

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
 ISSN Online: 2617-4707
 NAAS Rating (2026): 5.29
 IJABR 2026; SP-10(8): 2116-2123
www.biochemjournal.com
 Received: 21-06-2026
 Accepted: 24-07-2026

Priya G Nair
 Assistant Professor, Krishi
 Vigyan Kendra, Tavanur,
 Malappuram, Kerala
 Agricultural University,
 Kerala, India

Mapping and managing the command area of the distributaries in Gayathri irrigation project using GIS tools

Priya G Nair

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8Sw.9717>

Abstract

Effective command area management relies on data regarding spatial and temporal variations in climate, land use, and soil types. It optimizes water resource planning, management, and allocation for engineers and farmers across irrigation blocks. Consequently, it enhances water allocation strategies, maximizes water use efficiency, and enables comparative analysis between distributary canals. Distributary delineation and boundary definition preceded the development of GIS-based soil and land use maps. Spatial maps for rainfall, maximum and minimum temperature, humidity, wind velocity, and sunshine hours were created. This technique can be used for generating thematic maps of irrigation requirement of canal command. The objective of this study was to review GIS applications and remote sensing used in developing spatial databases for irrigation management, alongside identifying future perspectives in the field. The spatial data analysis for historical years showed that peak monthly average rainfall in distributary command occurred in July, reaching 400 to 500 mm. The Bhavani Nagar soil series makes up 30.99 percent of the command area and this soil series is located primarily between the eastern and central regions of command. The predicted data analysis of rainfall indicates monthly peak rainfall in June and reached its lowest point in January for predicted year 2026 and 2031. The predicted year 2031 displayed a 11.7% decline in rainfall compared to 2026.

Keywords: Geographic information system (GIS) and remote sensing (RS) techniques, distributary command, historical data, predicted data

Introduction

Global climate change threatens water resources, creating knock-on risks for food, employment, and energy security. (Patel *et al.*, 2023) ^[7]. Shifting rainfall patterns across different regions and seasons are seriously harming crops. Extreme weather variations lead to contrasting disasters, brief, intense downpours trigger destructive flooding, while delayed and insufficient rainfall produces severe droughts. (Shah *et al.*, 2015) ^[10]. Misusing water and natural resources lead to severe environmental disasters, with drought being the worst outcome (Kesarwani *et al.*, 2023) ^[4].

To solve this problem, it is essential to check how much water is available across different areas and times. For assessing water availability, accurate and reliable data is essential. Irrigation management data is complex, highly localized, and constantly changing over time. This initiative spans from individual farms to entire catchment areas covering millions of hectares of irrigated land. GIS technologies such as Arc/Info software helped plan and manage water resources with high efficiency (Nandi *et al.*, 2016) ^[6]. A well-established geo-referenced database and map of climate, crop, soil and canal network is needed for estimation of regional irrigation water requirement of a command area. The database helps for computing effective rainfall, evapo-transpiration, crop coefficient, percolation application efficiency, cropping pattern distribution. GIS also helps in preparing the effective irrigation schedule based on available water for irrigation

Materials and Methods

Description of study area

The Gayathri Irrigation Project (GIP) is a medium-scale water scheme in Palakkad, Kerala, spanning two phases with the Meenkara and Chuliyar reservoirs in Muthalamada panchayat,

Corresponding Author:
Priya G Nair
 Assistant Professor, Krishi
 Vigyan Kendra, Tavanur,
 Malappuram, Kerala
 Agricultural University,
 Kerala, India

Chittur. There were 19 distributaries in GIP, out of this, 11 distributaries in LBC and 8 distributaries in the RBC. The location map of the study area is shown in Fig.1. The study area belongs to Agro Ecological Unit (AEU) 23 in the humid tropics. The area gets most of its rain from the southwest monsoon, and a smaller amount from the northeast monsoon. The annual rainfall in this area averages 1,500 to 2,000 mm, representing only half of the state average. (Surendran *et al.*, 2015) ^[11]. Average annual temperatures fluctuate between a low of 23.7°C and a high of 32.4°C. Wind speeds peak between December and

January at 9.5 km/h, while humidity levels remain high from June to September and around 84 to 88 per cent during this period (CGWB, 2013) ^[1]. Sandy clay loam and sandy loam dominate the area's soil texture (CGWB, 2013) ^[1]. Paddy is the primary crop in the eastern district study area, supplemented by coconut, mango, vegetables, and banana. It is cultivated across two distinct seasons: the first and second crop. Farmers grow the Kharif (Virippu) crop from May to August, and the Rabi (Mundakan) crop from November to February.



Fig 1: Location of study area

Acquisition of meteorological data

The various meteorological parameters were collected includes rainfall, maximum and minimum temperature, humidity, wind velocity and sunshine hours. Historical meteorological data spanning 15 years (2004–2018) were collected from the Indian Meteorological Department, Pune, and the Regional Agricultural Research Station, Pattambi, Palakkad. The study utilized rainfall data collected during the same period from five rain gauge stations: Meenpara, Chulliyar, Kollengode, Chittur, and Alathur.. The Water

Resources Department (Govt. of Kerala) and the India Meteorological Department provided this data. Rainfall and temperature projections for 2026 and 2031 were sourced from the Indian Institute of Tropical Meteorology (IITM) Centre for Climate Change Research (CCR) portal. These datasets utilize the CMIP5 climate model under the RCP4.5 scenario. The predicted data was used to check for the change in meteorological parameters. Table 1 lists the software and tools used in this study.

Table 1: Software and Tools used for the study

Sl. No	Model/software	Source	Activity
1	ArcGIS 10.3.1	ESRI	Establishment of geospatial database
2	SPAW	USDA & ARS	Estimation of soil characteristics
3	CMIP5 Climate model	CCCR-IITM	Predicted data of future climate scenario
4	NetCDF	University Corporation for Atmospheric Research	Interface for storing and retrieving predicted data in form of arrays
5	GIS tools:	Clip, Buffer, IDW, Intersection, Data management	

ArcGIS software

Environmental Systems Research Institute (ESRI) developed ArcGIS to manage, edit, view, and analyze geographical data. Organizations mainly use it to create and analyze maps.

ArcMap is a core component of Esri's ArcGIS suite for geospatial processing. The program's table of contents and data frame sections allow users to explore data, symbolize features, and create maps. Map preparation and analysis were conducted using ArcGIS 10.3.1. The software offers

capabilities for creation of maps, spatial analysis of geographic data, manipulation and editing of geodatabase. The methodology utilized clip and buffer tools for data extraction, while conversion tools transformed layers between shapefile and Keyhole Markup Language (KML) formats. Additionally, data management tools facilitated data exportation. The Inverse Distance Weighting (IDW) method was applied within the proximity analysis tool to interpolate meteorological parameters including average

rainfall, temperature extremes, wind velocity, and solar radiation for the command area.

Using the CMIP5 climate model under the RCP 4.5 scenario, meteorological data was projected for 2026 and 2031. This model utilizes standardized simulations to evaluate historical accuracy and project future climate change.

Net CDF

NetCDF software was used to convert the model output in an array form. This software had a set of interfaces for array-oriented data access. It supports a machine-independent format for representing the scientific data.

Geospatial database for distributary command

The geospatial database consists of point, line and polygon feature class created in ArcGIS platform. The database included maps for distributary command areas, land use, soil types, and interpolated meteorological parameters. The GIP distributaries were identified by comparing the ArcGIS canal map with official schematics and ground-truthing data. Each distributary was then isolated using the ArcGIS Clip tool. The distributary boundary was demarcated using the ArcGIS buffer tool, with the calculated area subsequently verified against Water Resource Dept., GoK.

The land use map for the Gayathri irrigation command was derived from the Bharathapuzha basin map provided by the Kerala Land Use Board. Using the ArcGIS Clip tool, the distributary command areas were isolated to analyze their specific buffer zones. This process determined the primary land-use categories and their respective areas across the various distributaries. The soil map of the study area was taken from Bharathapuzha basin soil map supplied by Directorate of Soil Survey and Soil Conservation, GoK. The soil map of the distributary command was clipped to

determine the buffer area and identify the major soil series and their respective coverage.

SPAW (Soil Plant Atmosphere Water), a hydrologic budget model developed by United States Department of Agriculture (USDA) - Agricultural Research Service (ARS) was used to prepare soil database. The soil properties like field capacity, wilting point and saturated hydraulic conductivity were determined using this model.

Meteorological data including temperatures, humidity, wind velocity, sunshine hours, and rainfall was collected from RARS Pattambi and IMD Pune. Because some of the stations sit outside the command area, their zones of influence were estimated using the Inverse Distance Weighted (IDW) interpolation tool in ArcGIS. The cell value was estimated using a linear combination of sample points, where weights were inversely proportional to the distance from the prediction location raised to the power of p .

Weight adjustments depend directly on the value of p . When $p=0$, the prediction equals the data mean. As p increases, the weight of distant points drops rapidly, leaving immediate surrounding points to dominate the prediction. ArcMap spatial distributions were developed on a monthly basis for all meteorological parameters, encompassing both historical datasets and predictive scenarios for 2026 (PD1) and 2031 (PD2).

Results and Discussion

Distributary command area map

All distributaries in the head, middle, and tail reaches of the RBC and LBC were identified using the GIP distributary command area map (Fig. 2) and selected for study.

The area of each distributary found through GIS matches the data from the Water Resource Department of Kerala. Table 2 shows the distributaries in the GIP.

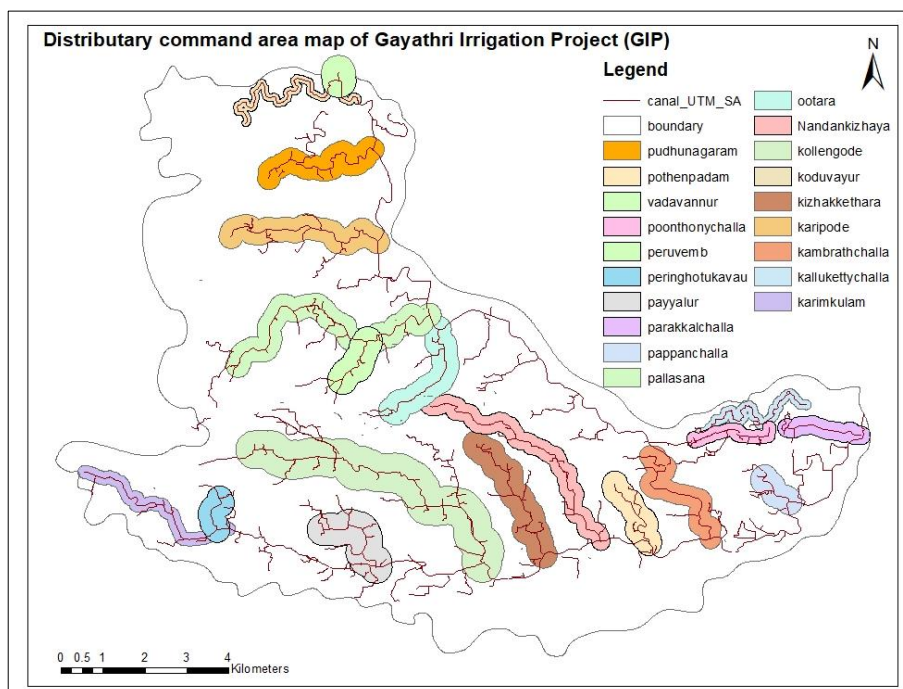


Fig 2: Distributary command area map of Gayathri irrigation project (GIP)

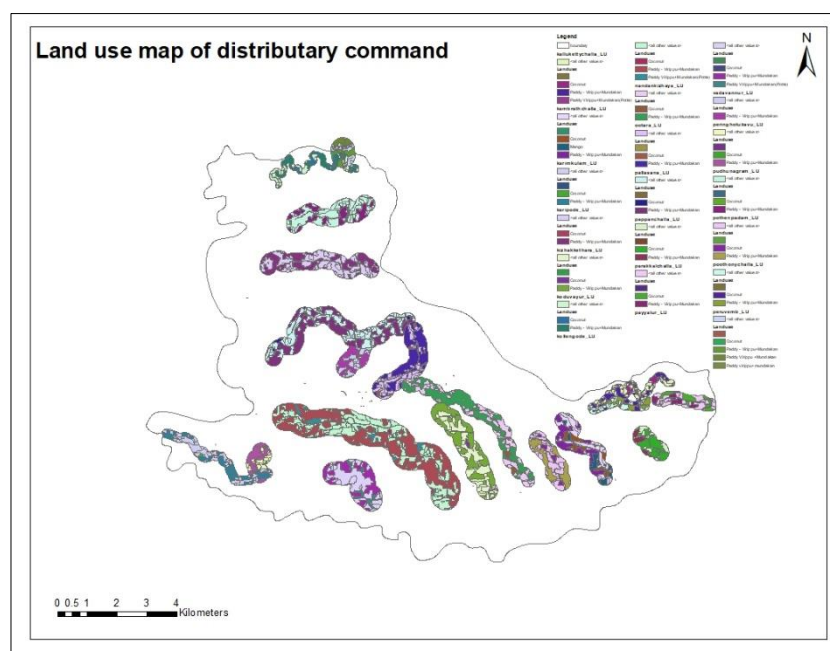
Table 2: Distributaries in Gayathri Irrigation Project

Distributary ID number	Distributary name	Length of canal (km)	Gross Command Area (ha)	LBC/RBC	Reach
DB1	Parakkalchalla	1.85	95.02	LBC	Head
DB2	Pappanchalla	1.02	84.17	LBC	Head
DB3	Kambrathchalla	3.87	183.85	LBC	Middle
DB4	Pothenpadam	2.14	137.30	LBC	Middle
DB5	Kallukettychalla	4.41	97.64	RBC	Head
DB6	Poonthonichalla	2.25	75.93	RBC	Head
DB7	Ootara	2.94	198.94	RBC	Middle
DB8	Vadavannur	1.22	118.87	RBC	Middle
DB9	Pallasana	7.76	377.20	RBC	Middle
DB10	Karipode	4.26	254.16	RBC	Middle
DB11	Pudunagram	3.84	202.55	RBC	Middle
DB12	Peruvemb	2.11	66.28	RBC	Tail
DB13	Koduvayur	6.18	105.20	RBC	Tail
DB14	Peringottukavu	0.95	82.15	LBC	Tail
DB15	Payyalore	2.18	202.40	LBC	Middle
DB16	Nandankizhaya	6.49	279.60	LBC	Middle
DB17	Kizhekkaethara	3.75	254.10	LBC	Middle
DB18	Karimkulam	4.57	145.88	LBC	Middle
DB19	Kollengode	7.45	702.30	LBC	Middle

Land use map of distributary command

By clipping the GIP land use map to the distributary command area, major crops were identified. Paddy was dominant across all distributaries, followed by coconut,

which closely aligns with the findings of Lakshmi *et al.* (2018) [5]. Vegetables and banana were the other crops cultivated in the command area. The land use map of the distributary command area is shown in Fig.3.

**Fig 3:** Land use map of distributary command

The major land use classification and its area coverage is shown in Table 3.

Table 3: Major land use and their respective areal coverage of GIP distributary command

Sl. No.	Land use classes	Area (km ²)
1	Paddy	58.41
2	Built up land	6.26
4	Mango	2.68
5	Mixed Crop (coconut, vegetables, banana)	23.88
6	Coconut	11.31
7	Vegetables	0.28
8	Banana	0.04
9	Arecanut	0.02

Paddy was the main crop in the distributary command followed by coconut. Vegetables and banana were the other crops cultivated in the command area.

Soil map of distributary command in GIP

The soil map of the distributary command area (Fig. 4) was adapted from the original GIP soil map. The various soil series such as Bhavani Nagar, Mungilmada, Kozhinjampara, Karinganthodu, Tolanur and Vadavannur were identified in the study area. The soil series with its area, percentage of area, and the textural class is shown in Table 4. Covering 41.18 km², the Bhavani Nagar series makes up 30.99 percent of the command area. This soil series is located primarily between the eastern and central regions.

Two other soil series, Mungilmada and Vadavannur, occupy 14.77% and 3.40% of the command area respectively, appearing in parts of the eastern tract. The central and western regions of the command area are dominated by the Karinganthodu (28.56%) and Tolanur

(11.62%) soil series, while the Kozhinjampara series (10.83%) occupies parts of the northwest. Among all identified groups, the Bhavani Nagar series exhibits the highest clay content, followed by the Karinganthodu and Mungilmada series.

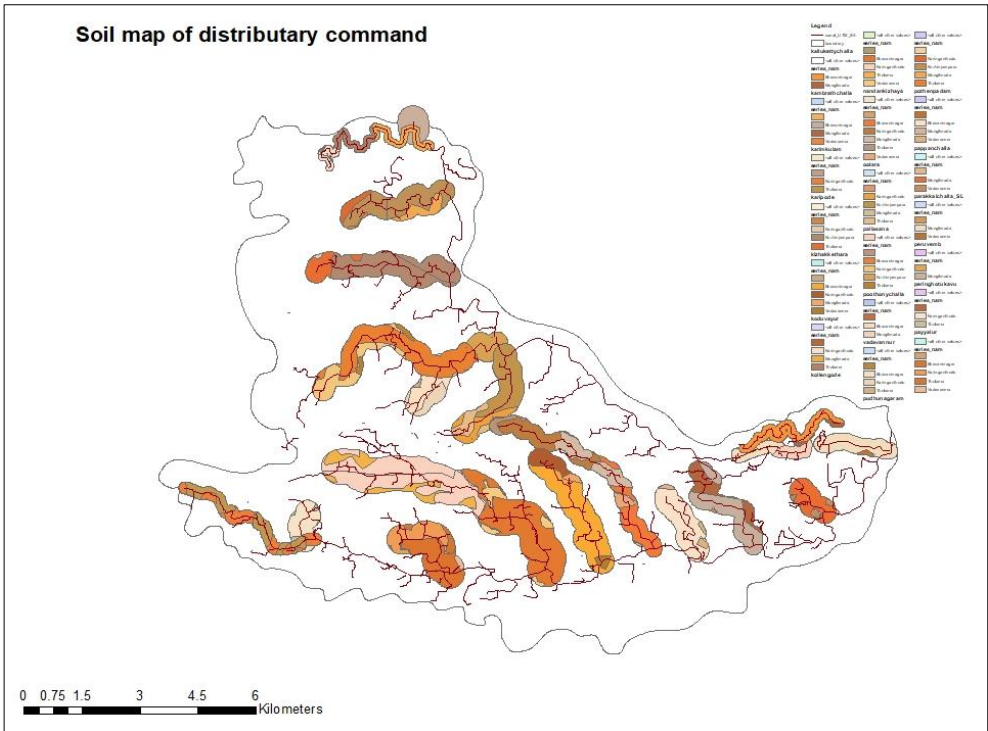


Fig 4: Soil map of distributary command

Table 4: Soil series with its area and textural class

Sl. No.	Name of soil series	Area (km ²)	Percentage of command area (%)	Texture
1	Vadavannur	4.53	3.40	Sandy clay loam (55% - sand, 15% - silt, 30% - clay)
2	Karinganthodu	37.95	28.56	Sandy clay loam (54% - sand, 12% - silt, 34% - clay)
3	Kozhinjampara	14.40	10.83	Sandy clay loam (62% - sand, 9% - silt, 29% - clay)
4	Mungilmada	19.63	14.77	Sandy clay loam (54% - sand, 12% - silt, 34% - clay)
5	Tolanur	15.44	11.62	Sandy clay loam (54% - sand, 16% - silt, 30% - clay)
6	Bhavani Nagar	41.18	30.99	Sandy clay (45% - sand, 17% - silt, 38% - clay)

The soil series Bhavani Nagar and Mungilmada were mostly seen in the distributary command areas of head reach of canal irrigation system, whereas soil series Karinganthodu was more predominant in tail reach of distributary command.

Estimation of soil properties from SPAW model

The soil properties viz. field capacity, wilting point and saturated hydraulic conductivity of different soil series were estimated from SPAW model and the results are shown in Table 5.

Table 5: Soil properties estimated by SPAW model for different soil series.

Soil Parameters	Field capacity (%)	Wilting point (%)	Saturated hydraulic conductivity (mm/hr)
Vadavannur	30.2	19.3	6.1
Tolanur	30.3	19.3	6.12
Mungilmada	32.5	21.6	3.52
Kozhinjampara	28.6	18.9	6.86
Karinganthodu	32.5	21.6	3.52
Bhavani Nagar	35.5	23.7	2.38

The Bhavani Nagar, Karinganthodu, and Mungilmada soil series exhibited higher field capacity and wilting points, alongside lower saturated hydraulic conductivity compared to other series. This pattern is likely attributed to the elevated clay content in these specific soils (Gülser C and Candemir F. (2014) [2], Seema *et al.*, 2019) [9].

Spatial map of meteorological parameters

Spatial map of meteorological parameters in the distributary command was prepared for months from January to December for historical data. The spatial ArcMap of all climate parameters viz. maximum temperature, minimum temperature, humidity, wind velocity and sunshine hours were generated. For example, the variations in rainfall and maximum temperature during October are depicted in Fig. 5 and 6, respectively. Specifically, rainfall within the canal command fluctuated from 139.4 mm to 162.8 mm, as shown in Fig. 5. The head reach of the canal command, located near the Palakkad rain shadow area, recorded the lowest value of 139.4 mm. This finding closely aligns with the results reported by Raj and Azeez (2010) [8]. The second lowest value was observed in tail reach of canal command

whereas highest values of rainfall were observed in the middle reach of the canal command. The average maximum temperature for the month October ranged from 31.96 to 32.03°C and is shown in Fig.6. In the canal command area, variations in maximum temperature were less pronounced

than variations in rainfall. The highest maximum temperatures occurred in the head reach, situated near the Palakkad rain shadow region. Consequently, spatial maps for minimum temperature, humidity, and wind velocity were analysed across all months using historical data.

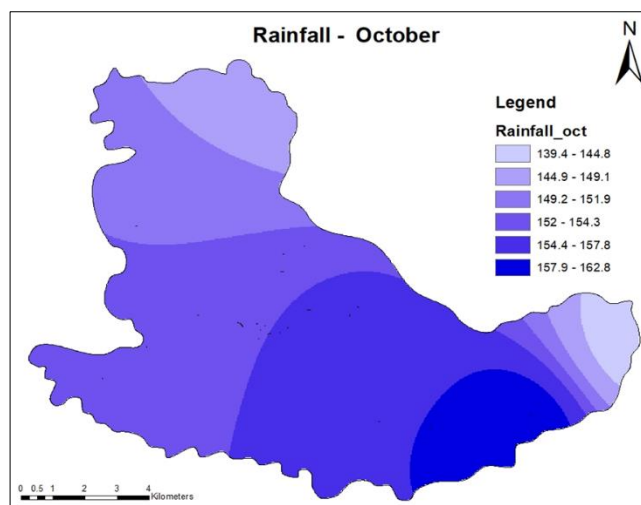


Fig 5: Spatial map of average rainfall for month October (historical data)

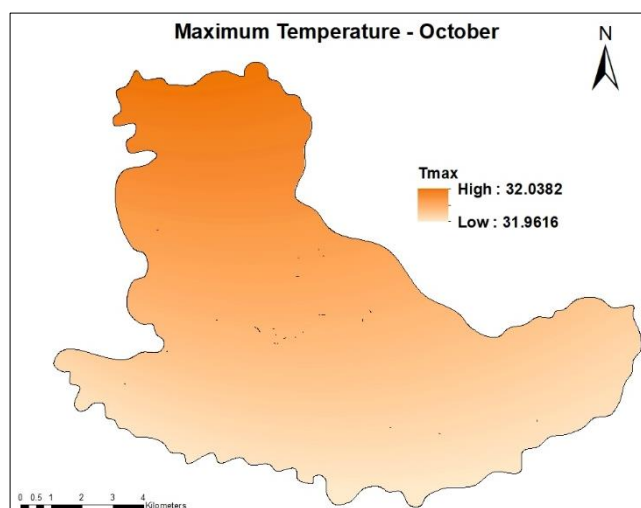


Fig 6: Spatial map of average maximum temperature of October (historical data)

Estimated meteorological data from spatial map and predicted data from climate model

Estimated spatial meteorological data reveal no significant variations in temperature extremes, humidity, wind velocity, or sunshine duration among the different sections of the distributary commands shown in Table 6. Tables 7 and 8

display the CMIP5 climate model grid data within the study area used as predicted data for 2026 (PD1) and 2031 (PD2). The forecast shows a rise in both high and low temperatures compared to past records. The maximum temperature of 43.3 °C recorded in March during PD2 aligns with the findings of Varughese and Hajilal (2016) ^[12].

Table 6: Command area historical weather data extracted from spatial maps.

Month	Min Temp (°C)	Max Temp (°C)	Humidity (%)	Wind Velocity (Km/day)	Sunshine (Hours)
January	22.7	32.8	57	227	8.5
February	22.7	35	54	201	8.4
March	24.7	36.6	59	131	7.1
April	25.6	36.1	67	102	4.8
May	25.1	32.9	75	128	3.4
June	23.7	30	84	105	3.4
July	23.4	29.3	88	102	2.9
August	23.2	29.8	86	102	4.8
September	23.8	30.5	83	107	4.1
October	23.9	32	78	111	6.6
November	23.8	32.1	72	130	6
December	21.4	32.1	63	210	7.8

Table 7: Predicted meteorological data of 2026 for the study area (PD1)

Month	Min Temp (°C)	Max Temp (°C)	Humidity (%)	Wind Velocity Km/day	Sunshine (Hours)
January	18.9	30.8	57	229	8.6
February	22.0	31.4	54	201	8.5
March	24.2	37.7	59	130	7.0
April	27.1	38.9	67	105	4.7
May	27.3	36.1	75	128	3.5
June	27.2	36.6	84	103	3.4
July	26.0	35.9	88	102	2.7
August	25.3	33.9	86	101	4.6
September	25.9	33.7	83	109	4.0
October	25.2	33.0	78	112	6.4
November	23.8	32.8	72	132	6.2
December	20.9	32.9	63	211	7.6

Table 8: Predicted meteorological data of 2031 for the study area (PD2)

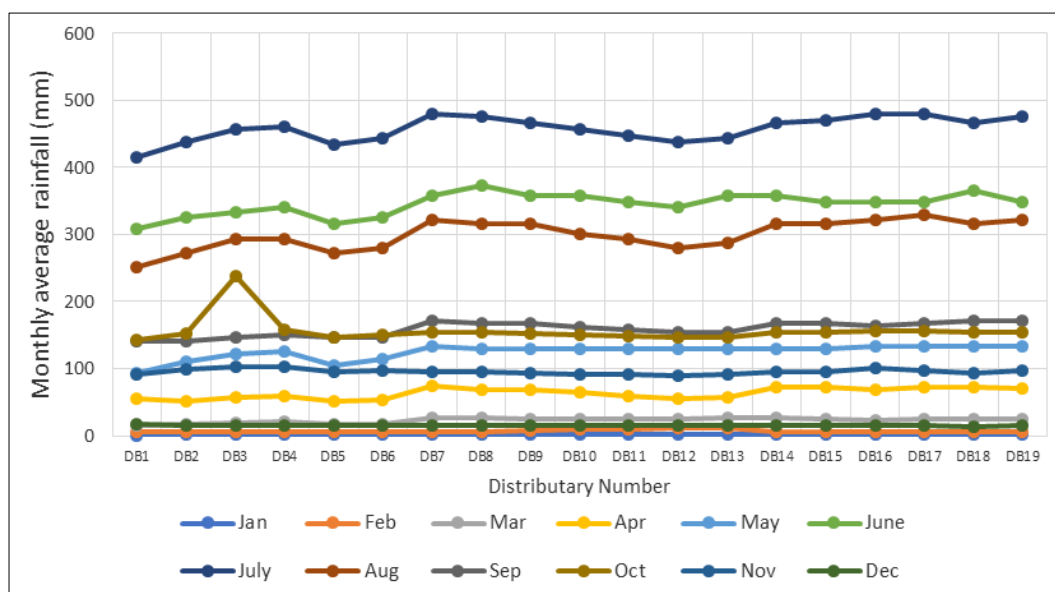
Month	Min Temp	Max Temp	Humidity	Wind velocity	Sunshine
	°C	°C	%	km/day	Hours
January	18.7	38.5	57	230	8.7
February	21.3	38.9	54	203	8.5
March	27.0	43.3	59	134	7.3
April	28.7	42.8	67	104	4.9
May	28.4	40.8	75	129	3.6
June	27.9	38.2	84	107	3.4
July	25.8	35.8	88	104	2.9
August	25.7	32.3	86	102	4.9
September	25.7	34.7	83	105	4.3
October	25.4	33.1	78	113	6.8
November	23.5	32.6	72	132	6.2
December	22.7	30.5	63	213	7.9

Spatial rainfall measurements and predicted climate model outputs

The peak monthly average rainfall of all distributaries occurred in July, reaching 400 to 500 mm, while June and August showed the next highest levels (Fig.7). The data indicates that southwest monsoon season accounts for the majority of the annual rainfall. All other months, monthly average rainfall observed in distributary command was below 200 mm.

The highest average annual rainfall values were recorded in distributaries 7 and 17, located at the mid and tail ends of

the canal command, respectively, while the lowest values occurred at the head end distributary 1,5 and 2 and 6 (Fig.8). These distributaries 1, 2, 5, and 6, were located in the head reach of the canal irrigation system. These low values indicate that the head-reach distributaries sit within the rain shadow area of the Palakkad Gap. This was in closely agreed with findings of Raj and Azeez (2010) ^[8]. Distributaries in the middle reach experienced relatively higher rainfall levels. Table 7 outlines the future projections for 2026 and 2031 derived from the CMIP5 climate model.

**Fig 7:** Historical data on monthly average rainfall across distributaries.

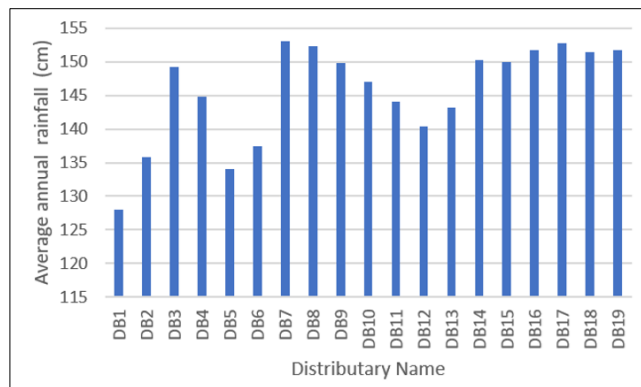


Fig 8: Historical data on average annual rainfall for distributaries

Table 9: Predicted monthly rainfall data for future periods PD1 (2026) and PD2 (2031).

Month	Rainfall (mm) PD1(2026)	Rainfall (mm) PD2 (2031)
January	1.2	1.7
February	5.7	229.0
March	58.6	60.4
April	109.9	100.9
May	185.5	110.4
June	449.7	229.9
July	263.8	193.5
August	215.6	94.8
September	126.4	114.8
October	121.8	101.2
November	86.1	76.2
December	15.7	134.2
Total	1640.0	1447.0

Rainfall peaked in June and reached its lowest point in January for both cases. Consistent with Raj and Azeez (2010) ^[8], the predicted year (PD2) exhibited an 11.7% decline in rainfall compared to PD1.

Conclusion

Geospatial database of distributary command of Gayathri irrigation project was created. This includes command area map, land use map, soil map and geospatial maps for various meteorological parameters maximum & minimum temperature, humidity, wind velocity, sunshine hour and rainfall for each distributary command. The analysis of spatial data revealed that Bhavani nagar soil series was most prevalent in the distributary command. Specifically, rainfall within the canal command one third of Kerala's annual average. The data indicates that southwest monsoon season accounts for the majority of the annual rainfall. In the canal command area, variations in maximum temperature were less pronounced than variations in rainfall. The head reach distributaries experienced maximum temperatures and minimal rainfall, confirming their location near the Western Ghats' Palakkad Gap rain shadow region.

Acknowledgement

Author express gratitude to major advisor Dr.Asha Joseph and Dr.Anu Varughese, advisory committee member and Department of irrigation and drainage engineering KCAEFT, Tavanur

References

1. Central Ground Water Board. Central Ground Water Board annual report 2013-14. New Delhi: Central

Ground Water Board; 2014. Available from: <http://cgwb.gov.in/Annual-Reports/Annual%20Report-2013-14.pdf>

2. Gülser C, Candemir F. Using soil moisture constants and physical properties to predict saturated hydraulic conductivity. *Eurasian Journal of Soil Science*. 2014;3:77-81.
3. Irrigation Research and Development Board. Irrigation Research and Development Board; 2020. Available from: <https://www.idrb-irrigation.org/>
4. Kesarwani M, Neeti N, Chowdary VM. Evaluation of different gridded precipitation products for drought monitoring: a case study of Central India. *Theoretical and Applied Climatology*. 2023;151:817-841.
5. Lekshmi GS, Saravanan E, Shaji PK. Cropping pattern of Palakkad district, Kerala, India. *Journal of Emerging Technologies and Innovative Research*. 2018;5(12):608-617.
6. Nandi S, Hansda T, Himangshu H, Nandi TP. Remote sensing: a miracle in irrigation management. *International Journal of Engineering Research*. 2016;1(5):215-219.
7. Patel NR, Pokhriyal S, Singh RP. Advancements in remote sensing based crop yield modelling in India. *Journal of Agrometeorology*. 2023;25:293-299.
8. Raj PPN, Azeez PA. Changing rainfall in the Palakkad plains of South India. *Atmosfera*. 2010;23(1):75-82.
9. Seema S, Dahiya R, Phogat VK. Investigation of hydraulic properties of soils varying in texture, organic carbon and soluble salt contents of arid and semi-arid regions. *International Journal of Current Microbiology and Applied Sciences*. 2019;8(4):2827-2838.
10. Shah R, Bharadiya N, Manekar V. Drought index computation using Standardized Precipitation Index (SPI) method for Surat District, Gujarat. *Aquatic Procedia*. 2015;4:1243-1249.
11. Surendran U, Sushanth C, Mammen G, Joseph EJ. Modelling the crop water requirement using FAO-CROPWAT and assessment of water resources for sustainable water resource management: a case study in Palakkad District of humid tropical Kerala, India. *Aquatic Procedia*. 2015;4:1211-1219.
12. Varughese A, Hajilal MS. Assessing long-term climate trends of Bharathapuzha Basin, Kerala, India. *International Journal of Ecology and Environmental Sciences*. 2016;42(2):119-124.