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Cauvery Water Policy Plan for Sustainable Agricultural and Domestic Usage

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***Abstract* - Cauvery River is the basic as well as major resource for water supply in central Tamil Nadu. The sharing of waters of Cauvery River has been the source of a serious conflict between Karnataka and Tamil Nadu. 30-year hydrological, agricultural and irrigational data of the Cauvery basin have been used in this study. This dissertation explores on the technical and practical reasons behind unsatisfactory water sharing among the stakeholders in disagreement. Relevant data is collected from various central and state government surveys and projects. Net irrigation requirement and the percentage of net area irrigated to net area sown are the parameters for agricultural demand and supply correlation. Population growth has been forecasted for the year 2017 for all three districts and thereby demand is calculated. Domestic supply is found out from the norms given separately for each state according to their demography. Difference between supply and demand for each district, consuming water from Cauvery River on the aspect of agricultural and domestic usage is determined and corresponding graphs plotted. Culturable Command Area and Potential created are the attributes for efficiency of irrigation project. Efficiency of major irrigation projects in Cauvery basin are compared state-wise in order to check for improvement. Groundwater exploitation is analyzed for Kerala, Tamil Nadu and Karnataka to derive an efficacious supply arrangement. Particular focus is supplemented for groundwater usage of Tamil Nadu with district-wise comparison on the basis of exploitation level. The flood discharge at Coleroon due to Kerala floods on August 2018 is studied to suggest a flood simulation model and ideas for storing excess flow. The suggestions provided will be a useful asset for the resolution of dispute and stakeholders and may engrain better understanding of the water resources scenario in the basin. This report will be a utilitarian for management of water sector in the basin.**

Keywords - Net Irrigation Requirement, Population Forecast, Performance Efficiency, Groundwater Exploitation, Trapezoidal method, Flow Simulation Model

I. INTRODUCTION

A. General

Cauvery, also referred as Ponni, is an Indian river flowing through the states of Karnataka and Tamil Nadu. It is the third largest river, after Godavari and Krishna in South India and the largest in Tamil Nadu which on its course, bisects the state into North and South. Originating in the foothills of Western Ghats at Talacauvery, Kodagu in Karnataka, it flows generally South and East through Karnataka and Tamil Nadu and across the southern Deccan plateau through the southeastern lowlands, emptying into the Bay of Bengal through two principal mouths in Poompuhar, Tamil Nadu. Amongst the river valleys, the Cauvery delta forms one of the most fertile regions in the country.

The Cauvery basin is estimated to be 81,155 square kilometers with many tributaries including Harangi, Hemavati, Kabini, Bhavani, Arkavat hy, Lakshmanatirtha, Noyyal and Arkavati. The river's basin covers three states and a Union Territory as follows: Tamil Nadu, 43,856 square kilometres; Karnataka, 34,273 square kilometres; Kerala, 2,866 square kilometres and Puducherry, 160 square kilometres. Rising in southwestern Karnataka, it flows southeast some 800 kilometres to enter the Bay of Bengal. In Mandya district it forms the island of Shivanasamudra, on either side of which are the scenic Shivanasamudra Falls that descend about 100 meters (330 ft). The river is the source for an extensive irrigation system and for hydroelectric power. The river has supported irrigated agriculture for centuries and served as the lifeblood of the ancient kingdoms and modern cities of South India. Access to the river's waters has pitted Indian states against each other for decades.

B. Timeline of the Dispute

The Cauvery water dispute is 123 years old. Here is a timeline of events leading to the recent verdict:

1892: Cauvery river water dispute starts between Madras Presidency (under the British rule) and the Princely state of Mysore. Madras disagrees to Mysore administration’s proposal to build irrigation systems, arguing that it would impede water flow into Tamil Nadu.

1913-1916: Mysore government writes to Madras Presidency, seeking permission to build a reservoir,

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leading to a dispute that ends with the arbitrator giving Mysore permission to construct a dam up to 11 tmc ft. The verdict is challenged.

1924: The dispute comes close to being resolved when Mysore and Madras reach an agreement under which Mysore is allowed to build a dam at Kannambadi village. The agreement is to be valid for 50 years and reviewed thereafter. Based on this agreement, Karnataka builds the Krishnaraja Sagar dam.

1929: An agreement is reached, meant to clarify the 1924 agreement allowing the construction of the Krishnaraja Sagar dam in Mysore and to specify exactly how much water would be released to Madras. Krishnaraja dam becomes functional in 1931 and the Mettur dam in 1934.

1974: The 1924 water sharing agreement between then Madras Presidency and Princely State of Mysore (now Tamil Nadu and Karnataka) lapses after expiration of its term of 50 years.

1986: Tamil Nadu approaches the center for setting up a tribunal for disputes arising out of Cauvery water sharing.

2 June 1990: A CWDT, headed by Justice Chittatosh Mookerjee, set up under the center after the Supreme Court’s direction.

25 June 1991: CWDT passes an interim award asking Karnataka to release 205 tmc ft of water to Tamil Nadu every year. It also directed Karnataka not to increase its irrigated land area from the existing 1,120,000 acres (around 4,500 km).

As a result, there was widespread dissatisfaction and violence in the two states.

11 December 1991: CWDT’s interim award notified by the center after the Supreme Court struck down an ordinance issued by Karnataka and upheld the award.

August 1998: The CRA constituted by the center for the implementation of the interim award of the CWDT.

September 2002: The CRA directs Karnataka to release 9,000 cusecs per day of Cauvery water to Tamil Nadu. The body was presided over by then prime minister Atal Bihari Vajpayee

5 February 2007: CWDT passes the final award and allotted 30 tmc to Kerala, 270 tmc to Karnataka, 419 tmc to Tamil Nadu and 7 tmc to Puducherry. Additionally, 14 tmc was reserved for environmental “inevitable escapades” into the sea.

19 February 2013: The center notifies the final award of the CWDT, on the direction of the Supreme Court.

19 March 2013: Tamil Nadu moves the Supreme Court, seeking directions to the water ministry for constitution of the Cauvery Management Board.

28 May 2013: Tamil Nadu moves the Supreme Court, seeking Rs2,480 crores in damages from Karnataka for not following the orders of the CWDT.

26 June 2013: Tamil Nadu moves SC for constitution of the Cauvery Management Board.

22 August 2016: Tamil Nadu files petition in the Supreme Court, seeking direction to the state of Karnataka to release water to Tamil Nadu.

6 September 2016: SC directs Karnataka to release 15,000 cusecs a day till 15 September. Karnataka released 10,000 cusecs of water from the Krishna Raja Sagar dam to Tamil Nadu. State witnesses’ widespread unrest.

12 September 2016: Supreme Court modifies direction, asks Karnataka to release 12,000 cusecs a day till 20 September instead of the earlier 15,000 cusecs per day till 16 September.

20 September 2017: Bench comprising CJI Dipak Misra and justices A.M. Khanwilkar and Amitava Roy reserve verdict in the Cauvery water dispute between the two neighboring states of Tamil Nadu and Karnataka.

February 16, 2018: Supreme Court reduces the allocation of Cauvery water from Karnataka to Tamil Nadu. The apex court directed the Karnataka government to release 177.25 tmc ft of Cauvery water to Tamil Nadu from its inter-state Biligundlu dam. The judgment clarified that Karnataka will now have an enhanced share of 14.75 tmc ft water per year while Tamil Nadu will get 404.25 tmc ft, which will be 14.75 tmc ft less than what was allotted by the tribunal in 2007.

C. Drawbacks of Present Scheme

The present scheme is not a basin organization integrated with land management, drought or flood management activities in the Cauvery basin. Rather, it focuses only on the dispute resolution over water sharing. The scheme consists of two levels of authorities. The Cauvery Water Management Authority (CWMA) at the highest level comprising temporary and permanent members of all the basin states and the Union government. It is headed by an eminent engineer or a member of the Indian Administrative Service. As its technical arm, another authority below CWMA, namely the CWRC, has been constituted to verify the factual positions—of reservoir storage, cropping patterns in the basin, inflows and outflows of reservoirs—so as to aid and advise CWMA to take appropriate decision on distress sharing formula and water sharing every year.

The scheme has no authority in the Cauvery basin like control over the dams, the reservoir inflows, outflows and their storage position in the Cauvery basin. It is dependent on states for data/information and has to act in accordance with the information provided by the basin states on inflows and outflows of 11 reservoirs. It has no mechanism to verify the data/information for its authenticity due to which the dispute can resurrect any time.

The scheme has no scope for environmentalists, ecologists and social scientists. The scheme does not have groundwater specialists and it has no authority to restrict programs that divert the water through the recharge of groundwater. So, another opportunity has been lost to create multi-disciplinary basin organization. In fact, the engineering fraternity should have told the legal fraternity to create an institution in line with what has been declared in the national water policies.

During a normal or above normal rainfall year, there would be no need for this scheme. But the real test of the scheme would lie in a rainfall deficient year—when a distress sharing formula would require much more than just techno-bureaucrats. Therefore, the scheme is poised for failure, leading to a repeat of the cycles of dispute witnessed in the past 150 years. If the scheme isn’t revamped, it may threaten the very federal fabric of the nation.

D. Need for Water Policy Plan

Many cities in developed countries like London, Melbourne etc. resort to implementing judicious water use policy for the public that is implemented strictly by the state and the general public. This reduces wastage of water in tough times and ensures ample amount of water is available for everyone.

In the context of the Cauvery water dispute, research by Indiaspend.org reveals that Karnataka's state capital Bangalore uses nearly half the amount of water from Cauvery designated for domestic use in the state. The research also shows that almost half of that water is wasted in distribution losses and wastage by individuals leading to a shortage. At least 8.5 million people live in the third-most populated city in India with 8.65 lakh water connections but they only receive 65 liters of water per day on average. In comparison, Bengaluru comes second to Kolkata which tops the water-wasting cities' list.

Cauvery water dispute has led to an extended tussle between states in India reaching legal blockades. Water sharing, a much-disputed issue in the country warrants a relook. As a fresh outlook, India can take a cue from successful management of water sharing from across the borders. As such, till the Center remains the sole advisor, interstate disputes are not likely to be resolved easily. A longer-term solution lies in a holistic economic-Eco systemic-institutional approach.

E. Objectives

The main objectives of the study are:

a) To analyze the Hydrological data of Cauvery basin.
b) To study the agricultural activities relaying on Cauvery river.
c) To estimate the domestic water consumption for areas depending on Cauvery water supply.
d) To evaluate the performance of Irrigation projects in Cauvery basin.
e) To develop suggestions for equitable and fair distribution of Cauvery waters for sustainable agricultural and domestic purposes among Karnataka, Tamil Nadu, and Kerala.

II. LITERATURE REVIEW

This chapter presents the background to the methodology adopted and source for data and maps used for analysis. The available published literature on agriculture, irrigation projects, groundwater and domestic usage is also briefly reviewed.

Dynamic Groundwater Resources of India, 2011-15: Level of usage of groundwater and the regulated usage for sustenance was given. The intensity of exploitation of groundwater by Kerala, Tamil Nadu and Karnataka were compared year-wise. Ways of managing ground water resources were discussed. On the basis of assessment, benchmarking was done for ranking embezzlement of ground water resources and categorized into safe, semi-critical, critical and over-exploited.

Cauvery Basin, Ministry of Water Resources, 2014: This report provides valuable information related to the topography, demography, climate, surface water resources, hydro-meteorology, tributaries, watersheds, irrigation projects, dams and canals and land use characteristics. The inference analyzed the proposal of inter-linking of rivers- Somasila-Grand Anicut Link and Cauvery(kattalai) and Vaigai-Gundar Link.

Integrated Hydrological Data Book, 2017: This journal reviews on storage capacity of Cauvery basin and its salient features. Flow of water by season and site was recorded and probed on. Maximum and minimum observation water levels were surveyed. Land utilization pattern was derived and net area irrigated by sources from Cauvery basin was dissected district-wise.

Agricultural Change and Irrigation Problem in the Cauvery Delta, 2006: Field level irrigation management changes for the past decade was studied and concluded with censures in existing irrigation pattern. Water requirement for different types of rice cultivation was assessed which was beneficial in calculating net irrigation requirement of major crops grown in Cauvery basin.

III. STUDY AREA

The basin covers major part of peninsular India, spreads over states of Tamil Nadu, Karnataka, Kerala and Union Territory of Puducherry which is nearly 2.7% of the total geographical area of the country. It extends over an area of 85,626.23 Sq. km with a maximum length and width of 560 km and 245 km, respectively and lies between 75°27'E to 79°54'E and 10°9'N to 13°30'N. It is bounded by the Western Ghats on the west, by the Eastern Ghats on the east & the south and by the ridges separating it from Krishna basin and Pennar basin on the north. The basin constitutes of 3 sub-basins namely Cauvery Upper, Cauvery Middle and Cauvery Lower sub-basin. There are 132 watersheds, each of which represents a different tributary system for size ranging from 362 Sq. km to 991 Sq. km with maximum number of watersheds falling in Cauvery Middle Sub-basin. On the basis of the 2011 Census, the total population in this basin is about 3,18,89,280. Cauvery River which is the main river in this basin rises at Talakaveri on the Brahmagiri range in the Western Ghats in Karnataka at an elevation of about 1341 m and flows for about 800 km before its outfall into the Bay of Bengal. The important tributaries joining the Cauvery are Harangi, Hemavathi, Kabini, Suvarnavathi and Bhavani. In the Cauvery basin, four distinct seasons occur. They are winter, summer, south-west monsoon, and north-east monsoon season in this basin. The basin is mainly influenced by South-West monsoon in the Karnataka & Kerala and North-East monsoon in Tamil Nadu. Rainfall in the delta area is of the order of 1000 mm annually.

The basin has a tropical and sub-tropical climate. In the upper reaches which include Kerala and Karnataka, the variation in temperature is minimal. The mean monthly temperature over the basin varies from 22.98° C to

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28.43° C. Around 21 land use classes exist in the basin. Agricultural land is dominant in this basin having an area of 53736.30 sq. km. (66.21%) followed by 16636.66 sq. km. of forest area (20.50%). The entire basin falls in three agro-climatic zones which include west coast plains and ghat region, east coast plain and hill region and southern plateau and hills region. Out of these, large portion of the basin consists of southern plateau and hills region.

There are around 42642 surface water bodies available in the basin. Number of reservoirs falling in the basin are 101; a large number of lakes comprising of 10692 are also present in the basin area whereas 30739 tanks are also present. There are about 29 major and medium irrigation projects in Karnataka and 25 major and medium irrigation projects in Tamil Nadu. There are 15 major hydroelectric projects with 24 power houses available in the basin. Number of dams falling in this basin are 96 whereas 10 barrage and 16 anicuts or weirs have been constructed in the basin. The utilizable surface water resource for the basin is 19 BCM. The Average Annual Runoff and Average Annual Water Potential in the basin are same as 21.36 BCM.

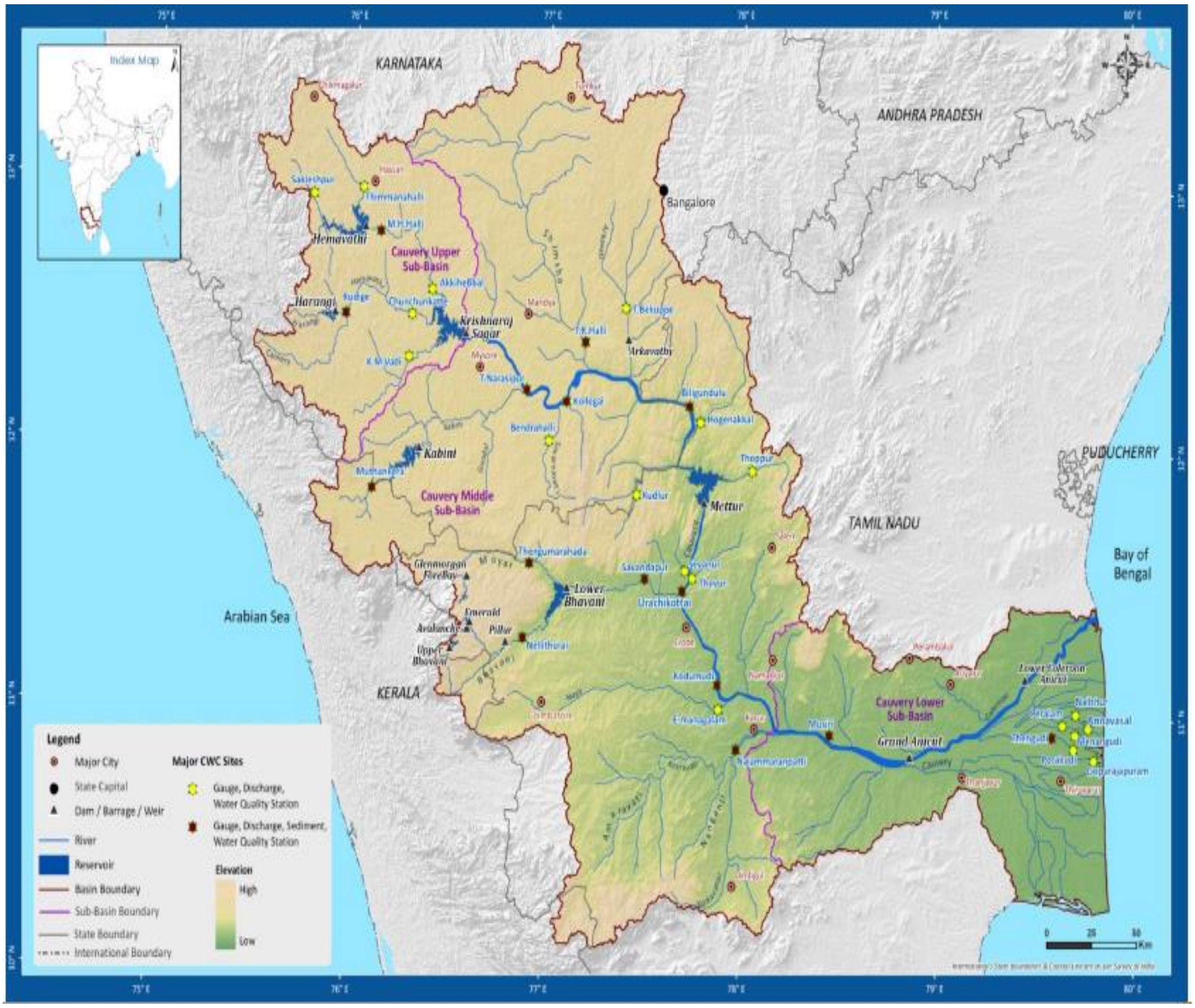

Fig. 1 Map of Cauvery Basin

IV. METHODOLOGY

A. General

The step-by-step procedure followed for the analysis is as follows:

- Data collection from central and state water resource development websites and chronicles.
- Exploration of agricultural activities of each district in Cauvery basin utilizing the surface water in a significant amount.
- Comparison of supply and demand of irrigation for the major crops.
- Calculation of domestic water usage demand of each district where the supply also includes that from Cauvery River.

- Comparison of supply and demand in the domestic water usage.
- Estimation of performance efficiency of major irrigation projects in the Cauvery basin.
- Assessment of groundwater exploitation by each district coming under Cauvery basin.
- Analysis of Coleroon discharge during Kerala Floods in August, 2018.
- Reconnoitering the results and coming up with potential suggestions for improvement in the present condition of water sharing by Kerala, Karnataka and Tamil Nadu.

B. Procedure for Agricultural Usage Analysis

1. Calculation of effective rainfall as per definition given by Food and Agricultural Organization of the United Nation in 1986.

TABLE I. FORMULA FOR CALCULATION OF EFFECTIVE RAINFALL IN MM

Monthly Rainfall in mm (x)	**Effective Rainfall in mm (y)**
If x<10	y = 0
If 10<x<51	$y = 0.0082x^2 + 0.0121x - 0.5$
If x>51	y = 0.7944x-23.938

2. Calculation of potential Evapotranspiration of the reference crop grown at the selected district using collected data particularly latitude and atmospheric conditions by Blaney-Criddle Equation.

$$ETo = p *(0.457\ Tmean + 8.128) \quad (1)$$

Where,
ETo is the reference evapotranspiration [mm/day] (monthly)
Tmean is the mean daily temperature [°C]
p is the mean daily percentage of annual daytime hours.

3. Calculation of Consumptive use of the reference crop using their specific crop factor.

$$Cu=ETo*Kc \quad (2)$$

Where,
Cu is the monthly consumptive use in mm/day
Kc is the crop factor.

4. Calculation of monthly net irrigation requirement of the crop without considering leaching requisite and after multiplying both the parameters by days of the picked month.

$$NIR=Cu-EF \quad (3)$$

Where,
NIR is the Net Irrigation Requirement in mm
Cu is the Consumptive Use in mm for the full month in mm
EF is the Effective Rainfall of the selected month in mm.

5. Calculation of irrigation demand for the whole district by multiplying total net irrigation requirement for a specific crop throughout its growth period, by area sown in hectares.
6. Calculation of irrigation supply to the district by multiplying total net irrigation requirement with the percentage of area irrigated suitably.
7. Graph is plotted by comparing irrigation supply and demand for each district of Karnataka and Tamil Nadu.

C. Procedure for Domestic Usage Analysis

1. Forecasting of Population of 2017 from Census data of 1991, 2001 and 2011 using Geometrical Mean method is done for each district utilizing water supply from Cauvery River.

$$r = \sqrt{(r1^2 + r2^2\ )} \quad (4)$$

$$P=Po*(1+r) \quad (5)$$

Where,
P is the Population Forecast for 2017
Po is the Population of 2011
n is the number of decades ((2017-2011)/10 = 0.6)
r1 and r2 are the decadal growth rates between 1991-2001 and 2001-2011 respectively
r is the root mean square value of overall growth rate within 1991-2011.

2. Calculation of daily domestic usage demand for a district by multiplying projected population by 135 litres per capita per day standard. Domestic usage demand is estimated in litres for a day district-wise for Kerala, Karnataka and Tamil Nadu.
3. Calculation of daily domestic water supply for a district by multiplying projected population with the allocated value by the state government which differs with each constituency according to its demography and urbanization state. Domestic supply is estimated in litres for a day district-wise for Kerala, Karnataka and Tamil Nadu.
4. Comparison of domestic supply and usage demand by plotting a graph representing all the districts for Kerala, Karnataka and Tamil Nadu.

D. Procedure for Irrigation Project Efficiency Analysis

1. Comparison of Culturable Command Area and Potential Area created for each irrigation project of Tamil Nadu and Karnataka coming under Cauvery basin.
2. Graph is plotted for major irrigation projects by comparing both the parameters for each state

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E. Procedure for Ground Water Usage Analysis for Tamil Nadu

1. Net Usable Availability and Current Usage values are obtained from Annual Dynamic Ground Water Resources Chronicle released by Ministry of Water Resources.
2. Graph is plotted comprising districts of Tamil Nadu coming under Cauvery Basin.
3. Each district is evaluated and categorized into 4 categories based on the level of exploitation - Safe, Semi-critical, Critical and Over - Exploited.

F. Procedure for Coleroon Discharge Analysis

1. Collection of discharge readings from Upper Anicut at periodic time instances from daily newspaper, "The Hindu".
2. Determination of time intervals according to the availability of data.
3. Estimation of average discharge for each interval using Trapezoidal Method.
4. Calculation of volume of water released into the Coleroon by multiplying average discharge by respective time interval.
5. In the same fashion, discharge analysis of Mettur dam is also carried out.

V. CALCULATIONS AND OBSERVATIONS

A. Annual Agricultural Water Need Analysis

A.1 Calculation of Effective Rainfall district-wise - The monthly effective rainfall was calculated for each district by using its mean monthly rainfall.

TABLE II. DISTRICT-WISE MONTHLY EFFECTIVE RAINFALL IN MM OF TAMIL NADU (JAN-JUN)

DISTRICT	JAN	FEB	MAR	APR	MAY	JUN
Thanjavur	8.83	1.04	1.53	8.28	19.75	15.18
Nagapattinam	7.19	1.9	3.06	4.16	14.4	20.03
Tiruchirapalli	0	0	2.92	8.5	30.48	8.88
Cuddalore	4.31	0	2.79	0.99	10.56	14.61
Erode	0	1.04	0.83	18.18	41.2	6.27
Salem	0	0	2.16	20.15	63.26	33.58
Namakkal	0	0	0	15.91	45.97	11.7
Dharmapuri	0.63	0	0	10.56	58.68	22.93
Tiruppur	0.71	0	0	10.56	56.54	21.83
Dindigul	2.37	0.83	0.63	20.6	20.6	5.8
Coimbatore	0	0	1.04	7.24	25.47	6.08
Theni	1.79	3.74	16.65	44.38	30.87	9.39
Pudukottai	53.91	79.33	112.69	69.01	73.77	41.2
Villupuram	3.02	0	0	1.79	13.1	16.65
The Nilgris	4.51	3.02	11.17	62.65	1.79	139.71

TABLE III. DISTRICT-WISE MONTHLY EFFECTIVE RAINFALL IN MM OF TAMIL NADU (JUL-DEC)

DISTRICT	JUL	AUG	SEPT	OCT	NOV	DEC
Thanjavur	19.75	59.47	76.16	107.14	121	67.42
Nagapattinam	26.19	39.38	52.72	174.03	309	202.7
Tiruchirapalli	3.88	49.38	29.37	90.61	84.6	29.92
Cuddalore	27.69	55.42	63.6	213.51	265	80.53
Erode	20.6	39.61	37.23	111.9	46	15.18
Salem	61.86	87.75	116.3	123.42	63.6	9.97
Namakkal	22.93	53.12	54.71	122.23	46.8	13.1
Dharmapuri	31.67	57.88	92.84	126.99	57.9	11.17
Tiruppur	30.54	56.47	91.46	127.18	53.44	14.96
Dindigul	8.83	26.9	43.58	119.05	71.4	29.29
Coimbatore	4.35	12.05	12.77	84.82	49.3	3.51
Theni	19.75	17.41	41.2	137.32	93.6	26.11
Pudukottai	17.41	21.45	14.47	1.28	0.83	4.12
Villupuram	39.61	94.43	83.31	152.42	148	63.45
The Nilgris	269.2	185.8	114.3	176.25	105	30.7

TABLE IV. DISTRICT-WISE MONTHLY EFFECTIVE RAINFALL IN MM OF KARNATAKA (JAN-JUN)

DISTRICT	JAN	FEB	MAR	APR	MAY	JUN
Mysore	0	0	0	18.18	76.95	11.8
Chamrajanagar	0	0	0	19.75	93.63	8.28
Mandya	0	0	0	16.65	80.13	20.61
Bengaluru	0	0	0	10.56	52.32	30.08
Tumkur	0	0	0	8.28	32.46	17.37
Hassan	0	0	0	22.14	53.12	42.79
Chikmagalur	0	0	1.64	24.52	65.03	76.95
Kodagu	0	0	1.79	59.47	121.4	326.4

TABLE V. DISTRICT-WISE MONTHLY EFFECTIVE RAINFALL IN MM OF KARNATAKA (JUL-DEC)

DISTRICT	JUL	AUG	SEPT	OCT	NOV	DEC
Mysore	20.55	11.8	38.03	95.22	15.9	0.63
Chamrajanagar	13.1	16.65	37.23	112.69	27.7	2.08
Mandya	15.18	22.93	79.33	115.88	20.6	1.79
Bengaluru	53.91	68.21	120.6	95.22	20.6	1.79
Tumkur	34.05	46.76	78.54	87.28	7.76	0
Hassan	108.7	50.74	43.59	96.81	21.4	0
Chikmagalur	155.6	80.92	58.68	98.39	22.9	0.83
Kodagu	741.9	403.5	147.7	152.42	34.9	1.28

TABLE VI. DISTRICT-WISE MONTHLY EFFECTIVE RAINFALL IN MM OF KERALA (JAN-DEC)

DISTRICT	JAN	FEB	MAR	APR	MAY	JUN
Wayanadu	20.55	11.8	38.03	95.22	15.9	0.63

JUL	AUG	SEPT	OCT	NOV	DEC
20.55	11.8	38.03	95.22	15.9	0.63

A.2 Calculation of Potential Evapotranspiration crop-wise

TABLE VII. DISTRICT-WISE MONTHLY POTENTIAL EVAPOTRANSPIRATION IN MM OF TAMIL NADU (JAN-JUN)

CROP	JAN	FEB	MAR	APR	MAY	JUN
Thanjavur						
Paddy	59.97	81.83	72.69	80.77	88.45	87.34
Sugarcane	122.66	125.46	148.67	165.22	180.93	178.64
Nagapattinam						
Paddy	62.13	61.35	72.69	78.52	86.11	87.33
Pudukottai						
Paddy	62.27	63.5	74.93	83.62	85.95	84.84
Trichy						
Banana	113.95	112.32	136.81	147.18	156.81	154.83
Cuddalore						
Paddy	64.29	61.35	72.69	78.52	86.1	87.32
Sugarcane	131.51	125.49	148.67	157.86	169.83	178.61
Erode						
Ragi	72.82	74.08	87.7	91.79	98.12	94.17
Sugarcane	131.02	133.35	157.86	165.22	176.62	169.51
Banana	113.59	115.57	136.81	143.19	153.07	146.91
Salem						
Ragi	72.68	73.95	87.7	91.79	95.61	94.31
Dharmapuri						
Ragi	67.63	66.92	82.6	89.23	93.15	89.16
Sugarcane	121.73	120.46	148.67	160.61	167.67	160.49
The Nilgris						
Coffee	63.24	68.79	81.08	87.56	95.62	88.99
Pepper	26.22	28.52	31.88	36.3	39.65	36.9
Namakkal						
Sugarcane	126.76	129.3	153.27	165.22	171.73	169.41
Groundnut	36.62	37.35	44.28	47.73	49.61	48.94
Dindigul						
Jower	42.46	41.92	49.56	53.54	55.42	56.25
Kovai						
Jower	42.3	43.15	51.09	53.54	54	53.23
Coconut	70.33	69.6	35.9	92.8	96.88	92.73

TABLE VIII. DISTRICT-WISE MONTHLY POTENTIAL EVAPOTRANSPIRATION IN MM OF TAMIL NADU (JUL-DEC)

CROP	JUL	AUG	SEP	OCT	NOV	DEC
Thanjavur						
Paddy	85.41	79.12	76.27	72.39	60.12	93.78
Sugarcane	174.71	161.83	156	148.06	105.83	122.66
Nagapattinam						
Paddy	90.24	83.78	78.52	96.44	64.3	64.29
Pudukottai						
Paddy	90.08	81.29	78.52	72.54	62.35	62.27
Trichy						
Banana	159.99	148.53	143.19	132.29	113.97	113.95
Cuddalore						
Paddy	87.81	81.43	78.52	74.64	64.31	64.29
Sugarcane	179.62	166.57	160.61	152.67	131.53	131.51
Erode						
Ragi	91.81	90.15	84.11	82.02	70.47	70.37
Sugarcane	165.25	162.27	151.39	147.63	126.84	126.67
Banana	143.22	140.63	131.21	127.95	109.93	109.78
Salem						
Ragi	94.7	87.63	84.11	79.34	70.34	70.24
Dharmapuri						
Ragi	89.38	85.16	81.55	76.63	67.8	65.19
Sugarcane	160.88	153.28	146.79	137.93	122.05	117.34
The Nilgris						
Coffee	87.44	82.53	79.16	80.32	68.96	67.25
Pepper	36.26	34.22	32.82	33.3	28.59	27.88
Namakkal						
Sugarcane	170.11	162.17	151.39	143.16	126.93	109.07
Groundnut	49.14	46.85	43.74	41.36	36.67	36.62
Dindigul						
Jower	56.48	53.83	50.46	47.93	42.51	42.46
Kovai						
Jower	53.35	50.82	48.93	47.77	42.36	42.3
Coconut	92.95	88.56	84.81	79.69	70.52	67.8

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

TABLE IX. DISTRICT-WISE MONTHLY POTENTIAL EVAPOTRANSPIRATION IN MM OF KERALA AND KARNATAKA (JAN-JUN)

CROP	JAN	FEB	MAR	APR	MAY	JUN
Wayanadu						
Coffee	103	102.5	122.9	125.3	130.6	124.07
Pepper	42.8	42.5	50.96	51.97	54.17	51.44
Hassan						
Ragi	60	62.04	74.94	78.99	82.86	76.15
Jower	36	37.22	44.97	47.39	49.72	45.69
Coffee	98.4	101.8	122.9	129.5	135.9	124.88
Coconut	62.4	64.53	80.6	64.81	88.94	81.96
Chikmagalur						
Coffee	98.2	97.84	118.7	125.3	127.3	120.67
Groundnut	31.1	31.02	37.64	39.74	40.37	38.26
Pepper	32.5	40.57	49.23	51.97	52.79	50.03
Kodagu						
Coffee	94.8	94.64	114.5	117	117.9	111.32
Pepper	39.3	39.24	47.49	48.49	48.9	46.16
Mysore						
Banana	97.8	104.3	124.9	131.2	133	122.54
Cotton	57.7	61.51	73.64	77.38	78.42	72.27
Bangalore						
Cotton	55.2	57.09	71.3	75.02	78.68	72.51
Mandya						
Paddy	57.2	58.76	70.44	74.02	77.44	71.56
Jower	39	40.06	48.03	50.46	52.8	48.79
Ragi	65	66.77	30.05	84.11	88	81.31
Chamrajanagar						
Ragi	62.8	64.66	80.05	84.11	85.13	81.13
Sugarcane	113	155.6	144.1	151.4	153.2	146.03
Groundnut	32.6	33.62	41.62	43.74	44.27	42.19
Banana	97.9	100.9	124.9	131.2	132.8	126.56
Tumkur						
Ragi	62.3	64.2	80.05	84.11	88.35	81.63
Jower	37.4	38.52	48.03	50.46	53.01	48.98
Groundnut	32.4	33.38	41.62	43.74	45.94	42.45
Coconut	64.8	66.77	83.25	87.47	91.89	84.9

TABLE X. DISTRICT-WISE MONTHLY POTENTIAL EVAPOTRANSPIRATION IN MM OF KERALA AND KARNATAKA (JUL-DEC)

CROP	JUL	AUG	SEPT	OCT	NOV	DEC
Wayanadu						
Coffee	123.7	117.5	117	113.5	99.9	103
Pepper	51.29	48.74	48.5	41.4	42.8	42.8
Hassan						
Ragi	75.92	72.17	68.8	68.69	60.4	60
Jower	45.55	43.3	41.3	41.21	36.2	36
Coffee	124.5	118.4	113	112.7	99.1	98.4
Coconut	81.82	71.82	74.2	71.45	62.8	62.4
Chikmagalur						
Coffee	115.6	114.2	109	108.3	95	94.2
Groundnut	36.65	36.2	34.4	34.35	30.3	29.9
Pepper	47.93	47.33	45	44.91	39.4	39.1
Kodagu						
Coffee	106.9	104.8	104	104.8	91.7	90.8
Pepper	45.82	43.46	43.3	43.44	38	37.7
Mysore						
Banana	122.3	120.5	115	11.52	98.3	97.8
Cotton	72.14	71.06	68	65.77	58	57.7
Bangalore						
Cotton	72.38	68.84	65.6	63.21	55.6	55.2
Mandya						
Paddy	71.51	68.04	67.3	65.06	55.4	55.1
Jower	48.76	46.39	44.3	44.36	37.8	37.6
Ragi	81.26	77.32	76.4	73.93	62.8	62.6
Chamrajanagar						
Ragi	81.08	77.14	73.9	71.59	63.1	62.8
Sugarcane	145.9	138.9	133	128.9	114	113
Groundnut	42.16	40.11	38.4	37.22	32.8	32.6
Banana	126.5	120.3	115	111.7	98.5	97.9
Tumkur						
Ragi	81.58	77.65	73.9	71.08	62.6	59.9
Jower	48.95	46.59	44.3	42.65	37.6	35.9
Groundnut	42.42	40.38	38.4	36.96	32.6	31.1
Coconut	84.85	80.75	76.8	73.92	65.1	62.3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

A.3 Calculation of Consumptive Use of each crop

TABLE XI. DISTRICT-WISE MONTHLY CONSUMPTIVE USE IN MM OF TAMIL NADU (JAN-JUN)

CROP	JAN	FEB	MAR	APR	MAY	JUN
Thanjavur						
Paddy	59.97	81.83	72.69	80.77	88.45	87.34
Sugarcane	122.7	125.46	148.67	165.22	180.93	178.64
Nagapattinam						
Paddy	62.13	61.35	72.69	78.52	86.11	87.33
Pudukottai						
Paddy	62.27	63.5	74.93	83.62	85.95	84.84
Trichy						
Banana	114	112.32	136.81	147.18	156.81	154.83
Cuddalore						
Paddy	64.29	61.35	72.69	78.52	86.1	87.32
Sugarcane	131.5	125.49	148.67	157.86	169.83	178.61
Erode						
Ragi	72.82	74.08	87.7	91.79	98.12	94.17
Sugarcane	131	133.35	157.86	165.22	176.62	169.51
Banana	113.6	115.57	136.81	143.19	153.07	146.91
Salem						
Ragi	72.68	73.95	87.7	91.79	95.61	94.31
Dharmapuri						
Ragi	67.63	66.92	82.6	89.23	93.15	89.16
Sugarcane	121.7	120.46	148.67	160.61	167.67	160.49
The Nilgris						
Coffee	63.24	68.79	81.08	87.56	95.62	88.99
Pepper	26.22	28.52	31.88	36.3	39.65	36.9
Namakkal						
Sugarcane	126.8	129.3	153.27	165.22	171.73	169.41
Groundnut	36.62	37.35	44.28	47.73	49.61	48.94
Dindigul						
Jower	42.46	41.92	49.56	53.54	55.42	56.25
Kovai						
Jower	42.3	43.15	51.09	53.54	54	53.23
Coconut	70.33	69.6	35.9	92.8	96.88	92.73

TABLE XII. DISTRICT-WISE MONTHLY CONSUMPTIVE USE IN MM OF TAMIL NADU (JUL-DEC)

CROP	JUL	AUG	SEPT	OCT	NOV	DEC
Thanjavur						
Paddy	85.41	79.12	76.27	72.39	60.12	93.78
Sugarcane	174.71	161.83	156	148.06	105.8	122.7
Nagapattinam						
Paddy	90.24	83.78	78.52	96.44	64.3	64.29
Pudukottai						
Paddy	90.08	81.29	78.52	72.54	62.35	62.27
Trichy						
Banana	159.99	148.53	143.2	132.29	114	114
Cuddalore						
Paddy	87.81	81.43	78.52	74.64	64.31	64.29
Sugarcane	179.62	166.57	160.6	152.67	131.5	131.5
Erode						
Ragi	91.81	90.15	84.11	82.02	70.47	70.37
Sugarcane	165.25	162.27	151.4	147.63	126.8	126.7
Banana	143.22	140.63	131.2	127.95	109.9	109.8
Salem						
Ragi	94.7	87.63	84.11	79.34	70.34	70.24
Dharmapuri						
Ragi	89.38	85.16	81.55	76.63	67.8	65.19
Sugarcane	160.88	153.28	146.8	137.93	122.1	117.3
The Nilgris						
Coffee	87.44	82.53	79.16	80.32	68.96	67.25
Pepper	36.26	34.22	32.82	33.3	28.59	27.88
Namakkal						
Sugarcane	170.11	162.17	151.4	143.16	126.9	109.1
Groundnut	49.14	46.85	43.74	41.36	36.67	36.62
Dindigul						
Jower	53.83	50.46	47.93	42.51	42.46	53.83
Kovai						
Jower	53.35	50.82	48.93	47.77	42.36	42.3
Coconut	92.95	88.56	84.81	79.69	70.52	67.8

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

TABLE XIII. DISTRICT-WISE MONTHLY CONSUMPTIVE USE IN MM OF KERALA AND KARNATAKA (JAN-JUN)

CROP	JAN	FEB	MAR	APR	MAY	JUN
Wayanadu						
Coffee	103.2	102.5	122.91	125.34	130.64	124.07
Pepper	42.78	42.5	50.96	51.97	54.17	51.44
Hassan						
Ragi	59.99	62.04	74.94	78.99	82.86	76.15
Jower	35.99	37.22	44.97	47.39	49.72	45.69
Coffee	98.38	101.75	122.91	129.54	135.89	124.88
Coconut	62.4	64.53	80.6	64.81	88.94	81.96
Chikmagalur						
Coffee	98.2	97.84	118.73	125.34	127.32	120.67
Groundnut	31.14	31.02	37.64	39.74	40.37	38.26
Pepper	32.52	40.57	49.23	51.97	52.79	50.03
Kodagu						
Coffee	94.79	94.64	114.54	116.95	117.94	111.32
Pepper	39.3	39.24	47.49	48.49	48.9	46.16
Mysore						
Banana	97.79	104.3	124.87	131.21	132.97	122.54
Cotton	57.67	61.51	73.64	77.38	78.42	72.27
Bangalore						
Cotton	55.2	57.09	71.3	75.02	78.68	72.51
Mandya						
Paddy	57.23	58.76	70.44	74.02	77.44	71.56
Jower	39.02	40.06	48.03	50.46	52.8	48.79
Ragi	65.03	66.77	30.05	84.11	88	81.31
Chamrajanagar						
Ragi	62.78	64.66	80.05	84.11	85.13	81.13
Sugarcane	113	155.56	144.08	151.39	153.24	146.03
Groundnut	32.64	33.62	41.62	43.74	44.27	42.19
Banana	97.93	100.87	124.87	131.21	132.81	126.56
Tumkur						
Ragi	62.29	64.2	80.05	84.11	88.35	81.63
Jower	37.38	38.52	48.03	50.46	53.01	48.98
Groundnut	32.39	33.38	41.62	43.74	45.94	42.45
Coconut	64.78	66.77	83.25	87.47	91.889	84.9

TABLE XIV. DISTRICT-WISE MONTHLY CONSUMPTIVE USE IN MM OF KERALA AND KARNATAKA (JUL-DEC)

CROP	JUL	AUG	SEPT	OCT	NOV	DEC
Wayanadu						
Coffee	123.69	117.54	117	113.48	99.85	103.2
Pepper	51.29	48.74	48.49	41.4	42.78	42.82
Hassan						
Ragi	75.92	72.17	68.75	68.69	60.4	59.99
Jower	45.55	43.3	41.25	41.21	36.24	35.99
Coffee	124.5	118.35	112.8	112.65	99.06	98.38
Coconut	81.82	71.82	74.16	71.45	62.83	62.4
Chikmagalur						
Coffee	115.6	114.15	108.6	108.32	95.03	94.22
Groundnut	36.65	36.2	34.42	34.35	30.31	29.87
Pepper	47.93	47.33	45.01	44.91	39.4	39.07
Kodagu						
Coffee	106.94	104.82	104.4	104.78	91.73	90.8
Pepper	45.82	43.46	43.27	43.44	38.04	37.65
Mysore						
Banana	122.32	120.49	115.2	11.52	98.31	97.79
Cotton	72.14	71.06	67.96	65.77	57.98	57.67
Bangalore						
Cotton	72.38	68.84	65.6	63.21	55.58	55.2
Mandya						
Paddy	71.51	68.04	67.26	65.06	55.38	55.09
Jower	48.76	46.39	44.32	44.36	37.76	37.56
Ragi	81.26	77.32	76.43	73.93	62.83	62.6
Chamrajanagar						
Ragi	81.08	77.14	73.87	71.59	63.11	62.78
Sugarcane	145.94	138.85	133	128.85	113.6	113
Groundnut	42.16	40.11	38.41	37.22	32.82	32.64
Banana	126.48	120.34	115.2	111.67	98.45	97.93
Tumkur						
Ragi	81.58	77.65	73.87	71.08	62.63	59.87
Jower	48.95	46.59	44.32	42.65	37.58	35.92
Groundnut	42.42	40.38	38.41	36.96	32.57	31.13
Coconut	84.85	80.75	76.82	73.92	65.13	62.26

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

TABLE XV. CROP-WISE KC VALUES AND GROWTH PERIOD

CROP	Kc VALUE	GROWTH PERIOD
Banana	0.9-1.05	300-365
Coffee	0.95-1.10	150-180
Cotton	0.5-0.65	180-195
Coconut	0.6-0.7	280-300
Rice	0.45-0.65	90-150
Jowar	0.3-0.45	120-130
Sugarcane	1.05-1.2	275-365
Ragi	0.3-0.45	125-180
Groundnut	0.25-0.45	130-140
Pepper	0.3-0.55	120-210

For each crop, monthly consumptive use differs district-wise according to the potential evapotranspiration rate value. Monthly Consumptive value is found out for a crop for a particular district for a whole year keeping in account of the crop pattern, sowing and harvest season and by multiplying per day consumption rate with the total number of cultivated days.

A.4 Calculation of Net Irrigation Requirement for each district - Effective Rainfall of a particular month of that specific district is subtracted from the Monthly Consumptive value of a crop of respective destined bounds. This value is multiplied with area sown in hectares for that specific district.

TABLE XVI. DISTRICT-WISE NET IRRIGATION REQUIREMENT IN METER CUBIC OF TAMIL NADU

CROP	ANNUAL NIR IN m	AREA SOWN IN HECTARES	ANNUAL NIR IN MC
Thanjavur			
Paddy	11.25	177426	1994.81
Sugarcane	22.02	7690	1693.57
Nagapattinam			
Paddy	10.04	163794	1644.66
Pudukottai			
Paddy	27.31	73625	2010.53

TABLE XVI. DISTRICT-WISE NET IRRIGATION REQUIREMENT IN METER CUBIC OF TAMIL NADU (contd.)

CROP	ANNUAL NIR IN m	AREA SOWN IN HECTARES	ANNUAL NIR IN MC
Trichy			
Banana	21.22	7360	1561.48
Cuddalore			
Paddy	12.55	139987	1757.13
Sugarcane	59.79	24443	1461.45
Erode			
Ragi	5.29	5326	281.99
The Nilgris			
Coffee	1.546	7600	117.53
Pepper	12.86	5410	696.02
Namakkal			
Sugarcane	12.71	14268	1814.1
Groundnut	2.02	31428	633.72
Dindigul			
Jowar	0.24	25400	614.1
Coimbatore			
Jowar	1.54	34400	528.77
Coconut	0.66	82704	544.68
Salem			
Ragi	0.436	8202	35.76
Dharmapuri			
Ragi	0.712	20895	148.77
Sugarcane	21.84	7905	172.64

TABLE XVII. DISTRICT-WISE NET IRRIGATION REQUIREMENT IN METER CUBIC OF KARNATAKA

CROP	ANNUAL NIR IN m	AREA SOWN IN HECTARES	ANNUAL NIR IN MC
Mandya			
Paddy	2.36	90200	2126.93
Jowar	3.17	1974	626.92
Ragi	0.289	85300	246.93
Chamrajanagar			
Ragi	0.16	17900	288.34
Sugarcane	0.65	28900	1886.9
Groundnut	0.34	20100	692.56
Banana	0.12	12810	1568.22
Tumkur			
Ragi	0.02	192100	308.46
Jowar	2.29	3000	687.24
Groundnut	0.76	93300	705.72
Coconut	0.66	122500	813.2
Mysore			
Banana	0.21	7820	1600.9
Cotton	0.29	3097	910.83
Hassan			
Ragi	0.34	53920	180.64
Jowar	0.09	6100	555.7
Coffee	0.02	36025	780.92
Coconut	0.01	62575	686.44
Bangalore			
Cotton	0.12	5481	683.36
Chikmagalur			
Coffee	0.07	88853	635.12
Groundnut	0.84	5200	438.8
Pepper	0.96	3500	335.4
Kodagu			
Coffee	0.02	101229	209.4
Pepper	0.17	8880	150.6

A.5 Calculation of Irrigation Supply for each district - Area Irrigated for each crop is multiplied with Annual NIR obtained to get the extent of supply for each district state-wise.

TABLE XVIII. DISTRICT-WISE IRRIGATION SUPPLY IN METER CUBIC OF TAMIL NADU

CROP	ANNUAL NIR IN m	AREA IRRIGATED IN HECTARES	ANNUAL SUPPLY IN MC
Thanjavur			
Paddy	11.25	136370	1533.21
Sugarcane	22.02	5911	1301.68
Nagapattinam			
Paddy	10.04	83879	842.23
Pudukottai			
Paddy	27.31	53768	1468.29
Trichy			
Banana	21.22	4078	865.22
Cuddalore			
Paddy	12.55	82550	1036.18
Sugarcane	59.79	14414	861.81
Erode			
Ragi	5.29	3484	184.48
Sugarcane	83.86	14610	1225.23
Banana	14.42	7026	1012.83
Salem			
Ragi	0.436	3964	18.36
Dharmapuri			
Ragi	0.712	9453	67.30
Sugarcane	21.84	3576	781.11
The Nilgris			
Coffee	1.546	3952	61.12

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 10 Issue 04, April-2021

Pepper	12.86	2813	361.93
Namakkal			
Sugarcane	12.71	6608	840.11
Groundnut	2.02	14554	293.48
Dindigul			
Jowar	0.24	11687	282.55
Coimbatore			
Jowar	1.54	20791	319.59
Coconut	0.66	49986	329.21
Erode			
Ragi	5.29	3484	184.48
Sugarcane	83.86	14610	1225.23
Banana	14.42	7026	1012.83
Salem			
Ragi	0.436	3964	18.36
Dharmapuri			
Ragi	0.712	9453	67.30
Sugarcane	21.84	3576	781.11
The Nilgris			
Coffee	1.546	3952	61.12
Pepper	12.86	2813	361.93
Namakkal			
Sugarcane	12.71	6608	840.11
Groundnut	2.02	14554	293.48
Dindigul			
Jowar	0.24	11687	282.55
Coimbatore			
Jowar	1.54	20791	319.59
Coconut	0.66	49986	329.21

TABLE XIX. DISTRICT-WISE IRRIGATION SUPPLY IN METER CUBIC OF KARNATAKA

CROP	ANNUAL NIR IN M	AREA IRRIGATED IN HECTARES	ANNUAL SUPPLY IN MC
Mandya			
Paddy	2.36	54770	1291.47
Jowar	3.17	1198	380.66
Ragi	0.289	51794	149.94
Chamrajanagar			
Ragi	0.16	116110	259.51
Sugarcane	0.65	26010	1698.21
Groundnut	0.34	18090	623.31
Banana	0.12	11529	1411.39
Tumkur			
Ragi	0.02	164802	264.63
Jowar	2.29	2574	589.58
Groundnut	0.76	80042	605.44
Coconut	0.66	105093	697.64
Mysore			
Banana	0.21	5223	1069.24
Cotton	0.29	2068	608.34
Hassan			
Ragi	0.34	50685	169.8
Jowar	0.09	5390	522.36
Coffee	0.02	33863	734.06
Coconut	0.01	58821	645.25
Bangalore			
Cotton	0.12	4220	526.19
Chikmagalur			
Coffee	0.07	49758	355.67
Groundnut	0.84	2912	245.73
Pepper	0.96	1960	187.82
Kodagu			
Coffee	0.02	10186	207.24
Pepper	0.17	8788	149.05

B. Daily Domestic Usage Analysis

B.1 Population Forecasting - Tamil Nadu

TABLE XX. GEOMETRIC MEAN METHOD- TAMIL NADU

DISTRICT	1991	2001	2011	R1 IN %	R2 IN %	R	2017
Ariyalur	636400	695524	754894	9.29	8.54	0.13	810676
Coimbatore	2493700	2916620	3458045	16.96	18.56	0.25	3956188
Cuddalore	2122759	2285395	2605914	7.66	14.02	0.16	2848341
Dharmapuri	1123600	1295182	1506843	15.27	16.34	0.22	1700848
Dindigul	1760601	1923014	2159775	9.22	12.31	0.15	2353407
Erode	1802900	2016582	2251744	11.85	11.66	0.17	2469442
Karur	854162	935686	1064493	9.54	13.77	0.17	1168152
Krishnagiri	1305100	1561118	1879809	19.62	20.41	0.28	2183100
Madurai	2400339	2578201	3038252	7.41	17.84	0.19	3377959
Nagapattinam	1377700	1488839	1616450	8.07	8.57	0.12	1728058
Namakkal	1322715	1493462	1726601	12.91	15.61	0.20	1928667

TABLE XX. GEOMETRIC MEAN METHOD- TAMIL NADU (contd.)

Pudukkottai	1327148	1459601	1618345	9.98	10.88	0.15	1757713
Salem	2573667	3016346	3482056	17.20	15.44	0.23	3944746
Sivaganga	1103100	1155356	1339101	4.74	15.90	0.17	1468317
Thanjavur	2053700	2216138	2405890	7.91	8.56	0.12	2570432
Theni	1049323	1093950	1245899	4.25	13.89	0.15	1351532
The Nilgiris	710214	762141	735394	7.31	-3.51	0.06	763343
Thiruvarur	1100100	1169474	1264277	6.31	8.11	0.10	1340657
Tiruchirappali	2196473	2418366	2722290	10.10	12.57	0.16	2977750
Tiruppur	1532000	1920154	2479052	25.34	29.11	0.39	3015253
Viluppuram	2755674	2960373	3458873	7.43	16.84	0.18	3827860

TABLE XXI. DOMESTIC DEMAND AND SUPPLY -TAMIL NADU

DISTRICT	DEMAND (LITRES PER DAY)	SUPPLY (LITRES PER DAY)
Ariyalur	109441196	6506817
Coimbatore	534085389	242779982
Cuddalore	384526097	50266185
Dharmapuri	229614543	19133044
Dindigul	317709907	39771784
Erode	333374625	83760719
Karur	157700509	20654074
Krishnagiri	294718562	24647940
Madurai	456024529	85028028
Nagapattinam	233287808	30795573
Namakkal	260370103	53347505
Pudukkottai	237291232	20983450
Salem	532540660	175929722
Sivaganga	198222739	30459047
Thanjavur	347008311	27080360
Theni	182456817	52028986
The Nilgiris	103051293	32411839
Thiruvarur	180988724	21962838
Tiruchirappali	401996267	13877807
Tiruppur	407059192	71097858
Viluppuram	516761120	35446169

B.2 Population Forecasting – Karnataka

TABLE XXII. GEOMETRIC MEAN METHOD- KARNATAKA

DISTRICT	1991	2001	2011	R1 IN %	R2 IN %	R	2017
Bangalore Urban	4839169	6537124	9621551	35.09	47.18	0.59	12698573
Bangalore Rural	717525	850968	990923	18.60	16.45	0.25	1131942
Chamarajanagar	883365	965462	1020791	9.29	5.73	0.11	1086274
Chikmangalur	1017283	1149007	1255104	12.95	9.23	0.16	1371318
Hassan	1569684	1721669	1776421	9.68	3.18	0.10	1882932
Mandya	1644374	1763705	1805769	7.26	2.38	0.08	1887311
Mysore	2281653	2641027	3001127	15.75	13.63	0.21	3361975
Ramanagara	955669	1030546	1082636	7.84	5.05	0.09	1142120
Tumkur	2305819	2584711	2678980	12.10	3.65	0.13	2877193

TABLE XXIII. DOMESTIC DEMAND AND SUPPLY - KARNATAKA

DISTRICT	DEMAND (LITRES PER DAY)	SUPPLY (LITRES PER DAY)
Bangalore Urban	2520666826	1739704560
Bangalore Rural	152812223	62256831
Chamarajanagar	146646973	59745063
Chikmangalur	185127951	68565908
Hassan	254195757	131805207
Mandya	254786987	217040767
Mysore	453866640	474038490
Ramanagara	154186204	62816601
Tumkur	388421067	189894744

B.3 Population Forecasting – Kerala

TABLE XXIV. GEOMETRIC MEAN METHOD- KERALA

DISTRICT	1991	2001	2011	R1 IN %	R2 IN %	R	2017
Idukki	10,55,100	11,29,221	11,08,974	7.03	-1.79	0.07	1153574
Wayanad	6,72,128	7,80,619	8,17,420	16.14	4.71	0.17	897318

TABLE XXV. DOMESTIC DEMAND AND SUPPLY – KERALA

DISTRICT	DEMAND (LITRES PER DAY)	SUPPLY (LITRES PER DAY)
Idukki	155732489	25904147
Wayanadu	121137869	24683325

C. Irrigation Project Efficiency Analysis

TABLE XXVI. EFFICIENCY OF IRRIGATION PROJECT- TAMIL NADU

PROJECT NAME	CULTURABLE COMMAND AREA (CCA) (TH HA)	POTENTIAL CREATED (PC) (TH HA)
Cauvery Delta	368	504.64
Cauvery Mettur	103.6	111.7
Kattalai	30.89	49.45
Lower Bhavani	83.77	68.02
Lower Coleroon Anicut	53.54	66
Mettur Canal	18.21	18.21
Parambikulam Aliyar	101.25	101.25

TABLE XXVII. EFFICIENCY OF IRRIGATION PROJECT- KARNATAKA

PROJECT NAME	CULTURABLE COMMAND AREA (CCA) (TH HA)	POTENTIAL CREATED (PC) (TH HA)
Cauvery Anicut	76.88	77.17
Harangi	54.82	54.59
Hemavathy	283.29	283.58
Kabini	87.89	44.51
Krishnarajasagar	79.31	79.31
Nugu	10.5	10.53

D. Ground Water Usage Analysis for Tamil Nadu

TABLE XXVIII. GROUND WATER USAGE ESTIMATION-TAMIL NADU

DISTRICT	NET GROUND WATER AVAILABILIY (IN MCM)	EXISTING GROSS GROUND WATER DRAFT FOR ALL USERS (IN MCM)	STAGE OF GROUND WATER DEVELOPMENT (IN %)	CATEGORIZATION OF DISTRICT
Ariyalur	314.97	161.52	51	Safe
Coimbatore	438.81	506.15	115	Over-Exploited
Cuddalore	1237.08	1066.76	86	Semi Critical
Dharmapuri	375.84	497.3	132	Over-Exploited
Dindigul	536.56	636.75	119	Over-Exploited
Erode	696.03	651.68	94	Critical
Karur	323.23	298.64	92	Critical
Krishnagiri	354.94	471.44	133	Over-Exploited
Madurai	658.68	380.27	58	Safe
Nagapattinam	159.16	162.88	102	Over-Exploited
Namakkal	491.73	439.84	89	Semi Critical
The Nilgiris	118.94	11.31	10	Safe
Perambalur	207.62	280.76	135	Over-Exploited
Pudukottai	1431.08	314.38	22	Safe
Salem	523.56	856.32	164	Over-Exploited
Thanjavur	789.05	819.33	104	Over-Exploited
Theni	357.18	307.78	86	Semi Critical
Thiruvarur	299.8	214.2	71	Semi Critical
Tiruchirapalli	725.6	571.15	79	Semi Critical
Villupuram	1498.28	1539.35	103	Over-Exploited

E. Coleroon Discharge Analysis

TABLE XXIX. DISCHARGE CALCULATION AT COLEROON

MONTH	TIME INTERVAL	Q(CUSECS)	Q AVERAGE	VOLUME (FT^3)	UNIT
	0	2000			
	24	2000	2,000	48,000	
JULY END	12	150	1,075	12,900	
	12	38793	19,472	2,33,658	
			TOTAL	0.29	Million Cubic Feet
	0	36000	41,000	-	
	15	107276	71,638	10,74,570	
	11	80000	93,638	10,30,018	
	12	71000	75,500	9,06,000	
AUGUST	12	46000	58,500	7,02,000	
	12	128000	87,000	10,44,000	
	24	135000	1,31,500	31,56,000	

TABLE XXIX DISCHARGE CALCULATION AT COLEROON (Contd.)

MONTH	TIME INTERVAL	Q(CUSECS)	Q AVERAGE	VOLUME (FT^3)	UNIT
	12	143000	1,39,000	16,68,000	
	12	160000	1,51,500	18,18,000	
	24	60000	1,10,000	26,40,000	
	24	110972	85,486	20,51,664	
			TOTAL	16	Million Cubic Feet

VI. RESULTS AND DISCUSSIONS

A. Irrigation Supply and Demand Graph

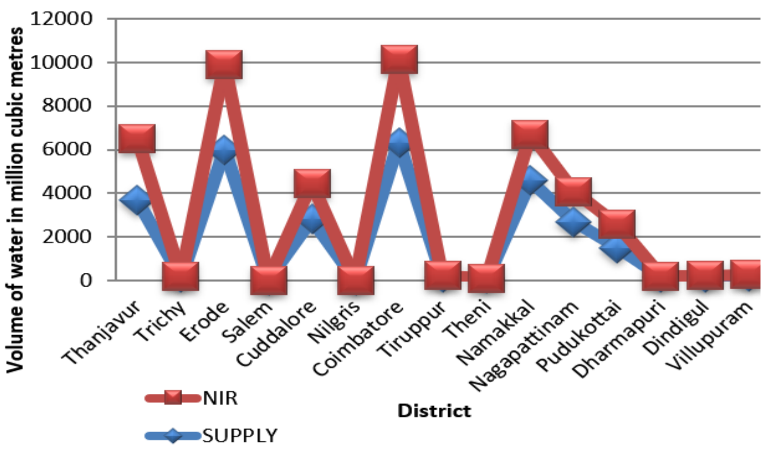
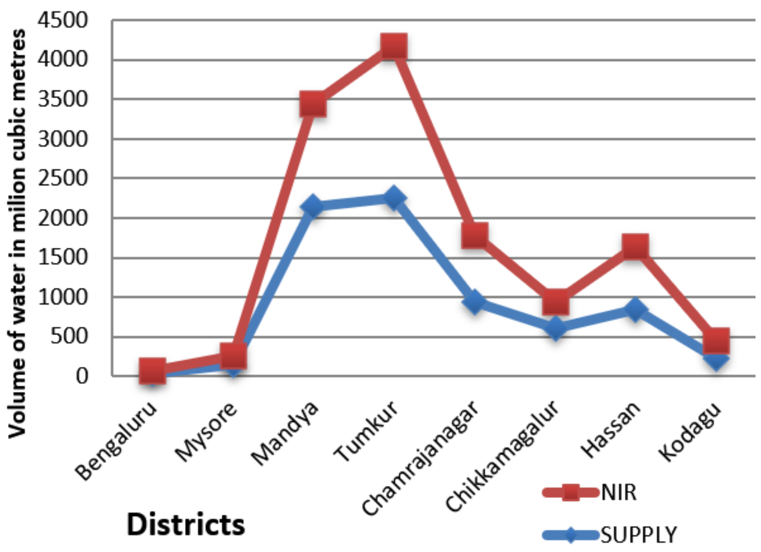


Fig 2 Graph between Irrigation Supply and Demand-Tamil Nadu



*F*ig 3 Graph between Irrigation Supply and Demand-Karnataka

Suggestions -

- From both the graphs and calculations, it is observed that Karnataka and Tamil Nadu are harvesting rice and sugarcane in large quantities. These water-intensive agricultural cropping patterns cannot be justified in this basin.
- At the policy level, what is grown in the basin area has never come under dispute. Apart from linking rivers and building canals and dams, modifying cropping patterns and supporting ground water management projects can be more focused on. This kind of approach is the key to fostering co-operation rather than competition.
- 23% of Karnataka's share of Cauvery water is utilized to irrigate paddy fields alone. Sugarcane also consumes around 3 Lakh Hectares. This type of irrigation is done for a region where the soil is porous sandy loam which has less water holding capacity, resulting in less effective flood irrigation.
- Before independence, farmers practiced rain-fed agriculture. After establishment of dams like Krishnarajasagar and Mettur dams, river flow was blocked to increase its irrigation potential. Farmers adapted to irrigation-fed practice which requires surface water utilization.
- Farmers in Karnataka can adopt less irrigated crops like Millets (ragi, jowar), Oilseeds (sesame, groundnut), Pulses (black gram), etc., which was predominant in the pre-independence era.
- Cauvery is a monsoon dependent perennial river. It is concluded from the study by Water Resources ministry that water yield in Cauvery is decreasing faster than the rate of declining rainfall in the basin. So, if water sharing conflict is the temporary issue, in the long run, drying up of Cauvery River is the major problem.
- For Tamil Nadu farmers, it is suitable to do inter-cropping using Banana, Sunflower, Cotton and Pulses as they require less water, maintain soil fertility and are indigenous to the region.
- Agriculture Model Intercomparison & Improvement Project (AgMIP) is implemented in Tamil Nadu. It suggested ways to cultivate paddy more climate and resource friendly. It also recommended direct sowing of rice seeds that does not require flooding.
- Using short-duration varieties crops which require less water as growth period is reduced.

B. Domestic Usage Supply and Demand Graph

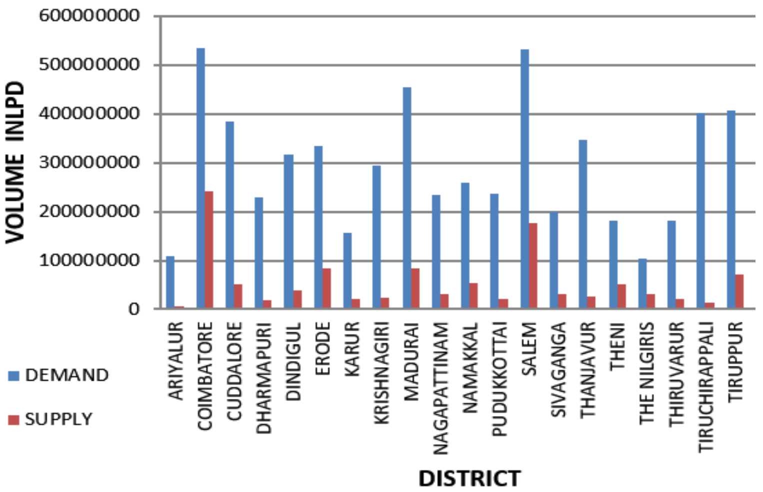


Fig 4 Graph between Domestic Supply and Demand- Tamil Nadu

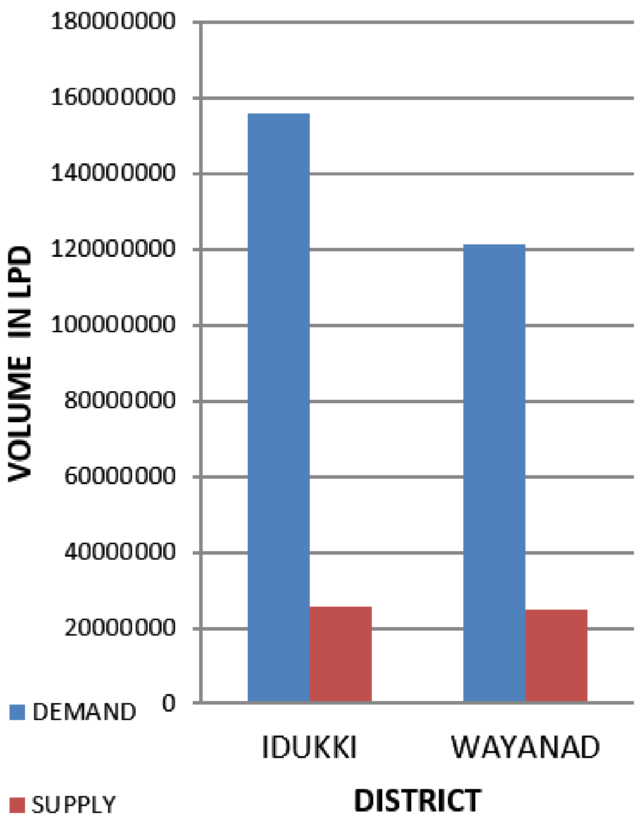


Fig 5 Graph between Domestic Supply and Demand- KL

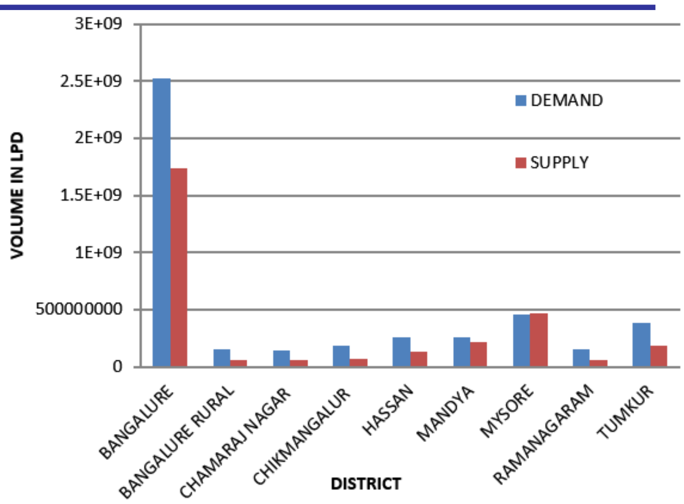


Fig 6 Graph between Domestic Supply and Demand-Karnataka

Observations and Suggestions –

- In all the three states, there is a considerable difference between demand and supply of water for domestic usage irrespective of rural or urban criteria. To eliminate this unpleasant gap, there are certain suggestions to minimize it.
- Rain water harvesting system must be established in each and every house as much as possible. Periodic inspection of proper installation and maintenance of these units must be carried out.
- Metered water supply and pump rating metres must be installed for both ground water and domestic supply to check whether the particular household is scrutinizing water supply.
- Control stations must be set up taluk-wise to check the quantity and quality of water supply with that of permissible values.
- Recycling of grey water will reduce the demand elaborately.

C. Irrigation Project Efficiency Graph

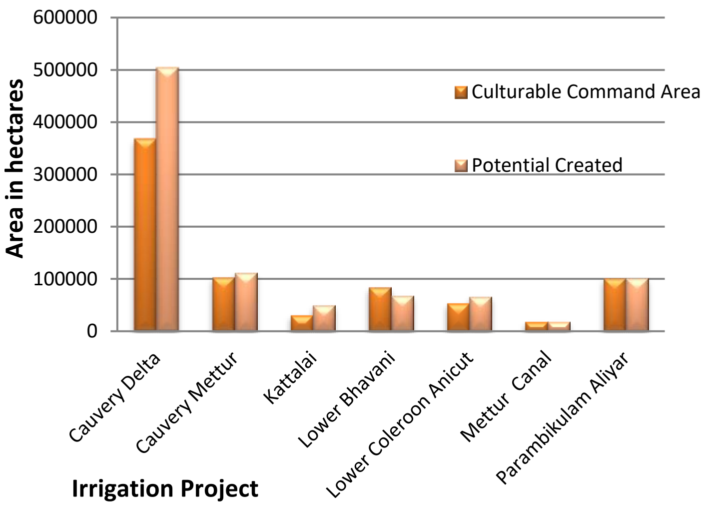


Fig.7 Graph between Irrigation Projects and their Efficiency-Tamil Nadu

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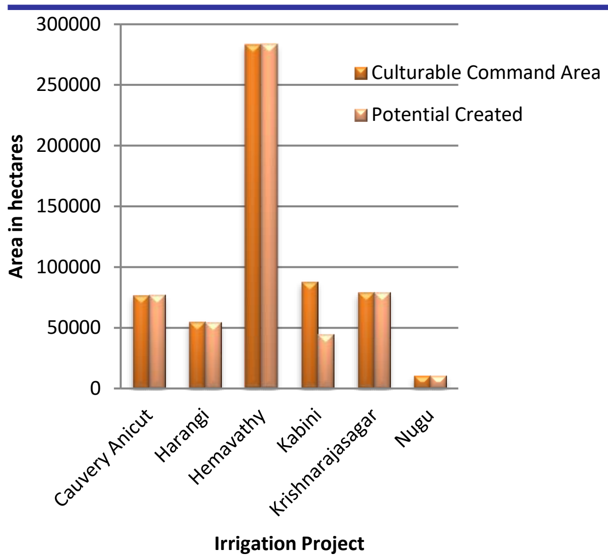

Fig. 8 Graph between Irrigation Projects and their Efficiency-Karnataka

D. Ground Water Usage Analysis

This report also does an extensive study about usage of ground water for agricultural and domestic purposes. For this procedure, fluctuation in ground water level of four different months to its corresponding decadal mean is taken for observation. The information is collected from the annual ground water report of Karnataka, Kerala and Tamil Nadu for the years 2014-2015, 2015-2016 and 2016-2017. The aim is to compare the change in ground water level in 2015 and change in ground water level 2016 for all three states.

D.1 Tamil Nadu

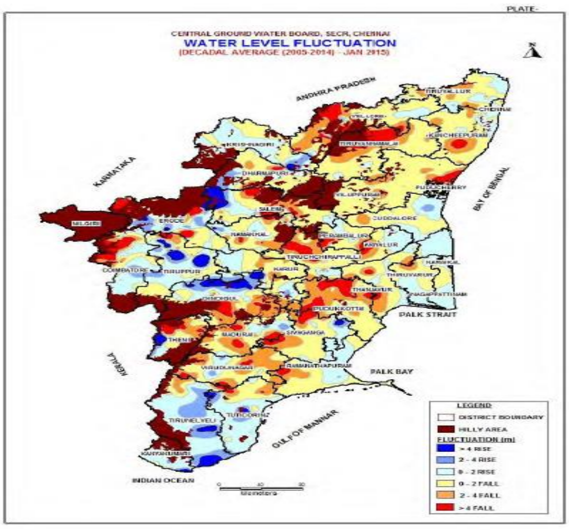

Fig. 9 Water level fluctuation - Decadal mean Jan 2015

Mean Water Levels for The Period January 2006-2015 & January 2016 - The water level data for January 2016 were compared with mean water level for the period January 2006-2015. Rise in the water level in the range of 0-2m has been observed in 49% of wells analyzed, spread all over the State and U.T. of Puducherry. Rise in the water level in the range of 2-4 m has been observed in 14% of wells analyzed and noted in Chennai, Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Theni, Trichy and Villupuram districts. Rise in water level more than 4 m has been observed in 11% of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dharmapuri (Undivided), Erode, Karur, Madurai, Namakkal, Perambalur (Undivided), Salem, Sivaganga, Theni, Trichy and Villupuram districts. The fall in water level in the range of 0-2m has been observed in 21% of wells analysed and noted in all the districts and U.T. of Puducherry. The fall in water level in the range of 2-4m has been observed in three percent of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dindigul, Erode, Madurai, Nilgiris, Pudukkottai, Salem, Sivaganga and Trichy districts. The fall in water level more than 4 m has been observed in two percent of wells analysed and noted in Coimbatore, Dindigul, Erode, Karur, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Theni and Villupuram.

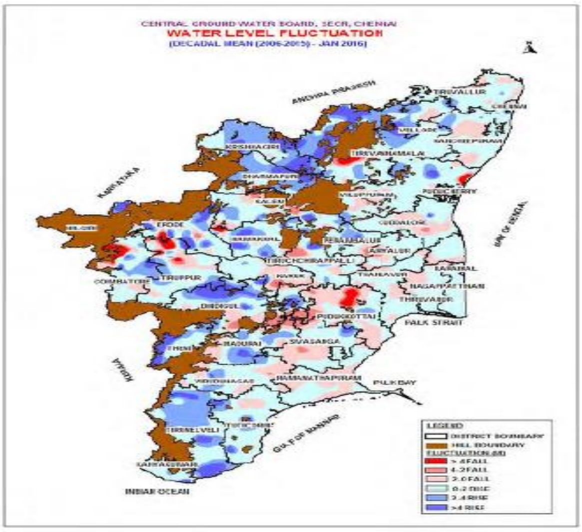

Fig 10 Water level fluctuation - Decadal mean Jan 2016

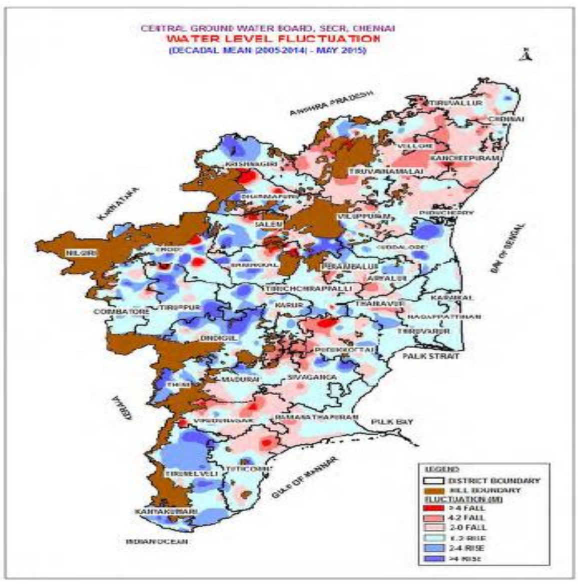

Fig 11: Water level fluctuation decadal mean –May 2015

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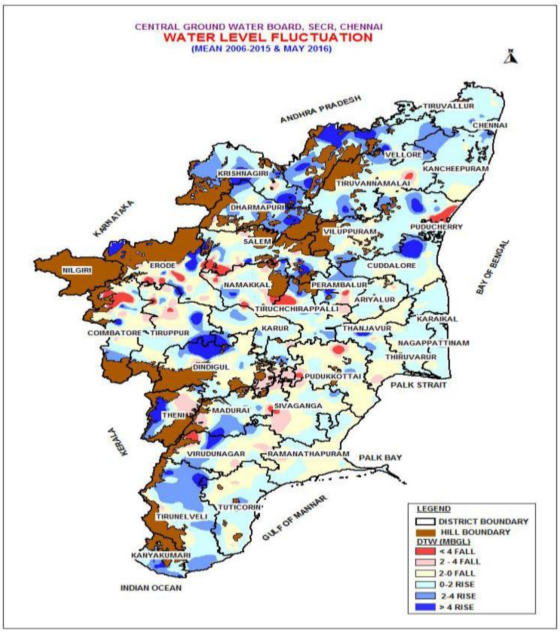

Fig 12 Water level fluctuation decadal mean –May 2016

Mean Water Levels for The Period May 2006-2015 & May 2016 - The water level data for May 2016 were compared with mean water level for the period May 2006-2015. Rise in the water level in the range of 0-2m has been observed in 42% of wells analysed, spread all over the State and U.T. of Puducherry. Rise in the water level in the range of 2-4 m has been observed in 14% of wells analysed and noted in Chennai, Cuddalore, Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Madurai, Nagapattinam, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Tiruvannamalai, Tiruchchirappalli and Tiruvarur districts. Rise in water level more than 4 m has been observed in eight percentage of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Kancheepuram, Kanyakumari, Namakkal, Perambalur (Undivided), Salem, Thanjavur, Theni and Tiruchirappalli districts. The fall in water level in the range of 0-2m has been observed in 25% of wells analysed and noted in all the districts. The fall in water level in the range of 2-4m has been observed in seven percentage of wells analysed and noted in Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Kancheepuram, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Theni and Tiruchirappalli districts. The fall in water level more than 4 m has been observed in four percentage of wells analysed and noted in Coimbatore, Dindigul, Erode, Madurai, Namakkal, Perambalur, Pudukkottai, Salem, Theni and Tiruchirappalli districts.

Mean Water Levels for the Period August 2006-2015 & August 2016 -The water level data for August 2016 were compared with mean water level for the period August 2006-2015. Rise in the water level in the range of 0-2m has been observed in 37% of wells analysed, noted all over the State and U.T. of Puducherry. Rise in the water level more than 2 m has been observed in 19% and of wells analysed and noted in all the districts except in Tiruvarur districts and U.T. of Puducherry. The fall in water level in the range of 0-2m has been observed in 31% of wells analysed and spread all over the State except and U.T. of Puducherry. The fall in water level in the range of 2-4m has been observed in 10% of wells analysed and noted in Coimbatore, Dharmapuri (Undivided), Dindigul, Erode (Undivided), Karur, Madurai, Nagapattinam, Namakkal, Nilgiris, Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Tiruvarur and Tiruchirappalli districts. The fall in water level more than 4 m has been observed in three percent of wells analysed and noted as isolated pockets in Coimbatore, Dharmapuri (Undivided), Erode (Undivided), Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Thanjavur, Tiruvarur, and Tiruchirappalli districts.

Mean Water Levels For the Period November 2006-2015 & November 2016 - The water level data for November 2016 were compared with mean water level for the period November 2006-2015. Rise in the water level in the range of 0-2m has been observed in nine percent of wells analysed, noted as isolated pockets in Chennai, Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Nagapattinam, Nilgiris, Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Tiruchirapalli, and Villupuram districts. Rise in the water level in the range of 2-4 m has been observed in two percent of wells analysed and noted in Dharmapuri (Undivided), Dindigul, Erode, Nagapattinam, Namakkal and Salem districts. Rise in water level more than 4 m has been observed in one percent of wells analysed and noted in Coimbatore, Erode, Namakkal, and Sivaganga districts. The fall in water level in the range of 0-2m has been observed in 41% of wells analysed and spread all over the State and U.T. of Puducherry. The fall in water level in the range of 2-4m has been observed in 26% of wells analysed and noted in Coimbatore, Dindigul, Erode, Karur, Madurai, Nagapattinam, Namakkal, Nilgiris, Perambalur (Undivided), Pudukottai, Ramanathapuram, Salem, Sivaganga, Thanjavur, Theni, Tiruvarur, Trichy, and Villupuram districts. Fall in water level more than 4 m has been observed in 21% of wells analysed and noted in Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Tiruvarur, Trichy, and Villupuram districts.

Mean Water Levels for the Period January 2005-2014 & January 2015 - The water level data for January 2015 were compared with mean water level for the period January 2005-2014. Rise in the water level in the range of 0-2 m has been observed in 33% of wells analysed, and noted in all the districts of Tamil Nadu and U.T. of Puducherry. Rise in the water level in the range of 2-4 m has been observed in seven percent of wells analysed and observed in Chennai, Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Madurai, Nagapattinam, Namakkal, Perambalur (Undivided), Salem and Trichy districts. Rise in the water level in the range of more than 4 m has been observed in five percent of wells analysed and noted in Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Kanyakumari, Madurai, Namakkal, Sivaganga and Theni districts. The fall in water level in the range of 0-2m has been observed in 34% of wells analysed and noted in all the districts and U.T. of Puducherry. The fall in water level in the range of 2-4m has been observed in 11% of wells analysed and noted in all districts except Kanyakumari, Nagapattinum, Nilgiris and U.T. of Puducherry. The fall in water level more than 4m has been observed in 10% of wells analysed and noted in Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Madurai, Namakkal, Perambalur, Pudukottai, Salem, Sivaganga, Thanjavur, Theni, Tiruvarur, Trichy and Villupuram districts.

Mean Water Levels for the Period May 2005-2014 & May 2015 - Rise in the water level in the range of 0-2m has been observed in 41% of wells analysed, spread all over the State and U.T. of Puducherry. Rise in the water level in the range of 2-4 m has been observed in 14% of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Trichy, Villupuram districts and Karaikal region of U.T. of Puducherry. Rise in water level more than 4 m has been observed in 10% of wells analysed and noted in Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Kanyakumari, Madurai, Namakkal, Perambalur (Undivided), Salem, Sivaganga, Theni and Trichy districts. The fall in water level in the range of 0-2m has been observed in 23% of wells analysed and noted in all the districts and U.T. of Puducherry except Karaikal region and Tiruvarur district. The fall in water level in the range of 2-4m has been observed in nine percentage of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Trichy and Villupuram districts. The fall in water level more than 4 m has been observed in three percentage of wells analysed and noted in Coimbatore, Dharmapuri (Undivided), Erode, Namakkal, Pudukkottai, Salem, Trichy and Villupuram districts.

Mean Water Levels for the Period August 2005-2014 & August 2015 - Rise in the water level in the range of 0-2m has been observed in 39% of wells analysed, noted all over the State and U.T. of Puducherry. Rise in the water level in the range of 2-4 m has been observed in 11% of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Tirunelveli, Trichy, and Villupuram districts. Rise in water level more than 4 m has been observed in eight percentage of wells analysed and noted in Coimbatore, Cuddalore, Dharmapuri (Undivided), Erode, Kanyakumari, Madurai, Namakkal, Perambalur (Undivided), Salem, Sivaganga, Theni and Trichy districts. The fall in water level in the range of 0-2m has been observed in 29% of wells analysed and spread all over the State and U.T. of Puducherry except Tiruvarur district. The fall in water level in the range of 2-4m has been observed in nine percentage of wells analysed and noted in Chennai, Coimbatore, Cuddalore, Dindigul, Erode, Kancheepuram, Karur, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Trichy and Villupuram districts. The fall in water level more than 4 m has been observed in four percentage of wells analysed and noted in Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Namakkal, Pudukkottai, Salem and Villupuram gar districts.

Mean Water Levels for the Period November 2005-2014 & November 2015 - Rise in the water level in the range of 0-2m has been observed in 33% of wells analysed, noted all over the State and U.T. of Puducherry. Rise in the water level in the range of 2-4 m has been observed in 16% of wells analysed and noted in Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Madurai, Nagapattinam, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Sivaganga, Thanjavur, Theni, Tiruvarur, Trichy and Villupuram districts and U.T. of Puducherry. Rise in water level more than 4 m has been observed in 10% of wells analysed and noted in Coimbatore, Cuddalore, Dharmapuri (Undivided), Dindigul, Erode, Madurai, Namakkal, Perambalur (Undivided), Pudukottai, Salem, Sivaganga, Thanjavur, Theni, and Trichy districts. The fall in water level in the range of 0-2m has been observed in 25% of wells analysed and spread all over the State except in Nagapattinam, districts and U.T. of Puducherry. The fall in water level in the range of 2-4m has been observed in 10% of wells analysed and noted in Chennai, Coimbatore, Dindigul, Erode, Karur, Namakkal, Nilgiris, Perambalur (Undivided), Pudukottai, Salem, Sivaganga, Trichy, and Villupuram districts. Fall in water level more than 4 m has been observed in six percent of wells analysed and noted in Chennai, Coimbatore, Dharmapuri (Undivided), Dindigul, Erode, Karur, Madurai, Namakkal, Perambalur (Undivided), Pudukkottai, Salem, Theni, Trichy, and Villupuram districts.

D.2 Karnataka

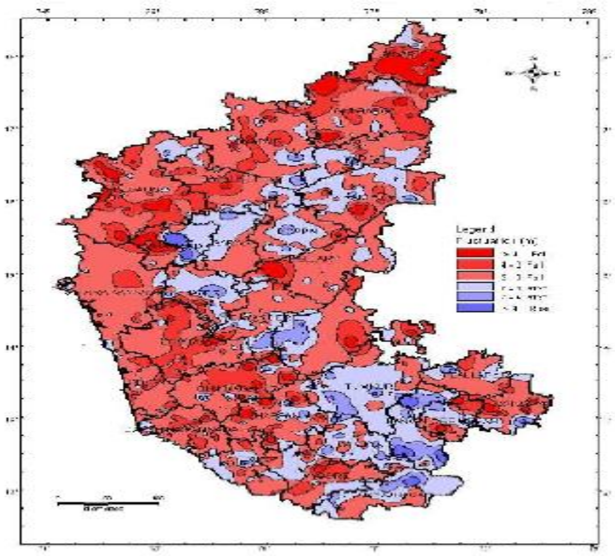

Fig 13 Water level fluctuation - decadal mean Aug 2016

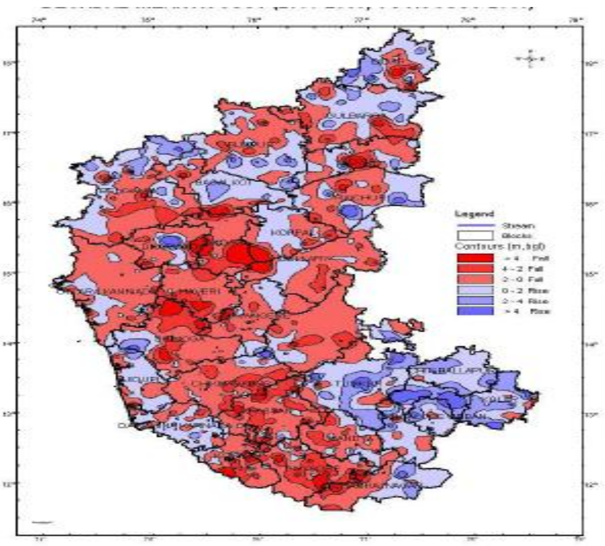

Fig 14 Water level fluctuation - decadal mean Aug 2015

Change in Water Level: Mean (January 2006 to January 2015)-Jan 2016 - Major parts of the districts, under consideration, are showing fall in water level as compared to decadal mean water level of 2006-2015 with respect to January 2016 water level. In the rise category, water level showing less than 2 m is observed in parts of all most all districts as minor patches. Rise in the range of

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2-4 m is observed in Bangalore rural, Bangalore Urban, Chamrajanagar, Chitradurga, Kodagu, and Mandya, Mysore, and Tumkur districts. Rise of more than 4 m water level is observed as small patches in parts of Bangalore Rural, Chikmagalur, Kodagu, Mandya, Tumkur, and Chitradurga districts. Fall in water level less than 2 m and 2-4 m is noticed in parts of almost all the districts. Fall of water level of more than 4 m is observed as small patches in all the districts.

Change in Water Level, Mean (May2006 to May 2015) – May 2016 - Rise in water level in the range of 0 to 2 m is observed in all parts under consideration. A rise in water level of 2 to 4 m is noticed as patches in almost all parts of the State except in the Mandya district. Rise in water level of >4m is noticed as small patches in all the districts except Mandya, and Chitradurga. Fall in water level of <2 m is noticed in almost all parts of the districts. Fall in Water levels in the range of 2 to 4 m is also noticed in almost all parts of the districts. Fall in water level of >4 m is noticed as small patches in almost all parts of the districts except Bangalore Urban district.

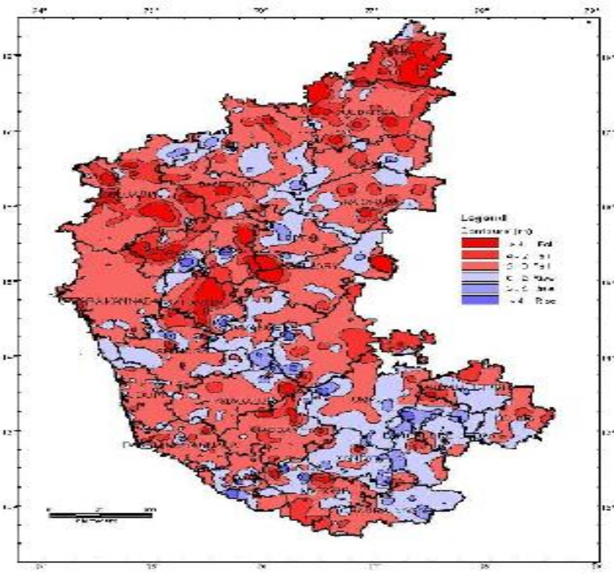

Fig 15 Water level fluctuation - decadal mean Nov 2016

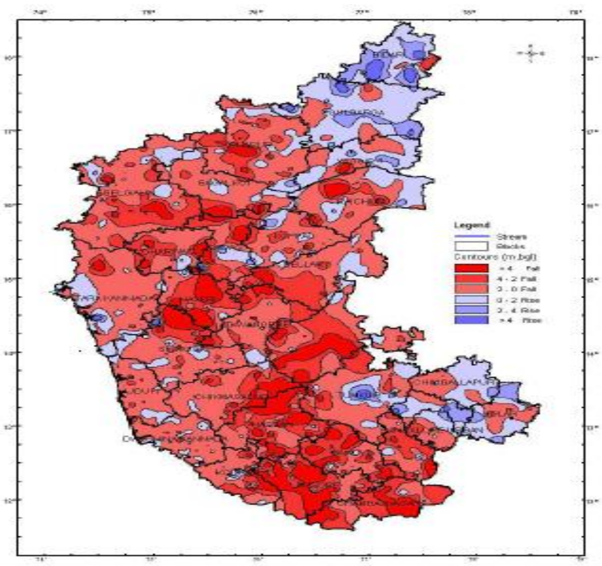

Fig. 16 Water level fluctuation - decadal mean Nov 2015

Change in Water Level, Mean (Aug 2006 to Aug 2015)-Aug 2016 **-** Major part of the State is showing fall in water level compared to decadal mean water level of 2006-2015 with respect to August 2016 water level. In the rise category, water level less than 2 m rise observed in parts of Chitradurga, Tumkur, Bangalore Urban, Bangalore Rural, Mandya, and Chamarajanagar districts. Rise of 2 to 4 m is observed in parts of almost all the districts except Mysore district. More than 4 m rise is observed as small patches in Bangalore Urban, Bangalore Rural, Chamarajanagar Ramanagara, Shimoga, and Tumkur districts. Fall in water level of less than 2m and 2 to 4 m is recorded in parts of almost all the districts of Karnataka State. Fall in water level of more than 4 m is observed in parts of almost all the districts except Hikkaballapura, Bangalore urban and Tumkur.

Change in Water Level, Mean (Nov 2006 to Nov 2015) – Nov 2016 **-** Major parts of the districts are showing fall in water levels as compared to decadal mean water level of November 2006 - November 2015 with respect to November 2016 water level. In the rise category, water level showing rise of less than 2 m is observed in parts of almost all the districts as minor patches. Rise in the range of 2 to 4 m is observed in parts of Bangalore Rural, Bangalore Urban, Kodagu, and Tumkur districts. Rise of more than 4 m in water level is observed as small patches in parts of Bangalore Rural and Tumkur districts. Fall in water levels of less than 2 m and 2 to 4 m are noticed in parts of almost all the districts. Fall of water level of more than 4 m is observed as small patches in all the districts.

Change in Water Level: Mean (January 2005 to January 2014)-Jan 2015 **-** In the rise category, rise of 0 to 2 m is observed in entire Karnataka State. Rise in water level of 2 to 4 m is noticed as patches in almost all districts except in Mysore and Hassan. Rise in water level of greater than 4 m is recorded as small patches in Bangalore Rural, Chamrajanagar, Chikmagalur, Chitradurga, Hassan, Kodagu, Mandya, and Tumkur districts of Karnataka State. In fall category, fall in water level of 0-2 m is seen in almost in all districts considered in Karnataka. Fall in water level of 2 to 4 m is noticed as patches in almost all districts considered in Karnataka State. Fall in water level of greater than 4 m is seen in almost all districts except Kodagu district.

Change in Water Level: Mean (May 2005 to May 2014) – May 2015 **-** Rise in water level of <2m is noticed in almost all parts of the State. A rise in water level of 2-4 m is noticed as patches in almost all parts of the State except in the coastal districts. Rise in water level of >4m is noticed as small patches in all districts except Bagalkot and Koppal districts. Fall in water level of <2 m is noticed in almost all parts of the State. Water level fall of 2-4 m is also noticed in almost all parts of the State except Koppal districts. Fall in water level of >4 m is noticed as small patches in almost all parts of the State except Chamrajanagar, Kodagu, Koppal and Tumkur districts.

Change in Water Level, Mean (Aug 2005 to Aug 2014)-Aug 2015 **-** Major part of the State, under consideration, are showing fall in water level compared to decadal mean water level of 2005-2014 with respect to August 2015 water level. In the rise category water level less than 2m rise observed in Chitradurga, Tumkur, Bangalore Urban, Bangalore Rural, Mandya, and Chamrajanagar districts. Rise of 2-4 m is observed as patches in Chitradurga, Tumkur, Bangalore Urban, Bangalore Rural, Mandya, and

Chamrajanagar districts. More than 4 m rise is observed as small patches in Chitradurga, Chikmagalur, Hassan, Tumkur, Bangalore urban, Mandya, Mysore, Chamrajanagar and Kodagu districts. Fall in water level less than 2m and 2-4 m is recorded in almost all the districts under consideration. Fall in water level of more than 4 m is observed in almost all districts except Chamrajanagar, Kodagu and Mandya districts.

Change in Water Level: Mean (Nov 2005 to Nov 2014) – Nov 2015 - Majority of the districts are showing fall in water level as compared to decadal mean water level of 2005-2014 with respect to November 2015 water level. In the rise category, water level showing less than 2m is observed in parts of all most all districts as minor patches. Rise in the range of 2-4 m is observed in Bangalore rural, Bangalore Urban, Chamrajanagar, Chitradurga, Kodagu, Mandya, Mysore, and Tumkur districts. Rise of more than 4m water level is observed as small patches in parts of Bangalore rural, Chikmagalur, Kodagu, Mandya, Tumkur and Chitradurga districts. Fall in water level less than 2m and 2-4 m is noticed in parts of almost all districts. Fall of water level of more than 4m is observed as small patches in all the districts.

D.4 Kerala

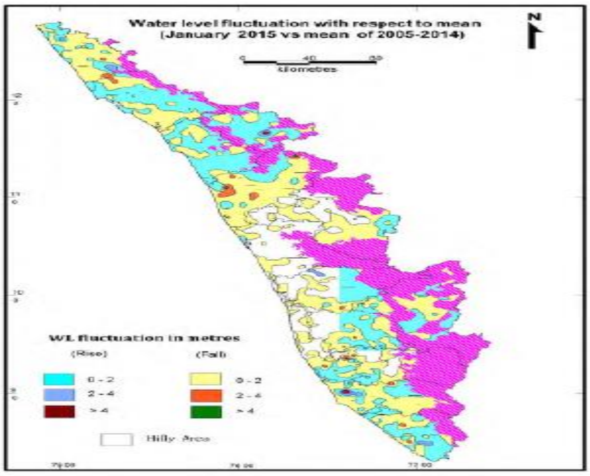

Fig. 17 Water level fluctuation - Decadal mean Jan 2015

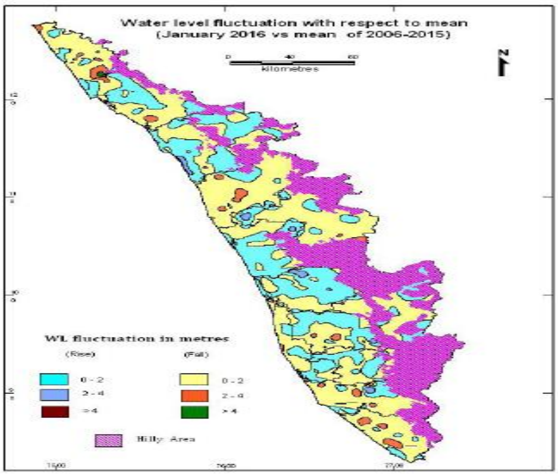

Fig. 18 Water level fluctuation - Decadal mean-Jan 2016

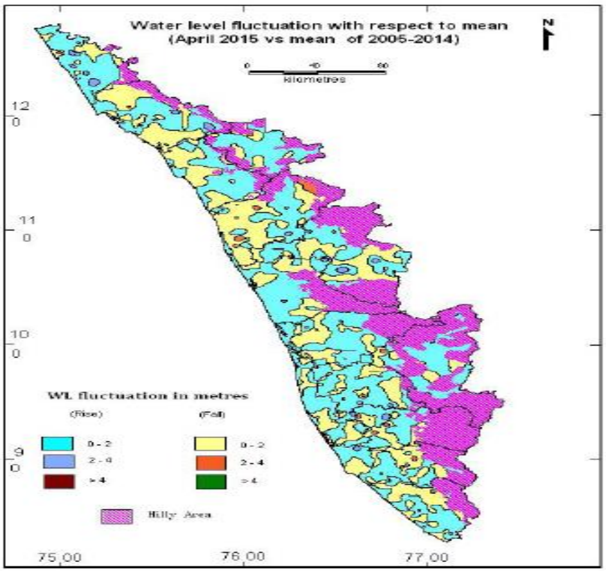

Fig. 19 Water level fluctuation - Decadal mean Aug 2015

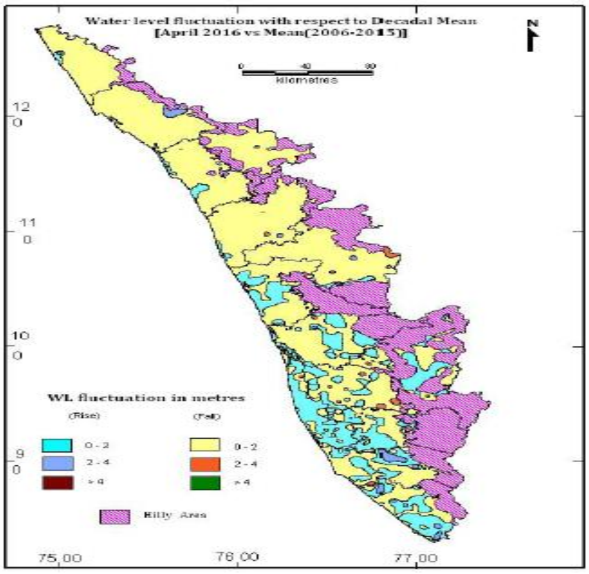

Fig. 20 Water level fluctuation Decadal mean- Aug 2016

Fluctuation between Mean January (2006-2015) and January 2016 - Most of the places in Wayanadu are observed with rise in the range of 0-2 m and in other parts of the districts show a decline in ground water level in the range of 0-2 m.

Fluctuation between Mean April (2006-2015) and April 2016 - The change in water level over the last ten years period is brought out by the comparison of water level with the mean value of April measurements of the period 2006-2015. This analysis indicates that the change in water level is mostly restricted to +2(rise) to -2(fall) m. Some parts of Idukki are showing rise in water level. However, fall in water level is predominant in many parts of Idukki district and almost all parts of Wayanadu district.

Fluctuation between Mean August (2006-2015) and August 2016 - The change in water level over the last ten years period is brought out by the comparison of water level with the mean value of August measurements of the period 2006-2015. This analysis indicates that the change in water level is mostly restricted to

+2(rise) to -2(fall) m. In rise category, Rise of in the range of 0-2 m is observed as small patches only in Idukki district. However major parts of Idukki district is showing fall in the range of 0-2 m. In case of Wayanadu, almost all parts are observed to be in the range of 0-2 m of fall and some parts are noticed with fall in the range of 2-4 m.

Fluctuation between Mean November (2006-2015) and November 2016 - The change in water level over the last ten years period is brought out by the comparison of water level with the mean value of November measurements of the period 2006-2015. Rise in the range of 0-2 m in some parts of Idukki and in a few areas of Wayanadu. Fall in the range of 0-2m is noticed in major parts of the districts. The occurrence of fall in the range 2-4 m is observed in some parts of Wayanadu and in a few areas of Idukki.

Fluctuation between Mean January (2005-2014) and January 2015 - The change in water level over the last ten years period is brought out by the comparison of water level with decadal mean value of January measurements for the period 2005-2014.This analysis indicate that the change in water level is mostly restricted to +2 (rise) to -2 (fall) m. Rise in water level is predominant in Wayanadu district and it is in the range of 0-2 m. But some parts of the district show fall in the range of 0-2 m. In Idukki area having fall in the range of 00-2m is comparatively larger than area with rise in the range of 0-2 m.

Fluctuation between Mean April (2005-2014) and April 2015 - Rise in the range of 0-2 m water level is predominant in both Idukki and Wayanadu district. However, in some parts of Idukki district and in very few places in Wayanadu district show fall in the water level when compared with the decadal mean. The range of fall is again between 0-2 m.

Fluctuation between Mean August (2005-2014) and August 2015 -Rise in the range of 0-2 m is observed in some parts of Idukki district and in a few places of Wayanadu districts. Other parts in Idukki district and in some places of Wayanadu district show fall in the range of 0-2 m. Fall in the range of 2-4 m is also witnessed in some parts of Wayanadu district.

Fluctuation between Mean November (2005-2014) and November 2015 - Rise in the range of 0-2 m is predominant in Idukki district. Some parts of Idukki and almost entire Wayanadu district are observed to have fallen in the range of 0-2 m.

D.5 Inference

Tamil Nadu - In the months of January, May and August while comparing the scenarios between 2015 and 2016, the districts under observation show expansion of areas where rise in groundwater level is observed. This change is high when compared to the corresponding situations of Karnataka. But the area under fall category has increased drastically when compared to the previous study periods and also larger than Karnataka. Though there is an increase in area under rise category for the months January, May and August, in November almost all the area has started to show drastic decline in groundwater level. So, the state needs some new ground water managing technique to soften this change.

Karnataka - In the months of January and May, while comparing the scenarios between 2015 and 2016, the districts under observation show expansion of areas where rise in groundwater level is observed. It is noticed that only some area under fall category in 2015 has shifted to raise category in 2016 for the month of August. But for November most of the districts under rise category have started to show decline in groundwater to a depth >2 m that of its decadal mean. Though there is an increase in area under rise category for the months January, May and August, in November almost all the area has started to show drastic decline in groundwater level. So, the state needs some new ground water managing technique to soften this change.

Kerala - The trend of increase in area under decline in groundwater is observed between fluctuations in the years 2015 and 2016. Almost all the parts of Idukki and Wayanadu are showing a fall in the range of 0-2 m in 2016, while during the same month of 2015 the area under the fall category is less. A significant increase in area having fall of groundwater level in the range 2-4 m is observed in the months of August and November between 2015 and 2016. The fall is within the range of 4m but, if this prevails for n number of years, recharging of ground water to the original depth will become a tough job.

D.6 Suggestions

All the three states have to be effectively managed for conservation of groundwater. However, Tamil Nadu and Karnataka require adopting a new conservative action immediately. In Kerala since they are equally utilizing groundwater, rainwater and river water, there is stretch for natural recharge. Based on the findings, following ideas can be considered:

- Reducing concrete surfaces and increasing green cover.
- Artificial Recharge techniques (indirect and direct) can be as adopted. One of the newly developed ways is sub-surface dams which has following advantages: minimum amount of evaporation loss, area acquisition is low, environmental flow is maintained and damage due to collapse is eliminated.
- Diversion of flood water towards areas with low rainfall and has soil having high water-retention capacity.

E. Coleroon Discharge Variation

E.1 Need for Analysis of Mettur dam

The project also explores the study of Mettur dam. This was carried out due to the recent conflict of releasing the discharge directly into the sea without proper assessment or utilization by the state government water authority. Another reason is due to the resistance from officials in releasing the inflow/outflow values to the public and news media. The study is done from data collected from "The Hindu" newspaper. The observation is made from 19th July to 2nd August 2018. These dates were purposefully nominated because of the heavy rainfall received by Karnataka during South-

West monsoon which in turn lead to excess amount of outflow from Kabini dam and Krishnarajasagar dam. Mettur dam reached its full capacity 39th time in 84-year history on 22nd July, 2018. Starting from the onset of August, the dam has been in its full

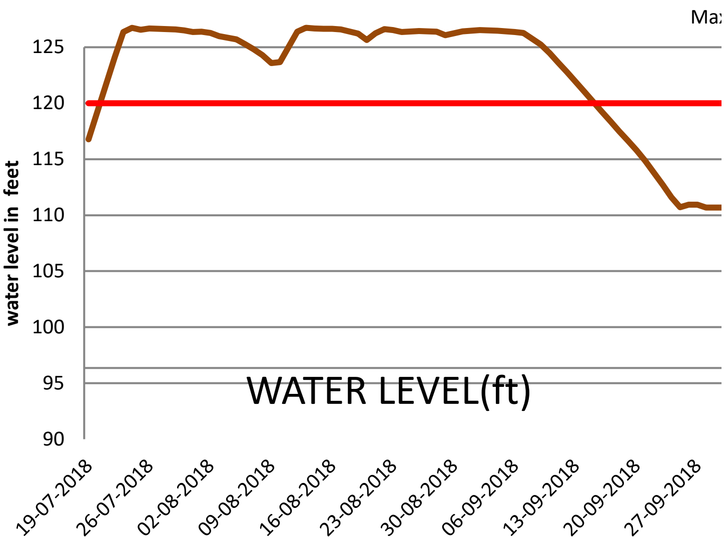

Fig. 21 Mettur Dam Water Levels

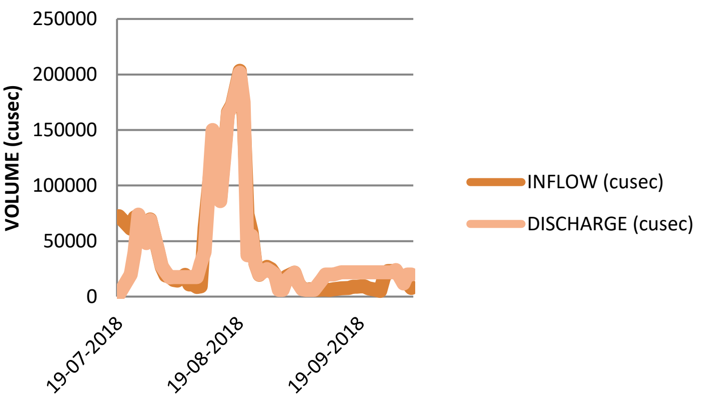

Fig. 22 Graph between Volume of Discharge and Inflow with Date of Mettur Dam

E.2 Observations

- Initially the outflow was kept less than the inflow. When the dam reached its full capacity, the outflow was made more or less equal to the inflow.
- During mid-August, both the inflow and outflow were equal and at their peaks.
- However, from the start of September, the outflow was maintained higher than the inflow. The reason may be clinched to two possibilities.
  - To alleviate the flood which may occur due to the upcoming North-East monsoon,
  - To irrigate Lake Samba or Lake Thaladi which help in crop cultivation for Thanjavur, Nagapattinam, Thiruvarur, Trichy, Peramblur, and Karur.

E. 3 Need for Analysis of Coleroon dam

- Apart from the inflow from Karnataka, Mettur dam also received water from Bhavani River in Kerala and Amaravathi River in Coimbatore. For second week of August, Cauvery met with heavy flow from Kerala. During this period, flow at Mayanur in Karur was heavy.
- Sometimes the flow reaches 2.21 Lakh cusecs which was present for three consecutive days. But the carrying capacity of Mukkombu is only 35000-36000 cusecs. So, to ease the flow, major part of the water is released into Coleroon. For this incident, this project also analyses Coleroon discharge for 12 days (peak time). The water levels were collected from newspapers and by discharge calculations, volume of water released from Coleroon were estimated.

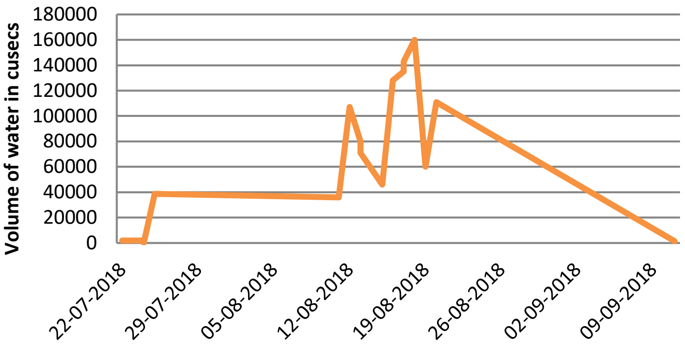

Fig. 23 Graph between Volume of discharge and Date

E.3 Observations

- From the calculations, it is observed that about 16 MCFt of water was directly released into the sea.
- The maximum water level was reached at Grand Anicut at the initial stage of peak flow itself. Once Upper Anicut releases water, it goes to Grand Anicut which was already full at that instance. So, the excess discharge was released straight to the sea because of inadequate storage capacity.

E.4 Suggestions

Regarding the condition when outflow is greater than inflow:

- The water which was released during the time period when inflow was equal to outflow, can be diverted to various irrigation fields of Thanjavur district where there is huge gap in irrigation supply and demand.
- The excess flow can also be diverted and stored in local water bodies. This is a very efficient procedure as Thanjavur is in semi-critical level of ground water exploitation and the minor difference between domestic demand and supply can be minimalized.
- Once the dam stops receiving a considerable amount of inflow, the outflow can be reduced and the water can be stored for dry season.

Regarding the condition where there is an exclusive flood alert:

The Central Water Commission in 1958 commenced Flood Forecasting Services. So far, they have established 175 functional sites in 15 states. But it does not include Cauvery basin. Therefore, in future, it is necessary to implement such sites not only for forecasting flood, but also to control water management as a whole. Thus, there arises a need for Flow Simulation Model.

F. Flow Simulation Model

- Quintessential aims and objectives should be instituted according to the history of flow pattern of Cauvery River.
- Entire basin has to be divided into number of categorized watersheds and sub-units, provided the present classification does not favor the new system.
- A panel of professionals, PWD employees and senior students can be allocated for examining the simulation system.
- Within the panel, teams can be split up into smaller crews and these crews can be assigned to different watershed units for resourceful functioning.
- In this way of team allocation, funding for human resources can be reduced to an extent as stipend can be given for college students and research scholars.
- Elementary information like Rainfall (DAD curve, Hyetograph, Intensity-depth), Infiltration data, Excess rainfall, Topography can be collected for 10 years and looked upon.
- Initially, it is hard to obtain historical data for all the small units. So, it is very important to install the necessary measuring devices according to the norms mentioned in Water Management Organization, mentioned in IS 4987-1968.
- After collection of data, the team has to simulate a model for their respective unit by considering all the hydrological aspects.
- The simulation model must be comprised of rainfall and channel flow relationship and discharge at outlet of each unit.
- This has to be submitted to the main panel. The panel members can compress all the small units together into a potential workable prototype for the entire basin.
- The simulation model of the entire basin should work in such a way that, hypothetically, if 75mm downpour starts at 12:54pm on 15th October for the duration of 6 hours in Kodagu, about X% of the rainfall excess will be predicted to cause Y% of inflow at Upper Anicut at 11:32pm.
- This process will require proper scheduling, working and implementing the system. This requires independent and unbiased Water Management Board for the Cauvery basin.
- For further improvement, the entire basin must be connected to a common database by technical assistance such as Internet of Things.

VII. CONCLUSION

The preliminary aim of the project was to focus primarily on domestic and agricultural usage of water in Kerala, Karnataka and Tamil Nadu, depending on Cauvery water and come up with feasible suggestions and ideas to overcome the inadequacy. As the study progressed, the scope of investigation extended to ground water analysis and evaluation of Coleroon Discharge for a particular flood period. General suggestions were given without paving way for political or legal issues. The project is done on a small-scale basis and the methodology adopted can be used for a grass-root level exploration.

Judicious use of ground water, rain water and surface water sources is the best simple-cut solution for the enigma of Karnataka and Tamil Nadu water sharing policy. The present scheme is not practically viable as they don't consider agricultural requirements and patterns into account. The resolutions should be a future-based approach. Ideas like ground water management, waste water recycling and more state-confined amendments will foster co-operation rather than competition between the states in dispute.

Socio-economic growth is directly proportional to the availability of resources where water is one among them. If sustainable water use is not put into implementation, researchers suggest that by 2030, there will be water-scarcity in river Cauvery, thereby, declining socio-economic growth of both the states.

Main sufferers of this century old dispute are the farmers. Approximately 7 farmers die each day as of 2015. Unless there is a hope to harmonize water policies, agricultural patterns and schedule, administrative strategies and mindset of citizens, Cauvery dispute cannot be solved just by technical interferences.

VIII. REFERENCES

1. T. Subramanium, Performance Evaluation of Cauvery Irrigation System, International Journal of Engineering Research and Applications, 2014, Vol.4 (Issue 6), pp. 191-197.
2. T.R. Neelakantan, C.R. Suribabu, & R. Selvakumar, Opportunity to restore irrigation tanks in the Cauvery delta by mining and deepening, Environment, Development and Sustainability, 2016.
3. S. Anbazhagan & P. Dash, Environmental case study of Cauvery river flood plain, Journal of Environmental Planning, 2003, Vol.7(Issue 12), pp. 30-35.
4. K. Ravi Kumar & Rakesh Khosa, Fair and equitable allocation of Cauvery River water, International Water Research Association, 2007, Vol.32(Issue 4), pp. 571-588.
5. Population Data, https://www.citypopulation.de/India-Agglo.html
6. Tamil Nadu Ground Water Data http://www.twadboard.gov.in/twad/com
7. Kerala Habitation Data http://indiawater.gov.in/IMISWeb/HabitationDirectory/Reports/rpt_HabInformation.aspx
8. The HINDU Newspaper

   Central Ground Water Board http://cgwb.gov.in/GW-Year-Book-State.html