resources Information System, Accessed from: https://indiawris.gov.in/wris/#/surfaceWater

[10] Water Resources of Andhra Pradesh, Accessed from: http://water-atlas.blogspot.com/p/part-iiandhra-pradesh-water-chapter_22.html





Source: CGWB, 2022

Dynamic Ground Water Resources (2011)	Telangana	Andhra Pradesh
Annual Replenishable Ground water Resources	15.10 BCM	20.78 BCM
Net Annual Ground Water Availability	13.68 BCM	18.88 BCM
Annual Ground Water Draft	7.50 BCM	7.01 BCM
Stage of Ground Water Development	55 %	37 %
Ground Water Development & Management		
Total mandals (Assessment units)	594	667
Over Exploited	13 Mandals	6 Mandals
Critical	7 Mandals	5 Mandals
Semi- critical	80 Mandals	19 Mandals
Saline	0	39 Mandals

With the help of a few research institutions, the Government of Andhra Pradesh in 2011 published an Atlas of water resources available in the state.[11] This publication estimated that the utilization of surface water in the regions of Andhra Pradesh and Telangana is much higher compared to its availability. The data shows that the water balance in the case of groundwater resources is positive, but in many sub-basins of United Andhra Pradesh, the water balance for groundwater resources is also negative. The report further gives sub-basin wise water balance status on the united Andhra Pradesh. It reveals that 10 sub-basins in these two states are utilizing more water compared to available ground and surface water.

Water availability, utilization and balance in United Andhra Pradesh

Water Resource	Availability (MCM)	Utilization (MCM)	Balance (MCM)
Total surface water	78,477.31	84,073.06	-5595.75
Total groundwater	34,250.54	14,004.74	20,245.81
Total water	1,12,727.85	98,077.80	14,650.05

http://water-atlas.blogspot.com/

[11] Water Resources of Andhra Pradesh, Accessed from: http://water-atlas.blogspot.com/

The dynamic groundwater resource assessment report of India, 2022 has observed positive impact on ground in Andhra Pradesh in terms of groundwater development. The report reveals that due to various activities of water conservations in the state, access rainfall, reduction in groundwater draft and some other reasons, the number of over-exploited mandals have decreased from 23 in 2020 to just six in 2022. Similar reasons also helped in increasing groundwater recharge in Telangana. The report reveals that in Telangana, the groundwater recharge has increased from 16.63 BCM in 2020 to 21.11 BCM in 2022. Similarly the overall extraction of groundwater has decreased from 53.32% to 41.6% during this period.[12]

2.3 Groundwater policies and governance in the state

Water policies in India aimed at optimising water availability for different purposes, especially for supply of water for drinking, food production, livestock, as well as for power generation, navigation, and various commercial and domestic uses. It simultaneously attempted the objectives of achieving efficiency, equity and sustainability in water use – the sustainability issues being particularly important in the light of the declining per capita availability and the pollution through human intervention.

The water policy has to be supported by legislation, i.e., laws and regulations; the laws set forth rights, obligations and institutional roles, and also establish a broad framework for more detailed requirements elaborated in subsequent subsidiary instruments such as regulations. Water laws and associated sector laws such as groundwater laws or laws of natural resources extraction and replenishments are the practical aspects of the water policy. While India has a national water policy in form of a guidance under which each state makes its own water policy. Likewise, making water laws and associated laws, along with the institution of implementation, are the sole function of the state governments. However, the plans or programmes of action and their implementation in India fall under the jurisdiction of both union and state governments.

Some 85% of the land-area of undivided Andhra Pradesh is underlain by the Weathered Granitic Basement hard rock aquifer system, which forms extensive but shallow groundwater bodies, which have low storage that can be easily depleted. Outside the command areas associated with the Godavari and Krishna rivers, the groundwater resources of this aquifer system have become critical or overexploited.

Acknowledging that water is a scarce natural resource and is fundamental to life, livelihood, food security and sustainable development, several supply side interventions like artificial recharge, rainwater harvesting, treatment and recycling of wastewater have been tried for several years. Reducing demand of groundwater through increasing water use efficiency, choosing less water intensive crops and regulating extractions have also been tried as effective management tools in recent years. The state also acknowledged that awareness and community participation is the most important link in ensuring effective management of water (Saha 2019).

[12] Central Ground Water Board, 2022, Dynamic Ground Water Resources in India, 2022, Accessed from: https://cgwb.gov.in/documents/2022-11-11-GWRA%202022.pdf

2.3.1 Regulatory framework in Andhra Pradesh

The important elements of policy and regulatory framework of groundwater in Andhra Pradesh, which continued in Telangana state after the bifurcation, include the following:

- Andhra Pradesh Ground Water (Regulation for Drinking Water Purposes) Act, 1996
- Andhra Pradesh Water Resources Development Corporation Act, 1997
- Andhra Pradesh Farmers' Management of Irrigation Systems Act, 1997
- Andhra Pradesh Infrastructure Development Enabling Act, 2001 (Act No 36 of 2001)
- Andhra Pradesh Water, Land and Trees Act, 2002.
- Andhra Pradesh State Water Policy, 2008

Key events in water policy evolution in Andhra Pradesh

1996	Enactment of Andhra Pradesh Groundwater Act (Regulation for drinking water purposes)
1997	Enactment of Andhra Pradesh Farmers' Management of Irrigation Systems Act to promote participatory management of irrigation systems in the state
1999	Spelt out Vision 2020, emphasizing the importance of water management and participatory approaches to irrigation management for sustainable growth in the agriculture and fisheries sectors
2000	Andhra Pradesh Water, Land and Tree Ordinance
2002	Enactment of Andhra Pradesh Water, Land and Trees Act (APWALTA)
2002	Release of Guidelines for Watershed Development in Andhra Pradesh based on the national guidelines (1994) and recommendations of the reviews done from time to time
2003	Andhra Pradesh Water Vision defining a broad policy framework for water in the state

2.3.2 Andhra Pradesh Water, Land and Trees Act (APWALTA)

Out of the above, APWALTA is an important example of regulatory approach to groundwater management. Under prevailing Easement Act, a land owner can legally abstract any amount of water by sinking a well. The lack of well-defined rights, the invisibility and indivisibility of groundwater and its complex flow characteristics make monitoring of its use difficult. To establish a regulatory framework and an institutional approach to manage groundwater, the Government of Andhra Pradesh introduced the Water, Land and Trees Act (APWALTA) in 2002. It was meant to promote water conservation and tree cover and regulate the exploitation and use of groundwater and surface water for protection and conservation of water sources, land and environment and matters connected therewith, or incidental thereto.

The Act prescribed that all groundwater users must register their wells and seek permission to construct new groundwater extraction structures. No well shall be sunk in over-exploited areas already notified, except for drinking purpose. Guidelines are issued on well spacing and depth to prevent over-exploitation and to safeguard drinking water sources.

Salient features: The salient features of WALTA include the following:

- Registration of wells
- Registration of drilling rigs
- Protection of public drinking water sources
- Need for permission to sink wells near drinking water source
- Prohibition for development in over-exploited areas
- Prohibition of water pumping in certain areas
- Prohibition of commercial exploitation in certain areas
- Prohibition of water contamination
- Closure of wells in case of contravention of any of the provisions of the act
- Promoting rainwater harvesting
- Re-use of water

The act was amended in 2004, which elaborated the role of the groundwater department.

- Provision for Divisional Authority
- All well sites to be selected by Groundwater dept. or geologists registered by the dept.
- Rig owners should drill site only after obtaining report from Hydro-geologist.
- Insurance was made mandatory before taking up for drilling.

Role of groundwater department in implementation of the Act:

- Registration of all the existing Rigs in the AP state.
- Assessing groundwater resource and categorising areas
- Providing the list of areas for Notification.
- Selection of well sites before drilling.
- Providing technical opinion in case of disputes.
- Joint inspection prior to leasing of sand reaches for mining.

Source: https://static.tllms.com/video_thumbnails/production/480/331807.jpg

2.3.3 Procedures

Permission for New Wells: A single window system at Mandal level is adopted for disposing the applications for sinking of new wells. On payment of Rs.100/- towards application fee to Mandal Revenue Officer, the farmer will apply permission for new well along with a demand draft for Rs.1000/- in the name of concerned District Deputy Director, Ground Water Department, towards groundwater survey charges. After receiving the application from the farmer, the Mandal Revenue Officers will verify spacing norms of 250 meters from the existing bore well of drinking water in the field to the proposed site for new well. If the MRO is satisfied for spacing norms, the case may be referred for TRANSCO clearance for power feasibility. After the clearance from TRANSCO, then the MRO will forward the application to the concerned District Deputy Director Ground Water Department to conduct investigations for groundwater feasibility.

After groundwater investigations are completed, the feasibility reports will be forwarded to the MRO for according permission to drill up to a maximum of 120m depth. Mandal Revenue Officers should ensure that the rig operated is registered with Ground Water Department.

2.3.4 Other legal provisions

Prior to the WALTA, Andhra Pradesh initiated some legal provisions to regulate groundwater development and use in the State. Starting with the Andhra Pradesh Ground Water (Regulation for Drinking Water Purposes) Act in 1996, the state restricted sinking of wells in the over exploited zone or within 200m or 500 m vicinity of any public drinking water source, without the permission of the Collector. It had a provision to restrict the use of groundwater from any such well that could influence the supply from a drinking water source, assessed by the Technical Officer on the basis of rainfall and other relevant factors, especially from February to July (summer or scarcity months). The Collector was given powers to seize the equipment and seal the well in case of violation.

2.3.5 Groundwater management initiatives

Government of Andhra Pradesh initiated measures to overcome the groundwater scarcity challenges such as groundwater recharge and improving water use efficiency. It also pioneered the promotion of community-based groundwater management (CBGWM) through such projects as APWELL (Dutch supported), APFAMGS (FAO supported), and two follow-up initiatives, APCBTMP and APDAI, financed by the World Bank.

Improving the recharge of groundwater: The Government of Andhra Pradesh initiated programmes to harvest rainwater by establishing the Water Conservation Mission (WCM) in the year 2000. The efforts under WCM are concentrated on engineering measures such as contour trenching, gully control works, construction of sub-surface dikes, check dams, percolation tanks and farm ponds, cleaning of feeder channels and desilting of water bodies. In addition, the centrally sponsored watershed development programmes to conserve rainwater over an area of about 10 million ha by 2007. These programmes have resulted in raising the groundwater levels and made several failed wells functional, thereby bringing down the number of habitations requiring transportation of drinking water.

Improving water-use efficiency: Government of Andhra Pradesh introduced participatory irrigation management by making farmers responsible for management of the irrigation systems by passing the APFMIS Act in1997. In all, 10,292 Water Users Associations at the tertiary level, and 170 Distributory Committees covering 10.0 million farmers and more than 2.0 million ha of irrigated land started working since 1997. The water charges collected are ploughed back to WUAs, Distributory Committees and Project Committees to improve operational performance through effective maintenance. The functioning of the farmers' associations and committees are reviewed to enhance their effectiveness. The experiences so far are quite impressive. Improved maintenance has stabilized water availability at the tail end, which was earlier deprived of canal irrigation. This has increased crop yields, cropping intensity and farm income.

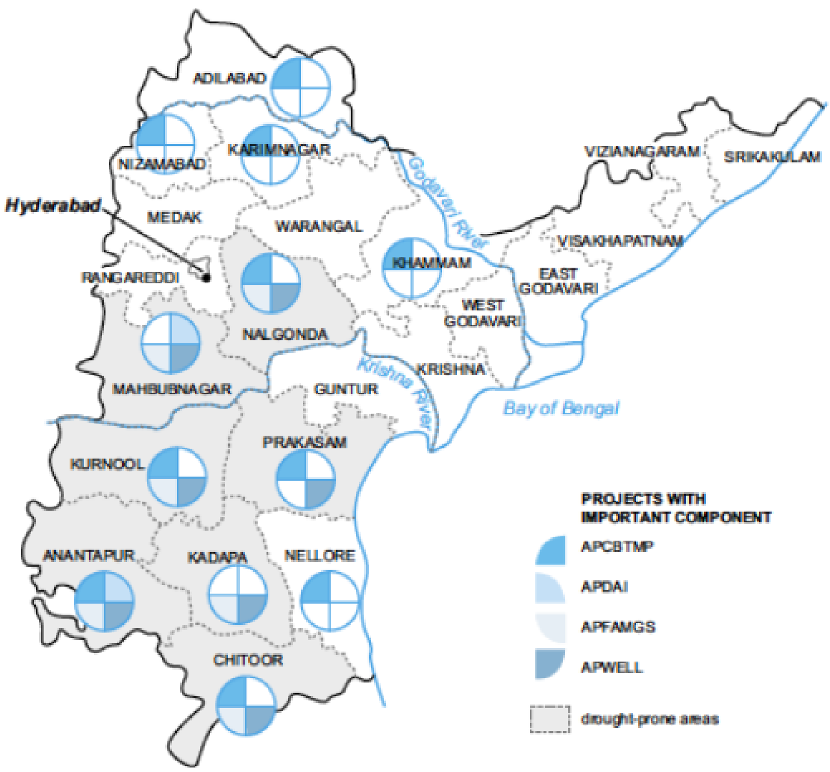
Main programmes: Andhra Pradesh had the following flagship programmes to address the water scarcity and for managing groundwater.

- Andhra Pradesh Groundwater Borewell Irrigation Schemes (APWELL) Project (supported by Dutch funding during1995-2003)
- Hydrology Project (1996-onwards)
- Community Based Tank Management Programme (World Bank supported APCBTM project 2006-2016)
- Farmer Managed Groundwater Systems (APFAMGS) was established in 2006 (with FAO funding) to include a groundwater component in the AP Drought Adaptation Initiative (APDAI) Project during 2006-09 in Mahbubnagar and Anantapur Districts.
- Mission Kakatiya (Ongoing)
- Jal Kranthi Abhiyan (Ongoing)
- PMKSY (Ongoing)

In 1974, the AP Irrigation Development Corporation (APSDIC) was set up to promote groundwater based irrigation facilities among small and marginal farmers in areas not falling under major and medium irrigation-canal command systems. It promoted, operated and maintained about 20,000 community bore well irrigation schemes, which in 1994 were handed over to farmers.

Based on the success of the community bore well schemes, APSIDC proposed the Groundwater Borewell Irrigation Schemes (APWELL Project) which was launched with Dutch funding in seven drought-prone districts during 1995-2003.

Location of the principal experience with CBGWM in Andhra Pradesh



Subsequently, Farmer Managed Groundwater Systems (APFAMGS) was launched in 2006 (with FAO funding support). The district-wise location of these four projects is shown in the adjacent figure (From: Gradunhoet al, 2009).

The main highlights of some of these programmes are given below.

Community Based Tank Management Programme: The World Bank Assisted Telangana Community Based Tank Management Project started in 2006-07 until July 2016.

Participatory Ground Water Management (PGM) component of CBTMP aims at empowering ground water users in the tank influence zone to wisely manage the dynamic ground water resources, replenished through rainfall, surface water sources and return circulation from irrigated areas. It covered 172 tanks falling with in 73 over exploited and critical groundwater basins as identified by the Ground Water Department.

Co-option of ground water users into WUA: In2008, the government decided to co-opt members having customary right like fishermen, people engaged in making pottery, washer men, ground water users outside the command area but within the demarcated zone of tanks selected for the Participatory Ground Water Management (PGM) activities under projects who are dependent on the water source for their livelihood into the respective Water Users Associations. The Groundwater Department was responsible for selection of tanks, demarcating the zone of influence, identification of five farmers for Participatory Hydrological Monitoring (PHM), installation of the PHM equipment, and selection of sites, and drilling of additional piezometers.

Capacity building of PGM group is carried out by Training Resource Persons (TRP) through specially designed training modules. Besides the PHM farmers, the trainings seek to build the capacities of the identified para workers to make a community initiative PGM. The ultimate objective of the PHM initiative in a tank is to enable the ground water user community to understand the resource position in the zone of influence through the data collected and analysed by themselves. This would enable them to plan for appropriate crops in the ensuing *rabi* season using participatory Crop Water Budgeting.

Achievements of APWELL: The pioneering APWELL Project covered around 14,000 ha of irrigated agriculture in 370 villages, involving 14,500 marginal farmers, in 7 of the 8 drought-prone districts of Andhra Pradesh. From 1995 it facilitated watershed conservation, recharge enhancement, installing community water wells and distribution systems, improved irrigation practices and rural electricity provision, as well as promoting sustainable agriculture practices and more profitable but less water-consuming crop selection. But the key innovation was the concept and practice of Participatory Hydrological Monitoring (PHM) – with the training of some 3,450 Water User Groups, 600 Female Self-Help Groups and 250 Groundwater (Bore well) Users Associations.

The APFAMGS Project (2006-12) took the APWELL experience a step further by adopting a sub-basin approach for selection of habitations (unlike APWELL which selected villages with an 'exploitable surplus' of groundwater).Although it covered the same seven drought-prone districts, included only about half of the APWELL villages. It was implemented via a nodal executing agency supported by a number of well-motivated local Civil Society Organisations working closely with socially-sensitive hydrogeologists.

Key characteristics of this programme included conveying realistic messages and proposing technically-sound and economically-feasible management measures.

The project operates through community-based organisations – village-level Groundwater Management Committees (GMC) comprising representatives of all groundwater using families in the community. The GMCs for a given groundwater body, sub-aquifer unit or sub-basin are federated into an aquifer level organisation (Hydrological Unit Network or HUN). The project has established 555 GMCs falling under 63 HUNs, and it is through these organizations that communities are collecting and analysing data and implementing decisions for sustainable groundwater management. The HUNs now have official legal status and run the Farmer Water Schools themselves.

APDAI Project: The Rain-Shadow Areas Development Department was established to intensify, coordinate and increase effectiveness of disperse government assistance for sustainable development in the drought-prone districts. The APDAI Project was being implemented during 2006-12, beginning with a range of pilot projects in Mahbubnagar and Anantapur Districts through a coordinating CSO collaborating with District Collectors. The main groundwater management related interventions included

(1) connecting several individual bore wells through a pipeline network for sprinkler irrigation allowing a larger area to be cultivated with less water, and improving social equity by encouraging non-well owners to make use of the shared system
(2) soil moisture conservation through enhancing soil water retention capacity and drought resilience by promoting increased biomass at farm level with tree planting on bunds, cultivating some green manure field crops and improved composting
(3) promotion of System of Rice Intensification (SRI), which greatly reduced consumptive water use and weed growth.

2.3.6 Challenges and opportunities

APWALTA is not applicable to extraction of groundwater from existing sources, use of which is believed to be responsible for over-exploitation in the area; therefore, a mechanism be to be devised in order to control draft from existing sources.

Present policies and legislations with strong focus on state control and regulation of ground water, missed the elements of community management of common property such as groundwater. Unregulated over-exploitation of groundwater resource continuing at rapid pace highlights the dismal status of growing gap between the policy and practice. Grass-root experiences, such as Social Regulation of groundwater, are promising and offering innovative and alternative solutions. (Rama Mohan RV, undated).

As per APWALTA, drilling new bore wells is not allowed within a specified distance from an existing irrigation bore well. This restriction denies many farmers access to groundwater, while the existing bore well owners continue to enjoy unrestricted access to groundwater. Social regulations and mutual sharing of water is required to address this disparity created by APWALTA.

Alternative approaches such as social regulations in groundwater management and sharing mechanisms shall be scaled-up for ensuring equitable distribution of groundwater without stressing the energy and groundwater resources. Gram panchayats should be capacitated and empowered to manage and regulate the groundwater resources within their area of operation.

Artificial recharge, rainwater harvesting, treatment and recycling of wastewater are some of the supply side interventions that can help in augmenting resources. Reducing demand of groundwater through increasing water use efficiency, choosing less water intensive crops and regulating extractions are also effective management tools (Saha, 2019).

Social regulation approach is observed to work better for sustainable groundwater management when compared to the knowledge-intensive approach, as the latter is not designed to address equity. Encouraging water sharing between well owners and others would contribute to achieving the twin objectives of conservation and improved access with equity.

There is need for developing an integrated model drawing from these three models in order to make it more generic and applicable globally. Such a model should integrate scientific, socioeconomic and policy aspects that suit the local conditions (Reddy *et al*, 2014).

2.4 Locally appropriate solutions for groundwater management

Groundwater has become a major source of water for domestic and agricultural use in India in the last three decades meeting nearly 60% of irrigation demand. The relative ease in accessing a captive source and extraction technology has facilitated this phenomenal rise in groundwater use, often threatening the sustainability of the very groundwater sources. Determining sustainable levels of extraction, in proportion to the recharge, is a challenge in complex aquifer systems in hard rocks, which comprise nearly two third of the country. Understanding the behaviour of groundwater in an aquifer is essential/ prerequisite to its use in a sustainable and viable manner.

2.4.1 Participatory groundwater management case study from district Mahbubnagar, Telangana

The state of Telangana, which was carved out of Andhra Pradesh in 2014, has 31 districts sub divided into 68 revenue sub-divisions and 584 mandals. It has a semi-arid tropical climate with predominantly hot and dry climate. Receiving around 904 mm rainfall, nearly 80% from Southwest monsoon, Telangana suffers from variability in annual and seasonal rainfall, making it drought prone in many parts. The entire state falls in the basin of two major rivers, Godavari and Krishna, which originate in the state of Maharashtra and enter into Andhra Pradesh, where they drain into Bay of Bengal.

Geologically, nearly 85% of Telangana state is underlain by consolidated gneissic formations, and the rest of the state is underlain by semi consolidated sedimentary formations. District Mahbubnagar falls in this hard rock area mostly with banded gneissic granite formations, with a small portion of granite in the southwest. These rocks have low primary porosity and the groundwater occurs in the fractured zones mostly at shallow levels.

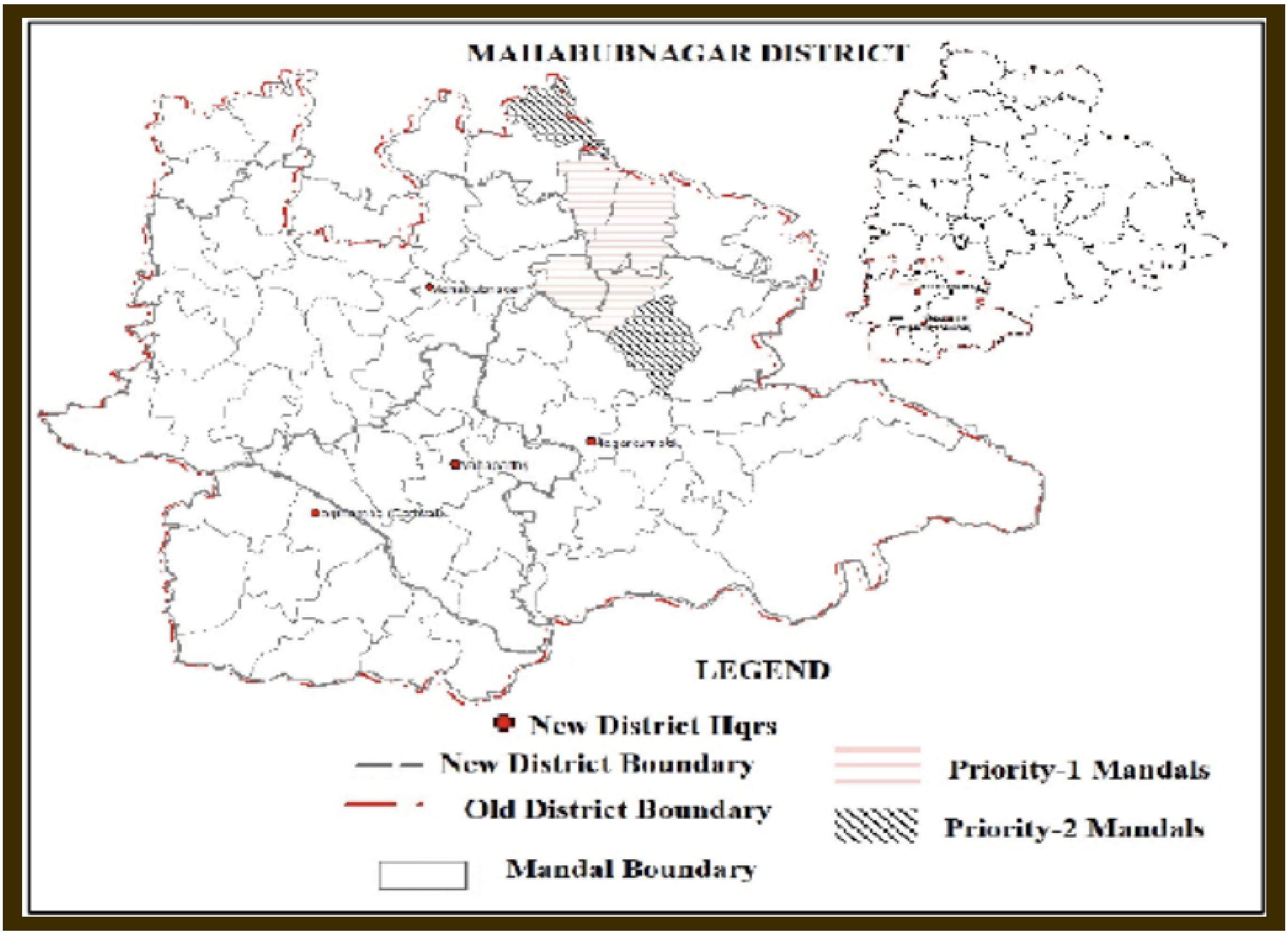
The study area selected was a part of a project covered under Integrated Watershed Development Programme around the turn of the century. It fell in a cluster of villages around Undyala in Chinna Chinta Kunta Mandal. The watershed development work was facilitated by Villages in Partnership (VIP), a voluntary organisation formed as a locally-organised community development group, working on the principles of partnership of people in development.

The study was based on a rapid assessment of the ground situation captured through site visits and interaction with the primary stakeholders, viz., the representatives of village level and watershed management committees, the field functionaries of line departments, elected representatives of the Gram- and Mandal-panchayats and the staff of the facilitating organisation - VIP. It was supplemented by review of reports and records provided by the committees and by VIP.

2.4.1.1 About Undyala watershed

The watershed project in Undyala cluster was taken up in 1996 by Villages in Partnership for development under Watershed Development Fund supported by the Government of India under the National Watershed Development Programme for Rainfed Areas (NWDPRA). VIP has been working for demand driven holistic development of these villages for several years and enjoyed a good rapport with the community.

The project was implemented over an area of about 2200 ha belonging to Undyala and two other villages Konkanonipalli and Dhamagnapur from 1996- 2000. The project covered a population of 4706 males and 4980 females from 1956– households. The Village Watershed Committees implemented various soil water conservation measures using ridge-to-valley principle and adopted water use practices to address the water scarcity through a variety of means, including crop production measures.



Location Map

Basic information about the project villages

S No	Village Name	Geographic area, ha	Households	Population Male*	Population Female*
1	Undyala	2,043	1,120	2,900	3,200
2	Konkanonipalli	654	356	836	809
3	Dhamagnapur	1,035	480	970	971
	Total	**3,732**	**1,956**	**4,706**	**4,980**

* As per 2011 census

The experiences of the community and the implementing organisation were studied through a series of interactions with the stakeholders and field observations. The main findings of this study are presented in the following section.

2.4.1.2 Watershed development phase

Discussions were held with the farmers, members of the then Watershed Management Committee and the representatives from the Gram Panchayat and Mandal Panchayat on their experience of developing their watershed and managing their water. Farmers narrated the story of how they came together and decided to take up watershed projects in times when the entire district was rainfed and experienced frequent droughts.

Community mobilisation was a long drawn process with the farmers and their opinion leaders assessing several factors affecting their farm production, and through a series of meetings gradually understood that watershed development would increase their water availability. Some farmers and their leaders took initiative to plan soil and water conservation measures with the help of Villages in Partnership and thus started the project with support from by the Government of India under the National Watershed Development Programme for Rainfed Areas (NWDPRA) in 1996.

Various soil and water conservation activities like farm bunds, gully plugs, percolation tanks, development of farmland by clearing wastelands, etc. were carried out. As a result of these interventions, soil moisture and groundwater recharge increased substantially. Prior to this project, only 1500 acres (600 ha) out of 2200 ha of the watershed area was under cultivation. Within a few years, the cultivated area increased to over 1600 ha. Farmers started taking crops like paddy, castor, pulses, chilly and sugarcane, whereas they depended on single season millet based cropping in the past. With this development, many farmers took up new wells or deepening existing wells so that they could irrigate their second crop after the rainy season. Nearly one third of the cropped area came under Rabi cultivation.

All these activities were supervised by the Watershed Committee to ensure quality, efficient resource use and speedy implementation. Even after a passage of more than two decades, the members could recall and talk with great pride on how they completed several works well in time and well within the budget. As per the provisions of WDF, the village set up a Development Fund of the order of 10% of project expenditure, which amounted to Rs 400,000 This was an important instrument for subsequent maintenance of the structures and also for taking up development activities in future.

2.4.1.3 Water management phase

With a rise in demand for water after the watershed project was over, the farmers faced shortages in the dry season. While this was anticipated by the Watershed Committee and the community in general, they required help of Villages in Partnership to take up interventions to tide over the deficit. Many farmers took up irrigation ponds either individually or in small groups with the help of Mandal Panchayat schemes. Here again the committee persuaded small farmers to sink these ponds, as the small farmers were worried about losing a lot of land in the ponds.

Induced recharge of borewells was another important measure adopted by the farmers by diverting water from nearby tanks (fed by seasonal streams) during the surplus season when the streams were flowing. It increased the availability of water in those borewells, enabling the farmers to take second, or in some good years, the third crop.

The watershed committee, together with the Gram Panchayat leaders sought support from the Mandal for this activity. Recently, the government sanctioned a grant for improving this system in case of three tanks (out of the five tanks in the village) by way of bund repairs, desilting, stone pitching and repair of the channels. The farmers are now planning to get the other two tanks repaired in this fashion.

People also talked about constructing a check dam during the watershed project well in time and spending only Rs 67,000, which meant a substantial savings compared to the estimated cost of Rs 1.5 lakh. Impressed with this efficiency and integrity, the District Collector sanctioned a diversion weir in the village. Further, the Collector granted the contract of construction of the school building to the committee.

Photo of the village pond

Pooling of borewells was another strategy used by some farmers, who formed small groups and shared the groundwater for cultivating their crops. They used to plan their cropping and irrigation based on the water availability in each season and also used water saving irrigation methods like drip and sprinkler. However, the sharing of water or pooling of borewell did not continue beyond the sporadic experiment.[13]

Operations and maintenance is another important aspect taken care of by the committee, not only for the assets created under the watershed project, but other development activities of the state. The farmers shared their experience of setting up a system of maintenance of drinking water hand pumps. The official system of maintenance used to take a few days to a week to get the hand pump repaired, and the villagers used to suffer due to having to fetch water from another source located far away.

[13] During this period, measures like connecting several individual bore wellsthrough a pipeline network and promotion of System of Rice Intensification (SRI) were implemented under the Andhra Pradesh Drought Adaptation Initiative (APDAI Project) during 2006-09 in Mahbubnagar and Anantapur Districts through a coordinating NGO collaborating. These interventions were found useful, but the coverage was limited.

The villagers deliberated upon this problem and decided to start their own maintenance systems. With the help of Villages in Partnership and support from UNICEF, they trained 29 youth in handpump maintenance and provided them with the tool kit. These youth used to attend to the repair and maintenance needs of the villages in the Mandal. They were so efficient and reliable in their service that even the district administration used to engage them for O&M of handpumps and pay for their services. Many new hand pumps were installed by these trained youth.

Photo of Drip irrigation system installed in a farmer's land

2.4.1.5 Suggestions for future

The committee members and the community representatives gave the following suggestions for the future and for the government.

- Number of wells has to be regulated, which can be done by the community itself. Government should authorise the people (or the Gram Panchayat) to regulate new wells. The community should be supported for making the existing sources functional using groundwater recharge and similar efforts.
- The government has several schemes of rural development, but these are presently implemented by contractors and the department officials without even informing the community. The government should consult the community and involve them in implementation and quality assurance, as it will lead to effective implementation.
- The community can take up several developmental activities if they are involved in planning and implementation. They gave examples of how they could utilise the Development Fund created in the watershed project for building roads to farms in the nooks and corners of the village.

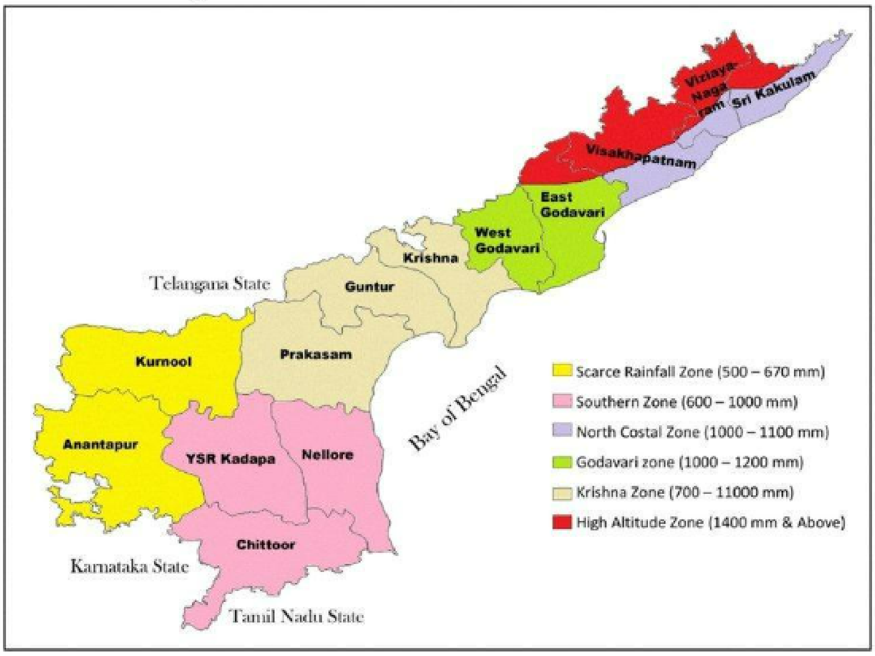
2.4.1.6 Discussion and analysis

Good practices and their effectiveness
This section enlists and explains some unique or good practices signifying the approach and its effectiveness.

The spirit of partnership: Villages in Partnership has an approach to rural development which is based more on **partnership development** rather than **service delivery**.

Systematic partnership building approach of VIP, emphasising on supporting the development needs and agenda of the community, as against pushing the externally driven development interventions, is the main factor in achieving this success. Another important aspect was the finding of a solution locally, instead of transplanting an external solution from other areas.

Agro-Climatic zones of AndhraPradesh



Technical support: was provided by VIP on need basis and at crucial junctures, may it be borewell recharge or hand pump maintenance training. The present setup at the Mandal Panchayat level and district level is inadequate considering the needs of several villages requiring such guidance and support.

Organisational aspects: Although the watershed committee is not in formal authority to maintain the structures or in taking up any water management activities, it is still as respected and acknowledged by the community. Some of the members subsequently became the Gram Panchayat members or Sarpanch, as well as office bearers in Cooperative Societies and other local self-governance structures (mainly, the Mandal Panchayat).

Strong community organisation sensitive and responsive to the needs of the community is one of the main factors behind the success of the project, and subsequent development in the village. Capacity and leadership building among the community representatives in general, village watershed committee, in particular was one of the major contributions of Villages in Partnership.

2.4.1.7 Applicability in other areas

The following strategies and approaches used in this project could be applicable to other areas with similar groundwater challenges:

Awareness building: Raising awareness of the farmers and other water users sharing a shallow aquifer and mobilising them to come together for planning and managing this as a common property resource.

Partnership approach: Villages in Partnership worked on encouraging people to identify and prioritise their development needs and finding their solution locally. It naturally created an atmosphere where the community's capacities grew. It has been the main factor in the success of this project and creating a community capable of addressing its development needs.

Strong committee: The watershed committee does not exist in its original form or as a formal authority today, yet it plays an important role in village development. The members are still active, some in their individual capacity and some others as members and office bearers of local organisations. The younger community members also seek their advice or guidance on matters important for village development.

2.4.2 Integrated watershed management in Anantapur

Ananthapuramu (more commonly referred to as Anantapur) district was bifurcated to form Ananthapuramu and Sri Sathya Sai districts in April 2022. Given the very recent nature of the bifurcation, much of this document will deal with data of the undivided (old) Ananthapuramu district.

Anantapur, known to be the **second driest district in the country** after Jaisalmer, and the driest in South India, is located in the Rayalaseema region in the southern half of the state of Andhra Pradesh.

Andhra Pradesh has 6 agroclimatic zones.[14] All of Anantapur falls under the Scarce/Scant Rainfall Zone where annual rainfall ranges between 500 to 670 mm.[15] Its geographical location in the middle of the peninsula renders it dry. Both of India's main monsoons often evade it due to its location - its great distance from the east coast prevents it from benefitting sufficiently from the north east monsoon and its location in the rain shadow of the Western Ghats largely cuts off its access to the south west monsoon. The annual average rainfall of the district is a low 552.3 mm.

The district experiences a **high degree of inter-annual variability in rainfall pattern**. From 1989 to 2018, Anantapur had a rainfall variability of 76%. **When rainfall does occur - its intensity, frequency, pattern and distribution are highly erratic**. Extreme rainfall events occur frequently. In some years, the rains have moved from crop to non-crop seasons. This **raises the risk associated with agriculture** and makes it frequently precarious.

Recurrent droughts and severe water distress are synonymous with the arid region. The district has seen 18 droughts in the 20 year between 2000 and 2020.[16] The frequency of droughts has increased particularly over the last three decades. In the 139 years between 1877 and 2016, Anantapur district received normal and above normal rainfall during 70 years (not serially or consecutively) and deficit rainfall in 69 years.[17]

With the extreme dryness and extended periods of soil moisture loss, the soil has experienced degradation. Over the last three decades, it has experienced an **80% reduction in the soil water retention capacity.** The region is succumbing to desertification. **The moisture index of the district is -75.5%.** Moisture Index indicates the water content in the soil and is critical for crops.

A low index number indicates that the rainfall received is not sufficient to meet the potential evapotranspiration demand. Evapotranspiration is the sum of direct evaporation from the land and transpiration from plants. In arid regions the annual potential evapotranspiration exceeds annual precipitation.[18] Between 1999 and 2015, acidity of the soil rose by more than 4%. Organic carbon in the soil, which is considered the building block of soil, reduced by 84%. The soils have become highly deficient in essential micronutrients like zinc, iron, phosphorus and potash.

Given the extended droughts, the erratic rainfall patterns, the aridity of the region and the soil degradation, water storage for both irrigation of standing crops and the recharge of groundwater through surface water systems including tanks, ponds and canals becomes absolutely critical.

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[14] https://mausam.imd.gov.in/amaravati/mcdata/APAgromet.pdf

[15] https://www.researchgate.net/figure/Agroclimatic-zones-of-Andhra-Pradesh_fig3_323877973

[16] https://timesofindia.indiatimes.com/city/amaravati/2-decades-of-drought-emptying-out-andhras-blessed-district/articleshow/87408762.cms

[17] https://www.deccanchronicle.com/nation/current-affairs/190516/anantapur-drought-due-to-location.html

[18] https://www.downtoearth.org.in/news/agriculture/desertification-in-india-ananthapuramu-in-andhra-is-so-sandy-it-draws-filmmakers-to-shoot-66457

2.4.2.1 Agriculture and water

Between 80 to 90% of the land under cultivation in Anantapur is rainfed [19 20 21]. **Changes in agriculture over the decades have served to exacerbate the water distress across the district.** Historically a large variety of millets were cultivated there. Over recent decades, that has changed – people have increasingly switched to growing commercial crops, particularly groundnut. Consequently, borewells have mushroomed.

Roughly 70% of the cultivated area in Anantapur is covered by groundnuts. This shift to monocropping of groundnuts has had other deleterious effects too – trees were removed as groundnuts can't thrive in shade. Anantapur has seen a massive dwindling of shrubs and forest. Approximately 11% of its area is classified as forest while the real coverage is closer to a significantly lower 2%. This has added to the issue of soil moisture loss. Temperatures have risen. All these issues together make returning to rainfed agriculture an uphill task.

In a vicious cycle, the shift in agricultural cropping patterns has severely depleted groundwater, and the depletion of groundwater has led to massive dwindling of area under cultivation. There has been a 50% drop in area under cultivation – from 30 lakh acres to 15 lakh acres over the past 30 years.[22] Standing crops had failed in 15 of the 26 years preceding 2019.

More recently, with water coming in from the new/upgraded canal projects, many farmers have taken to using the canal-irrigated area for horticulture — for crops such as orange, grapes and banana. This is concerning because one of the reasons attributed to the drying up of borewells is the use of groundwater to irrigate water intensive agricultural crops. One prevailing view is that the soil of Anantapur is more conducive to the growth of tree crops such as tamarind, drumstick, gooseberry, neem which are more likely to be economically and environmentally beneficial to this region.

2.4.2.2 Water Deficits - Famines, Poverty, Farmer Suicides and Out Migration

The region has an extremely long history of famines. As per the 1961 District Census Handbook for Anantapur[23] the earliest famine on record occurred in 1792-93. Several famines followed before a really great famine that raged between 1876 and 1878. Subsequently the district's history has been replete with scarcity conditions amounting to famine over and over and over again. It suffers issues with irrigation and is listed amongst some of the poorest districts in the country with[24] a **high poverty rate** (over 76% according to some estimates).[25] With land holdings of barely 1-5 acres, 90% of the farmers in the district are small and marginal farmers. The lack of water leading to crop failure and ever spiralling debts incurred on **failing borewells** has led to a **large number of farmer suicides over the years**.[26] An estimated 223 farmers took their lives between June 2014 and October 2016 because of debt.[27]

[23] http://lsi.gov.in:8081/jspui/bitstream/123456789/2788/1/21660_1961_ANA.pdf

[24] http://af-ecologycentre.org/ananthapur/

[25] https://thewire.in/politics/rayalaseema-politics-andhra-pradesh

[26] https://timesofindia.indiatimes.com/city/amaravati/2-decades-of-drought-emptying-out-andhras-blessed-district/articleshow/87408762.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Irrigation

The district is part of river Pennar (80%) and river Krishna (20%) basins. It is mainly drained by the Pennar and its tributaries Jayamangali, Chitravathi, Vedavathi (also called Hagari) Chitravathi, Papagni, Maddileru and is divided into 100 watersheds.[28] [29] Most of the district is covered primarily under Minor Irrigation Sources in addition to a few major irrigation projects.

There are four Medium Irrigation projects 1) Upper Pennar Project (Ayacut 10048 Acres) 2) Pennar Kumudvathi Project (Ayacut 6126 Acres) 3) Bhairavanithippa Project ((Ayacut 12000 Acres) and 4) Yogivemana Reservoir Project (Ayacut 11510 Acres) and also called Maddileru Project.

The Tungabhadra Project High level canal (TBP HLC) system stage-I and II (A joint venture of Karnataka and Andhra Pradesh States) is one water supply source for the district. The more than a decade old Tungabhadra High Level Canal (THLC) modernisation project launched in 2008 is yet to see the light of the day. The delay in the execution of Penna Ahobilam Balancing Reservoir (PABR) project stage-1 and II has contributed to the inability of the district to benefit from THLC water.[30]

The Anantha Venkata Rami Handri Neeva Sujala Sravanthi (HNSS) is an ongoing major irrigation project in the district. It was originally designed for utilisation of 40 TMC ft of Krishna water to irrigate 6.025 Lakh Acres in Kurnool, Anantapur and Chittoor districts. Of this, 345,000 Acres is situated in Anantapur district. Its water is drawn from the foreshore of Srisailam reservoir - its main canal runs for a length of 565 Kms.

Four branch canals - Peruru Branch Canal, Madakasira Branch Canal, Punganur Branch Canal and Niva Branch Canal were proposed along the main canal. Three distributories - Atmakur, Thamballipalli and Vayalpadu were also proposed along the main canal. Three reservoirs were proposed in Anantapur under phase 2 of this project - Gollapalli Reservoir, Cherlopalli Reservoir and Marala Reservoir. Jeedipalli Reservoir was a phase 1 reservoir.

While much of the main canal work of HNSS is complete and the proposed reservoirs are constructed, the distributary/branch canals to take water to the hinterland away from the HNSS network is not complete. The lining of canals is also not complete.[31] The need has been recognised to expand the capacity of both the main and branch canals in order to provide the requisite water.[32]

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[27] https://www.thenewsminute.com/article/failed-borewells-and-farmer-suicides-human-cost-anantapur-s-agrarian-crisis-83777

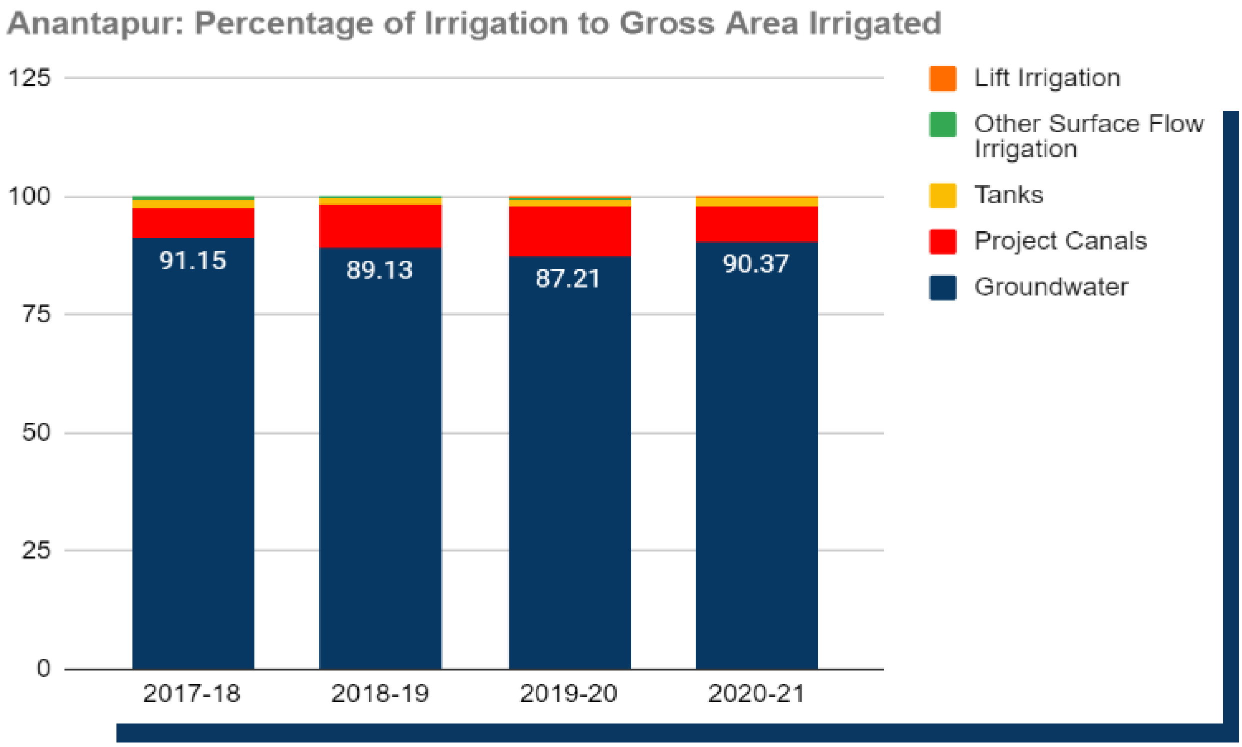
[28] http://cgwb.gov.in/AQM/NAQUIM_REPORT/AP/ananthpuramuamu.pdf

[29] https://irrigationap.cgg.gov.in/wrd/static/districtProfiles/Anantapur-IP.html#:~:text=Further%20in%20this%20district%20there,and%20also%20called%20Maddileru%20Project

[30] https://www.newindianexpress.com/states/andhra-pradesh/2022/jan/17/tungabhadra-dam-has-water-but-land-to-remain-parched-as-govt-fails-to-complete-pabr-2407665.html

[31] https://www.newindianexpress.com/states/andhra-pradesh/2020/jan/19/incomplete-canal-system-defeats-purpose-of-handri-neeva-sujala-sravanthi-in-andhra-pradesh-2091549.html

[32] https://www.thehindu.com/news/national/andhra-pradesh/tenders-to-widen-hnss-canal-minister/article34683807.ece



Andhra Pradesh has sought to re-engineer the HNSS and Galeru Nagari Sujala Sravanti (GNSS) lift water schemes by connecting both the schemes through a pipeline without increasing the Ayacut under both the schemes put together and without increasing the quantum of water utilisation.[33] [34] The re-engineering project has been challenged in the National Green Tribunal which has stayed the project.[35] The project has also met with political resistance.[36]

All the irrigation projects have the potential to alleviate the district's water crisis – perennial irrigation sources if directed to tanks across the district will help recharge groundwater in the vicinity of the tanks and benefit many who cultivate around those tanks. The district has some 1265 tanks. As of 2017, more than 60,000 farm ponds had been dug up under the "Panta Sanjeevani" programme.

2.4.2.3 Groundwater

For the irrigated agriculture in the district, groundwater is the primary source, accounting for over 85% of the irrigation. The real borewell boom began in the 90s and went out of control. However, as is to be expected in a highly arid zone, a major concern in the district is the falling groundwater levels.

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[33] https://www.thehansindia.com/andhra-pradesh/peddireddi-ramachandra-reddy-sets-stone-for-rs-4374-crore-gnss-hnss-linkage-scheme-694119

[34] http://www.indiaenvironmentportal.org.in/content/472505/the-rejoinder-by-andhra-pradesh-related-to-ec-granted-to-hnss-and-gnss-irrigation-scheme-11022022/

[35] https://www.deccanchronicle.com/nation/politics/050721/case-filed-against-ap-for-taking-up-projects-illegally.html

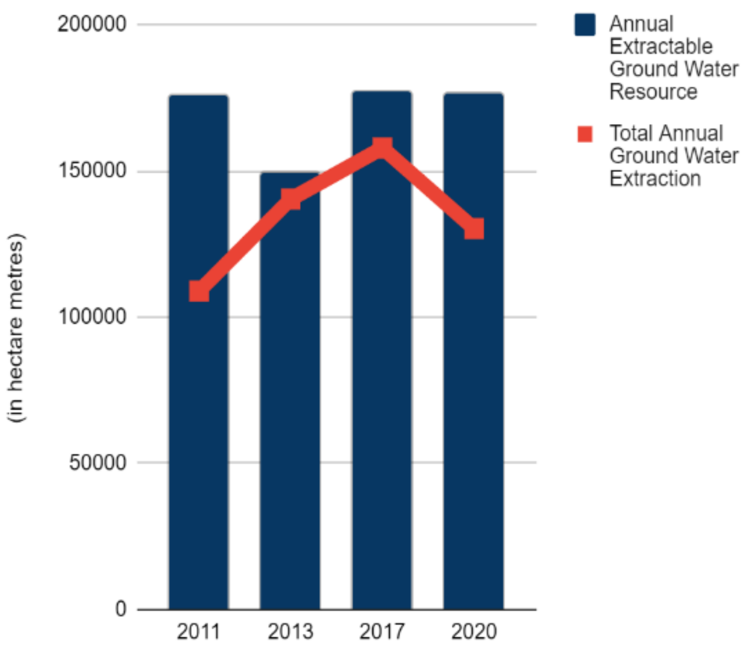
[36] https://www.thehansindia.com/andhra-pradesh/renovate-tanks-to-avoid-water-crisis-in-rayalaseema-697942

Most years in the past two decades, in much of Anantapur, borewells don't find water till about 500-600 feet. In parts of the district, they have breached the 1,000-foot mark.[37] Anantapur has 272,607 borewells,[38] though the carrying capacity of the district is a quarter of that at 70,000. More than half of these borewells had run dry by 2019. In 2019, only those mandals and villages closer to PABR, HNSS reservoirs and main canals had sufficient groundwater and water tables were available at less than 10 metres depth.

Central Groundwater Board Data shows that the total annual groundwater extraction has been increasing since 2011 but showed a decline in 2020 - the decline coincides with two factors - excess rainfall in 2020, as well as, the country wide lockdown due to the Covid-19 pandemic.

Good rainfall over 2020-21 (60% excess) and 2021-22 (37% excess), saw groundwater levels increase in the district. Additionally, the two main canal projects in the district - HNSS and Tungabhadra - saw good inflows. The groundwater levels increased and all reservoirs, ponds, and canals have good storage levels. Around 70 % of the district is in the safe zone in 2022.

However, as per projections in Andhra Pradesh's State Level Action Plan on Climate Change (SAPCC), there is a decrease in the southwest monsoon rainfall over Rayalaseema from the 2020s to 2080s. The decrease is expected to be drastic over Anantapur and Kadapa districts.[39] The surface-air-temperatures projections identify Anantapur and Kadapa as the strongest heat pockets in Rayalaseema. The projected temperatures increase by about 2.5°C from 2020s to 2080s.



The Andhra Pradesh Water Land and Trees Act (APWALTA) is enforced in 134 villages in the district. The act is designed to protect and conserve water, land and environment by promoting water conservation, enhancing tree cover and regulating exploitation and use of ground and surface water.[40]

[37] https://thewire.in/agriculture/its-raining-sand-how-anantapur-came-to-resemble-a-desert

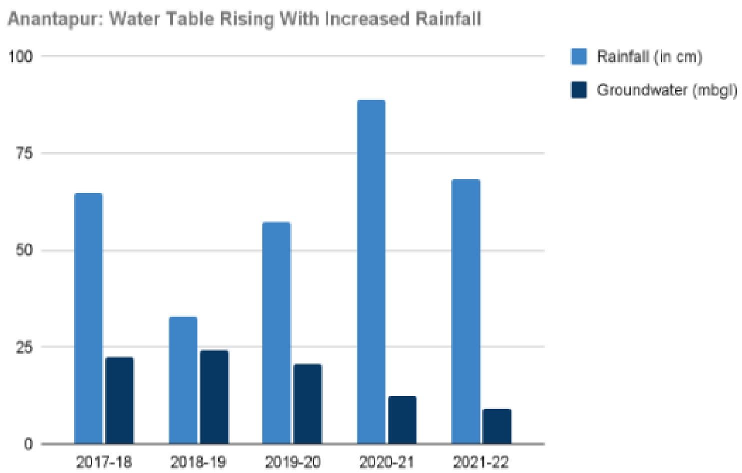
[38] https://www.newindianexpress.com/states/andhra-pradesh/2022/mar/29/anantapur-upbeat-as-groundwater-levels-rise2435344.html#::text=ANANTAPUR%3A%20The%20groundwater%20levels%20in,12.20%20metres%20in%202020%2D21

[39] https://moef.gov.in/wp-content/uploads/2017/08/Andhra-pradesh.pdf

[40] https://www.indiawaterportal.org/articles/andhra-pradesh-water-land-and-trees-act-apwalta

2.4.2.4 Accion Fraterna Ecology Centre

The Accion Fraterna Ecology Centre (AF-EC), founded in 1982, has been doing a wide spectrum of far-reaching work to empower the local communities of Anantapur District. The district's key ecological issues - droughts, groundwater depletion, and desertification- have shaped the organisation's **focus areas which include natural resources management (NRM), watershed development, drought management, environmental development and policy advocacy, and sustainable agriculture.**



Interventions in all these areas are also geared to help the district with climate adaptation and mitigation. AF-EC's fraternal organisation, Rural Development Trust, founded earlier in 1969 and working across Andhra Pradesh and Telangana and implements programmes spanning many sectors, some of which are focused on rainwater harvesting and climate resilience in agriculture.

Since 1986, AF-EC's contributions to alleviating Anantapur's water issues with its participatory watershed development programme, in particular, have been substantial.

A watershed, also known as a **drainage basin/catchment area**, is an area of land that drains water into a specific waterbody. It is an independent drainage unit for surface water runoff. One watershed is separated from another by a natural boundary known as the water divide or the ridge line.

The organisation's work on watersheds began well before the government started large scale watershed programs; **AF-EC's programmes are amongst the largest watershed development programmes implemented by an NGO in India.** It has won many state and district level awards for its work in this area. Its Muttala watershed is a model watershed that is visited by many Project Implementing Agencies (PIAs) from across AP and Telangana States to learn from and to emulate the processes followed by AF-EC.

In the initial years, AF-EC focused on soil conservation, rainwater harvesting, and the improvement of vegetation and biomass. Starting from the mid-90's to the early 2000's, the government started implementing watershed development programs on a large scale in many districts of Andhra Pradesh (AP). This included the Drought Prone Area Programme (DPAP) and more specifically the Desert Development Programme (DDP),[41] in Anantapur. In 2008, the Government of India (GoI) and the Government of Andhra Pradesh (GoAP) started work on the Integrated Watershed Management Program (IWMP) on a large scale.[42] The IWMP was implemented by the Department of Land Resources, Ministry of Rural Development. In 2015, IWMP along with On-Farm Water Management (OFWM) scheme and Accelerated Irrigation Benefit Programme (AIBP) was subsumed into Pradhan Mantri Krishi Sinchayee Yojana (PMKSY).

[41] http://iwmp.ap.gov.in/WebReports/Content/Programmes.html

[42] http://af-ecologycentre.org/wp-content/uploads/2019/04/Watershed-Development-A-Oasis.pdf

As per GoI's Ministry of Rural Areas & Employment's **Common Guidelines for Watershed Development 2008**, each watershed spanning 2000 to 3000 ha is called a 'Mega Watershed'. Each mega watershed is subdivided into 3 to 5 micro watersheds, depending on the number of villages/ habitations falling within the mega watershed.

Under the IWMP, some mega watersheds of about 7500 acres to 12,500 acres in Anantapur were identified for watershed development. AF-EC was chosen as the Project Implementing Agency by GoAP for 3 mega watersheds:

1. In 2009-10, Muttala mega watershed in Atmakur Mandal (4 micro watersheds - Papampally, Muttala, Goridindla, D.K. Thanda);
2. In 2010-11, Bandameedipalli mega watershed in Rapthadu mandal (3 micro watersheds - Bandameedapalli, Yerragunta, Varimadugu);
3. In 2011-12, Kuderu mega watershed in Kuderu mandal (5 micro watersheds - Kammuru, Kuderu, Antharaganga, Aravakuru, and Kadadarakunta).

The projects together span an area of 11,808 acres. The period of implementation of each project was set at 4 to 7 years from the date of entering MOU between the parties.

AF-EC was also chosen as the Project Facilitating Agency (PFA) for 6 watershed development projects in Kalyandurg Mandal funded by National Bank for Rural and Agriculture Development (NABARD):[43]

- Garudapuram
- Mallipalli
- Papampalli
- Guntapalli
- Dasampalli
- Battuvanipalli

An area of 6310 hectares was covered under these watersheds with a budget of Rs.7.26 crores.

The objectives of both programmes were broadly similar and they were to be implemented with a participatory approach involving all sections of people: 1) Conservation of soil, water and improvement of vegetation resources (NRM) in the village; 2) Promotion of horticulture and development of agriculture; 3) Provision of employment for labourers during the program and thereby the enhancement rural employment opportunities on sustainable basis; 4) Recharging of groundwater 5) Provision of credit for poor families to start off-farm and non-farm income-generating activities; and 6) Building of capacity to promote institution building.

[43] http://af-ecologycentre.org/projects/watershed-management/nabard/

2.4.2.5 AF-EC's overall process in rolling out the IWMP Project

Formation of Watershed Development Committee (WDC)

As a **first step, awareness campaigns are organised to introduce the concept, need and importance of watershed programmes** in all the micro watershed villages. The **process is made broad and inclusive**; modalities of implementing a participatory watershed programme are discussed with opinion leaders, community based organisations, Gram Panchayats representatives etc. Once there is a buy-in then a Grama Sabha is conducted in each of the micro watershed villages. The details of the programme guidelines, and procedures were explained to the community. Emphasis is laid on the need for conservation and sustainable management of natural resources through a participatory management process.

The **Gram Sabha then selects the WDC members** (about 13 to 15 people), by consensus. **Care is taken to ensure that the WDC has wide representation** including from among small and marginal farmers, the landless poor, SC/ST and women in order to make it participatory in the widest sense possible. The roles and responsibilities are clarified.

Preparation of the detailed project report and handling of finances

The mega watershed, which normally comprises 4 or 5 habitations or villages, spans an extent of 2000 Ha to 5000 Ha. **The entire mega watershed is subdivided into micro watersheds** in such a way that the boundary of each micro watershed matches with village boundary to as great an extent as possible while also ensuring that the ridge to valley approach is followed for drainage line systems.

The **goal of the ridge to valley approach is to conserve the maximum quantity of water starting at the ridge all along its journey to the valley**. It involves reducing to a considerable extent both the surface run-off volume and the velocity of water. The ridge-to-valley approach detains, diverts, stores and uses available rainwater. This approach ensures conservation of rainwater, which in turn, brings agricultural and economic stability. This approach also helps in strengthening the durability of soil and water conservation structures downstream.

In each micro watershed village, PRA (Participatory Rural Appraisal) exercises are run. The natural resources and social structure maps of the village are drawn. A transect walk is taken up to assess the land configuration, soil types, existing vegetation etc. After collecting information, net planning is done.

Household socioeconomic surveys are conducted. Survey holding wise net planning is done with each farmer in order to decide the location specific interventions to improve the productivity of rainfed farm lands and the financial implications are assessed. Additionally a plan for other livelihoods spanning 5 years is drawn up.

The detailed project report covers the required soil and moisture conservation works, rain water harvesting structures, dry land horticulture, vegetation improvement works, etc. Where the financial requirements exceed the budget under IWMP, MGNREGS funds were also available to tap into.

The payment for works in the watershed programme is done through EFMS (Electronic Fund Management System). The system is highly transparent with regard to financial transactions of the programme.

A Watershed Development Fund (WDF) is created by pooling contributions by each farmer equal to 5% of the total cost of the works taken up each in his/her land. This fund remains with the WDC to be used for post project maintenance of the assets created.

Watershed	Area planned for treatment (Ha)
Muttala	2535
Bandameedipalli	4942
Kuderu	4331

User groups

In order to **inculcate a sense of ownership and responsibility for the programme components,** many kinds of farmer user groups were formed within the watershed - based on size of holding or based on other activity affinities such as dryland horticulture, fodder development etc. The group met regularly to track progress and discuss issues. Each group member was expected to contribute/save at least Rs.50/- per month. The State Level Nodal Agency sanctioned grants matching user groups contributions - this was used to buy implements, seed etc.

Watershed development activities

Entry point activity: the specific activity for each community is chosen based on its specific needs - these activities range from providing access to safe drinking water by building reverse osmosis plants or building water troughs for cattle, etc. **The idea of the activity is to cohere the community around the project.**

Contour trenches on the ridges help **impound rainwater, improve moisture content** in upland areas. They also eventually lead to regeneration of vegetation in their surroundings. Importantly, they also aid recharge of groundwater downhill.

Afforestation of the inclines (hills) between the ridge and valley with fodder, fruit and drought resistant species **impedes soil erosion** and also **functions as a carbon sink.**

The **drainage lines** are then dotted with various types of structures and constructions - **rock fill dams, gabions, loose boulder structures**, etc. These structures serve to **collect water** as well as slow down the flowing water thereby **increasing base flows** in the drainage system and **preventing further deepening of gullies**.

Depressions in the lowest contours in rain fed agricultural land holds are identified for the construction of **farm ponds**. Rainwater collected in these ponds are often used to provide **critical timely irrigation to rainfed crops during long dry spells.** The inner sloping sides and the bottom of the ponds are lined with cement mortar to prevent seepage and store water for longer periods.

Check dams are constructed across streams to **impound rainwater** that can stay for up to 6 months. They **increase groundwater and rejuvenate the base flows in streams.** Borewells in the vicinity of the check dam are rejuvenated to aid in providing assured irrigation to crops. The check dams also provide water for animals, birds etc.

Percolation tanks, meant to harvest the rainwater over a large area are constructed. The groundwater recharge capability of these structures is very high.

Dry land horticulture is an assured income yielding intervention in drought prone areas like Anantapur district. Farmers in watershed villages undertake this in large tracts of rainfed areas. Block plantations are raised in village community lands; they increase the greenery and biomass and also help in mitigating climate change. The plantations comprise species like jamun, neem, tamarind and yield income to village panchayats. Fodder plots are raised. The fodder is used to feed milch animals, and other small ruminants.

There is provision for landless poor to take up income generating activities under watershed development programmes. Beneficiaries receive loans from a revolving livelihood fund and repay the same in equal monthly instalments with a nominal interest.

Source: https://www.deccanherald.com/sites/dh/files/articleimages/2023/01/19/hydroistock-1179738-1673367241-1182693-1674148676.jpg

Source: http://e-krishiuasb.karnataka.gov.in/GetImage.aspx?id=10&depID=9&subDepID=4&cropID=0&Video_Id=158

2.4.2.6 Impact of watershed programmes

AF-EC's achievements on the watershed programmes between 2010 and 2021 can be summarised as follows:

Number of Projects	NABARD – 6 completed, 2 in progressMoRD/IWMP -3 Mega Watersheds completed
Mandals covered	1. Kalyanadurg2. Setturu3. Kundurpi 4. Rapthadu 5. Atmakur6. Kudair
Total No. of Micro Watersheds	20
Total No. of habitations / Villages	30
Total watershed project area treated	50,270 Acres
Total project cost (Rs. In lakhs) :	26,12,96,000/-

Groundwater development: Open wells and borewells – status and irrigated area

The irrigated area increased by 56% over the course of the project as a result of the programme.

Type of Well	Pre watershed development programme					Post watershed development programme				
	Total number	Fully functional	Seasonally functional	Fully Defunct	Area irrigated (in Ha)	Total number	Fully functional	Seasonally functional	Fully Defunct	Area irrigated (in Ha)
Open Wells	71	36	10	25	82	71	41	12	18	94
Bore wells	2465	919	312	1234	3069	2916	1632	776	508	4822
Total	2539	955	322	1259	3151	2973	1673	788	512	4916
As % of total wells		37.6%	12.7%	49.6%			56.3%	26.5%	17.2%	

As can be seen, the proportion of fully defunct wells has come down from half to one sixth.

The water levels in open wells and borewells increased impressively.

	Pre project	Post project
Average depth of water table in open wells	6.3 M	4.0 M
Average depth of water table in borewells	52 M	20 M

2.4.2.7 AF-EC's water related programmes - why and how it works

Holistic approach to addressing the district's severe water crisis. AF-EC lays **great emphasis on both supply (recharge of groundwater and conservation of surface water) as well as demand (focus on sustainable, climate resilient agriculture) as well as on water use efficiency.** While the stress on both supply and demand is relevant for most regions across India, it is particularly crucial in a severely dry, arid district like Anantapur where every drop of water is hard to come by and needs to be conserved and made the utmost efficient use of.

AF-EC, through its sustainable agriculture work, actively promotes land use changes in favour of dryland horticulture and low water intensive crop systems including multiple and mixed crops that are drought resistant. This is addition to its focus on farm rainwater harvesting to provide protective irrigation during water stress periods, mobile sprinklers for efficient use of scarce water during water stress, capacity building of the communities on enhancing production and on sustainable agricultural practices, watershed related and livelihood related training and awareness building campaigns and convergence of various government programme to complement watershed interventions and resources.

Village/(micro) watersheds - Around the mid-1990s, AF-EC realised that the "**Area Development Approach"** that was being used up to that point in time, **was disjointing and scattering environmental activities and efforts across a large area in the district** and making them **less effective and efficient.** From this learning emerged the development of the 'village watershed' concept. In the village watershed approach the entire land in the village is considered as a micro-watershed and taken up for integrated development adopting a participatory approach.

A micro-level and integrated ridge to valley participatory watershed development approach in select villages has created a better impact. It has improved the quality and quantum of and carrying capacity of natural resources in the villages.

Building "participation" and collectivism/inclusivity into the DNA of the community - AF-EC has had decades of experience in building strong village level community institutions. Its participatory approach, through building and using the village level institutions, has ensured that the benefits are more equitably distributed, that the concerns and needs of all segments of the community, particularly the marginalised, are addressed, and that the created processes and infrastructure are sustainable in the long term.

AF-EC works directly with over 40,000 farmers & farm labour on various projects. **Their participatory approach is designed to make people the key players in their own development and involved and responsible right from the planning stages to the monitoring and evaluation of the completed projects.** AF works with people through their formal and informal organisations and groups.

There are 856 SMGs (Sasya Mitra Groups or Friends of Plants Groups) functioning across 214 villages and 25 registered MACS (Mutually Aided Cooperative Societies) and enlists their active participation in Planning, Implementation, Monitoring and Evaluation (PPIME) in all its programmes. (In the remaining villages there are Watershed Development Committees or WDCs).

AF-EC's participatory approach also extends to other likeminded organisations with similar objectives like research bodies, universities, CSOs, intellectuals, technical experts with whom they work to achieve objectives.

Public opinion building - AF-EC recognises the criticality of public awareness, public understanding of issues and public opinion in shaping government policy and government decision making. It has, therefore, proactively focussed on public opinion building and policy advocacy through various campaigns, discussions and through networking.

It engages with varied stakeholders including Community Based Organisations, Civil Society Organisations, Non-Government Organisations, government officials, writers, Farmers' Associations, etc. It uses these engagement opportunities to influence policy makers towards a pro-environment, pro-poor policy for drought mitigation, sustainable agriculture and rural livelihoods.

An example of where this approach has paid off is the increasing public awareness that the canals (HNSS and THLC) that bring water to Anantapur district be used to the maximum extent possible to fill all surface water bodies (irrigation tanks, minor tanks, etc.) in their distributary network's vicinities rather than diverting or creating separate parallel channels to specific parts of the district.[44]

AF-EC has built the understanding that an equitable distribution of water for the entire population is only possible if available water is let into village tanks improving the groundwater table for the farmers to draw. Pushback is now possible against politically assertive public representatives from serving narrow interests.

[44] https://www.deccanchronicle.com/nation/current-affairs/070519/anantapur-borewells-dry-up-as-groundwater-levels-go-down.html

2.4.3 Farmer-centric Integrated Watershed Management

ICRISAT worked in more than 60 villages in India implementing watershed management for companies. It is looking to craft future CSR involvement in forming clusters to create larger watershed areas and thereby become more impactful. It wants to involve CSR engagement in the entire process from water management all the way through to creating market linkages and all the steps in between.

The public sector power finance company - RECL has, as part of its corporate social responsibility (CSR) activities, partnered with, and supported this ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) led initiative to improve the livelihood of smallholder farmers by adopting a science-led, evidence based participatory integrated watershed development approach. The two project sites under this partnership are Wanaparthy district in Telangana and Anantapur district in Andhra Pradesh. The ground partner for the project in Anantapur is Samatha Society for Rural Education and Development. The project benefits from ICRISAT's core strength in dryland agricultural research by the implementation of demand side management components of the project just as much as its focus on surface water body management.

This consortium's aim for the project is to sustainably increase agricultural productivity and improve livelihoods in vulnerable and rainfed areas using a participatory integrated watershed management approach in order to upgrade rainfed agriculture for sustainable intensification. With specific regard to the water aspects of the project the intent is to enhance water availability and use efficiency as well as to build community capacity towards this end.

The Anantapur project, envisioned to be carried out between 2014 and 2022, is being implemented across four villages - Kondampalli, Gonipeta, Settipalli and Cherlopalli in Penukonda mandal. The project area has a population of 8,700 and covers 6,810 ha. Of this about 3,150 ha is under cultivation by 1,480 households. The major crops cultivated are groundnut, maize, paddy, finger millet and sunflower.[45]

A multi-disciplinary team of scientists/managers is implementing the project with a field-based Scientific Officer at each site. For effective outreach to the community and for aiding implementation, ICRISAT has tied up with a local non-governmental organisation SAMATHA Society for Rural Education and Development in Penukonda. The project consortium also includes the state and line departments of the Government of Andhra Pradesh, and the Krishi Vigyan Kendra of Anantapur which is an agricultural extension centre linked to Indian Council of Agricultural Research as well as community based organisations in the villages. RECL is supporting the project with CSR funds.

The site selection was done jointly with the Joint Director of Agriculture, the Project Director of the District Water Management Agency, the Penukonda Assistant Director of Agriculture and agriculture officers based on several factors including representativeness in terms of soil, landscape, rainfall, crops and socioeconomic conditions; presence of farmers willing to participate; a compelling need for a watershed programme, and significant area under rainfed agriculture.

[45] http://idc.icrisat.org/idc/wp-content/uploads/2022/01/RECL-ICRISAT-April2021-Sept2021%2029102021.pdf

They also took into consideration topography, drainage maps, and farmers' inputs among other things. During the site selection process, the existing water resources were surveyed. The findings included:

- Kondampalli and Settipalli have 300 borewells each, Gonipeta 16, Cherlopalli has nil.
- Open wells depths ranged from 20 to 40 ft. Settpalli had over 200 open wells.
- Borewell water table depths ranged from 300 to 500 ft.
- Groundwater table in the borewells and the duration of water availability had declined.

The next step was to put in place the institutional arrangement necessary for effective implementation. A 19 member watershed committee was formed – chosen from across the four villages with care taken to ensure representation from all sections of the communities. A bank account was opened for the committee to operate funds for project related activities. The watershed committee's responsibilities include conducting gram sabhas regularly or as needed to ensure planning, execution and monitoring of works in the watershed.

Soil health mapping was the chosen entry point activity for the project. It served to build a connection with the community. The exercise helped assess soil fertility status while simultaneously providing training to the farmers on the soil sampling method.

The preparation of the work/action plan was the next exercise. This was carried out jointly in a participatory manner by ICRISAT scientists, farmers and Samatha staff. The group conducted a transect walk in order to prepare the action plan covering all four villages. The intervention sites were finally chosen based on a combination of technical feasibility and farmers' opinions. The action plan drawn up comprised:

- soil and water conservation activities – construction of nala plugs/rock filled dam, sunken pits, farm ponds, masonry check dams, well recharge pits
- productivity enhancement (crop demonstration)
- livelihoods, and income generating activities including vermicomposting;
- afforestation/avenue plantation
-

Capacity building/ awareness creating activities around the project were planned. These covered:

- group formation (around a task, issue, etc.)
- participatory soil sampling
- soil health,
- action plan preparation,
- use and application of improved crop productivity initiatives,
- integrated pest management

A multi-disciplinary team of scientists and experts from ICRISAT regularly facilitate planning and guidance on project activities which are implemented according to farmers' demands and technical feasibility, through the scientific officers and Samatha team.

A team of line-staff members, supported by Samatha staff at each site, helps reach out to farmers and share knowledge through various kinds of activities and meetings. Samatha is involved in community mobilisation, construction of water harvesting structures, implementation of action plan on ground and data collection and reporting. The ICRISAT developed MPRO App and WhatsApp are key modes used for monitoring of field activities.

2.4.3.1 Implementation and Impact

Phase 1 Work (2014-17)

Rainwater harvesting and groundwater recharging structures constructed created a net storage capacity of 35600 m^3 that resulted in total conservation of about 70000 m^3 of surface runoff water in 2-3 fillings.

In-situ moisture - border strip system in Anantapur was found to be beneficial in terms of moisture conservation. It increased yield by 28% over conventional flat cultivation. In the border strip flooding method, the farm is divided into a series of strips. The strips are separated by low levees or borders and run down the predominant or any other desired slope. To irrigate, water is turned from the supply ditch onto the head of the border. Water moves, confined and guided by two borders in a thin sheet towards the lower end of the strip. The surface is essentially level between two borders so that the advancing sheet of water covers the entire width of the strip.

Work	Number
Farm ponds	50
Check dams	12
Rock filled dams	172
Sunken pits	21
Borewell recharge pits	19
Dug well recharge pits	27
Farm pond with plastic lining and drip	4

Phase 2 - Revived in 2020 to continue pending research and development work

The water related focus in the second phase is to intensify on-farm water solutions. The benefits of the 58 farm ponds built in the first phase began to accrue. Enthused by this many more farmers volunteered to construct ponds on their farms. 142 new farm-ponds were dug across four villages in Anantapur watershed until March 2021. Between April and September 2021 these ponds were cement lined and fenced with barbed wire. Additionally, another 58 farm ponds were constructed during April – Sept 2021, making it a total of 200 during this phase.

Major water conservation measures implemented include 15 check dams, 256 rock-filled-dams/loose-boulder-structures, 43 open-well/borewell recharging pits and 7 sunken/mini-percolation pits.

A total of 4 check dams were constructed up to September 2021 - 1 each in Settipalli and Cherlopalli villages, and 2 in Kondampalli village. 7 rock fill dams were constructed: 2 each in Kondampalli and Gonipeta villages and 3 in Settipalli village. Storage capacity of at least 66,000 m3 has been created and it benefits smallholders in the region by providing water all year through.

Some of the impacts observed include

An assessment of groundwater during December 2020 showed a higher water level of between 1-14 m in Anantapur, mainly due to good rains that year. Even so, the watershed villages' water level was around 1.1-1.8 m higher than adjoining non-watershed villages.

In some cases, there was an even higher increase with groundwater levels reaching up to 14 metres as in Kondampalli. About eight borewell recharge pits have ensured that water is readily available throughout the year. The overall increase in groundwater levels is certainly in great part attributable to the increased storage capacity created in the villages.

In Gonipeta the check dam built in the project's first phase ensured that about 16 ha of land has water available all year. Groundwater in some cases is now available at a depth of 2 metres providing enough water for cultivation during the rainy and post-rainy seasons.

In project villages as compared to non-watershed villages, even a 10-foot deep farm pond has yielded quick access to irrigation water.

Increased water availability due to watershed interventions has enabled farmers in two states to grow new and better crops and increase production on drought-stricken lands that barely supported subsistence. Improved cultivars in groundnut and pigeonpea coupled with moisture conservation practices have led to productivity improvement by 25% in groundnut, and 27% in pigeonpea.

The ICRISAT watersheds have provided a proof of concept for scaling out a wide range of solutions to improve rural livelihoods while building drought resilience.

2.4.3.2 ICRISAT Approach: Why and how it works

- **Science-led, evidence based** integrated watershed development approach.

- **Extensive networks and diversity of partnerships:** ICRISAT has extensive global, regional and local networks, both public and private. As a CGIAR research institution it has access to the extensive One CGIAR network of over 3000 partners (which includes water focussed organisations like International Water Management Institute). It is growing its private industry partnership portfolio as well as its partnerships with development agencies, international and local non-governmental organisations.

- **Consortium approach:** ICRISAT recognised that the development and management of watersheds is complex, that it falls within the ambit of many institutions, and that it is multidisciplinary. It also recognised that converging the various institutions and disciplines is key to a successful watershed project. It has spent considerable time and resources in learning through its pilot programmes on how to effectively bring about convergence between the various institutions which come with their differing strengths, limitations and ways of functioning.

The consortiums for watershed level projects include national and state agricultural research institutions, government departments, local non-governmental organisations, farmers' organisations, women's self-help groups, etc. A process is then run to align all parties on a common shared vision/goal, and have clarity on each entity's role in reaching that goal, as well a joint commitment to do so.

- **Scaling program:** ICRISAT sees its structured outreach and scaling program as a key priority. The program is in its early stages. The IDC provides the delivery mechanism for the program. The program has started rolling out with piloting model sites of watershed management in a few dryland regions in India. Through these pilots, ICRISAT has become a 'centre for quality data' on the hydrological processes.

- The issues of creating impacts at scale are the subject of research and learning as the program progresses. The IDC plays the role of a catalyst supporting the development of multi-stakeholder consortia to implement large-scale projects. It actively prioritises learning from the facilitation/catalysing process. IDC sees immense scope for scaling up its learnings across India.

- **Leveraging corporate social responsibility:** ICRISAT developed a CSR strategy in 2014, which expanded engagement with private companies outside of the agriculture and food space, to include a range of businesses to support their work. Through this initiative, they have accessed new sources of funds in India for this kind of work. The private sector is mandated to use 2% of their profits for societal development including investments in agriculture. ICRISAT's CSR funders/partners so far include Asian Paints Ltd., JSW Foundation, Mahindra & Mahindra Ltd, PowerGrid Corporation of India Ltd., Rural Electrification Corporation Limited, ABInbev (SABMiller India), Tata Trusts, Trident Sugars Limited, Ultratech Cements Ltd and the Coca-Cola India Foundation.

2.4.3.3 Samatha Approach: Why and how it works

- Decades of experience with on-ground implementation of water resources related activities (including in watershed development) with various kinds of partners/government programs. The organisation has staff formally trained on watershed development processes and activities. They have experience in conducting the Participatory Rural Appraisals (PRAs), in preparing the micro action plans, in preparing village level water management plans(including on water budgeting, crop planning).

- Building and nurturing community based organisations, groups etc.

- Wide local network in the mandals of their operation, through their work on a range of rural issues that extend beyond natural resource management.

- Members of PRADAN (Professional Assistance for Development Action), APNA (Andhra Pradesh NGOs Alliance), Vibhavani - have access to knowledge, learning and support through these networks.

3. Lessons from the fieldwork in Telangana and Andhra 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 Andhra Pradesh and Telangana.

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

The state of Telangana, which was carved out of Andhra Pradesh in 2014, has 31 districts sub divided into 68 revenue sub-divisions and 584 mandals. It has a semi-arid tropical climate with predominantly hot and dry climate. Receiving around 904 mm rainfall, nearly 80% from Southwest monsoon, Telangana suffers from variability in annual and seasonal rainfall, making it drought prone in many parts. The entire state falls in the basin of two major rivers, Godavari and Krishna, which originate in the state of Maharashtra and enter into Andhra Pradesh, where they drain into Bay of Bengal.

Geologically, nearly 85% of Telangana state is underlain by consolidated gneissic formations, and the rest of the state is underlain by semi consolidated sedimentary formations. District Mahbubnagar falls in this hard rock area mostly with banded gneissic granite formations, with a small portion of granite in the southwest. These rocks have low primary porosity and the groundwater occurs in the fractured zones mostly at shallow levels.

According to the data available on the website of Central Ground Water Board, the yield of wells ranges between 2-5 cubic meter per hour in Dharwars, 10-35 cubic meter per hour in granite gneiss, khondalites and charnokites, 7-50 cubic meter per hour in Cuddapahs, 0.5-1.50 cubic meter per hour in Shales and 10-40 cubic meter per hour in Deccan traps. In the region of soft rock formations the yield varies from 12-220 cubic meter per hour in Gondwana to 15-60 cubic meter per hour in alluvial formations[46][1]. 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.

[46] Website of Central Ground Water Board: http://cgwb.gov.in/gw_profiles/st_ap.htm

3.2 The efficacy of participatory data collection

The dynamic groundwater resource assessment report of India, 2022 has observed positive impact on ground in Andhra Pradesh in terms of groundwater development. The report reveals that due to various activities of water conservations in the state, access rainfall, reduction in groundwater draft and some other reasons, the number of over-exploited mandals have decreased from 23 in 2020 to just 6 in 2022. Similar reasons also helped in increasing groundwater recharge in Telangana. The report reveals that in Telangana, the groundwater recharge has increased from 16.63 BCM in 2020 to 21.11 BCM in 2022. Similarly the overall extraction of groundwater has decreased from 53.32% to 41.6% during this period[47] [2].

The Meta data presented in the above paragraph has been collected by expert agencies, which gives us detailed information about groundwater development. However, such Meta data is not enough to instigate people to act or change their behaviors. To effectively manage ground water resources, participatory data collection plays a vital role in sensitizing people and changing their behavior. It further helps them to take collective decisions related to water conservation and usage.

The participatory groundwater management program adopted by three villages in Mahboobnagar in Telangana devised their own system of data collection to make their local decisions. Similar efforts were also made by people in Anantpur in Rayalseema region of Andhra Pradesh. These two case studies have shown that participatory data collection is not only effective but also empowering.

3.3 Understanding the prevailing policy framework and using it beneficially

Water policies in India aimed at optimising water availability for different purposes, especially for supply of water for drinking, food production, livestock, as well as for power generation, navigation, and various commercial and domestic uses.

It simultaneously attempted the objectives of achieving efficiency, equity and sustainability in water use – the sustainability issues being particularly important in the light of the declining per capita availability and the pollution through human intervention. Andhra Pradesh and Telangana have many legislations and programs for management of groundwater resources. Some of them are listed below.

- Andhra Pradesh Ground Water (Regulation for Drinking Water Purposes) Act, 1996
- Andhra Pradesh Water Resources Development Corporation Act, 1997
- Andhra Pradesh Farmers' Management of Irrigation Systems Act, 1997
- Andhra Pradesh Infrastructure Development Enabling Act, 2001 (Act No 36 of 2001)
- Andhra Pradesh Water, Land and Trees Act, 2002.
- Andhra Pradesh State Water Policy, 2008

[47] Central Ground Water Board, 2022, Dynamic Ground Water Resources in India, 2022, Accessed from: https://cgwb.gov.in/documents/2022-11-11-GWRA%202022.pdf

A cluster of three villages in Mahboobnagar in Telangana namely Undyala, Konkanonipalli and Dhamagnapur have effectively used available policy, programs and institutional framework for the management of groundwater. The effective use of the National Watershed Development Program for Rainfed Areas and other state supported schemes helped farmers of these villages to harvest two to three crops in this highly dry region. With the help of AF-EC and ICRISAT, two different clusters of villages have also utilized various policies and programs effectively.

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. Telangana has continued many legislations of undivided Andhra Pradesh, now with more detailed aquifer level data; the state may require revisiting its set of policies for groundwater management.

3.5 Planning for Balancing Demand with Supply

The National Water Information Centre has identified 36,733 small, medium and large surface water bodies in Andhra Pradesh and 17,088 such water bodies in Telangana that provide water for various purposes such as irrigation, drinking water and industrial use[48][3]. The united Andhra Pradesh is a riverine region where more than 40 small and big rivers flow. Krishna and Godavari river basins are largest river basins in this landmass that is spread over 150 lakh hectare land of Telangana and Andhra Pradesh. These two river basins provide 64 BCM for various uses[49][4]. From all river basins these two states receive 78.5 BCM water for utilization. Most of it is used only for irrigation.

The use of groundwater for irrigation has tremendously increased in the last three decades; it has therefore promoted unsustainable management of the groundwater resources. In Andhra Pradesh the gross irrigated land area using groundwater has increased from 5.9 lakh hectares in 1980 to 15 lakh hectare in 2012-13. It is expected to sharply increase in coverage of irrigated land in the next few years in the state. Many parts of Telangana and Andhra Pradesh receive very less rainfall, yet the whole landmass of these two states has capacity to replenish more than 35 BCM ground water. Of this, Telangana has 13.68 BCM and Andhra Pradesh has 18.88 BCM groundwater available in a year. According to the data published by the Central Ground Water Board on its website, the groundwater development in Telangana is 55% and 37% in Andhra Pradesh.

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.

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[48] Website of India Water Resources Information System, Accessed from: https://indiawris.gov.in/wris/#/surfaceWater

[49] Water Resources of Andhra Pradesh, Accessed from: http://water-atlas.blogspot.com/p/part-iiandhra-pradesh-water-chapter_22.html

3.6 Enhancing supply by groundwater conservation and recharge

All three case studies part of this report have shown that integrated and participatory approach has helped to enhance supply of groundwater both in Andhra Pradesh and Telangana. Moreover, all of these experiments were done in the driest region of these two states to demonstrate that careful selection of techniques and concerted collective efforts can lead to good results.

Watershed activities carried out with the help of ICRISAT in a few villages of Anantpur in Andhra Pradesh led to significant growth in water level in just a few years. An assessment of the project observed that in villages where the project was carried out the ground water level was 1.1 to 1.8m higher compared to adjoining non-project villages. Similarly the experiment of VIP in three villages of Mahboobnagar in Telangana showed that enhancing supply of groundwater using watershed approach in three villages and effective management led to harvest of three crops a year in a dry region.

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

India has 18% of world population, having 4% of world's fresh water, out of which 80% is used in agriculture. India receives an average of 4,000 billion cubic meters of precipitation every year. However, only 48% of it is used in India's surface and groundwater bodies.

A dearth of storage procedure, lack of adequate infrastructure, inappropriate water management has created a situation where only 18-20% of the water is actually used. India's annual rainfall is around 1183 mm, out of which 75% is received in a short span of four months during monsoon (July to September). This result in run offs during monsoon and calls for irrigation investments for the rest of the year.

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

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

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

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5. Acknowledgements

We gratefully acknowledge the help and guidance of farmers and the members of Udyala Watershed Management Committee and representatives from the village who participated in the discussions. Special thanks to Dr T Nagender Swamy, Mr T Sridhar and Mr G Venkatram Reddy from VIP and Mr C Raghavendra Chary, retired Deputy Director of Groundwater Department of Telangana State for his valuable insights on water management in the region.

We gratefully acknowledge the help and guidance of Prof P S Kulkarni, retired Head of Geology Department, Maulana Azad College, Aurangabad, Dr Joy K Joy, Society for Promoting Participative Ecosystem Management (SOPPECOM), Pune for painstakingly reviewing the earlier drafts of this document and giving their valuable feedback for improving the same.

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