A comprehensive approach using remote sensing and geographic information systems (GIS) is proposed for the purpose of optimizing water resources in the Tirupati Revenue Division, located in the Chittoor District of Andhra Pradesh.

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Abstract: This research highlights the imperative need for the implementation of strategic water resource management strategies in order to address the increasing water scarcity resulting from population increase, industrialization, and urban development in the specific geographical region under investigation. The proposal suggests the implementation of small-scale projects along the Swarnamuki river belt with the objective of improving water resources for agricultural development in areas with high concentrations of water bodies in the eastern region, as well as addressing anticipated storage deficiencies. By using satellite data and the METRIC approach, this study computes the evapotranspiration (ET) for the Tirupati region, therefore uncovering significant water requirements for crops such as sugarcane. The research provides support for the use of drip and sprinkler systems as new irrigation technologies, emphasizing their potential to effectively reduce water usage. Furthermore, it proposes the use of drip irrigation techniques for sugarcane cultivation and the adoption of the System of Rice Intensification (SRI) for paddy farming as effective measures to mitigate water wastage, emphasizing the need of flexible agricultural approaches. In general, the research offers significant insights into irrigation methods that may effectively reduce water wastage and improve agricultural output, so making a vital contribution to the sustainable management of water resources.

1. Introduction:

Water supplies are being put under strain as a result of population growth, industrialization, and urbanization. Water scarcity is caused by factors such as large fluctuations in annual and inter-annual rainfall, ineffective infiltration, low hydraulic conductivity and storitivity, and high evaporative demand. The development and management of watersheds involve optimal use of water, land, and biomass resources in order to satisfy fundamental necessities in a manner that is environmentally sound. In order to accomplish this goal, runoff and soil loss must be reduced, and infiltration must be increased. Saving water can be accomplished by lowering surface runoff, increasing infiltration rates, and constructing buildings that are suited to their environments. Thematic data can be generated and analyzed with the use of remote sensing and GIS. However, remote sensing provides frequent synoptic coverage of the ground surface, which can be easily researched and represented in GIS. This is a significant advantage. For the purpose of runoff computation, it may include information on land utilization, land cover, and terrain topography (elevation, slope, and drainage network). Therefore, geospatial techniques may be used to select water harvesting sites in order to maximize the availability of surface and ground water for irrigation, domestic usage, and other purposes (Krishnan & Sankararajan, 2021).

The most severely impacted industry across the board is agriculture due to the global water crisis. Seventy percent of the world's freshwater is used for agriculture. Water is essential to the production of food. Since the production of biomass requires a significant amount of water, we could argue that agriculture is both the source of and a victim of water scarcity. The rising demands brought on by population growth come at a high cost to the environment. The supply of water and the demand for it, in addition to agricultural practices, could be impacted by climate change and the generation of bioenergy. Agriculture, both rain-fed and irrigated, is impacted by climate change because of the way it alters hydrological regimes and the availability of freshwater (López-Mata et al., 2019). There has been an increase in temperature, as well as increased rainfall variability, semi-arid regions have seen a decrease in precipitation, while temperate regions have seen an increase in rainfall. This has a particularly negative impact on agriculture in tropical and subtropical regions. River runoff and aquifer recharge both have an effect on the amount of water that is available and enhance the demand that humans place on water resources.

Water is scarce in India since the country has 16% of the world's population but just 4% of its pure water supply. Irrigation accounts for the majority of water consumption. Agriculture consumes up to 80 percent of the world's fresh water resources. Irrigation uses up roughly 80 percent of India's available water resources. Given its size of 3.3 million square kilometers and annual rainfall of 1170 millimeters, it is estimated that India has water resources equal to 4,000 cubic kilometers. Over half of this water is lost through processes such as evaporation, percolation, and underground flow to the oceans, which leaves 1953 billion cubic meters (BCM) of water that can be accessed. According to Phansalker and Verma (2005), the amount of water that is available varies, bringing the total down to 1086 BCM. It is anticipated that by the year 2025, the Annual Water Resource will have decreased to 1496 cubic meters, from 2214 cubic meters in 1996. According to (Gulati et al., 2009) findings, just 25 percent of the water resource that is available has been developed

2. Materials and Methodology

Crop evapotranspiration refers to the combined process of evaporation from the soil surface and transpiration from plants. It is a ETc, or reference evapotranspiration, is a fundamental parameter used in the assessment of crop water needs and the development of effective irrigation management strategies. In this study, the estimation of crop evapotranspiration (ETc) was conducted using a combination of satellite-derived reference evapotranspiration (ETo) and the crop coefficient (Kcb) technique. Following the pre-processing of satellite pictures, the estimation of ETc was conducted over the whole of the research region. The FAO-56 technique is often used for calculating evapotranspiration (ETo) and is frequently accessed via the Google Earth Engine Flux (EEFlux) webpage on a daily basis. The estimation of the basal crop coefficient (Kcb) is conducted via the use of the normalized difference vegetation index (NDVI) in relation to Kcb. The procedure for this estimation is elucidated as follows.

2.1 Data Used

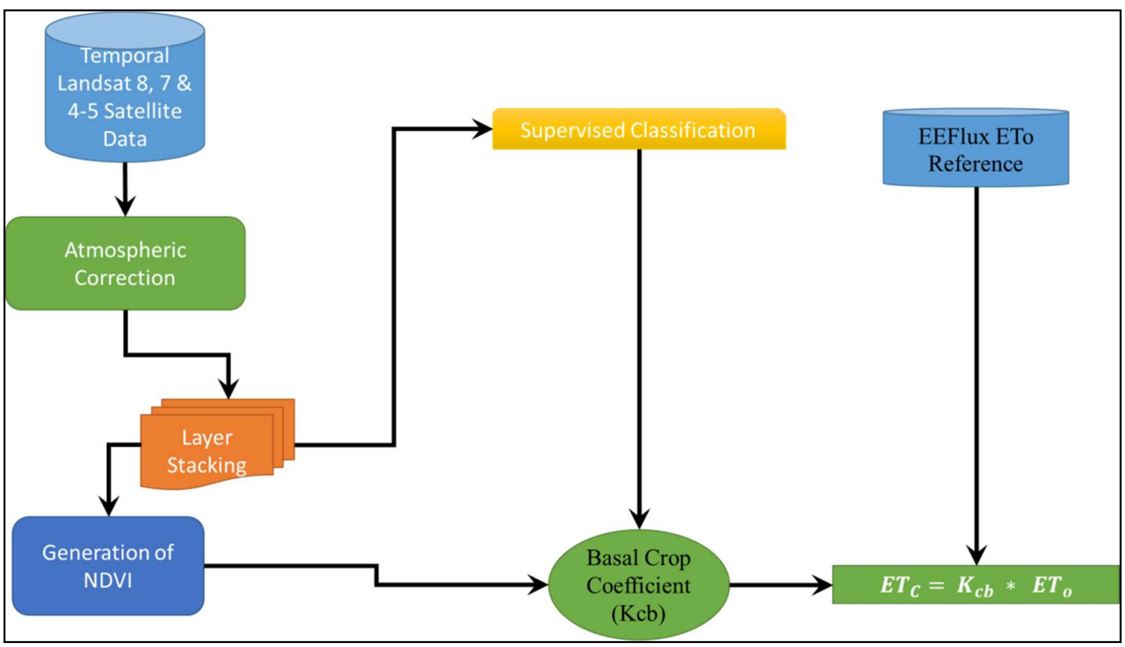
In order to accomplish the purpose of the current study, the researchers used several satellite products, supplementary data, and software tools.

Remote sensing data refers to the collection of information about an object or phenomenon from a distance, often using sensors or instruments.

The satellite dataset used in this work is shown in Table 1. Specifically, Landsat 8, 7, and 4-5 data were employed throughout the pre-monsoon and post-monsoon periods of the years 1997, 2008, and 2016.

S. No	Data Type	Date of Acquisition	Resolution	Source
1	Landsat - 8	April 2016 December 2016	30 m	https://earthexplorer.usgs.gov/
2	Landsat - 7	April 2008 December 2008	30 m	
3	Landsat 4-5	March 1997 December 1997	30 m	
4	METRIC (ET reference)	April 2016 December 2016	30 m	http://eeflux-level1.appspot.com/

Table 1 : Details of satellite data products used in this Study



Methodology flowchart

2.2 Ground Measurements

GPS coordinates were collected from study area for the sample sites for accurate identification of particular locations and for further analysis. Ground measurement site map is shown in figure 1.

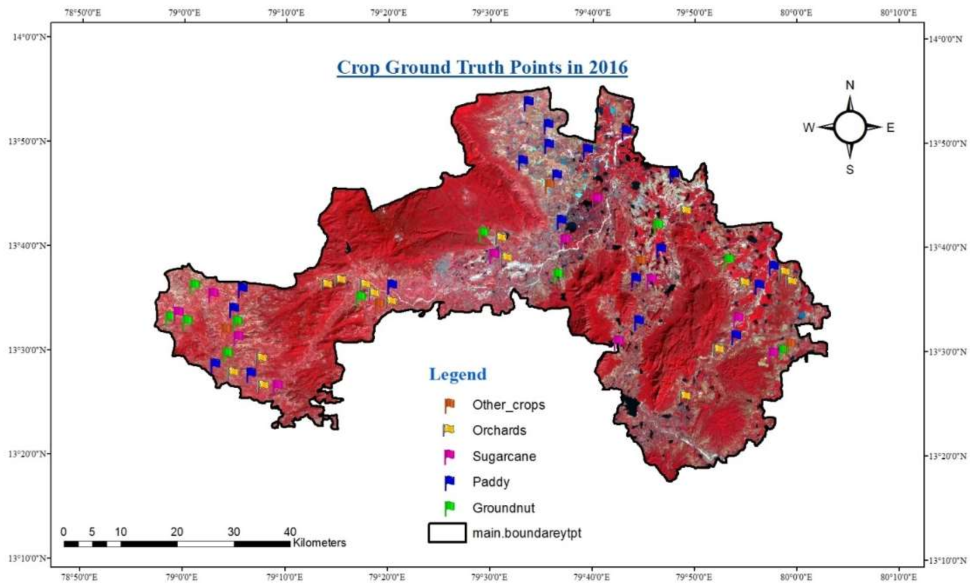


Fig 1: Ground truth measurement site map

2.3 Basal Crop Coefficient

The approaches for determining crop coefficients play a vital role in the estimation of crop evapotranspiration (ETc) and the formulation of irrigation scheduling strategies. The use of generalized coefficients often necessitates the implementation of local adjustments, hence generating inherent uncertainty. Vegetation indices (VIs) obtained using remote sensing techniques, such as the normalized difference vegetation index (NDVI), provide immediate and valuable information on crop variability. There is a scarcity of research available that indicates the potential of vegetation indices (VIs) in accurately estimating the basal crop coefficient (Kcb). The primary objective of this work is to use NDVI measurements in order to estimate Kcb values, with the ultimate goal of enhancing irrigation water management.

$$K_{cb} = K_{cb\max} \frac{\left(NDVI - NDVI_{\min}\right)}{\left(NDVI_{\max} - NDVI_{\min}\right)} \quad (1)$$

Where $K_{cb\max}$ is Basal crop coefficient and $K_{cb\max}$ is Basal crop coefficient at effective full ground cover i.e., 1.3 (Hunsaker, 1994)

2.4 Potential/ Reference Evapotranspiration

The use of the METRIC technique, in conjunction with Landsat data and the Google Earth Engine Evaporation Flux (EEFlux), offers a straightforward and precise means of estimating soil water storage capacity at a spatial resolution of 30m. Notably, this approach does not need the use of soil or vegetation maps. The process of evapotranspiration (ET) is of utmost importance in the hydrological cycle, and it is significantly influenced by sun radiation. The Potential Evapotranspiration (PET), also known as grass reference Evapotranspiration (ETo), plays a crucial role as an agrometeorological parameter, contributing to water balance models and regional evaluations of water demand for rainfed agriculture. The PET product has a precision level ranging from 80% to 90%.

2.5 Crop Evapotranspiration

Crop evapotranspiration (ETc) is defined as the combined process of evaporation and transpiration from a healthy crop, cultivated in expansive agricultural areas with enough water and fertilizer supply (Ding et al., 2013). The estimation of crop evapotranspiration (ETc) plays a crucial role in the calculation of the soil water balance and the development of effective irrigation scheduling strategies. The behavior of ETc is influenced by weather patterns and the state of the crops. Mathematically, the expression for ETc may be formulated as

3. Results and Discussion

3.1 Water Harvesting Sites

Dams block water or subsurface streams. They retain, gather, and store water for equal distribution (Zhang et al., 2023). Worldwide, dams have provided agricultural and urban water for millennia (Chelshi, 2023). The appropriateness of a built dam type in a possible dam site is always questioned. Dam type appropriateness decisions may include trade-offs between various intangibles.

Many methods are used to identify water collecting locations. The most prevalent method, AHP, combined with remote sensing and GIS, provides a worldwide site selection notion (Jayswal et al., 2023). Water harvesting and recharge locations rely on terrain, climate, precipitation, soil porosity, stream order, catchment area, and slope. These characteristics are acquired from various sources, incorporated into the GIS environment using multi-criterion decision making, and the location is chosen. The table below lists water harvesting site selection criteria.

Structure	**Slope %**	**Porosity and permeability**	**Runoff potential**	**Stream order**	**Catchment area (*10^4 m^2)**
Farm ponds	0–5	Low	Medium/high	1	1–2
Check dams	<15	Low	Medium/high	1-4	>25
Subsurface dyke	0-3	High	Medium/low	>4*	>5
Gully plug	15-20	Low	High	1	-
Percolation pond	<10	High	Low	1-4	25-40

Table 2: Selection criterion used for water harvesting sites

3.2 Slope Role

Line slope specifies its steepness and direction. It calculated slope steepness. One of the most essential elements in choosing locations for water collecting structures like check dams is topography steepness and surface runoff potential.

The slope indicates topography, which helps choose water gathering sites. The slope % is defined according to Integrated Mission for Sustainable Development (IMSD, 1995) and Food and Agriculture Organization (FAO, 1977) recommendations for choosing water collecting location. Present area slope classifications are displayed in the figure. CartoDEM (30m resolution) is used to generate % slope map in ArcGIS surface tools.

The slope map provides significant data on the zone's steepness, allowing us to estimate spillover. The region's slope may be divided into seven slant classes: (a) ‘nearly level’ (0–1%), (b) ‘very gentle’ (1–3%), (c) ‘gentle’ (3–5%), (d) ‘moderate strong’ (5–10%), (e) ‘strong’ (10–15%), (f) ‘moderate steep’ (15–30%), and (g) ‘very steep’ (> Slope grades 'nearly level' and 'sensitive' are increasingly suitable for water collection.

3.3 Runoff Generation

Runoff potential depends on DEM slope. According to slope-based criteria for surface runoff production, slope categories will be graded from least to most suited, with steeper slope categories generating more runoff. Runoff potential is classified as ‘moderate’ (200-300 mm), ‘poor’ (100-200 mm), and ‘very poor’ (<100mm).

Proposed aircraft for water resource management research. With above prospects and previous chapter studies of drainage morphometry, land resources, and land use land cover analysis and GIS integration, acceptable and necessary proposals are presented to the research region. Slop is the main source of runoff, thus the Tirupati Revenue Division receives water and soil conservation site suitability maps from slop and existing water resources location study.

Building modest irrigation projects

Apart from its tributaries, the Swarnamuki River runs 80 kilometers in Tirupati Revenue Division. Detailed examination after even shows no irrigation project except Kalyani tributary river. This river has greater discharge than others when it rains more. This project using natural briars is low-cost and beneficial for agriculture and drinking water.

3.4 Building medium and minor check dams

With serious stream network analysis and runoff calculations, a location map was proposed for the constriction of check dams like rock bonds, concrete dams, and earth bounds, especially in the west due to water scarcity. More check dams in that region will help recharge ground water and meet agricultural water needs Farm pound digging and contour ditching from the vast area of research, it is difficult to identify potential locations, but GIS was used to extract barren and fallow land locations suitable for these types of construction to recharge ground water and expand the agricultural mask. This structure is simple and affordable. This style is also suggested for agricultural land and will assist farmers. Fig.5.5 shows where to build farm pound and contour ditches.

3.5 Other water-saving methods Except from above, this area has additional water saving methods like fallows.

3.5.1. Reusing wastewater Tirupati Revenue Division's largest city produces more urban waste water. Industrial and associated uses of urban waste water may boost indirect agricultural development using waste water cleansing plants. As fresh water can be converted to agriculture, more irrigated land is feasible. However, adopting and managing it is more expensive, so the government may lead water conservation.

3.5.2. Modernized irrigation

Modern drip, sprinkler, and subsurface irrigation minimize water evaporation compared to surface irrigation. It also waters plants straight at their roots. Thus, water waste will decrease and production will increase. According to FAO, converting traditional irrigation methods to modern irrigation will increase the irrigated area by three times. A small attempt was made to irrigate the area with 100% modern irrigation methods using existing water.

The calculation of Evapotranspiration values was conducted during the pre-monsoon and post-monsoon seasons of 2016. This was done in order to provide accurate ground truth data on crop conditions for that specific year, enabling the categorization of crops for the same time period. The subsequent years, namely 1997 and 2008, were analyzed by referring to the District Hand Book and assuming ET values similar to those of 2016.

3.6 Pre-Monsoon Water Requirement

The reference data for evapotranspiration (ET) has been multiplied by the basal crop coefficient (Kcb). The following ranges of evapotranspiration (ET) were observed for the key crops during the Pre-monsoon season of 2016.

S.No	Crop	Range (mm/day)
1.	Groundnut	3.5 to 4.01
2.	Paddy	5.7 to 6.12
3.	Sugarcane	4.16 to 4.438
4.	Orchards	2.271 to 3.246

5.	Other Crops	1.545 to 2.116

Table 3: ET ranges in 2016 pre-monsoon

The Paddy crop exhibits a wider range of ET values during the pre-monsoon period in 2016, with Sugarcane and Groundnut following suit. The range of evapotranspiration (ET) values for orchard crops is quite low due to the prevalence of younger plantings, which constituted around 20% of orchard crops between 2008 and 2016, as reported in the handbook. Younger plants typically need less water during their first growth phases.

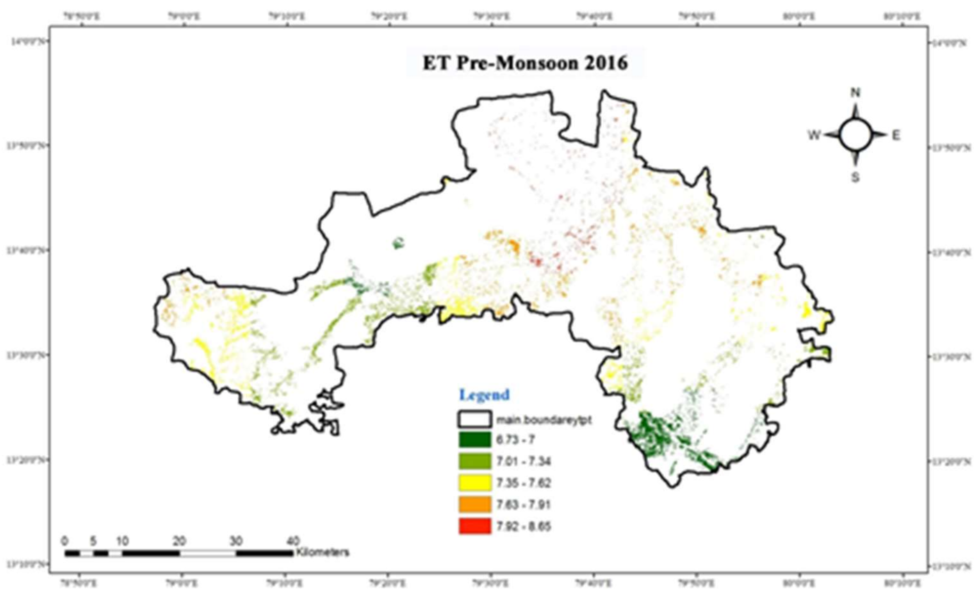


Fig 2. Evaporation in 2016 pre monsoon

The mean values of evapotranspiration (ET) for different crops are as follows: 3.76 mm/day for Groundnut, 5.91 mm/day for Paddy, 1569.14 mm/day for Sugarcane, and 2.76 mm/day for Orchards. The water consumption of the aforementioned crops per hectare, taking into consideration their respective growth periods, is as follows:

S. No	Crop	Growing Period	Average ET (mm/day)	Water requirement (mm/growing period)	Water requirement (cubic meter/ ha)
1.	Groundnut	140	3.76	525.70	5257.00
2.	Paddy	140	5.91	827.40	8274.00
3.	Sugarcane	365	4.30	1569.14	15691.35

4.	Orchards	365	2.76	1006.67	10066.70
5.	Other Crops	90	1.83	164.70	1647.00

Table 4 :Pre-monsoon average ET and water requirement per ha

Sugarcane, a significant agricultural commodity in the nation, necessitates a substantial amount of water over its whole growth cycle, which spans from 12 to 18 months. The specific duration of this cycle is contingent upon the agro-climatic areas, which range from sub-tropical to tropical. According to the Food and Agriculture Organization (FAO), the yearly water demand for this particular crop is within the range of 1500-2500 mm. The estimated yearly water demand for sugarcane in our research region is 1569.14 mm during a period of 12 months.

S. No	Crop	Water requirement (cubic meter/ ha)	Area (Ha) Pre monsoon			Total Water Consumption (Million Cubic meter/Total Cropped Area)		
			1997	2008	2016	1997	2008	2016
1.	Groundnut	5257	21348	419	3326	112.23	2.20	17.48
2.	Paddy	8274	22774	2252	3132	188.43	18.63	25.91
3.	Sugarcane	15691	8653	4475	4992	135.78	70.22	78.33
4.	Orchards	10066.7	7563	8463	10402	76.13	85.19	104.71
5.	Other Crops	1647.	7201	796	1090	11.86	1.31	1.80

Table 5: Pre-Monsoon Water requirement and Consumption for different crops

3.7 Post-Monsoon Water Requirement

The ET reference data has been multiplied by the basal crop coefficient (Kcb). The following information presents the range of evapotranspiration (ET) values for the key crops during the post-monsoon season of 2016.

S.No	Crop	Range (mm/day)
1.	Groundnut	3.42 to 3.76
2.	Paddy	5.538 to 5.914
3.	Sugarcane	3.84 to 4.564
4.	Orchards	2.193 to 3.346
5.	Other Crops	1.21 to 1.896

Table 6: ET ranges post-monsoon

The range of evapotranspiration (ET) values for the aforementioned crops varies from 1.21 to 5.91 mm/day, with the maximum ET being reported by the paddy***:***

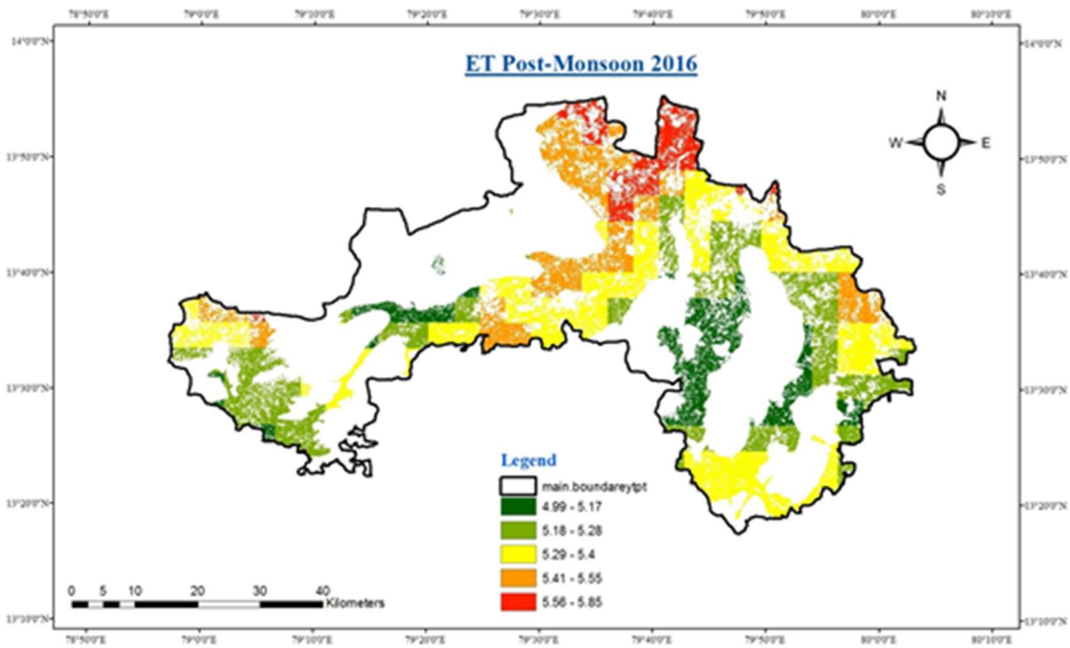


Fig 3. Evapotranspiration in 2016 post monsoon

S.No	Crop	Crop Period	Water Requirement Avg. Value (mm/day)	Water requirement (mm/crop period)	Water requirement (cubic meter/ ha)
1.	Groundnut	140	3.59	502.60	5026.00
2.	Paddy	140	5.73	801.64	8016.40
3.	Sugarcane	365	4.20	1533.73	15337.30
4.	Orchards	365	2.77	1010.87	10108.68
5.	Other Crops	90	1.55	139.77	1397.70

Table 7: Post-monsoon average ET and water requirement per ha

The groundnut crop exhibits an average evapotranspiration of 3.59 in its third position during the post-monsoon season, with a water need of 5026 cubic meters per hectare. The rice crop has the greatest average evapotranspiration (ET) value, whereas sugarcane surpasses it in terms of water need, with a daily rate of 15331.3 mm/day. This is due to the longer growth time of sugarcane compared to paddy.

S.No	Crop	Water requirement (cubic meter/ ha)	Area (Ha) Pre monsoon			Total Water Consumption (Million Cubic meter / Total Cropped Area)		
			1997	2008	2016	1997	2008	2016
1.	Groundnut	5026.00	26384	20594	20594	132.61	103.51	103.51
2.	Paddy	8016.40	38414	44440	34440	307.94	356.25	276.08
3.	Sugarcane	15337.30	8653	4992	5732	132.71	76.56	87.91
4.	Orchards	10108.68	7563	8463	10402	76.45	85.55	105.15
5.	Other Crops	1397.70	37599	32765	22382	52.55	45.80	31.28

Table 8: Post-Monsoon Water requirement and Consumption for different crops

The water consumption for high water need crops, such as paddy, saw a drop in 2016 as compared to the levels seen in 1997. This occurrence may be attributed to a decline in the overall cultivated land area. Nevertheless, under the provided cropping plan, rice cultivation continued to occupy the top position. The total area under cultivation is mostly allocated to crops other than paddy. However, if the current tendency persists, there is a possibility of further reduction in the cultivated area for paddy, perhaps leading to its replacement by other crops such as orchards, which have shown an increasing trend in cultivated area over the years. Hence, the adoption of System of Rice Intensification (SRI) may be considered for paddy farming, while the implementation of drip irrigation can be recommended for sugarcane production, with the aim of mitigating excessive water consumption in both agricultural practices.

3.8 Other important factors in growth performance of agriculture sector

3.8.1 Fertilizers Consumption

Soil productivity increases with proper fertilizer and manure application. From 2007 to 2016, Tirupati Revenue Division consumed more fertilizers, as seen in Fig. 5.10. Urea, NPK, DAP, and others are used 76, 25, 95, and 200 percent more. Chemical fertilizers have helped farmers grow crops since the 1930s. Chemical fertilizers can cause stream pollution, crop burn, air pollution, soil acidification, and mineral loss. Farmers in these regions should limit fertilizer use and switch to organic farming to naturally increase soil fertility.

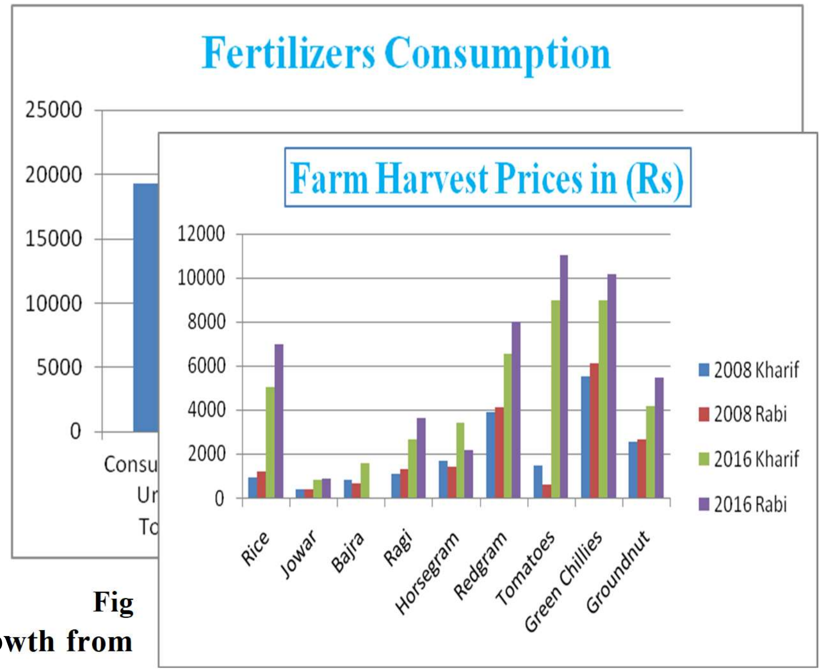


Fig 4. Fertilizers consumption growth from 2007-2016

3.8.2 Farm Harvest Prices

Agricultural harvest prices include product and input prices at various marketing phases. In India, the government's agricultural price strategy tries to ensure growers receive fair prices to stimulate investment and productivity. Annual minimum support prices for main agricultural goods are set after considering Commission on Agricultural Costs and Prices recommendations. In real life, harvesting prices are rising double and triple but minimum support rates are not, so farmers are converting to laborers and losing agricultural land. Fig 5.11 displays agricultural crop harvest prices. Massive increases lead to agricultural deficits. The government will disclose the minimum support price as rates rise.

Fig. 5 Farm harvest prices growth from 2008-2016

3.8.3Agricultural Credit

Each economic sector relies on credit. Farmers need credit for investment and working capital. Poor investment credit hinders HYV seed expansion and optimal input use. Like other sectors, agriculture needs easy, appropriate, and timely credit. Even though India has several Rural Financial Institutions (RFIs), the formal banking industry neglects a substantial percentage of the rural population. However, formal Indian banks have rigid credit flows and security-based lending. Additionally, "Long gestation period, lack of educated technical staff to discover potential activity, inadequate eligibility, and security issues contribute to limited loan flow to agriculture. For agriculture financing to move quickly, it must be fixed.

3.8.4 Irrigation system

The Revenue Division's agriculture and allied operations require irrigation, thus the study area's needs must be met. Modern drip, splenkar, and tube well irrigation increases, as seen in Fig.5.12. It is good, but only 10–15% of the remaining land uses traditional methods, which require more water. The irrigation system in this income division has to be changed.

Fig. 6 Irrigation system growth from 1997-2008-2016

3.8.5 Agricultural literacy

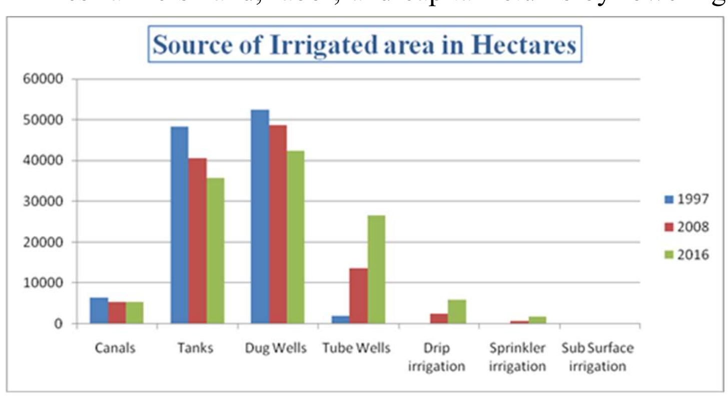
Agricultural literacy involves critical thinking and value judgments regarding agriculture's economic, environmental, and social and political impacts. An agriculturally literate person can assess “trade-offs” to people and society from agricultural activities. Decisions and values shape agricultural content. The ability to discuss and make decisions about societal choices shows agricultural understanding.

However, the Revenue division does not have clear statistics on this, and most of the area is rural, and I have seen little agricultural literacy. Thus, farmers must be educated through street performances, night schools, and other techniques to use technology immediately.

3.8.6 HYV, SRI and Mechanization

Modern methods and technology including high-yielding variety (HYV) seeds, tractors, irrigation infrastructure, herbicides, and fertilizers transformed Indian agriculture into an industrial system during the Green Revolution. Mostly found by M.S. Swaminathan. The Green revolution, started by Norman Borlaug, used agricultural research and technology to boost output. Implementation of high yields variety is not complete in study area.

The System of Rice Intensification SRI maximizes farmers' land, labor, and capital returns by lowering their seed, water, and labor needs. This boosts their incomes and helps the environment. SRI plants are resilient to water stress, storm damage, pests, and diseases, which is needed as climate change threatens. This skill may grow in importance. According to the divisional agriculture officer interview, the revenue division has practiced fewer than 20 to 30 hectors of SRI during the past five years. Thus, ground-level technological deployment is crucial for water and agricultural sustainability.



The income division is improving as mechanization continues, but the percentage is low. According to the district statistical handbook, the improvement from 10 years is only 15 to 20% in all types of mechanization. The research region did not properly implement technological mechanization including harvesting machinery and cultivator’s machinery save for land ploughs and electrical pump sets.

3.8.7 Agricultural research staff and centers

The study region had 1–2 agricultural staff per mandal and little technical staff, who were mostly involved in administrative tasks. Most of the study area lacks time to solve basic difficulties. The Southern Zone headquarters, Regional Agricultural Research Station (RARS), Tirupati, is one of two research stations in the study area. The station is 7 kilometers from Tirupati on the Tirupati–Chittoor route. The station was founded in 1979 to research groundnut and groundnut-based agricultural systems, soil and water management, pulses, biofuels, watershed management, and fodders. By 2011, RARS, Tirupati had established Agricultural Polytechnic College in addition to research. Institute of Frontier Technologies was founded in RARS, Tirupati with modern infrastructure and lab facilities to explore biotechnology, bioinformatics, nanotechnology, bio control, soil and water analysis, and quality analysis. The university and Tirupati's best labs are at this institute. Another research station is Krishi Vigyan Kendra, Vanasthali, in Renigunta mandal near Karakambadi. Has district-level Farm Science Centers created by the Indian Council of Agricultural Research (ICAR), New Delhi to speed up technology transfer to farmers. These centers transfer cutting-edge agricultural technologies to end users to boost production and productivity. It collaborates with other agencies. Farmers are interacting with both research sites and answering their agricultural questions. Research is also being implemented locally.

4. Conclusion

In conclusion, the research emphasizes how urgently the study region requires strategic water resource management, in particular as a reaction to the concentrated distribution of current water bodies in the eastern side and the expected gap in water storage projects. The plan that has been presented places an emphasis on the building of modest projects along the Swarnamuki river area. The goal of the strategy is to strengthen water resources in order to facilitate increased agricultural production.

In addition, a technique that is based on remote sensing is used in the research to estimate the amount of evapotranspiration (ET) that occurs in the Tirupati Region. The use of the METRIC method makes it easier to calculate ET values for a variety of crops throughout the pre-monsoon and post-monsoon seasons in the year 2016. The results highlight the enormous water needs of crops such as sugarcane, calling for novel irrigation techniques such as micro-irrigation, with drip and sprinkler systems displaying significant water consumption savings. The findings also call for innovative irrigation strategies such as micro-irrigation.

According to the findings of the study, there is a possibility that excessive water consumption may be reduced by applying the System of Rice Intensification (SRI) for paddy farming and by boosting drip irrigation for sugarcane. In addition, the research identifies fluctuations in farmed areas across various types of crops, which indicates the need for adaptable agricultural techniques. In general, the study produces useful insights for the management of water resources in a sustainable manner, and it argues for the use of contemporary irrigation practices in order to improve water usage efficiency and agricultural yields in the area.

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