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Irrigation status, issues and management in Andhra Pradesh

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Abstract
Water is a finite resource and managing water in days of rapid socio-economic growth and change is challenging. Irrigation is science of artificial application of water to the land in order to fulfill the water requirements of the crops throughout the crop period. Irrigation potential of Andhra Pradesh is 103.11 lakh acres out of 199.04 lakh acres of cultivable area. In the present study the data was collected from secondary data referring Agriculture Dash Board-Government of Andhra Pradesh, AP Water Resource board, websites and research journals. Andhra Pradesh has one of the largest irrigated areas. With a gross irrigated area of 6.28 m. ha, the state accounts for nearly 7.3 per cent of the total irrigation in the country. Groundwater is the major source of irrigation in the state, with nearly 49 per cent of the net irrigation is from wells and tube wells. The rest of the irrigation is from sources such as canals, tanks and other sources. The major irrigation issues identified in the state are over exploitation of ground water resources, deteriorating groundwater quality and climate change. Management strategies proposed for these issues are finding alternate sources of water, repair, renovation, and restoration of water bodies, basin management, water efficient technological solutions, water conservation measures, water shed management, conjunctive use of surface and ground water, contingency crop planning for the project area, resilience and adaptation to climate change and enhanced co-ordination among agencies such as State Pollution Control Board, Industrial Development Corporation, State Finance Corporation, Irrigation Department, Panchayatraj Department, Ground Water Department, and some other non-Governmental Agencies. Major Medium Irrigation Projects working in Andhra Pradesh are 95 projects. Andhra Pradesh is undergoing a dramatic shift in the irrigational pattern moving from large scale surface to ground water irrigation. Different programmes and irrigation projects being taken up can improve the irrigation status in India.

Keywords: irrigation potential, water resource board, andhra pradesh, irrigation project

Introduction
Irrigation is the sector which touches rural livelihood in terms of increased output of agricultural production. Andhra Pradesh is one of the most important agrarian states in the country. Irrigated agriculture has been fundamental to state's economic development and poverty alleviation. The expansion of irrigation is widely believed to have played a major role in the region's rapid agricultural growth over the last three decades ensuring economic agricultural prosperity in the dry regime. Keeping in view of the importance of irrigation for transformation of the rural economy, successive Governments have focused on expanding irrigation facilities in the State. Water security is intimately tied with food security, livelihood, health, environment, economic development and overall well-being of the society. Water is a finite resource and managing water in days of rapid socio-economic growth and change is challenging. The water challenges for the state are, therefore, manifold – improving and safeguarding the existing drinking water supplies, managing water for irrigation, industry, power supply and environmental prevention of pollution.

The state of Andhra Pradesh is blessed with about 40 major and medium rivers out of which Godavari, Krishna Vamsadhara, Nagavali and Pennar are major interstate rivers contribute to the major chunk of the surface waters. The state has about 40000 minor irrigation sources spread over the thirteen districts. Cropping intensity increased from 110 per cent in 1960-61 to 123 per cent in 1999-2000. This is mainly due to the increase in area under irrigation. Primarily dependent on rainfall for irrigation the state exhibits spatial and temporal variations in the quantity of precipitation received from south west and north east monsoons. Such variation has its impact in the growth of irrigation over time and space.

- Geographical area of AP 402.70 lakh acres
- Total cultivable area 199.04 lakh acres
- Irrigation potential 103.11 lakh acres

Materials and Methods

The state of Andhra Pradesh is divided into 13 administrative districts spread across two unofficial regions namely Coastal Andhra and Rayalaseema. Coastal Andhra is divided into 9 districts viz. Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam, Sri Potti Sri Ramulu Nellore. Rayalaseema comprises 4 districts viz. Kurnool, Chittoor, Kadapa and Anantapur. The present study is primarily based on the information gathered from various sources that deal and dealt with the study in Andhra Pradesh. The data was collected from secondary data. The information relevant to the study has been taken from Agriculture dash board of Government of Andhra Pradesh, AP Water Resource Board, websites and research journals. The data pertaining to Irrigation status, issues in 13 districts of Andhra Pradesh is collected, then interpreted and management strategies were recommended for the irrigated issues existing in Andhra Pradesh.

Results and Discussion

The history of growth of irrigation in Andhra Pradesh

It can be classified into three distinct phases as follows

- Era of adaptive irrigation
- Era of canal construction
- Era of atomistic irrigation

Era of adaptive irrigation: Since time immemorial until the early 1800s, farming communities adapted their agrarian lives to the hydrology of river basins.

Era of canal construction: Around 1810, the British East India Company began changing this adaptive irrigation regime by undertaking gigantic projects that reconfigured river basins. Large canal projects were also undertaken in the south of India, particularly in Andhra Pradesh. The irrigation sector was principally dominated by major, medium and minor canal irrigation till 1980s.

Era of atomistic irrigation: The availability of small mechanical pumps and boring rigs provided a technological breakthrough in this era. With the fact that tanks and canal systems are unable to meet the growing demand of irrigation; 1990, saw a transformation from a centrally managed surface irrigation regime to distinct managed water scavenging irrigation regime particularly in the hard rock regions of Rayalaseema which are largely bypassed by the canal irrigation systems.

Irrigational sources in Andhra Pradesh

Andhra Pradesh has one of the largest irrigated areas. With a gross irrigated area of 6.28 m. ha, the state accounts for nearly 7.3 per cent of the total irrigation in the country. Groundwater is the major source of irrigation in the state, with nearly 49 per cent of the net irrigation is from wells and tube wells. The rest of the irrigation is from sources such as canals, tanks and other sources. The state is mostly underlain by hard rock aquifers, with very poor storage and yield potential. Most parts of the state do not provide a favourable environment for intensive use of groundwater resources. Yet, limited access to water from surface irrigation systems such as reservoir and canal-based systems and tanks, makes farmers resort to well irrigation through open wells.

Table 1: Irrigated area in Andhra Pradesh by different sources (2016-17)

Sources	Gross area irrigated (lakh ha)	Net area irrigated (lakh ha)	Irrigation intensity
Tanks	327	293	1.12
Canals	1882	1429	1.32
Ground water	1532	1080	1.42
Other sources	145	125	1.16
Total	3886	2927	1.33

***Source*:** Agriculture dashboard, Govt. of Andhra Pradesh

Issues and management of irrigation

Over exploitation of ground water resources

Rainfall within the state has remainedthe key determinant for both surface water and groundwater irrigation. Any change in the rainfall pattern therefore significantly influenced the overall irrigation efficiency of the state. Time and again literature on rainfall variability indicated increase in uncertainties, particularly, over the last 20 years. This in turn has resulted into drying up of tanks and emergence of rampant tube well as the most feasible and lucrative alternative. Such indiscriminate usage of ground water is more intense in drought affected districts of Rayalaseema which is largely bypassed by the canal irrigation systems. According to Department of Ground Water, Andhra Pradesh the state is classified into four categories as follows:

- Very High Usage districts comprising Anantapur
- High Usage Districts comprising of Kadapa, Chittore
- Moderate Usage districts comprising of Nellore, Kurnool and Prakasam.
- Low Usagedistricts comprising Srikakulam, Vizianagaram, Vishakhapatnam, West Godavari, East Godavari, Krishna and Guntur.

Management

Use less water: As individuals, one of the things everyone can do to make a difference is to use less water for luxury purposes. Throughout countless neighborhoods, large amounts of water are used for swimming pools while water hoses are kept running to wash cars and for other miscellaneous reasons. To conserve water one should turn off the faucet and reduce the usage of washing machines, dishwashers and similar appliances. It is advised to save a massive amount of water by deciding not to use water for decorative and unnecessary reasons at home.

Policies to be changed: There are many scientists, researchers, and sustainable companies believe that many of the policies should be changed with the consideration of saving groundwater in mind instead of treating it like an endless resource.

Find alternate sources of water: One of the most effective ways to address the issue of groundwater depletion is to find alternative sources of water. Alternative water sources can be used to help replenish aquifers. Deriving water from other sources would also give aquifers time to refill instead of pumping too much water from them at once.

Repair, renovation, and restoration: The Government of Andhra Pradesh have sanctioned an amount of Rs.91.45 Crores totake up Repair, Renovation, and Restoration for 342

water bodies for stabilization of total Ayacut 100832 acres in five Districts of Andhra Pradesh (Ananthapuram, Chittoor, Kadapa, Kurnool and Srikakulam).

Basin management: Water resource development is to be planned in an integrated manner at the river basin level and effective basin wise programs have to be evolved considering the inter-relationships of soil conservation, afforestation, land development, controlled grazing etc. The development of forests in upland of the water basin where the slopes are high will help in minimizing the landslides, leading to lesser sediment transport. Environmental monitoring of the catchment area on continuous basis and soil conservation measures such as contour bundling, check dams, afforestation etc. to be practiced.

Water efficient technological solutions: Drip irrigation is an effective tool for conserving water resources and studies have revealed significant water saving ranging between 40 and 70 per cent by drip irrigation compared with surface irrigation, with yield increases as high as 100 per cent in some crops in specific locations. In view of its higher water use efficiency, wider adaptability to diversity of soils, crops, climate etc., its wide scale applicability in the project site is highly recommended (Kumar *et al.,* 2011).

Water conservation measures: Various water conservation measures suggested for adaptation are as follows:

- creation of low reservoirs for storing the water
- prevention of losses through seepage and leaks
- improving usage efficiency through better usage practices
- educating the users, and
- recycling and reuse of wastewater.

For example, the last of the above measures, i.e., the recycling of wastewater is currently being practiced in few industries, where the treated liquid effluent is used for gardening purposes. It not only reduces the load on thewater resources but also gives indirect financial benefit for its usage instead of freshwater. In addition, the percolated water will improve the ground water resources.

Deteriorating groundwater quality

The introduction of intensive irrigated agriculture particularly in the semi-arid areas of the state has resulted in the development of twin problems of waterlogging, soil salinization and seawater intrusion. This in turn has resulted into reduced crop yields, frequent crop failures, increase in costs of cultivation and reduced income of the small and marginal farmers. According to state Ground water department, totally 30 Mandals (East Godavari 10, Guntur 7 and Krishna 13) are categorized as poor quality areas and thereby unsuitable for irrigation purposes.

Management

Increased participation of the public: The public can approach the State Pollution Control Boards or Local Administration for taking necessary action against the polluters in their locale. Few State Governments, such as Andhra Pradesh, are encouraging people to take part in developmental programs. Isolated cases are reported in literature that people have taken initiative on their own and successfully solved their drinking water problems after not getting much encouragement from the local Governments or administration. Such successful cases may induce inspiration among the public in other parts of the country. This will help in spreading mass awareness about significance on usage of water resources. It leads to pride and satisfaction for being part of the Governance and sharing the responsibilities.

Climate change

Climate change with expected long term changes in rainfall patterns and shifting temperature zones are expected to have negative effects on irrigation.

Management

Watershed management as a climate proofing mechanism: Watershed management can be implemented as effective adaptive strategy to climate change. Several water harvesting structures like check dams, percolation tanks, farm ponds etc can be used as a mechanism to recharge ground water aquifer.

Effective community mobilization and institution building: Perhaps the most critical aspect of any adaptation strategy is effective community mobilization and institution building at the grass root level. Community's ability to pool collective resources and facilitate the transfer of knowledge and technology may be the most effective mode to combat climate extremes. Since, climate change affects farmers collectively, it is thereby imperative to call for collective action as a possible solution to combat shocks. Several grass root institutions like water user associations, watershed committees, user groups, forest groups climate schools etc needs to be promoted in the project areas. There is a need to create awareness among the people by using mass media followed by individual contact method through trained extension agents. Dissemination of the understanding that faulty irrigation practices, inefficient water use can disturb the ecological balance and consequently, to climate change is necessary. Such an understanding would provide an opportunity to take resilience measures towards ecological redressal and willingness for benign action to minimize and mitigate the bad consequences of climate change.

Farmers innovativeness and adaptability need to be upheld through services supporting the agricultural sector like better access to credit for inputs, improvement of market chains, extension services, better access to information, etc.. Finally, negotiating and implementing some form of water entitlements within irrigation projects could help in devising community management strategies and be an option to achieve equity and sustainability of water allocation and help in mitigating shocks and negative externalities.

Conjunctive use of surface and ground water: Conjunctive management of rain, surface water and groundwater is the big hitherto underexploited opportunity for supply-side management. The presence of canals, tanks and wells in the project areas such a management strategy can act as an effective climate proofing strategy.

Contingency crop planning for the project area: In the context of currentclimate, as well as predicted increases in mean temperature and rainfall variability, adaptation and mitigation strategies are needed urgently for agricultural crops so that they are better adapted to biotic and abiotic stresses, leading to higher crop productivity. Use of alternative crops or cultivars adapted to the likely changes, alteration in the planting date, and management of plant spacing and input supply might help in reducing the adverse impact in most of the project villages.

Use of resource-conservation technologies and a shift from sole cropping to diversified farming system is highly recommended. Horticulture and agro-forestry need to be given more encouragement. Enabling policies on crop insurance, subsidies and pricing related to water and energy uses need to be strengthened at the earliest. Policies that would encourage farmers to enrich organic matter in the soil need emphasis. It is also necessary to develop a robust early warning system of spatio-temporal changes in weather as well as other environmental parameters. Contingency crop planning will require greater attention. Long-term strategic approaches to efficiently conserve and utilize rain water on the one hand and in-season tactical approaches to mitigate the adverse effects of weather aberrations on the other are also needed (Joshi and Kar, 2009).

Resilience and adaptation to climate change: It is often implies improving or at least maintaining the natural resource base through technological innovations, institutions building and policy imperatives. Mitigation on the other hand is an approach to lower down climate change variables within permissible limits. Considering the fact that mitigation and adaptation/resilience are completely different approach to deal the same problem its integration is all the more important in irrigated agriculture. Such an integration of adaptation to mitigation empowers the adaptation framework within the national and international climate change framework. It helps to prioritize the fiscal allocation and institutional support towards agriculture. Effective integration of resilience, adaptation and mitigation strategy is required for irrigated agriculture. This is essentially to prioritize the fiscal and institutional policies for irrigational development and management of climate shocks.

Enhanced co-ordination among agencies: The last, but not the least, of the strategies is the enhanced co-ordination among various Agencies such as State Pollution Control Board, Industrial Development Corporation, State Finance Corporation, Irrigation Department, Panchayatraj Department, Ground Water Department, and some other non-Governmental Agencies etc. to name a few. In fact, this is also one of the major aspects pointed out by the UNICEF-WWF study. Even though the regulations are very strong, the lack of co-ordination among the concerned Agencies will not produce the result (at a faster rate) with the same effect. As a result, the estimates of the developmental project cause rise so steeply that no more economically viable. In fact, there are a few instances reported, where the absence of the co-ordination of among above-mentioned Agencies led to alarming and severe economic problems. Therefore, the concerned Agencies should co-ordinate among themselves to see that the developmental projects/programs reach the public in time (Ramakrishna and Babu, 2014).

Irrigation projectsin Andhra Pradesh

Andhra Pradesh is a riverine state with 40 major, medium and minor rivers. Godavari, Krishna, Vamsadhara, Nagavali and Pennar are major interstate rivers.

Table 2: Types of irrigation projects based on irrigated ayacut

S. No.	Type of Irrigation project	Ayacut area covered
1	Major Irrigation Projects	Ayacut above 25000 Ac (10,000 ha.)
2	Medium irrigation projects	Ayacut above 5000 Ac up to 25000 Acres (10000ha.)
3	Minor irrigation projects	Ayacut up to 5000 Acres (2000 ha)

***Source*:** irrigationap.cgg.gov.in

Major and medium irrigation projects

Major Medium Irrigation Projects in Andhra Pradesh are 95 projects.

(Source: India-Water Resources Information System Web Geographic Information System)

Pattiseema project: The government had come up with the idea of building a lift irrigation scheme at Pattiseema village in Polavaram Mandal in West Godavari district in January 2015 to quickly get Godavari water to meet the irrigation needs of Krishna delta, which was started facing increased water shortage in recent times, as the main project was expected to take a longer time.

Polavaram project: Polavaram Project is a multi-purpose irrigation project which has been accorded national project status by the union government. This dam across the Godavari River is under construction located in West Godavari District and East Godavari District in Andhra Pradesh state and its reservoir spreads in parts of Chhattisgarh and Odisha States also.

It is a National River-Linking Project, which works under the aegis of the Indian Ministry of Water Resources, was designed to overcome the deficit in water in the country. As a part of this plan, surplus water from the Himalayan rivers is to be transferred to the peninsular rivers of India. This exercise, with a combined network of 30 river-links and a total length of 14,900 kilometers (9,300 mi) at an estimated cost of US$120 billion (in 1999), would be the largest ever infrastructure project in the world. In this project's case, the Godavari river basin is considered as a surplus one, while the Krishna River basin is considered to be a deficit one. Based on the estimated water requirements in 2025, the Study recommended that sizeable surplus water was to be transferred from the Godavari River basin to the Krishna River basin.

Ultimately the Polavaram right bank canal would be remodeledto enhance its capacity to 30,000 cusecs by raising its embankments for augmenting water transfer to meet shortages in the Krishna river basin and the needed environmental flows downstream of Prakasam barrage. A 25 MW hydropower station can be established utilizing Polavaram right bank canal water near Vijayawada city by transferring water via Budameru river and Eluru canal to Prakasam barrage pond.

Veligonda project: Veligonda project is an under construction irrigation project located in Prakasam district in Andhra Pradesh, India. When completed, the project will provide irrigational facilities to 459,000 Acres and drinking water to 1.5 million people in 29 Mandals of fluorine and drought affected areas in Prakasam district, Nellore district and Kadapa district by diverting 43.5 TMC of floodwater of Krishna river from foreshore of Srisailam Reservoir near Kollamvagu and proposed to store in Nallamalasagar Reservoir. The water for the project is drawn

through two 18.8 km long tunnels across Nallamala hills. The project has been renamed to Poola Subbaiah irrigation project. The construction includes two parallel tunnels of 18.8 km with 9.2 m and 7 m internal diameter and 21.6 km Flood flow canal for the water transmission system linking with Srisailam Reservoir up to Guntur-Kurnool road. The project is being implemented by double shielded tunnel boring machine to make the tunnel without disturbing wildlife in the Nagarjunsagar-Srisailam Tiger Reserve.

Veligallu dam reservoir project: It is an irrigation project across Papagni river near Galiveedu in Kadapa district of Andhra Pradesh, India. The project's goal is to allow for the irrigation of a total of 24000 acres (Galiveedu, Lakkireddypalli and Ramapuram Mandals of Rayachoti Taluk) in Rayachoti Taluk of Kadapa district and for drinking water provision for a population of 1 Lakh. The project's anticipated gross storage capacity is 4.64 Tmcft.

Table 3: Water saving and yield enhancing micro irrigation technologies

S. No.	Micro irrigation technology	Names of the crops for which technology can be used ideally	Nature of saving in applied water
1	Pressurized drip system (inline and online drippers, drip tape)	All fruit crops, cotton, castor, fennel, maize, coconut, arecanut, chilly, cauliflower, cabbage, ladies finger, tomatoes, gourds, mulberry, sugarcane, water melon, flowers.	Reduces non beneficial evaporation from the area not covered by canopy. Reduces deep percolation Water saving also comes from reduction in evaporation from fallow after harvest. Extent of water saving higher during initial stages of plant growth. Significant yield and quality improvement.
2	Overhead (movable) sprinklers (rain guns)	Pearl millet, sorghum, wheat, cumin, mustard, cow pea, chick pea, grasslands and pastures and tea estates	Reduces conveyance losses Improves distribution efficiency slightly Reduces deep percolation Marginal yield growth
3	Micro sprinklers	Potato, groundnut, garlic, onion, herbs and ornamentals	Reduces seepage, evaporation and losses in conveyance. Reduces deep percolation, over furrow irrigation and small border irrigation Yield growth and quality improvement significant
4	Plastic mulching	Potato, groundnut, cotton, castor, brinjal, chilly, cauliflower, cabbage, ladies finger, flowers, maize	Keeps complete check on the evaporation component Stops non-beneficial evaporation, kills weed and pests Extent of water saving higher over drip irrigation Faster germination and significant yield growth
5	Green houses	All horticultural and plantation crops	Reduces non beneficial evaporation Distribution uniformity is poor and depends on number of micronutrients on lateral

***Source*:** Dinesh Kumar M, Sivamohan MVK, Niranjan V and Nitin Bassi, 2011

Table 4: Ayacutdetails under Minor Irrigation in 13 districts of Andhra Pradesh

S. No	District	Total Registered Ayacut in Acres	Ayacut Irrigated in Kharif 2014	Gap Ayacut in Acres	Proposed Gap Ayacut to be Bridged during the year				
					2015-16	2016-17	2017-18	2018-19	2019-20
1	Srikakulam	275386	234171	41215	8243	7240	7852	9050	8830
2	Vizianagaram	268319	237960	30359	6072	5872	5878	6050	6487
3	Visakhapatnam	230665	79933	150732	30146	28956	28952	31452	31226
4	East Godavari	130415	94632	35783	7157	6057	6952	6152	9465
5	West Godavari	112655	32113	80542	16108	14108	15252	15562	19512
6	Krishna	103693	38727	64966	12993	11956	11952	13052	15013
7	Guntur	31708	26010	5698	1140	1050	1120	1065	1323
8	Prakasam	140242	11567	128675	25735	24752	26900	25652	25636
9	SPSR Nellore	282852	136293	146559	29312	28952	28521	29985	29789
10	YSR Kadapa	107872	2000	105872	21174	22174	23568	21174	17782
11	Kurnool	80160	51265	28895	5779	5698	5258	5528	6632
12	Anantapur	141936	2441	139495	27899	26859	25655	28599	30483
13	Chittoor	300307	7340	292967	58593	57895	56896	59856	59727
	Anicuts & open head channels	354234	41507	312727	62545	61489	60458	61545	66690
	GRAND TOTAL	2560444	995959	1564485	312896	303058	305214	314722	328595
	Or say in Lakh Acres	25.6	9.96	15.64	3.13	3.03	3.05	3.14	3.29

***Source*:** http://irrigationap.cgg.gov.in/wrd/home

The financial inputs needed per year in average is Rs.2000 Cr to stabilize the total gap Ayacut in next five years and also to create new Ayacut for achieving following growth engines.

- Effective and sustainable Irrigation infrastructure and its management.
- Area of cropping land is to be increased duly bridging the gap Ayacut
- De-silting of tanks to increase the capacity of tank, to increase the ground table thereby increase the irrigated Ayacut.
- Increase in water use efficiency to irrigate more Ayacut with minimum water.
- Agricultural output is to be increased by better irrigation practices.
- Water conservation and better water management.
- Increase the role of farmers and ease the burden on Government.
- Area planted with cash crops is to be increased

considerably.
- Value of Agricultural exports is to be increased.
- Beneficiary income is to be increased.

Jalasiriharati Scheme: Chief Minister N. Chandrababu Naidu has said that 28 irrigation projects will be completed in the next three months under 'Jalasiri Harati' scheme to help keep drought away from the State.

Smart water grid scheme: The Purushothapatnam and Pattiseema lift irrigation projects will cater to the needs of 11 districts, except Vizianagaram and Srikakulam, under the 'Smart Water Grid' scheme.

Neeru-Chettu Programme is a programme implemented with a view to improve water conservation and management in the State with people's participation in order to make the state drought proof. This Neeru-Chettu Programme is also water Conservation work which will improve the storage capacities of tanks and in turn improve the Ground water table of the surrounding areas.

The Vision of the Honourable Chief Minister of Andhra Pradesh is to prepare the state as a drought proof state within 5 years and is aimed to eradicate of poverty and reducing economic inequalities by better Water Conservation. Water Conservation Mission Under primary sector mission is one of the seven missions constituted for invigorating the growth engines with the main objective being poverty alleviation.

Water Conservation Mission has been constituted by involving relevant line departments.

Two aspects of the mission are

1) Water Conservation: Which would take into account the total rainfall, surface flow and the ground water and prepare a plan to make its optimum use by preventing wastage into the sea. The approach has to be from the ridge to the valley and the major departments to be involved in this exercise should be Irrigation, Forest, Rural Development and Ground Water.

2) Water Management: Which would require making most efficient use of the conserved water for various sectors of state economy and the major departments involved in this exercise, would be agriculture, Animal Husbandry, Horticulture, Fisheries, Rural and Urban Water Supply etc.

Conclusion

Andhra Pradesh is undergoing a dramatic shift in the irrigational pattern moving from large scale surface to ground water irrigation. Several studies pointed out that in the recent years (since 2002), irrigation growth of the state has become very sensitive to rainfall. This is evident from decline in the ground water irrigation in the shallow hard rock regions of Rayalaseema occasionally suffering from droughts. Evidence suggests that climate change has transformed groundwater into a more critical and yet threatened resource, and requires a reorientation of the state's water. Different programmes and irrigation projects being taken up can improve the irrigation status in India.

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