FINAL REPORT

FEASIBILITY STUDY FOR CONDUCTING WATERSHED EVALUATION – SRIPERUMBUDUR

Prepared for

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Executive Summary

This feasibility study, prepared by CII-Triveni Water Institute, investigates water availability, demand, and management strategies for the Sriperumbudur watershed in Tamil Nadu, covering the watershed's dynamic water requirements against the backdrop of rapid urbanization and industrial expansion. The study utilized CII's WATSCAN tool—a GIS and remote sensing-based Decision Support System—to assess water allocation, usage, and future sustainability, producing detailed recommendations for optimal water distribution, infrastructure improvements, and sustainable practices.

Project Background and Objective

The Sriperumbudur watershed is part of the Adyar River system, located in Tamil Nadu's Kancheepuram district. Characterized by significant industrial and agricultural activities, this area faces challenges in water distribution and availability due to increasing population density, urban growth, and seasonal climate variability. The primary objective of the study is to evaluate the watershed's baseline conditions, water availability, and user demand to formulate an efficient water allocation strategy that balances current needs with sustainable practices.

Methodology and Approach

1. **Site Reconnaissance and Stakeholder Engagement**: A preliminary visit in early 2024 involved meetings with stakeholders including district officials, agricultural departments, and water resource agencies. This engagement phase aimed to gather local data and establish a collaborative framework for the study.
2. **Data Collection and Analysis**: The study incorporated spatial data (e.g., topography, land use, and soil types) and non-spatial data (e.g., rainfall, temperature, and groundwater levels).

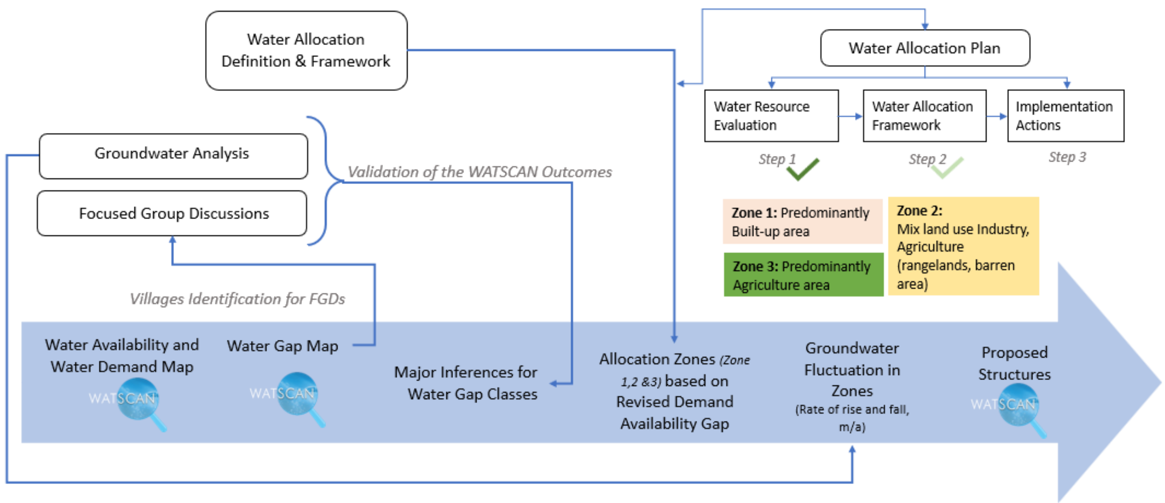


Figure 1: Project Approach

Data from multiple sources, including IMD and Sentinel-2 imagery, facilitated a detailed characterization of the watershed.

3. **Application of WATSCAN**: WATSCAN was employed to map water availability, water demand, and the demand-supply gap across the watershed. The analysis examined surface and groundwater resources, creating a detailed map of water availability zones and gaps.

Watershed Characterization and Water Assessment

1. **Topography and Drainage**: The watershed topography ranges from 6 to 163 meters above mean sea level. The presence of Chembarambakkam Lake, a major water body, contributes significantly to local hydrology. The watershed delineation identified 110 sub-watersheds, each playing a role in the region's drainage and water distribution.
2. **Land Use and Land Cover:** Analysis of land cover shows a diverse landscape with 34% built-up areas, 25% agriculture, 24% range grasses, and 8% water bodies. Built-up areas and industrial zones indicate high water demand and reflect ongoing land use transformation.
3. **Climate and Rainfall:** With an annual average rainfall of approximately 1297 mm, the area experiences significant seasonal variability. The northeast monsoon contributes the majority (54%) of annual rainfall. Data analysis over a 50-year period reveals substantial rainfall variability, affecting water availability across seasons.
4. **Soil Types and Water Infiltration**: Predominantly loamy and clayey soils exhibit high runoff potential and low infiltration rates, impacting water retention and influencing flood risks.

Key Outputs from WATSCAN

1. **Water Availability and Demand Mapping**: WATSCAN generated spatially detailed maps, identifying zones with high and low water availability, considering rainfall, topography, land use, and soil characteristics.
2. **Water Demand Gap Analysis**: The study categorized areas based on water demand-supply balance, distinguishing three classes—negative, marginal, and positive water gap areas. These classifications informed the zoning for water allocation and targeted intervention.
3. **Groundwater Trends**: A comprehensive groundwater analysis highlighted the influence of industrial and agricultural activities on groundwater levels, identifying specific areas with declining trends, especially in industrialized zones.

Agricultural and Household Surveys

1. **Agriculture Survey Findings**: Conducted across nine villages, the survey found that 91% of respondents rely on surface water for irrigation, with surface flow as the dominant irrigation technique. Paddy is the primary crop, and double cropping is common. However, irrigation and water conservation techniques are limited, with only 2% adopting drip irrigation.
2. **Household Water Use**: A separate survey with 300 households revealed that most respondents rely on municipal water sources, with minimal groundwater use. A majority (77%) reported no issues with water quality, though a portion experienced saline or turbid water. Rainwater harvesting systems are used by 30% of respondents.

Water Allocation Framework

The report outlines a water allocation framework based on revised water demand and availability, categorizing the watershed into three primary zones to optimize resource distribution:

1. **Zone 1**: Built-up and high-demand areas—characterized by significant water demand due to population density and industry. This zone prioritizes sustainable water use, conservation measures, and infrastructure improvements.
2. **Zone 2**: Mixed-use areas, including industrial and agricultural land—balanced in demand and supply but with potential for increased future demand. Recommended strategies include moderate water allocation and conservation programs to sustain local ecosystems.
3. **Zone 3**: Predominantly agricultural zones—experiencing low water demand relative to availability, this area is allocated higher water for ecological and conservation activities.

Groundwater Fluctuations and Water Gap Analysis

Groundwater monitoring data (2010-2023) aligned with WATSCAN's water gap classifications. Areas with negative water gaps exhibited high stress on groundwater resources, especially within industrial zones. Positive water gap areas maintained stable groundwater levels but faced risks from high runoff during monsoon seasons. This fluctuation analysis emphasized the need for tailored management interventions in each zone.

Existing and Proposed Structures

The report evaluated existing infrastructure for water management and identified additional structures to support groundwater recharge and sustainable water use. Proposed infrastructure includes:

1. Structures positioned along key drainage channels to optimize groundwater replenishment.
2. Increased focus on Zones 2 and 3 to support irrigation and manage potential agricultural expansion.
3. Infrastructure recommendations were guided by observed water gap areas and groundwater trends, aiming to support agricultural productivity while preventing over-extraction in stressed regions.

Conclusion and Way Forward

The Sriperumbudur watershed faces mounting pressure on its water resources due to industrial and population growth. The study's zoning strategy and proposed infrastructure are designed to address water scarcity, support groundwater recharge, and promote sustainable water use. The report highlights the importance of collective action among government, industry, and community stakeholders to manage these resources effectively over the next 10-20 years, ensuring water security for Sriperumbudur's diverse user base and protecting ecosystem health amid continued development.

Objective and Scope

Project Objective

The present study for Sriperumbudur watershed, in Kancheepuram district, Tamil Nadu, intends to undertake watershed level evaluation for the delineated Sriperumbudur watershed, for understanding baselines for estimation of water allocations across users in the defined watershed.[1] The study makes use of an integrated - Water Resource Evaluation and Planning Tool, CII's WATSCAN, for water demand assessment for the delineated Sriperumbudur watershed. WATSCAN is an IT-driven, GIS and Remote Sensing based Tool, used for demand-supply analysis to facilitate appropriate decision-making for an improved water scenario for a district.

Project Scope

Below are the components defined for the study on a macro level.

1. Component A: Preliminary Site Visit
2. Component B: Data Collection and Collation
3. Component C: Watershed Delineation, characterization, and outcomes using WATSCAN
4. Component D: Assessment of surface and dynamic groundwater resources

[1] Watershed is defined as an area with size 50,000-200000 hectares that is equivalent to 500-2000 sq km.

For details on the sub – tasks, refer to image below along with the timelines.

Table 1 Project Timeline

S. No	Activities	M1 Nov-23	M2 Dec-23	M3 Jan-24	M4 Feb-24	M5 Mar-24	M6 Apr-24	M7 May-24	M8 Jun-24	M9 Jul-24
	Project Kick-off meeting (virtual)	Δ								
	Workshop 1	ϕ								
I.	**Component A**									
a.	Reconnaisance visit - defining the project area									
b.	Stakeholder identification, select meetings									
II.	**Component B**									
a.	Data Collection, Collation									
b.	Data Synthesis									
III.	**Component C**									
a.	Conceptual Model Design - Hydrological Assessment Watershed Delineation & Characterisation				Δ ϕ					
b.	CII's WATSCAN Tool application - key outcomes									
c.	Model Calibration & Grid (micro watershed) Superimposition									
IV.	**Component D**									
a.	Water demand-supply (availability) analysis Gap assessment									
b.	Field visits and Focussed Group Discussions									
c.	Model refinement and Grid Superimposition									
d	Demand-Supply Re-analysis									
V.	**Detailed Project Report**									ϕ Δ

Δ Invoicing Milestone
ϕ Workshop (suggestive month)

DEFINING THE STUDY AREA

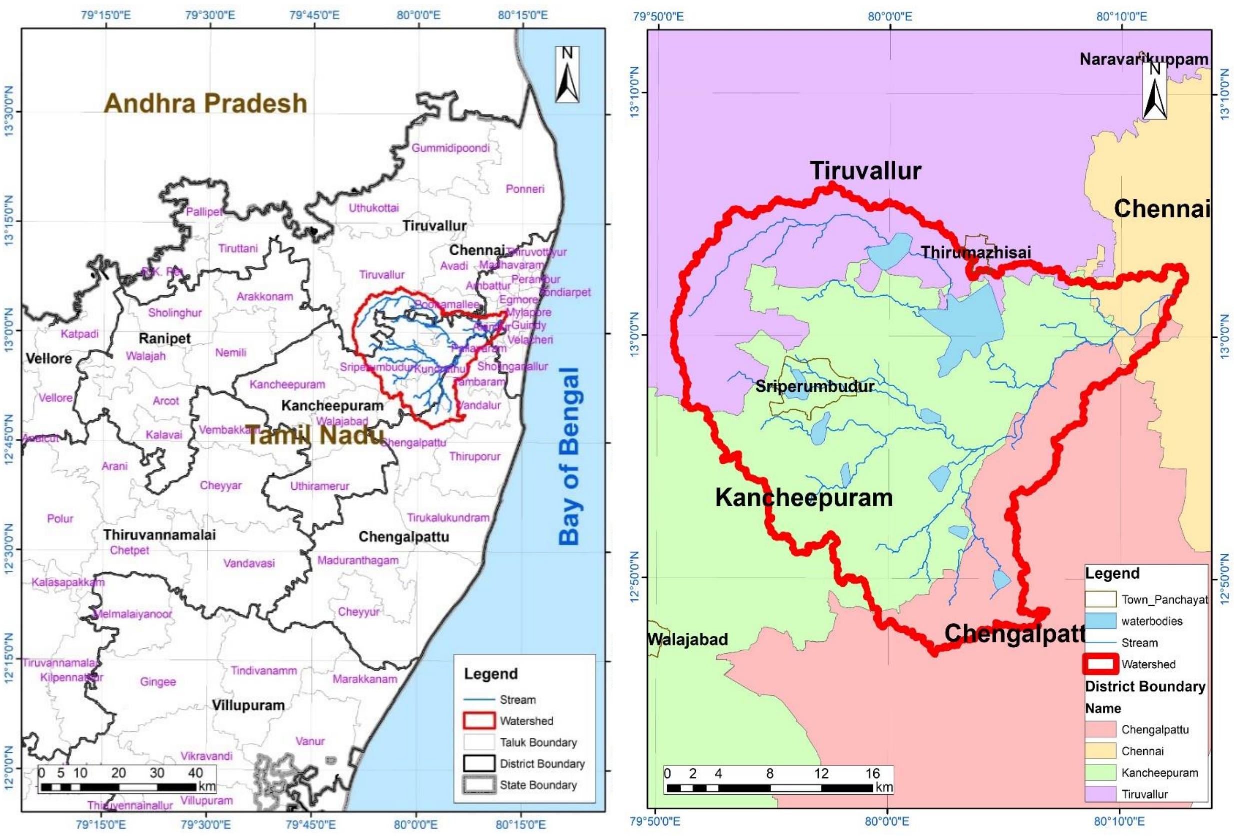


Figure 2: Geographical area and watershed boundary of Sriperumbudur.

Sriperumbudur also known as Thiruperumbudur, is a town panchayat and the headquarters of Sriperumbudur taluk located in Kancheepuram district of Tamil Nadu. It is located 40kms southwest of the capital city Chennai on the national highway 4, falling under the metropolitan area. Sriperumbudur is bounded by districts Kancheepuram, Chengalpattu, Thiruvellur and Chennai.

Sriperumbudur taluk has a total population of 510,836 as per the Census of India 2011. The total area of Sriperumbudur according to the land use categorisation, is 31772.85 ha, of which 21.74% is cultivable area and 79.56% is irrigated area to the total cultivable area[2]. Kancheepuram is one of the fastest growing industrial districts in Tamil Nadu. The total area of the district is 4615.71 sq.km (Rural: 380038.1 hectares and Urban: 66459.3 hectares).

[2] District census Handbook 2011: Kancheepuram <Source: https://censusindia.gov.in/census.website/>

PROJECT APPROACH

ABOUT WATSCAN

CII's WATSCAN is a GIS and Remote Sensing based integrated decision support system (DSS) framework for water resources evaluation. WATSCAN integrates components of the land phase of hydrological cycle with groundwater and hydro chemical components on a basin or subbasin-wide basis. To accomplish this, the modules that constitute WATSCAN DSS framework for integrated hydrological-hydro chemical-groundwater quality model have been carefully chosen to make it distributed in space, comprehensive, continuous in time, and conceptual. In keeping with the above, WATSCAN simulates the land phase of the hydrological cycle from SWAT ArcView GIS version, which is a physically based, time continuous model to obtain groundwater aquifer recharge and contaminant loadings in various components of runoff. Further, groundwater module and groundwater quality module for simulating contaminant concentrations in groundwater aquifers make use of MODFLOW and MT3D (a companion software of MODFLOW). In addition, complex processes such as nitrification and denitrification in the unsaturated zone make use of Michaelis-Menten mixed-order kinetics. These modules constitute a framework for integrated hydrological-hydro chemical-groundwater quality model.

WORKING OF DSS FRAMEWORK

WATSCAN DSS framework helps predict the impact of management decisions on water, sediment, and contaminants in watersheds, as well as groundwater aquifers. This interaction between groundwater and surface water in watersheds has significant impacts on water rights. DSS framework uses the water balance approach of Soil & Water Assessment Tool (SWAT) to simulate components of the land phase of hydrological cycle or watershed hydrologic partitioning. The water balance is calculated considering precipitation, soil, shallow aquifer, and deep aquifer components. Groundwater limits for the integrated DSS correspond to those of the surface water basin/ subbasin. These boundaries are designated as no flow boundaries. Laying out the grid mesh over basin/ sub-basin is the starting point using groundwater model MODFLOW and its companion software MT3D. The input packages to groundwater model are linked with the land phase of the hydrological cycle and include recharge, wells, and contaminant loadings. Recharge rates are passed from SWAT HRUs to the MODFLOW grid, and groundwater-surface water interactions simulated by MODFLOW are passed to SWAT subbasins. The well package simulates pumping or injection wells. In the centre of each grid cell is a node: the point at which hydraulic head is estimated. Groundwater quality using MT3D module further works as an extension

of the groundwater and land phase of the hydrological cycle models, where the inputs to this module are linked to outputs of the land phase of the hydrological cycle as well as groundwater model and include contaminant loads such as those that are leached from land-based application of excess fertilizers, groundwater discharge, and hydraulic heads as continuous outcomes. This makes use of advective–dispersive-decay solute transport as a starting step for the grid-wise formulation of this module.
DSS Framework is successfully loaded on GIS platform that helps combine database management, undertake geostatistical analysis, graphical display, and serves as an integrated environment in which field data are analysed and checked, and the integrated model is formulated and operationalized.

APPLICATIONS

WATSCAN DSS framework has been widely implemented across various geographies in India for various kinds of evaluations such as a) siting of green field projects, infrastructure projects; b) source evaluation and protection; c) water resource evaluations; d) identification of strategies (both supply side and demand side) for water security in watersheds; e) smart cities; f) fate and transport of contaminants; f) contaminant source apportionment etc.
Input databases have been customized and integrated with readily available databases. Major inputs to the integrated model can be categorized into spatial and non-spatial data. Spatial datasets pertain to topography, land use, aquifer, and soil type. Non-spatial inputs include data on weather, soil properties, land use/cover characteristics, groundwater levels, fertilizer use, crops, water demands, contaminant loads etc.

Activities under Components A, B, C and D

Component A: Reconnaissance Visit and Stakeholder Meetings

The reconnaissance site visit and stakeholder meetings were the initial steps in understanding the study area's context and engaging relevant stakeholders for conducting feasibility study in Sriperumbudur town. During the reconnaissance visit, the project team gathered essential data and information about the project areas, demography, water supply distribution, agricultural landscape, and industrial activities. Interactions with key government departments, such as the Indian Meteorological Department and the Water Resource Department, provided valuable insights on rain gauge stations, rainfall patterns, water availability, and distribution. Additionally, meetings with industrial development corporations shed light on industrial activities and their impact on water consumption patterns. Following the reconnaissance visit, the stakeholder meetings brought together diverse stakeholders to discuss project objectives, gather inputs, for fostering collaboration.

Departments visited for collection of information during the visit in January 2024.

1) District Collector Office, Kancheepuram
2) Department of Agriculture & Horticulture, Kancheepuram
3) Department of Animal Husbandry
4) Department of Economics & Statistics, Kancheepuram
5) Revenue office, Kancheepuram
6) Indian Meteorological Department, Regional Meteorological Centre, Chennai
7) Water Resource Department (Surface Water), PWD, Palar Basin Circle, Chepauk, Chennai
8) Water Resource Department (Ground Water), PWD, Tharamani, Chennai
9) Tamil Nadu Industrial Development Corporation Limited (TIDCO), Egmore, Chennai
10) State Industries Promotion Corporation of Tamil Nadu (SIPCOT)

Glimpses of Site Visit

Figure 5 District collector office, Kancheepuram

Figure 3 IMD Regional Office

Figure 4 Horticulture Department, Kancheepuram

COMPONENT B: DATA COLLECTION, COLLATION AND DATA SYNTHESIS

The study evaluation is based on various physical characteristics of the watershed. Major data inputs considered for the assessment can be categorized into spatial and non-spatial data sources. Spatial datasets pertain to topography, land use, and soils, processed from various satellite and available secondary databases. Non-spatial datasets include data on weather (rainfall, temperature, humidity, and wind direction), soils, land use/ cover characteristics, water use and demands. The table below provides an insight of the type of data and the sources from where it is obtained.

Table 2: List of data and sources

Type of Map	Source
Administrative Boundary	Tamil Nadu Geographical Information System (TNGIS) Tamil Nadu e-Governance Agency (TNeGA)
Socio-Economic	Census of India
Village Boundary	Census of India, Survey of India
Landuse	Multiple Sources
Built-up	Sentinel-2 LULC
Industrial	Google and National Atlas and Thematic Mapping Organization (NATMO)
Agriculture	Sentinel-2 LULC, IWMI - GIAM, NATMO
Water Bodies	Sentinel-2 LULC, Google
Rainfall	India Meteorological Department
Temperature	India Meteorological Department
Soil	FAO, NATMO
Topography	SRTM
Slope	DEM
Groundwater & Rainfall Data	State Ground and Surface Water Resources Data Centre, Tharamani, Chennai

Component C: Watershed Delineation, Characterization, and Outcomes Using WATSCAN.

As mentioned in the section above, the study makes use of CII's WATSCAN Tool, an integrated Decision Support System (DSS) that derives information from satellite sources and available secondary datasets in a digitized format. WATSCAN is physically based, uses readily available inputs, is computationally efficient for use in large watersheds, and can simulate long-term yields for determining impact of land management practices.

WATSCAN has been applied in this project for estimating various components of the land phase of the hydrological cycle. It provides, an integrated and holistic understanding of water scenario in the area. Land use changes may have strong influence on runoff generation and water availability in an area.

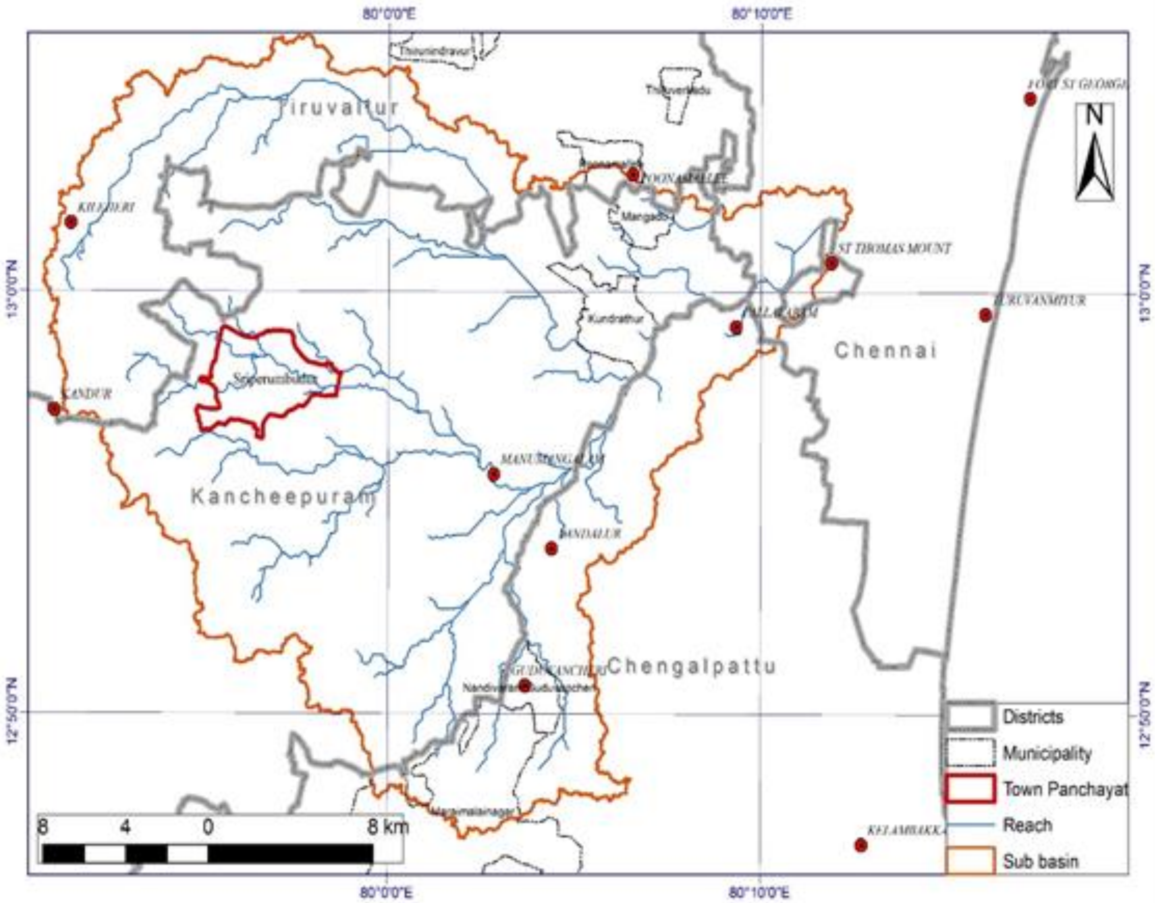


Figure 6 Delineated Watershed of Sriperumbudur town

Watershed Delineation

Sriperumbudur's geographical area of delineated watershed is 768 sq. km. It is a part of Adyar River system. The delineated watershed map represents the geographical and hydrological area (Refer to Figure 5).

Boundary Lines delineate the outer edges of the watershed, usually following natural features such as ridgelines or high points were water flows in different directions. Rivers, streams, lakes, and other bodies of water within the watershed are indicated, illustrating how they are interconnected and how they receive runoff from the surrounding land. Drainage patterns, flow direction, and watershed sub-basins are included to illustrate the movement of water within the watershed and its tributary systems. There are 110 sub watersheds in Sriperumbudur (Refer to Figure 6).

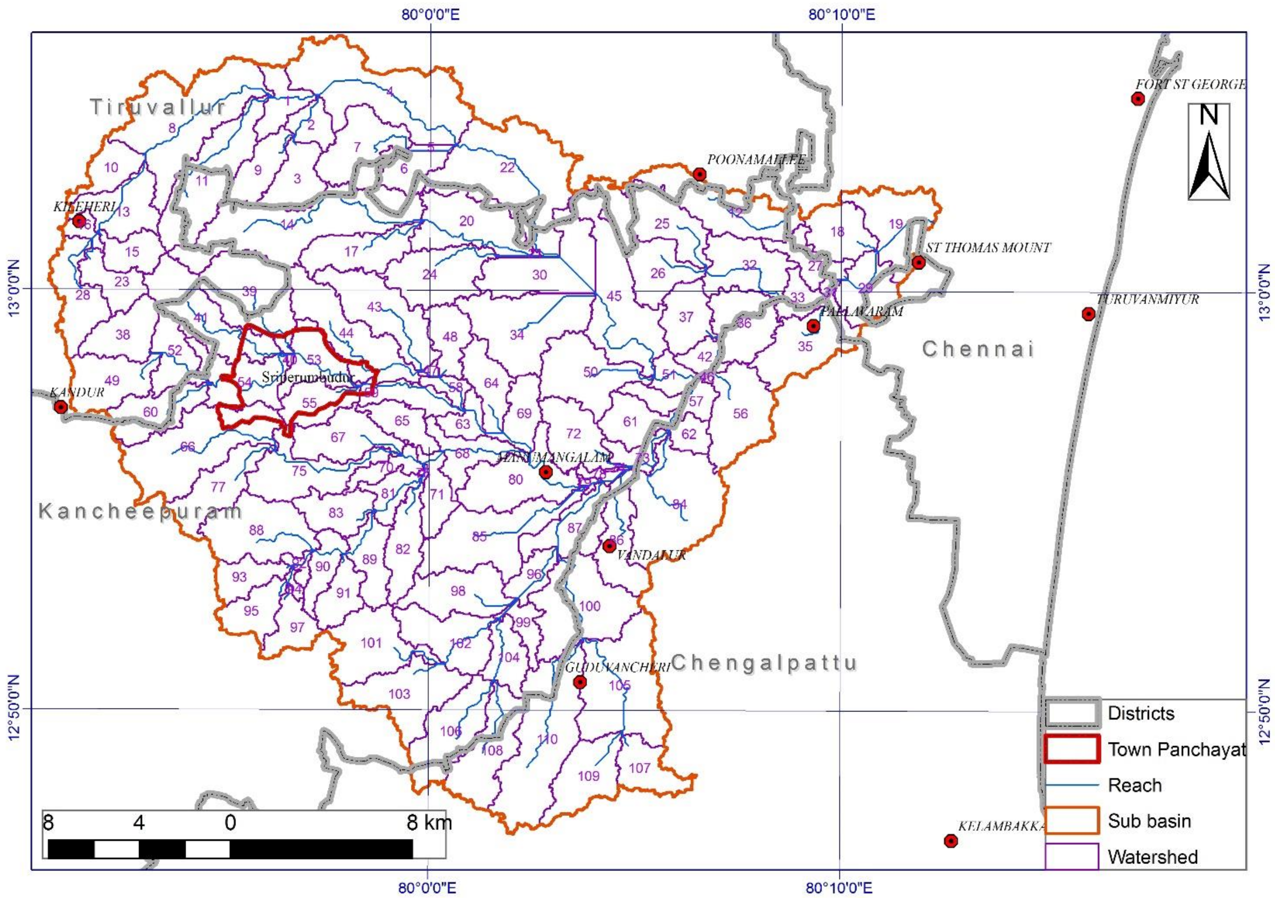


Figure 7: Delineated plant's watershed, showing major drainage, sub-watershed and administrative boundary of Sriperumbudur town.

WATERSHED CHARACTERIZATION

Detailed characterisation of Sriperumbudur's watershed addressing topography, drainage, soils, landuse and hydro-meteorological parameters such as rainfall, temperature, was undertaken to assess the water scenario of the watershed.

TOPOGRAPHY AND DRAINAGE

Topographical assessment was undertaken for the Sriperumbudur. Topographical features like elevation contours, hills, valleys, and other landforms are depicted to show the terrain of the watershed, which influences the flow of water within it.

The Digital Elevation model (DEM) (a function of topography and slope) for the town was developed to delineate the sub basins using the satellite. The topography shows elevation between 6m amsl to 163m amsl. Higher elevations observed towards west and northwest part, lower elevations towards northeast part (Refer to Figure 7). Watershed is fed by several water bodies. Chembarambakkam Lake is a major waterbody in Sriperumbudur watershed.

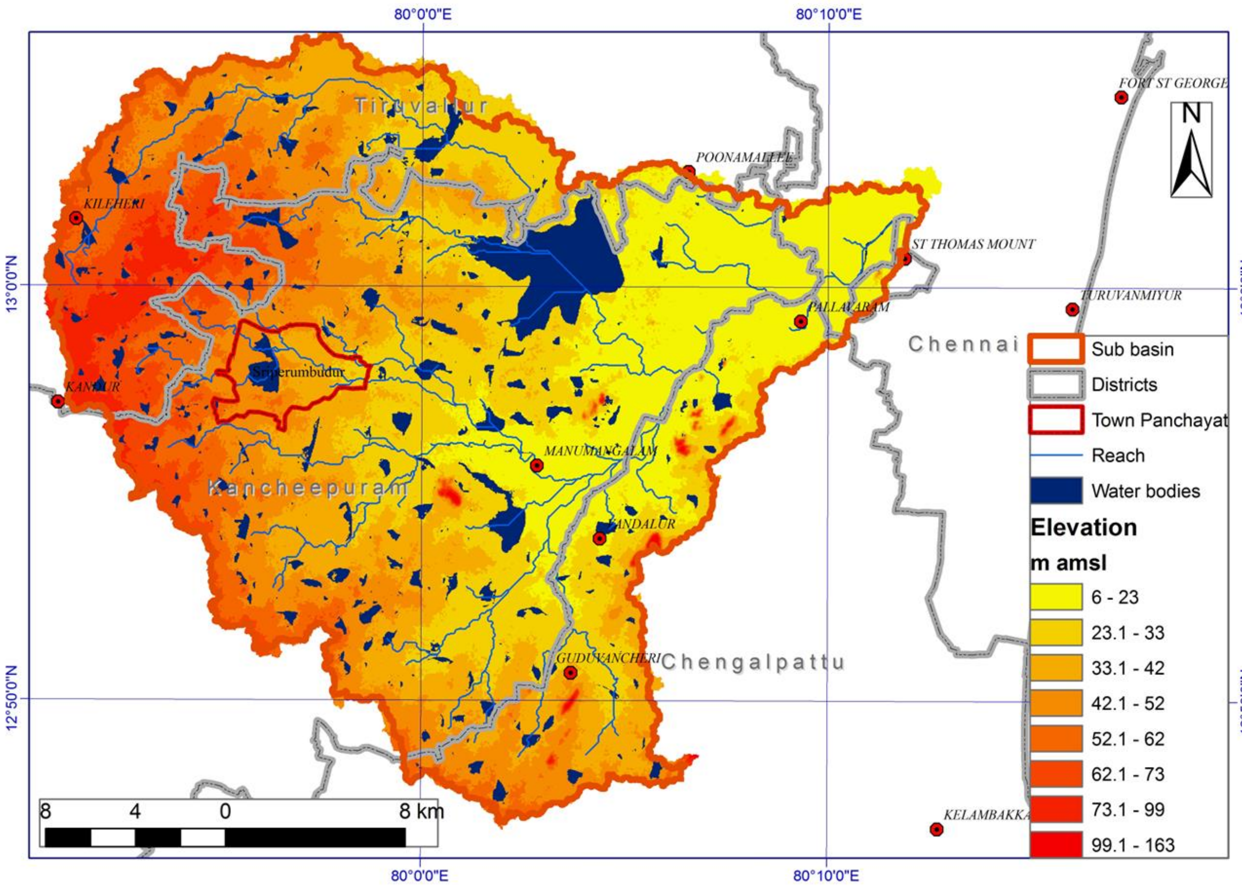


Figure 8 :Topography and Drainage of Sriperumbudur town

Source: SRTM 30M RESOLUTION data

LANDUSE AND LANDCOVER PATTERN

Land cover is that which covers the surface of the earth. Land cover includes water, grassland, forest, bare soil, etc.

Land cover refers to the surface cover on the ground, whether vegetation, urban infrastructure, water, bare soil, or other. Identifying, delineating, and mapping land cover is important for global monitoring studies, resource management, and planning activities. Identification of land cover establishes the baseline from which monitoring activities (change detection) can be performed and provides the ground cover information for baseline thematic maps (Refer to Figure 8).

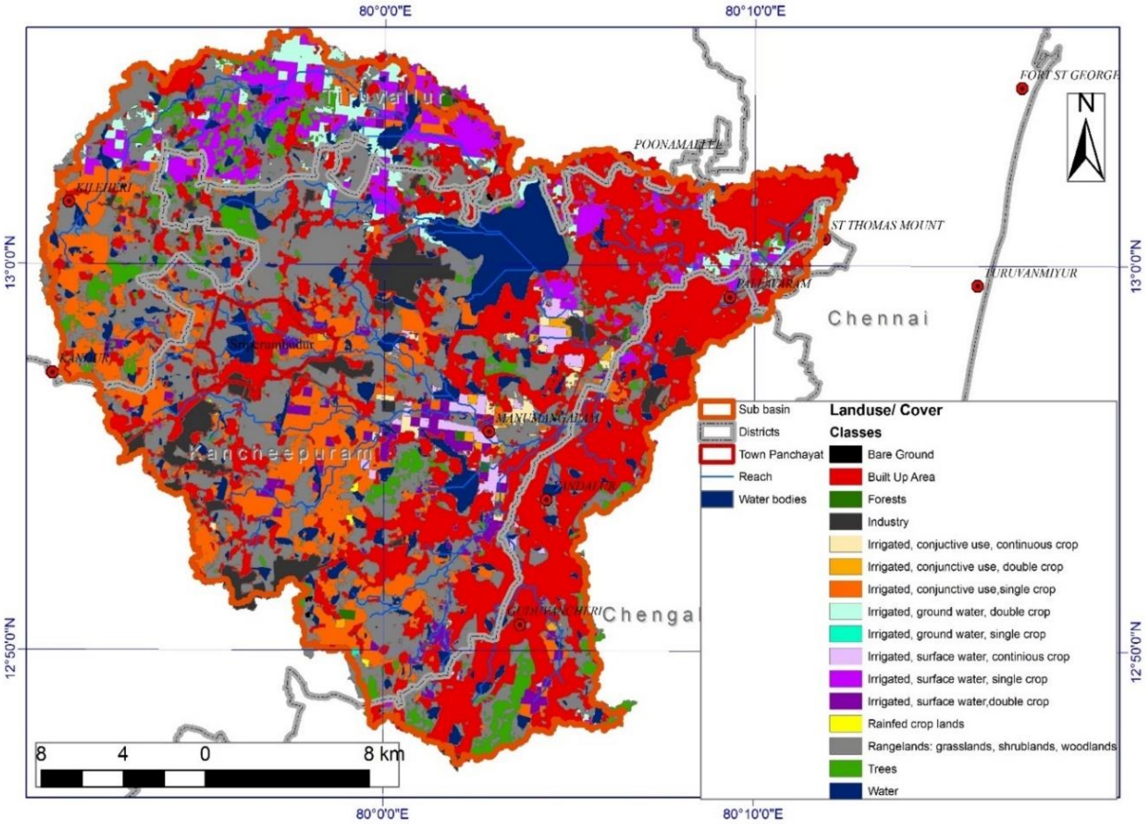


Figure 9 :Landuse and landcover pattern of Sriperumbudur town

Source: Sentinel-2 data (2022)

Landuse characteristics of a given area have a significant impact on hydrological behaviour. Extent and type of vegetation and soil types are important hydrological determinants. In this watershed area, the distribution of land cover is diverse, with built-up areas constituting 34% of the total landscape. Agriculture occupies 25% of the watershed, while range grasses cover 24%, reflecting significant land use for farming and pastoral activities. Water bodies, including rivers, lakes, and ponds, account for 8% of the watershed area, providing critical aquatic habitats and water resources. Forested areas, comprising 5% of the landscape, play a vital role in biodiversity conservation and ecosystem services. Additionally, industrial zones cover 4% of the watershed, supporting economic activities and development (Refer to Figure 9,10 and 11). The following maps depict the distribution of land use of built-up area, industry, and agriculture within the watershed area.

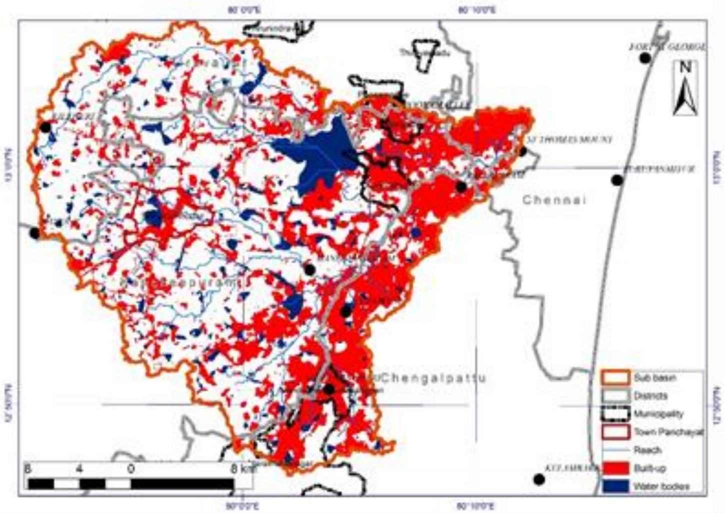


Figure 11:Landuse- Built-up area

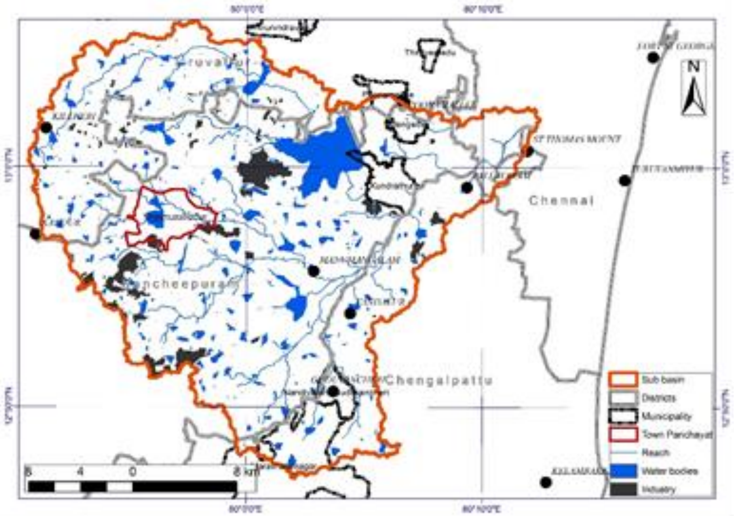


Figure 12:Landuse- Industry

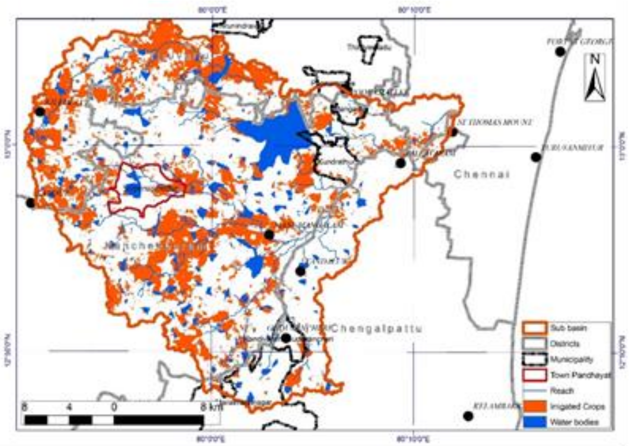


Figure 10: Landuse - Agriculture

SOILS

The hydrological evaluation also calls for an estimation of water infiltration as rainfall rates exceeding infiltration produce runoff. A point-by-point measurement of infiltration across the watershed is not viable. Hence, mapping of soil units has been done to estimate the infiltration rates. Soil data for the district was obtained from digitised FAO soil database, supported by information available from National Bureau of Soil Survey & Land Use Planning NBSS&LUP and secondary literature.

Soils in the watershed are predominantly loam and clay loam soils. These soils have high runoff potential and low infiltration rates (Refer to Figure 12).

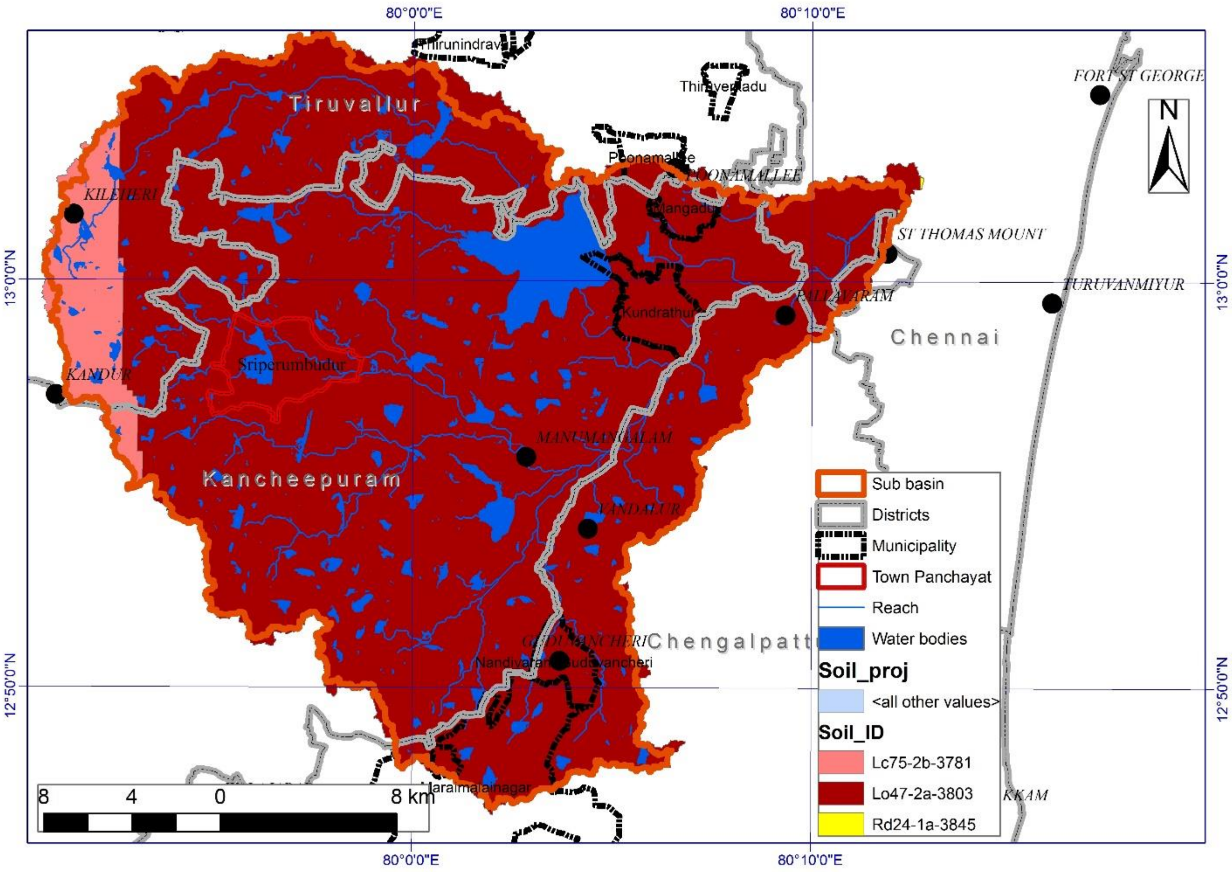


Figure 13:Soil Type in Sriperumbudur Watershed

CLIMATE

The hydrological flows for a watershed are dependent on a very crucial parameter—rainfall. The spatial and temporal variability in rainfall leads to variability in flows depending on physical factors as explained in the preceding sections—topography, land use and soil properties. These together and interactively (dynamically) help in determining the watershed's spatial-temporal availability of flows and various components of the land phase of hydrological cycle.

The climate is normal during winter but very hot in summer in the district. Maximum temperature has been recorded in May and minimum temperature has been recorded in January. In 2009-10, maximum temperature of the was 20.8ºC[3]

RAINFALL

The pre-monsoon rainfall is almost uniform throughout the district. The coastal regions get more rain rather than the interior regions. This district is mainly depending on the seasonal rain, the distress conditions prevail in the event of the failure of rain.

Northeast and southwest monsoon contribute rainfall of 54% and 36% respectively to the total annual rainfall[3]. The highest rainfall was observed in the year 2021 with 1698.2 mm and lowest was 833mm in the year 2018[3]. Table 4 shows the annual rainfall for the district over the 5-year period (2018-2022).

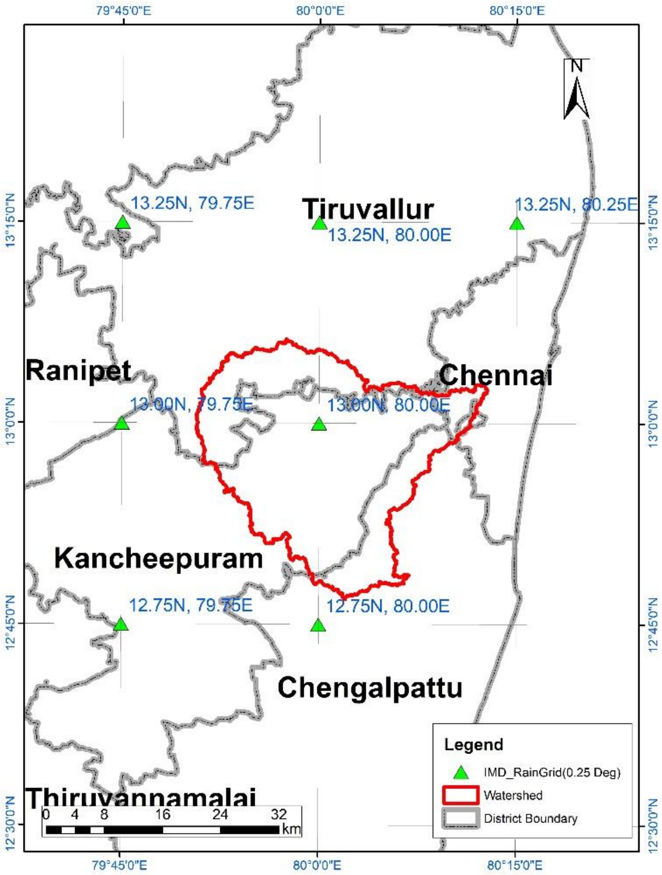


Figure 14 :Rainfall Grids (IMD) for Kancheepuram District

[3] District census Handbook 2011: Kancheepuram

The following databases were considered for analysing rainfall patterns in the watershed.

- Daily rainfall gridded dataset (0.25X0.25 Grids) for 3 representative grids from India Meteorological Department for 1971-2022
- Long-term monthly rainfall data of Kancheepuram district from IMD Climatological Tables (2018-2022)

The IMD grid-based rainfall analysis shows the area receives an annual average rainfall of about 1297 mm, with a coefficient of variation (CoV) of about 31% (Refer Table 3).

Analysis of IMD daily gridded data analysed for 3 grids (0.25X0.25) over the period 1971 -2022 shows,

- Rainfall varied between 495.5 to 2396.5 mm across the area.

The analysis of IMD's long term monthly rainfall table shows rainfall for Kancheepuram district from 2018-2022, indicating that almost 79.7% of the rainfall is received during the months of June to November, with November showing maximum rainfall (Refer to Table 4).

Table 3:Rainfall Analysis -IMD Grids

Sl. No	IMD Grid	Lowest annual rainfall (mm)	Highest annual rainfall (mm)	Normal Rainfall(mm)	Coefficient of Variation (%)
1	12.75N, 80.00E	736.8	2418	1299	27%
2	13.00N, 79.75E	650.0	2346	1207	36%
3	13.00N, 80.00E	664.6	2425	1386	29%
	Average	495.5	2397	1297	31%

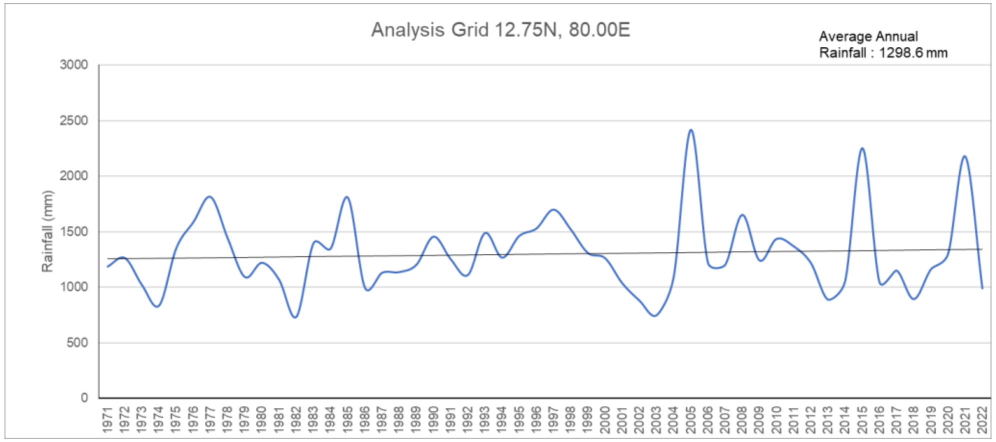
Table 4: Annual rainfall data (in mm) for 2018-2022

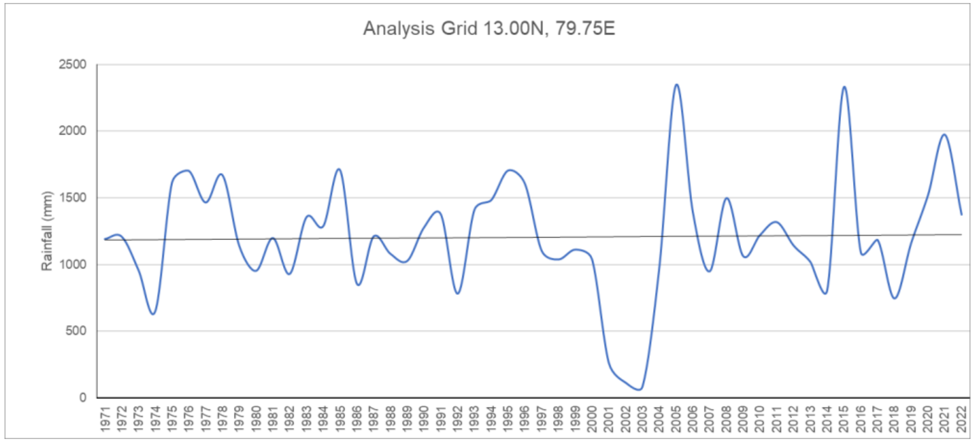
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2018	2.6	1.8	7.9	0.4	6.2	51.1	64.8	189.7	91.4	133	241.1	43.0	833.0
2019	0.2	0.3	0.1	2.7	5.6	39.3	150.7	130.9	108.8	303.3	205.6	184.1	1131.6
2020	45.3	0.7	0	12.7	0	47.6	203.4	51.1	110.7	152.3	392.1	218.7	1234.6
2021	100.7	6.7	0	23	55.1	43.7	194.1	143.4	136.3	233.7	660.1	101.4	1698.2
2022	52.9	0	0.2	6.0	128.4	96.2	105.9	145.5	69.1	155.0	374.7	270.7	1404.6
Avg	40.34	1.9	1.64	8.96	39.06	55.58	143.78	132.12	103.26	195.46	374.72	163.58	1260.4

The IMD gridded rainfall data was superimposed on the delineated plant watershed to understand the rainfall characteristics within the watershed and the same has been represented in Figure 13.

Table 5:Long-term monthly rainfall data from IMD Grids (1971-2022)

Sl. No	IMD Grid	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	CoV
1	12.75N,80.00E	26.3	13.9	7.7	15.9	37.4	56.3	94.3	131.7	120	260.6	367.1	167.7	1298.6	27%
2	13.00N,79.75E	18	12.2	5.5	19.3	39.4	70.5	108.1	130.8	138.7	221.3	293	150	1206.7	26%
3	13.00N,80.00E	25.4	14.1	6.9	17.2	42.3	74	112.5	137.7	138.3	264.2	382.3	170.6	1385.5	29%





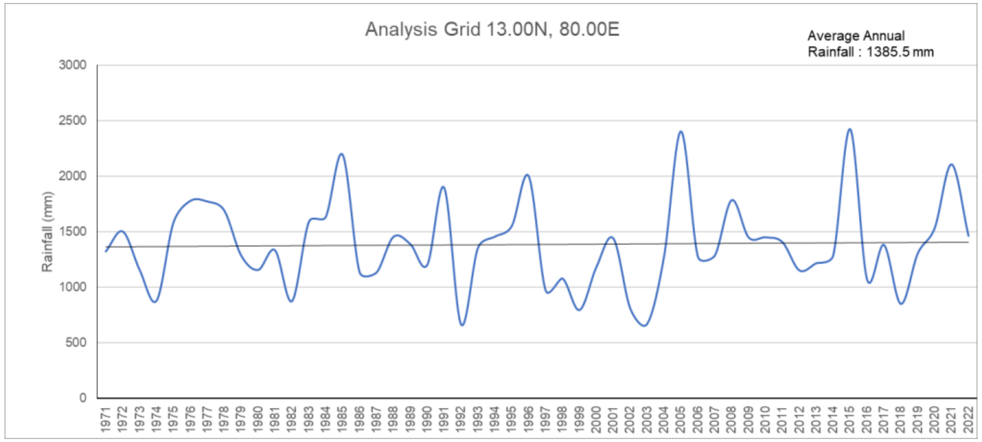


Figure 15: Analysis of Rainfall (IMD Grids)

Source: IMD Grid

Rain Gauge Data

The data presented in this section has been sourced from the State Ground and Surface Water Resources Data Centre, Tharamani, Chennai which is responsible for monitoring and managing the rain gauge stations (locations depicted in Figure 16). The data procured was analysed to understand the rainfall distribution of total 13 rain gauge stations w.r.t coefficient of Variation and average annual rainfall. From the figure, it can be observed that there are total of 6 rain gauge stations located within the watershed namely, Sriperumbudur, chembarambakkam, Padappai, Tambaram, Meenambakkam and Korattur Anicut.

Table 6 Rain gauge location details

Sr	District	Station Name	CoV %	Average Annual Rainfall, mm
1	Chengalpattu	Tambaram	40.63	1191.77
2	Chengalpattu	Chengalpattu	40.97	1319.61
3	Chennai	Chennai_Meenambakkam	27.59	1569.52
4	Chennai	Chennai -Nungambakkam	30.65	1476.59
5	Chennai	Chennai - Tharamani	29.43	1434.62
6	Chennai	Chennai _ Mylapore Dgp Office	31.98	1566.61
7	Chennai	Chennai Egmore	35.83	1517.35
8	Kancheepuram	Chembarambakkam	33.28	1417.79
9	Kancheepuram	Padappai	40.34	1478.31
10	Kancheepuram	Sriperumbudur	37.50	1367.10
11	Thiruvallur	Korattur Anicut	36.79	1245.24
12	Thiruvallur	Kesavaram Anicut	34.70	1155.07
13	Thiruvallur	Thiruvallur	45.65	1361.67

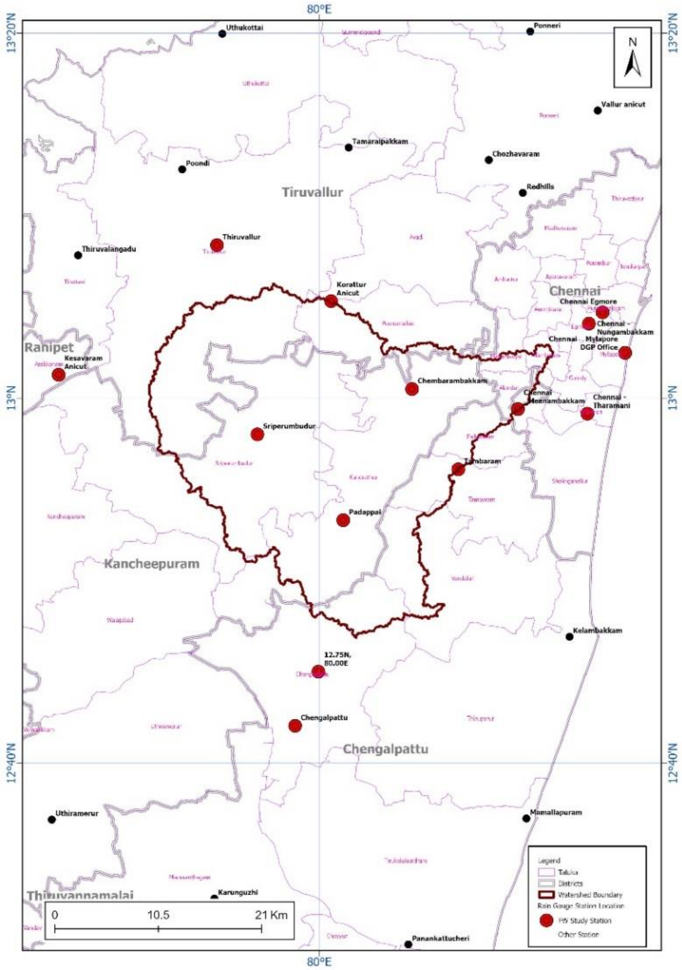


Figure 16 Rain gauge station location map.

Component D: Key Outcomes Of WATSCAN Application

Water Availability Map

The outcome identifies pockets of water surpluses and scarcity. It is the total amount of water leaving the Hydrological Response Unit (HRU) and entering the main channel during the time step.

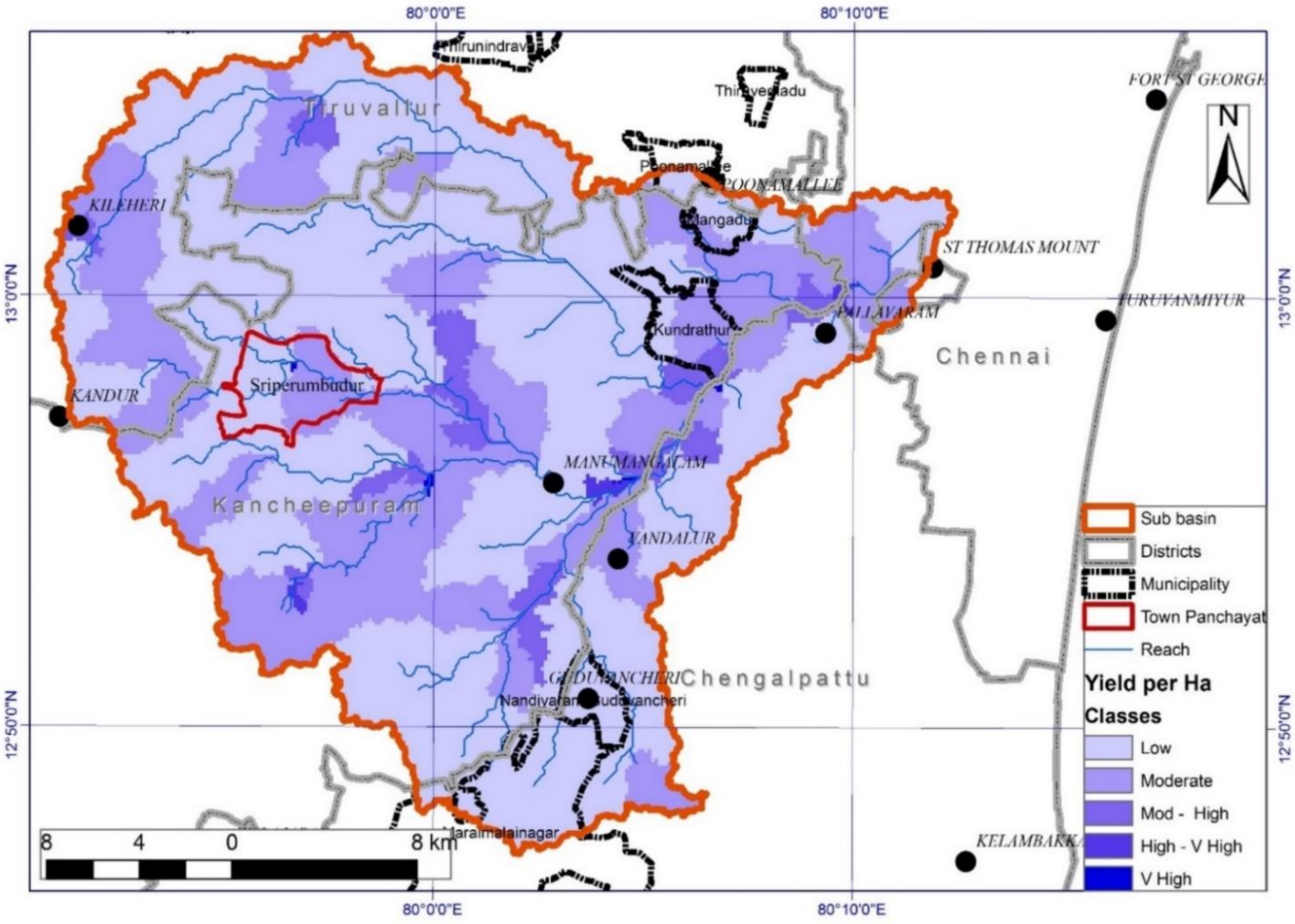


Figure 17 : Water availability map.

Application of WATSCAN produces spatial and temporal outcomes achieved in digital formats and map layouts created at a scale that is comprehensive and visually understandable. This involves assessment of millions of pixels of information and data synthesised.

The adjacent map shows pockets of high and low water availability (generation). This is the WATSCAN outcome that involves interplay of various parameters such as rainfall, topography, slope, landuse, soils, and climate parameters.

Water Demand map

The analyses determine areas of high-water demand.

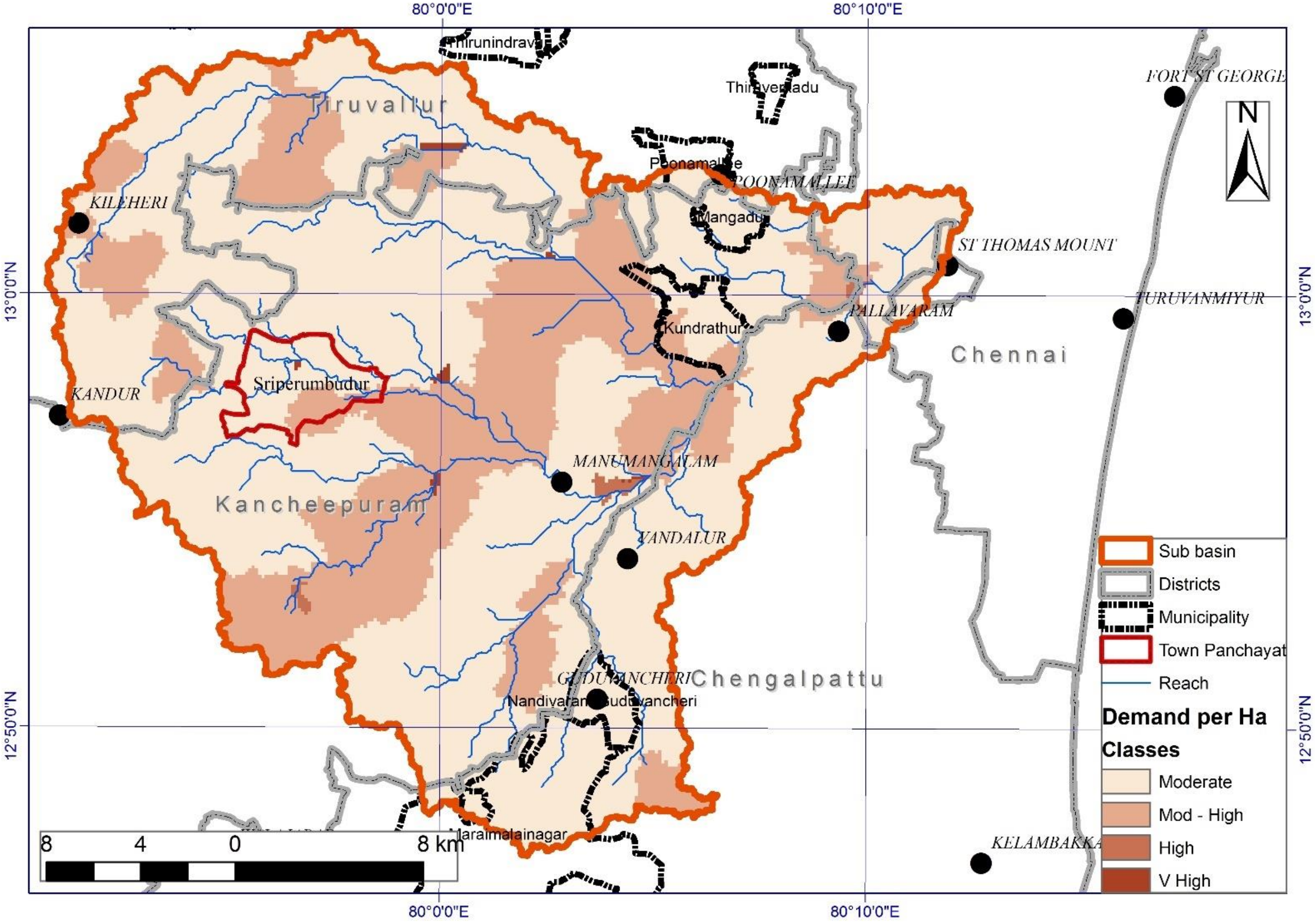


Figure 18: Water demand map

Water Demand in the delineated watershed (Refer to adjacent Figure 17) is based on distribution of various economic activities in the watershed.

WATER AVAILABILITY AND WATER DEMAND GAP ASSESSMENT

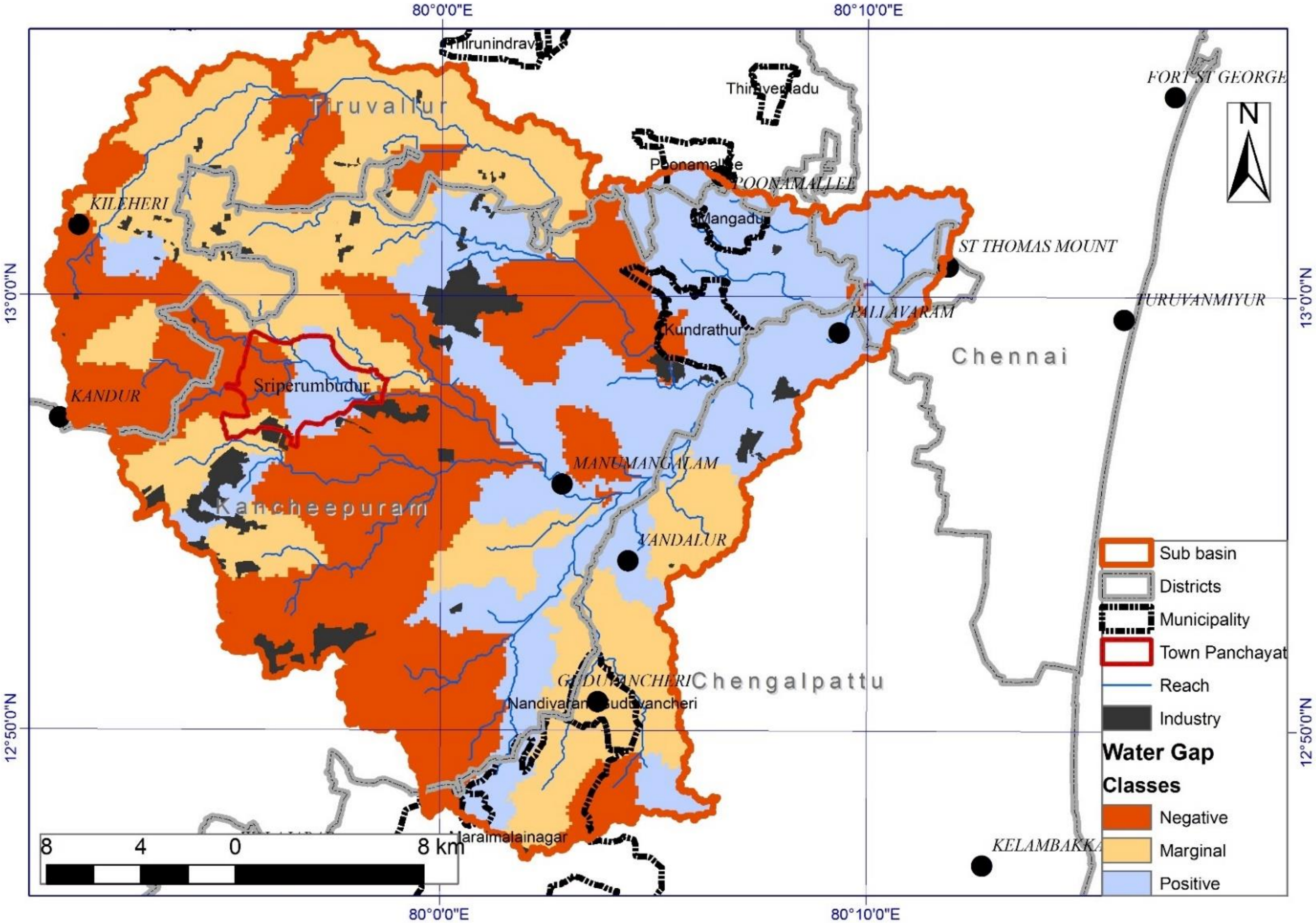


Figure 19: Water availability and water demand gap assessment map

Based on the water availability and water demand assessment in the delineated watershed (Refer to adjacent Figure 18) the water demand gap was assessed.

Based on the three outcomes outlined previously, along with additional parameters depicted in below (Refer to Figure 19), the study centres on three key water demand sectors: Industry, Agriculture, and Built-up areas. It also considers water gap classifications: Negative, Marginal, positive[4]. Another aspect under examination is the topographical and geographical positioning of villages in relation to upstream, downstream, and areas around town. Specific villages have been identified for on-ground surveys & focused group discussions (Refer to Figure 19)

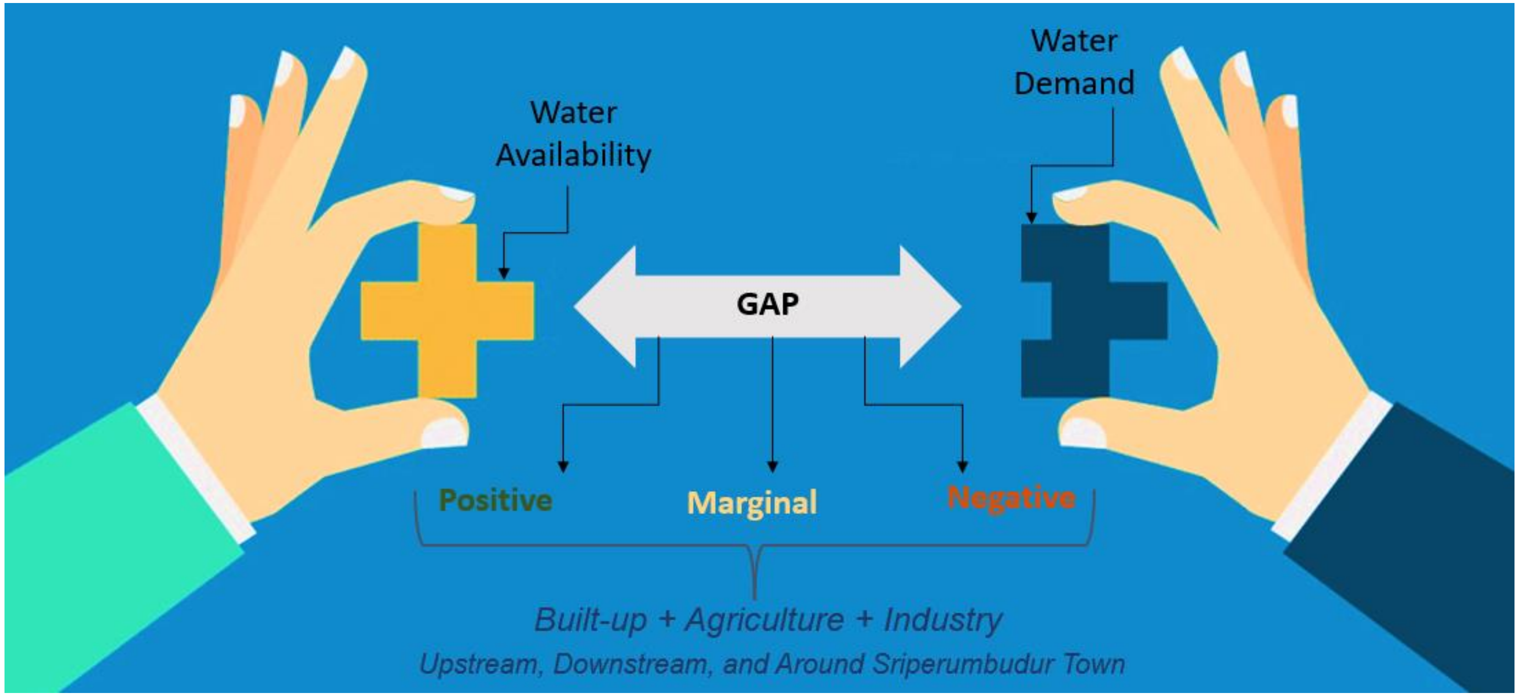


Figure 20: Parameters of gap assessment.

[4] Water Gap mm/ha = Yield/ha – Demand/ha
Negative Water Gap Areas: -80 mm/ha to -0.05 mm/ha
Marginal Water Gap Areas: -0.05 mm/ha to 0.13 mm/ha
Positive Water Gap Areas: 0.13mm/ha to 13.97 mm/ha

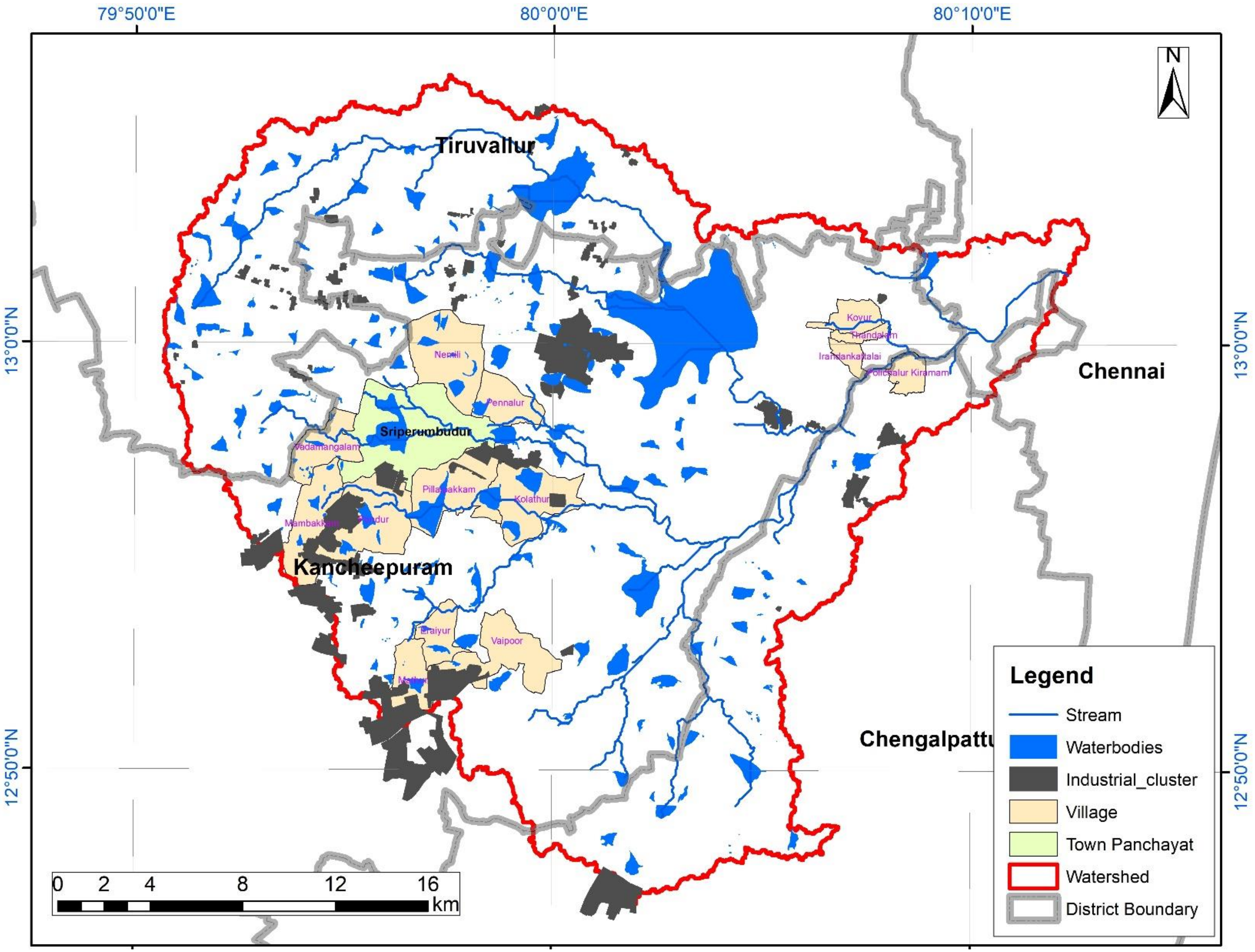


Figure 21: Selected villages for on-ground surveys and FGDs

Priority Villages
Nemili
Pennalur
Kolathur
Pillaipakkam
Pondur
Mambakkam
Vadamangalam
Mathur
Eraiyur
Vaipoor
Kovur
Thandalam
Irandankattalai
Polichalur Kiramam

GROUNDWATER ANALYSIS

The data presented in this section has been sourced from the State Ground and Surface Water Resources Data Centre, Tharamani, Chennai which is responsible for monitoring and managing groundwater resources across the state. This data includes observations from various wells spread across the watershed (Table 7). The primary focus is on assessing the groundwater trends over time and comparing it with the overall water availability across different regions within the watershed.

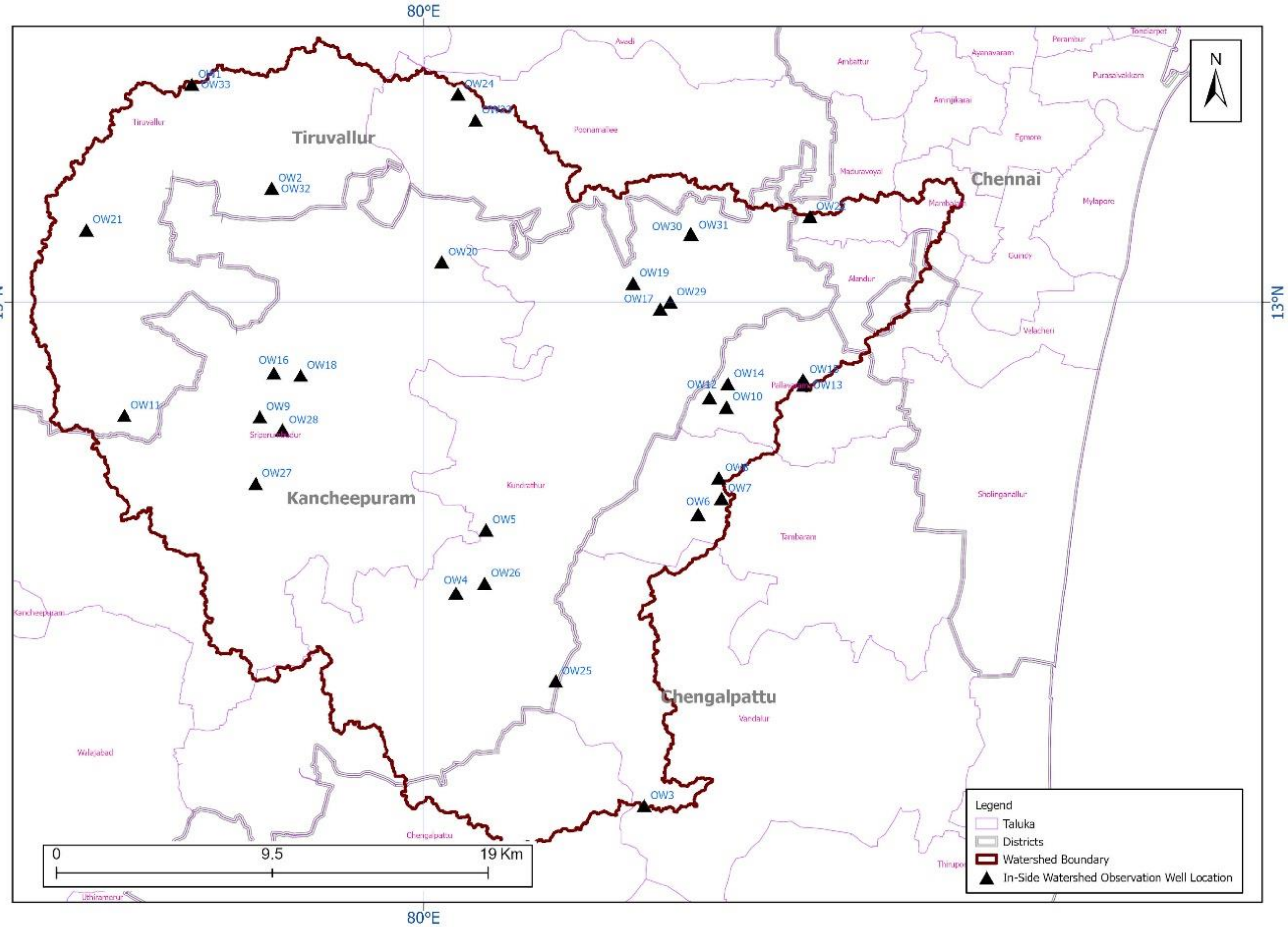


Figure 22 Groundwater monitoring well location map

Analyses of the data from the observation wells for the period 2010 to 2023 within the watershed (Refer to Figure 21), provides valuable insights which corelates well with the WATSCAN outcome (Water Demand Gap – Figure 18) . The watershed is divided into distinct zones based on water gap analysis (Refer to Figure 18), categorized as Positive, Marginal, and Negative water gaps. These classifications provide a clear understanding of the areas where water is either sufficient, on borderline, or inadequate.

Table 7 Monitoring well details

WELL CODE (ASSIGNED)	Well, No (As Per Dept.)	Latitude (N)	Longitude (E)	Well Type	District	Taluk	Block	Village
OW1	New (mnr)	13.08667	79.90833	Bore Well	Thiruvallur	Thiruvallur	Kadambathur	Melnallathur
OW3	OW124806800514	12.80167	80.08722	Dug Well	Chengalpattu	Chengalpattu	Kattankulathur	Kannivakkam
OW4	OW125308800046	12.88556	80.01278	Dug Well	Kancheepuram	Sriperumbudur	Kundrathur	Salamangalam
OW5	OW125438800129	12.91056	80.02472	Dug Well	Kancheepuram	Sriperumbudur	Kundrathur	Padappai
OW6	OW125500800631	12.91667	80.10861	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Irumbuliyur
OW7	OW125523800704	12.92306	80.11778	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Tambaram
OW8	OW125552800700	12.93111	80.11667	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Tambaram
OW9	OW125719795607	12.95528	79.93528	Dug Well	Kancheepuram	Sriperumbudur	Sriperumbudur	Vadamangalam
OW10	OW125733800711	12.95917	80.11972	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Tiruneermalai
OW11	OW125734795243	12.95583	79.88167	Dug Well	Thiruvallur	Thiruvallur	Kadambathur	Thirupanthiyur
OW12	OW125746800647	12.96278	80.11306	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Thiruneermalai
OW13	OW125804800901	12.96778	80.15028	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Pallavaram
OW14	OW125806800713	12.96833	80.12028	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Anakaputhur
OW15	OW125812800900	12.97000	80.15000	Dug Well	Chengalpattu	Tambaram	St.Thomas Mount	Pallavaram
OW16	OW125821795627	12.97250	79.94083	Dug Well	Kancheepuram	Sriperumbudur	Sriperumbudur	Pwd Lake
OW17	OW125952800537	12.99778	80.09361	Dug Well	Kancheepuram	Sriperumbudur	Sriperumbadur	Thirunageswaram
OW18	OW125955793905	12.97167	79.95139	Dug Well	Kancheepuram	Sriperumbudur	Sriperumbudur	Thirumangai
OW19	OW130029800458	13.00806	80.08278	Dug Well	Kancheepuram	Sriperumbudur	Kundrathur	Chembarambkkam
OW20	OW130059800026	13.01639	80.00722	Dug Well	Kancheepuram	Sriperumbudur	Sriperumbudur	Chettipedu
OW21	OW130149795140	13.02917	79.86667	Dug Well	Thiruvallur	Thiruvallur	Kadambathur	Mappedu
OW22	OW130204800910	13.03444	80.15278	Dug Well	Thiruvallur	Ambattur	Puzhal	Porur
OW23	OW130426800108	13.07250	80.02056	Dug Well	Thiruvallur	Poonamallee	Poonamallee	Nemam
OW24	OW130500800049	13.08278	80.01361	Dug Well	Thiruvallur	Poonamallee	Poonamallee	Korattur
OW25	PZ125103800308	12.85083	80.05222	Bore Well	Kancheepuram	Sriperumbudur	Kundrathur	Madampakkam
OW26	PZ125322800127	12.88944	80.02417	Bore Well	Kancheepuram	Sriperumbudur	Kundrathur	Padappai
OW27	PZ125544795601	12.92889	79.93361	Bore Well	Kancheepuram	Sriperumbudur	Sriperumbudur	Pondur
OW28	PZ125700795639	12.95000	79.94417	Bore Well	Kancheepuram	Sriperumbudur	Sriperumbadur	Sriperumbadur
OW29	PZ130002800551	13.00056	80.09750	Bore Well	Kancheepuram	Sriperumbudur	Kunnathur	Kunrathur
OW30	PZ130139800620	13.02750	80.10556	Bore Well	Kancheepuram	Sriperumbudur	Kundrathur	Mangadu
OW31	PZ130139800621	13.02750	80.10583	Borewell	Kancheepuram	Sriperumbudur		Mangadu
OW32	PZ130244795624	13.04556	79.94000	Bore Well	Thiruvallur	Thiruvallur	Kadambathur	Illupur
OW33	PZ130512795430	13.08667	79.90833	Bore Well	Thiruvallur	Thiruvallur	Kadambathur	Melnallathur

These observation wells were overlaid on the WATSCAN outcome i.e. Water Gap map (Figure 18) with the following water gap classes

Water Gap mm/ha = Yield/ha – Demand/ha

Negative Water Gap Areas: -80 mm/ha to -0.05 mm/ha

Marginal Water Gap Areas: -0.05 mm/ha to 0.13 mm/ha

Positive Water Gap Areas: 0.13mm/ha to 13.97 mm/ha

The observations basis the analysis of groundwater data and water gap classes is as under.

Negative Water Gap Areas (-80mm/ha to -0.05 mm/ha):

Regions shaded in red represent areas with a negative water gap, where water resources are significantly stressed (i.e. demand is more than the yields). Wells within these zones, such as OW27 (Figure 23), typically show declining groundwater levels, confirming the over-extraction or depletion of water resources. These areas are at high risk of water scarcity and **require urgent water management and conservation measures.**

Marginal Water Gap Areas (-0.05mm/ha to 0.13mm/ha):

The yellow-shaded regions correspond to areas with a marginal water gap. Observation wells in these areas such as OW 25 & OW8 (Figure 24) display fluctuating trends, indicating uncertainty in meeting water demands. These areas, while not critically water stressed, are vulnerable to slipping into a negative water gap status if not timely managed.

Positive Water Gap Areas (0.13mm/ha to 13.97mm/ha):

Blue-shaded regions indicate a positive water gap, signifying that water resource availability (yields) are more than the demand. Observation wells in these areas, such as OW18 and OW4, (Figures 22 & 23) show stable or increasing groundwater levels, reflecting sufficiency of water resources in these zones. These areas are less likely to face water scarcity in the near future but are prone to floods.

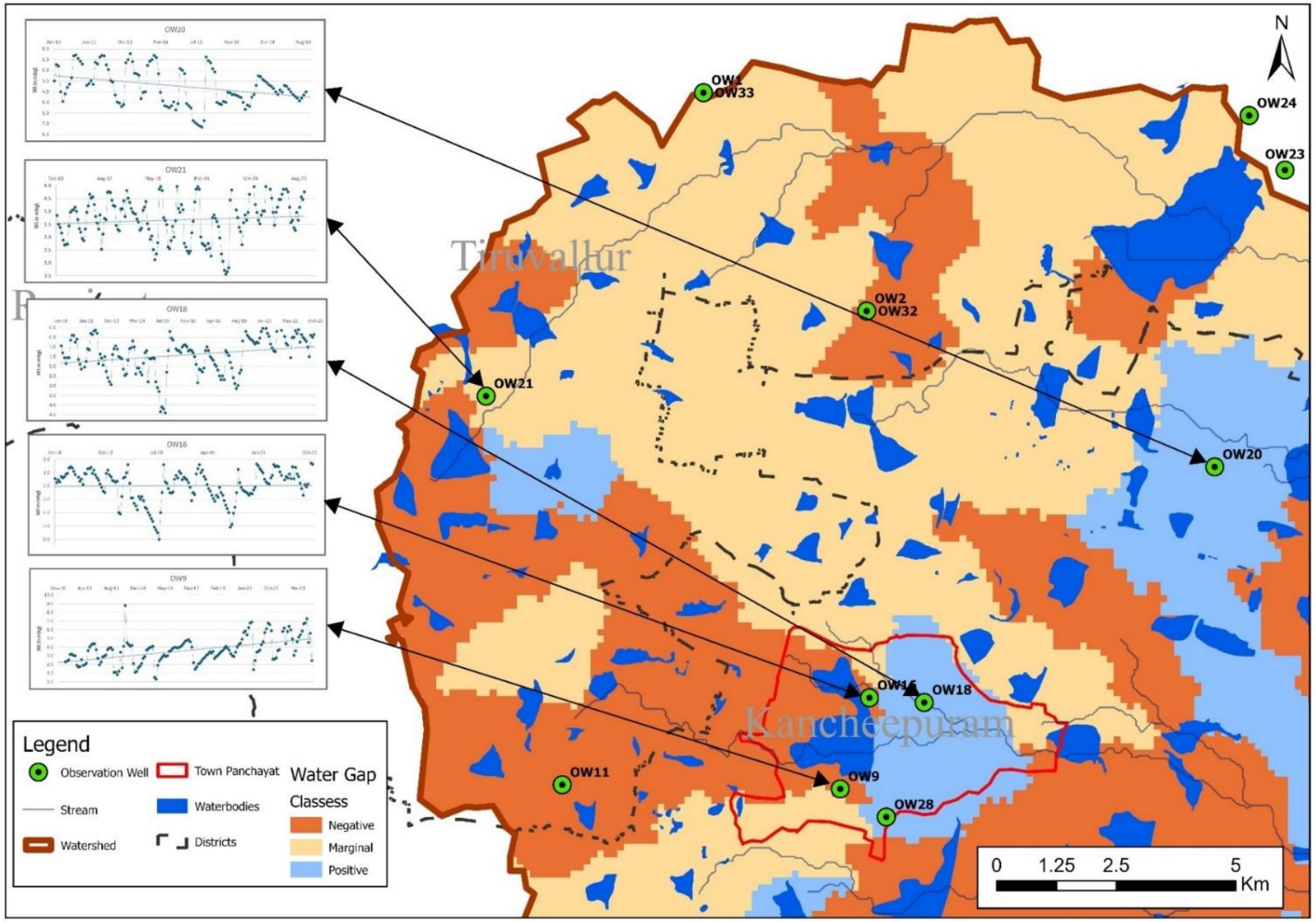


Figure 23 Monitoring wells superimposed on Water Gap map

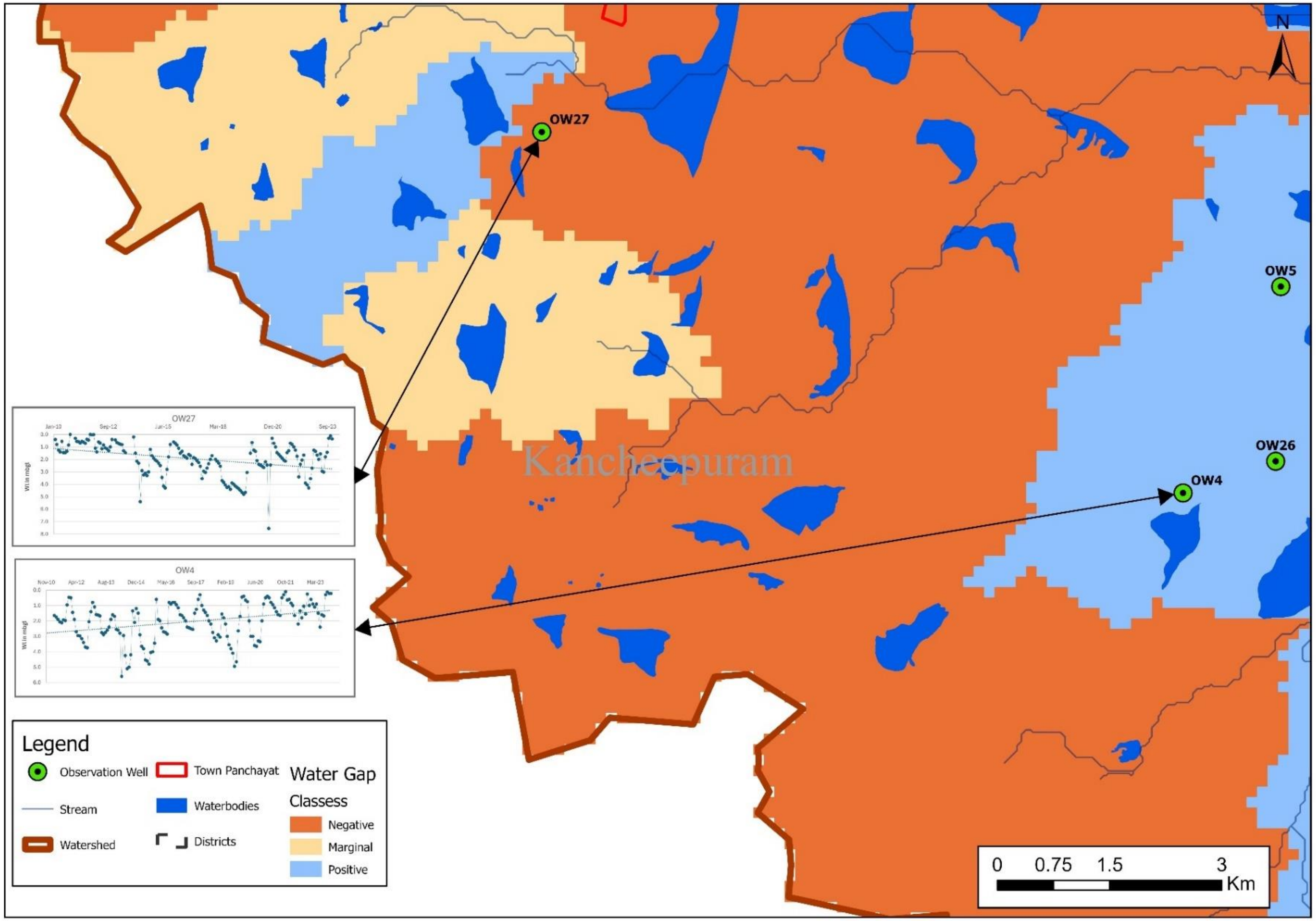


Figure 24 Monitoring wells superimposed on Water Gap map

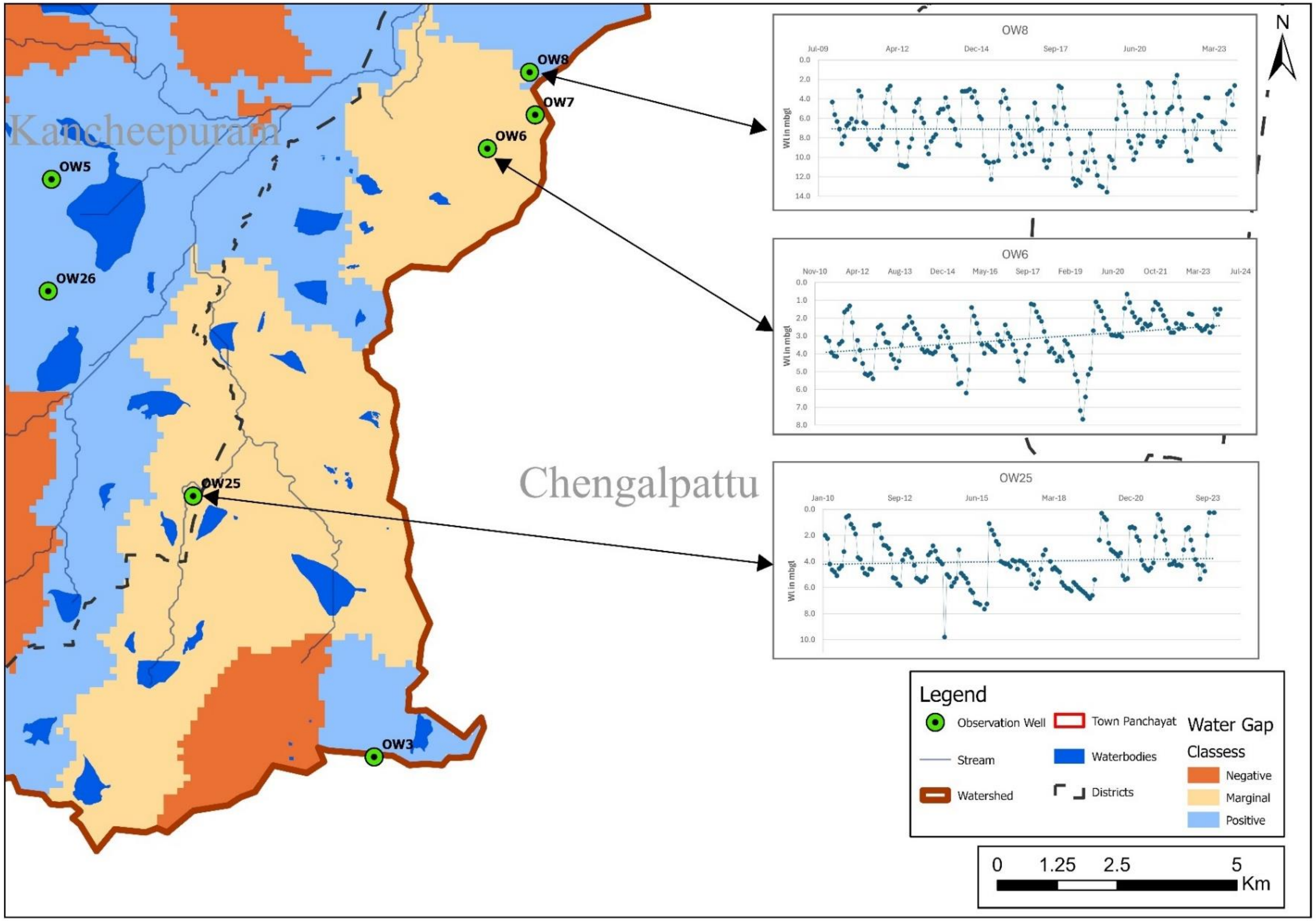


Figure 25 Monitoring wells superimposed on Water Gap map

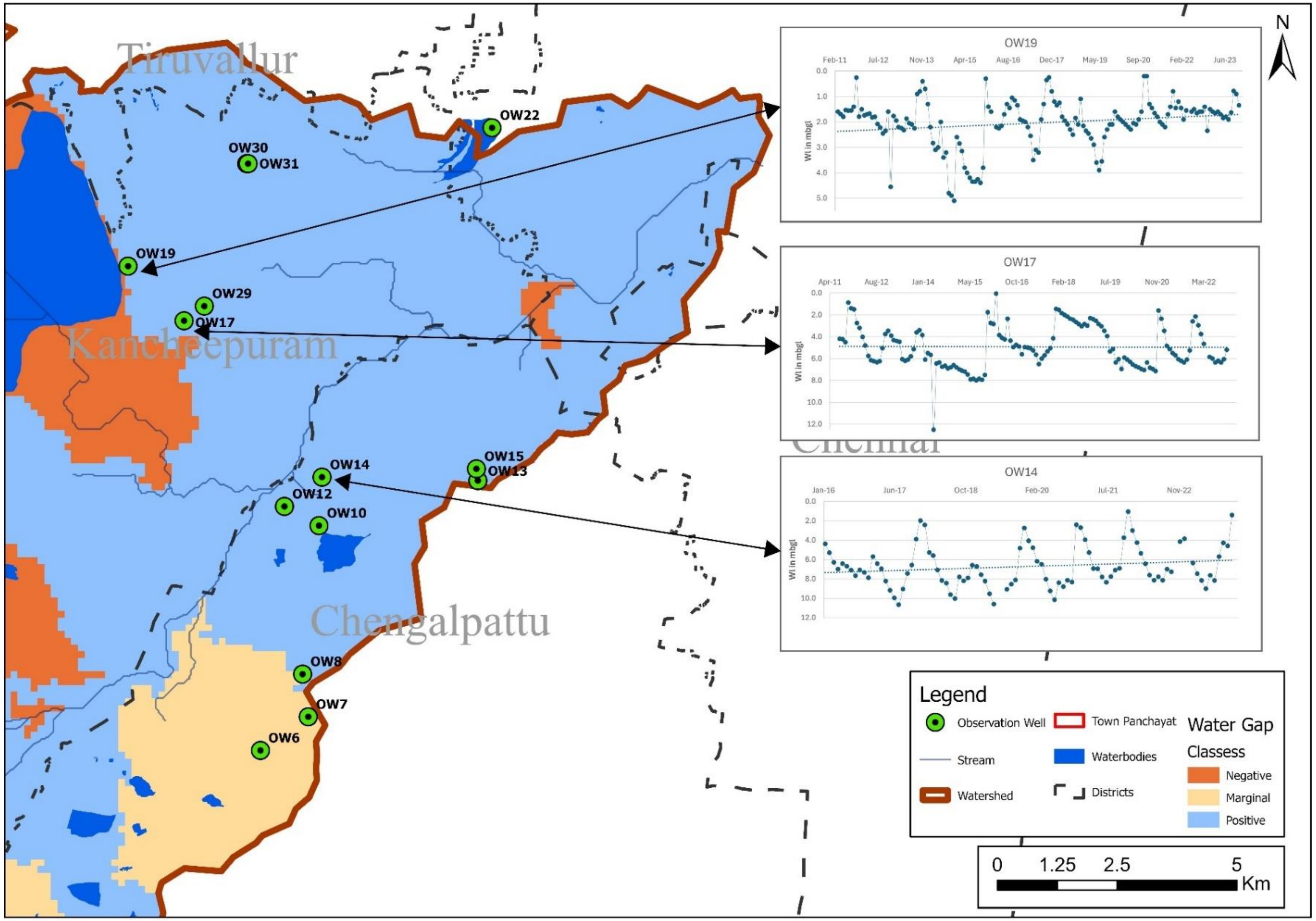


Figure 26 Monitoring wells superimposed on Water Gap map

KEY POINTS FROM FOCUSED GROUP DISCUSSIONS

Focused Group Discussions (FGDs) both at household level and agriculture level are integral to the project, with CII WI tasked with narrowing down the locations (villages) for FGDs. The activity aims to deepen understanding of local perspectives and needs, informing effective project planning and implementation (Probable Phase II). This section is further sub divided to focus on key points from both agriculture and household level interactions conducted by on field partners Mryada

AGRICULTURE SURVEY

The agriculture survey covered nine villages within the watershed area, engaging 200 respondents. Pillaipakkam had the highest participation with 52 respondents, while Pondhur had the lowest with just one.

Sr	Village Name	Sample Size
1	Eraiyur	25
2	Kolathur	50
3	Kovur	16
4	Maathur	11
5	Pennalur	22
6	Pillaipakkam	52
7	Pondhur	1
8	Vadamangalam	16
9	Vaipoor	7
Grand Total		**200**

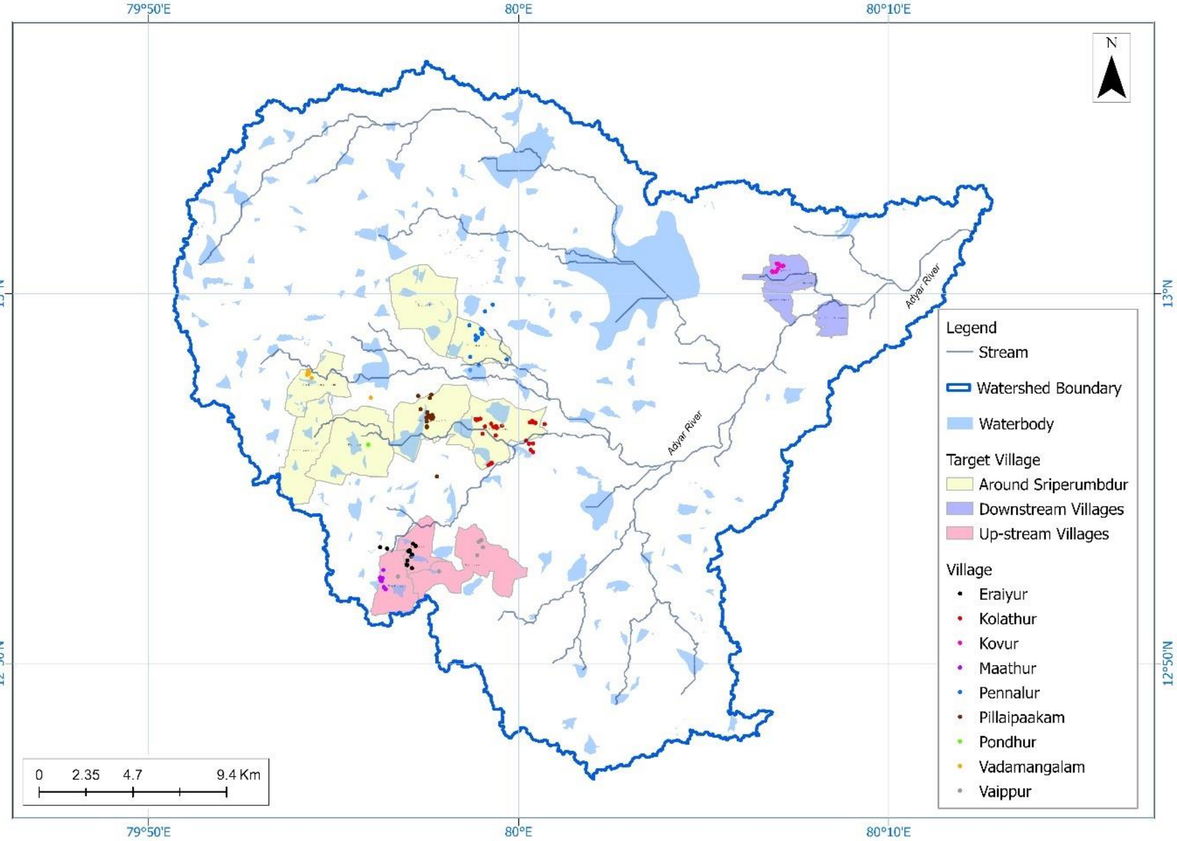


Figure 27 Agriculture survey sampling locations map

1. Occupation and Membership: Farming is the primary occupation across all villages. Only 28.5% of farmers are part of farming groups, leaving 71.5% without such affiliations.
2. Education: Majority of farmers (94.5%) have education up to the matriculation level, with minimal representation at higher education levels.
3. Land Holdings: Marginal farmers are the most prevalent, with self-operating farmers owning 56% land, while 44% are on leased land.

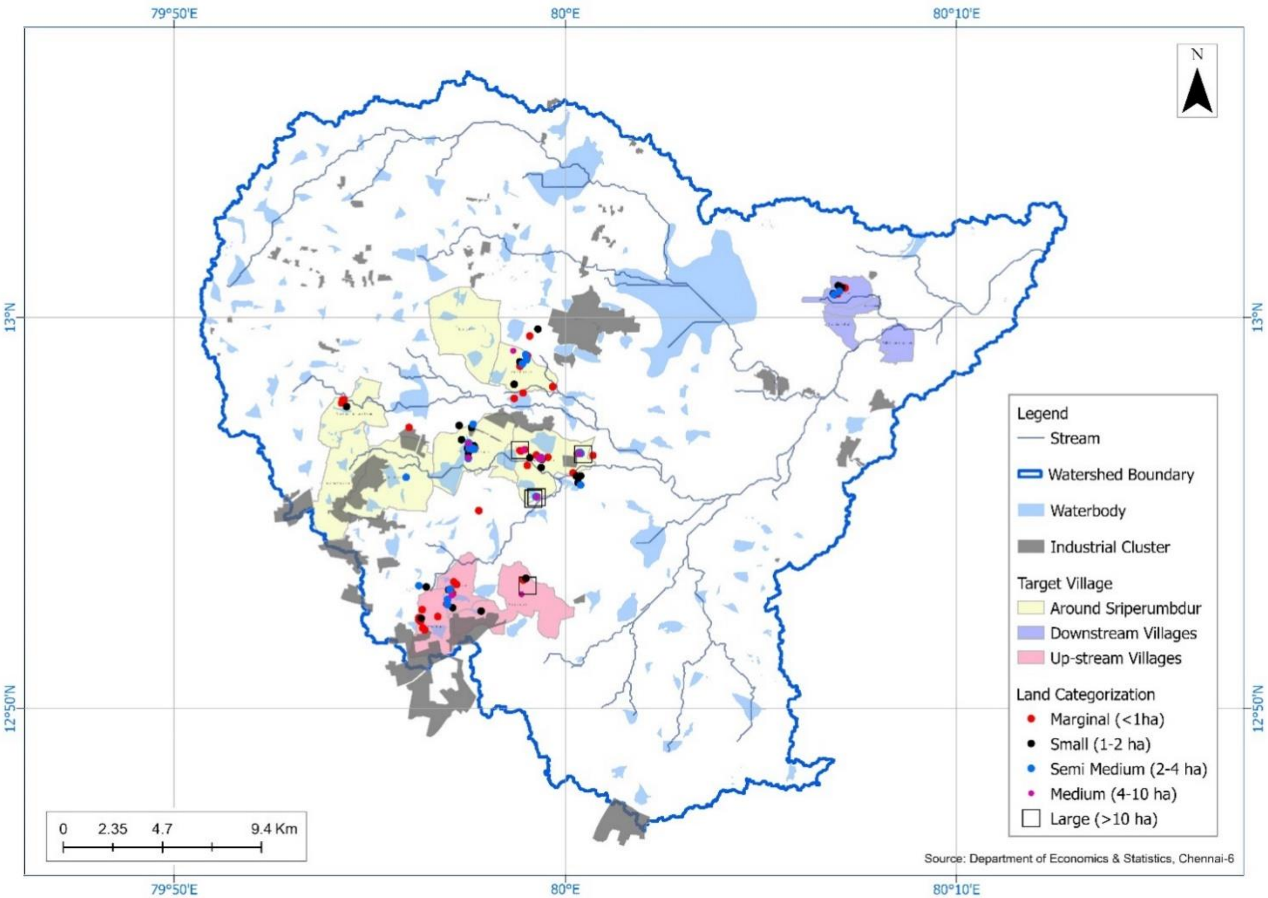


Figure 28 Map showing the farmer categorization

Land Holding	**Area**	**% of total**
Marginal	(<1ha)	49.5%
Small	(1-2 ha)	27.0%
Semi Medium	(2-4 ha)	15.0%
Medium	(4 – 10 ha)	5.5%
Large	(>10 ha)	3.0%

4. Irrigation Sources and Method: According to the respondents, approximately 91% use surface water for irrigation, while 8.5% rely on groundwater, and 0.5% use a combination of both sources. The dominant irrigation method is surface flow (98%).

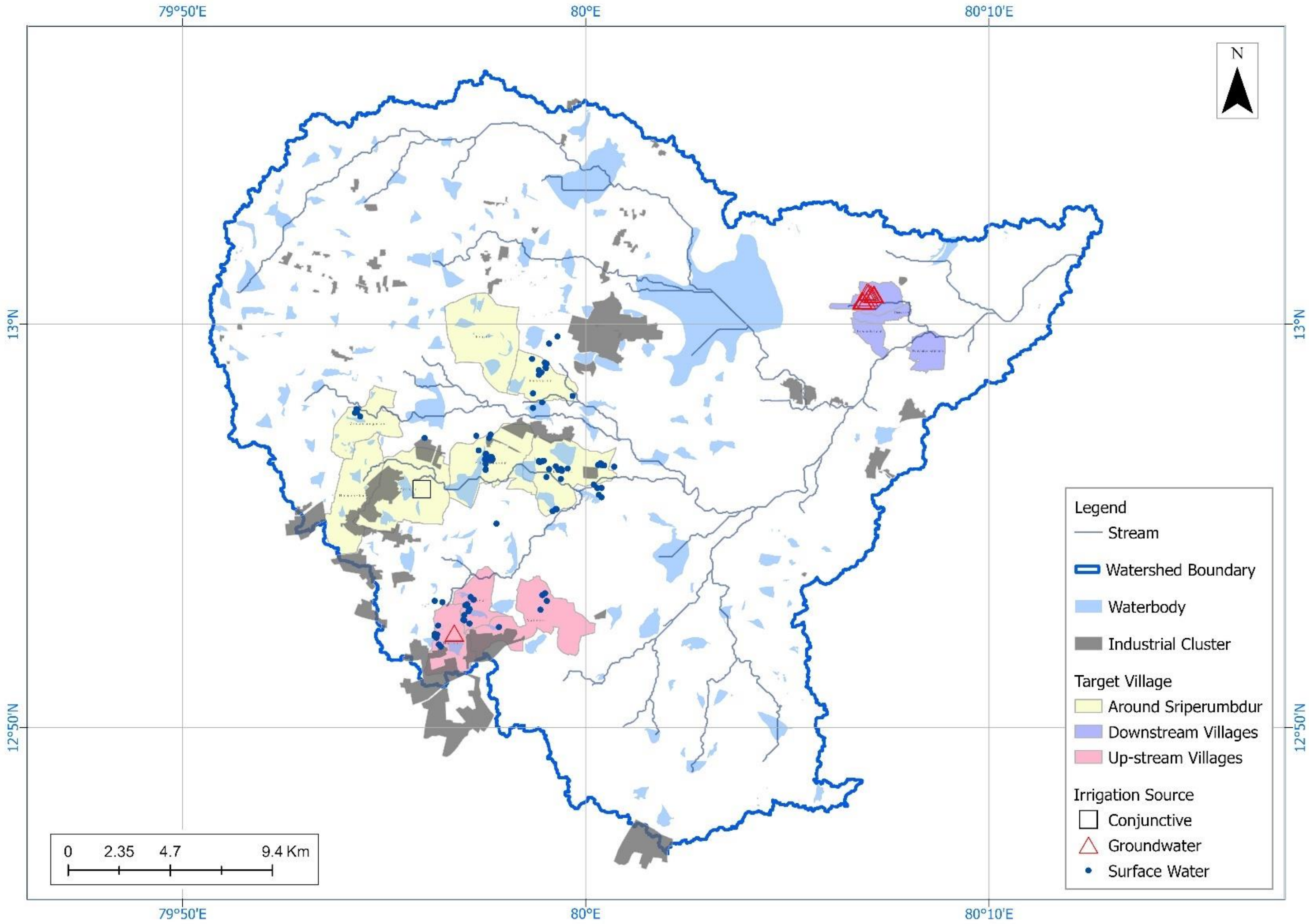


Figure 29 Irrigation sources across surveyed villages

Suggestion/Recommendation

1) **Assess Surface Flow Efficiency**: It's important to evaluate the efficiency and sustainability of this method. Investing in research and technology to improve surface flow techniques could enhance water use efficiency and crop yields.

2) **Consider Alternative Irrigation Methods**: Given the dominance of surface flow, there may be an opportunity to explore and promote alternative irrigation methods such as drip or sprinkler systems, especially in areas where water conservation is a priority.

3) **Water Resource Management**: Implement water resource management strategies to balance reliance on surface water with sustainable practices. This could involve monitoring water quality and availability, promoting conservation practices, and exploring innovations in water management.

5. Water Quality: 76.5% of respondents reported issues with irrigation water quality, including turbidity and unpleasant smells, while 23.5% reported no issues.

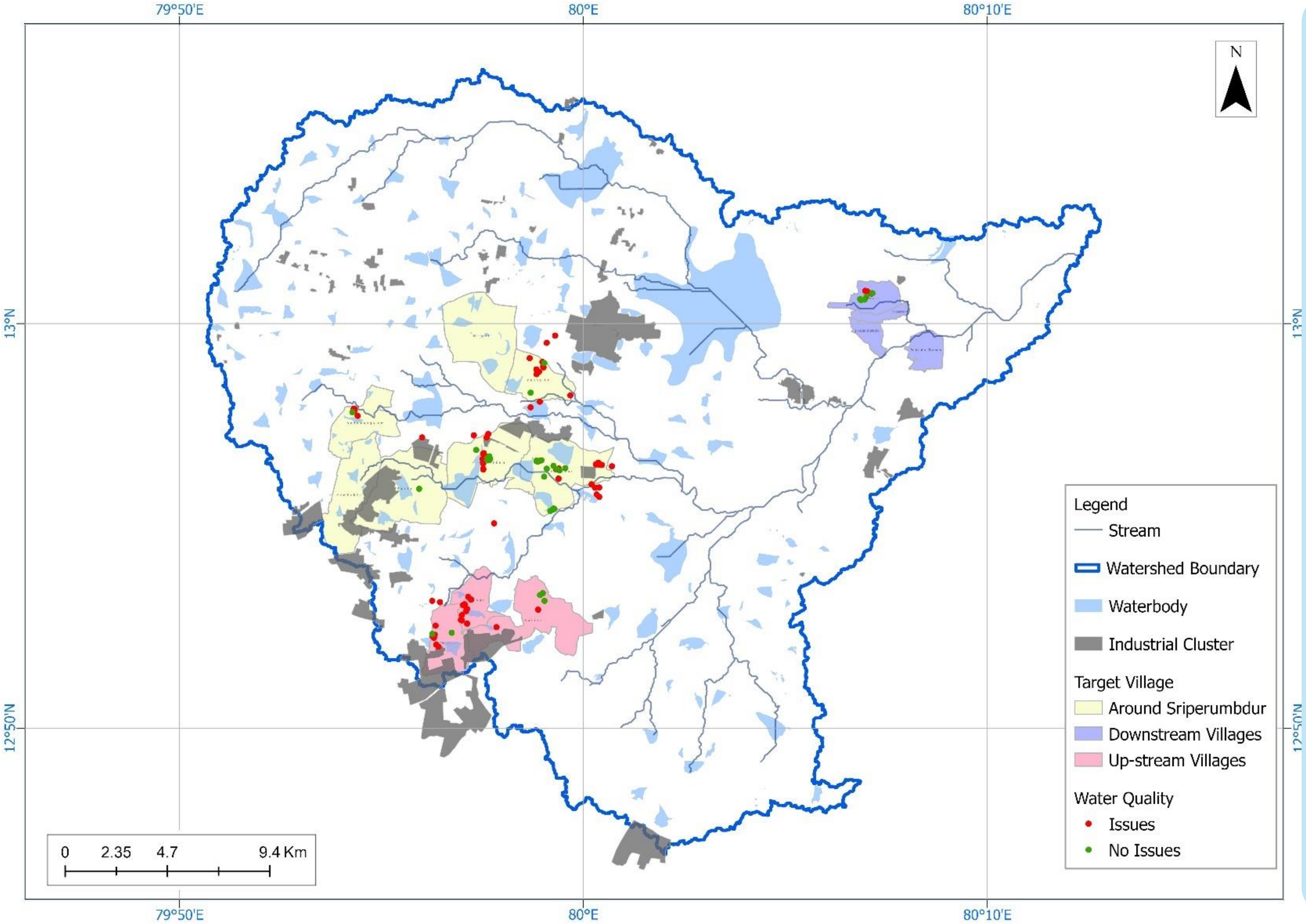


Figure 30 Water quality across surveyed villages

Suggestion/Recommendation

1) **Invest in Water Quality Assessment**: Conduct thorough assessments of the water sources used for irrigation to identify and understand the causes of turbidity and unpleasant smells. This can help in developing targeted solutions to address these issues.

2) **Implement Water Treatment Solutions**: Based on the findings from the water quality assessments, consider investing in appropriate water treatment technologies to improve water quality. Options may include filtration systems, sedimentation basins, or chemical treatments.

3) **Monitor and Evaluate**: Establish a regular monitoring system to track water quality over time. This will help in assessing the effectiveness of implemented solutions and make necessary adjustments based on real-time data.

6. Cropping Pattern: In the villages of Pennalur, Vadamangalam, Pillaipakkam, Kolathur, Vaipoor, Eraiyur, and Mathur, paddy is the primary crop grown. Data reveals that 92% of the respondent farmers practice double cropping, growing paddy as both their first and second crops, while 8% of the farmers cultivate only paddy as their single crop.

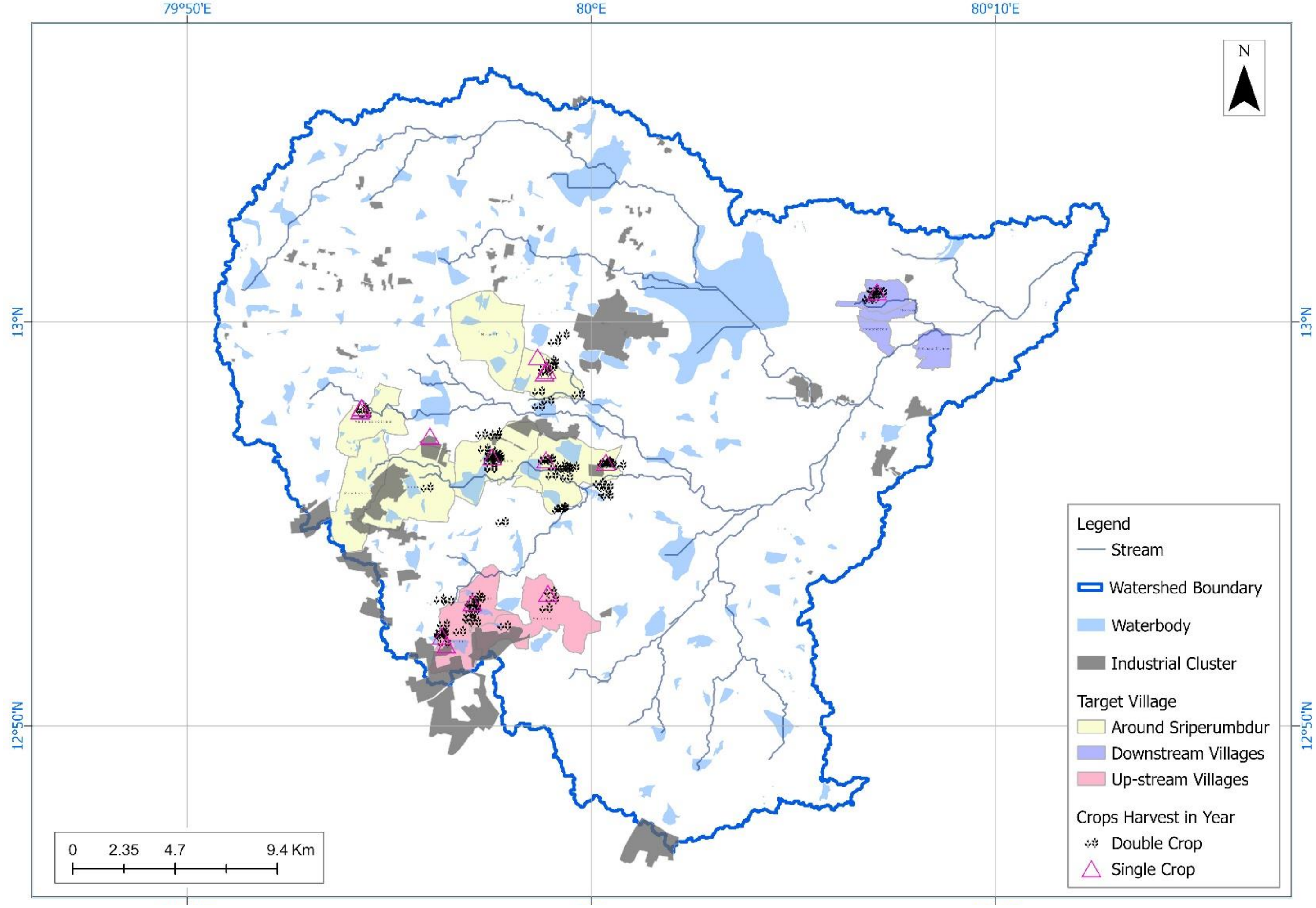


Figure 31 Crop details

Suggestion/Recommendation

1) **Promote Sustainable Practices and diversification:** Although paddy is the primary crop, exploring and promoting crop diversification can help mitigate risks associated with paddy cultivation, such as pests, diseases, or market fluctuations.

2) Provide training and resources for farmers interested in incorporating other crops into their rotation.

7. Water-Saving Techniques: Only a small percentage (2%) use sprinkler or drip irrigation systems, primarily in Kolathur and Pillaipakkam, indicating a significant area for improvement.

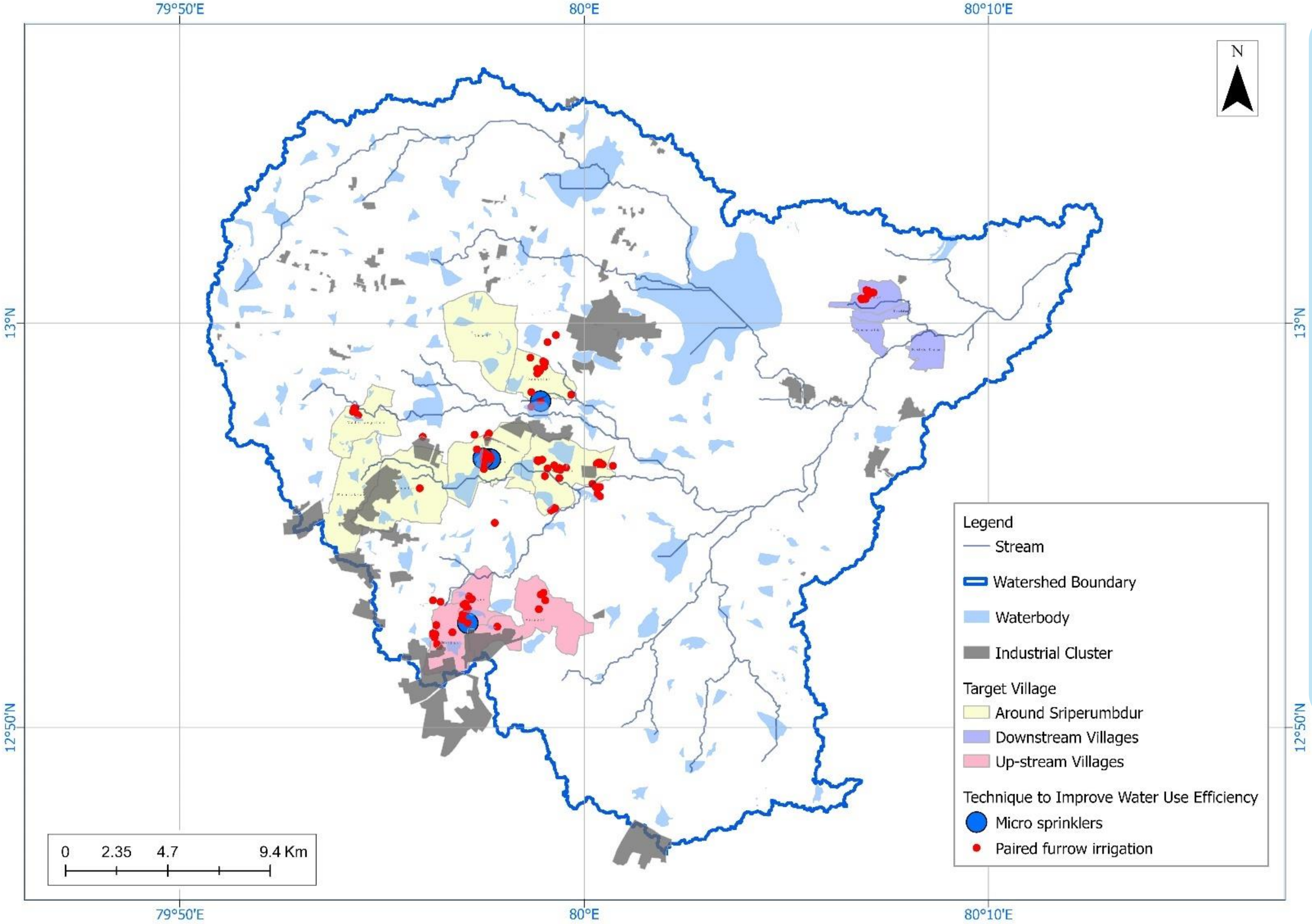


Figure 32 Irrigation techniques deployed to improve water use efficiency.

Suggestion/Recommendation

1) **Promote Efficient Irrigation Technologies:** Launch educational campaigns and workshops/exposure visits to demonstrate the benefits of improved irrigation - sprinkler and drip irrigation systems. Highlight their advantages, such as water conservation, improved crop yields, optimized input usage, reduced labor and higher incomes.

2) **Expand Infrastructure and Support**: increase availability of irrigation infrastructure and technical support in areas where adoption is low.

3) Showcase Success Stories

8. Soil Testing and Fertilizer Use: A large majority (84%) have not undertaken soil testing. Of those who have, only 2.5% received soil health cards. Most farmers (95.5%) do not follow fertilizer recommendations, with only 4.5% adhering to suggested practices. Biofertilizers are rarely used. Additionally for Pest Control: 76% of farmers use chemical or organic pesticides, while 24% do not use any pest control methods. Only one respondent uses organic fertilizers for pest control.

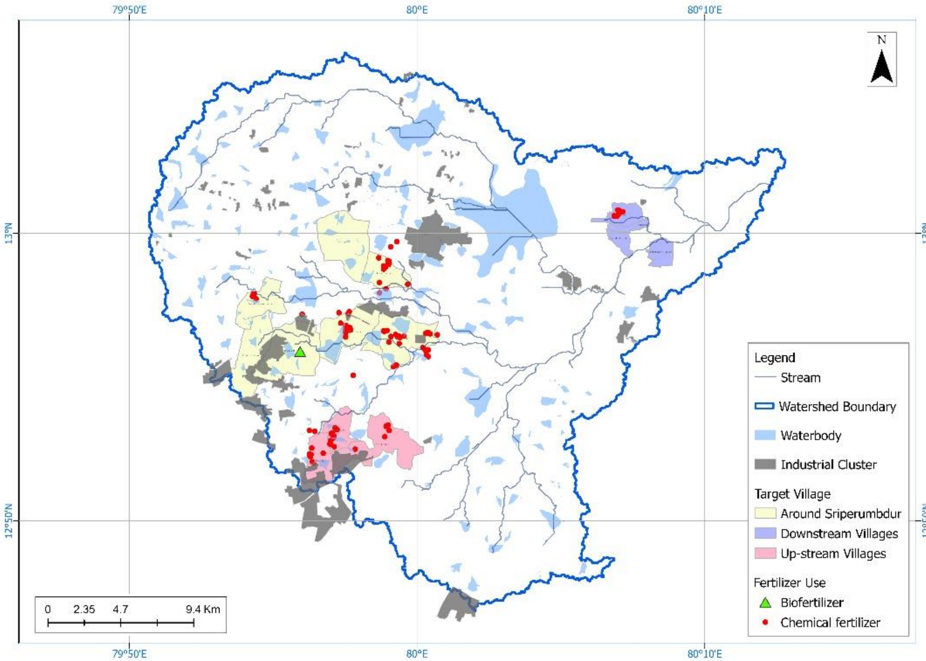


Figure 33 Fertilizer use

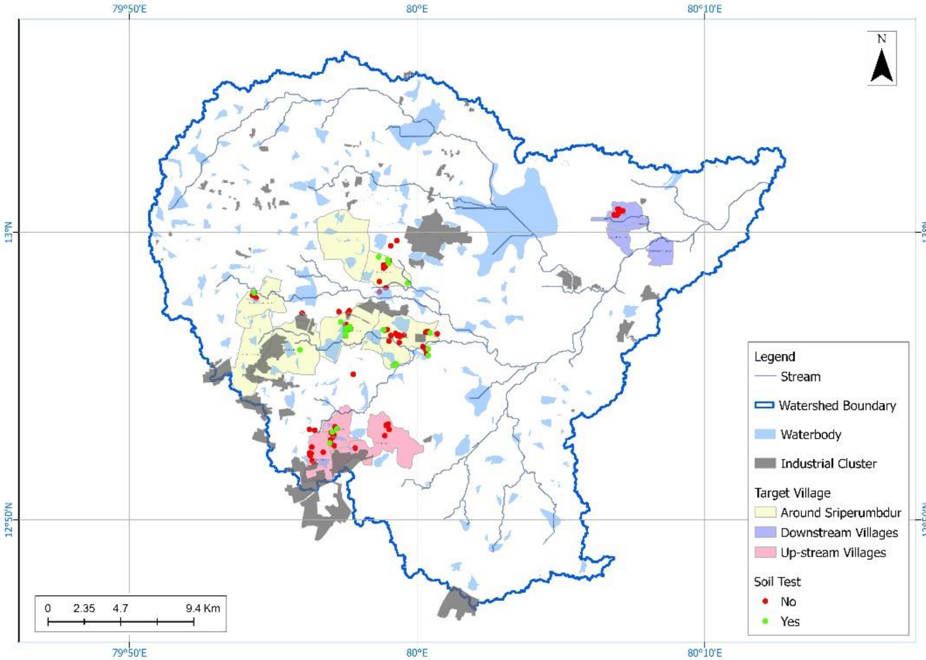


Figure 34 Soil Test Conducted

Suggestion/Recommendation

1) **Promote Soil Testing –** increased awareness and accessibility of soil testing services.
2) **Distribute Soil Health Cards -** Ensure that farmers who undergo soil testing receive comprehensive soil health cards that include specific recommendations for improving soil fertility.
3) **Promote Biofertilizers**
4) **Support Sustainable Practices:** Encourage the adoption of sustainable agricultural practices by providing resources and training on soil health, efficient fertilization, and pest management.
5) Support farmers in transitioning to practices that enhance long-term soil and crop health.

9. Water Conservation Intervention and Training Programs: A mere 2.5% of respondents implement soil and moisture conservation activities, with the rest not engaging in such practices. 14.5% of respondents have attended various farming training programs, while 85.5% are unaware of such opportunities.

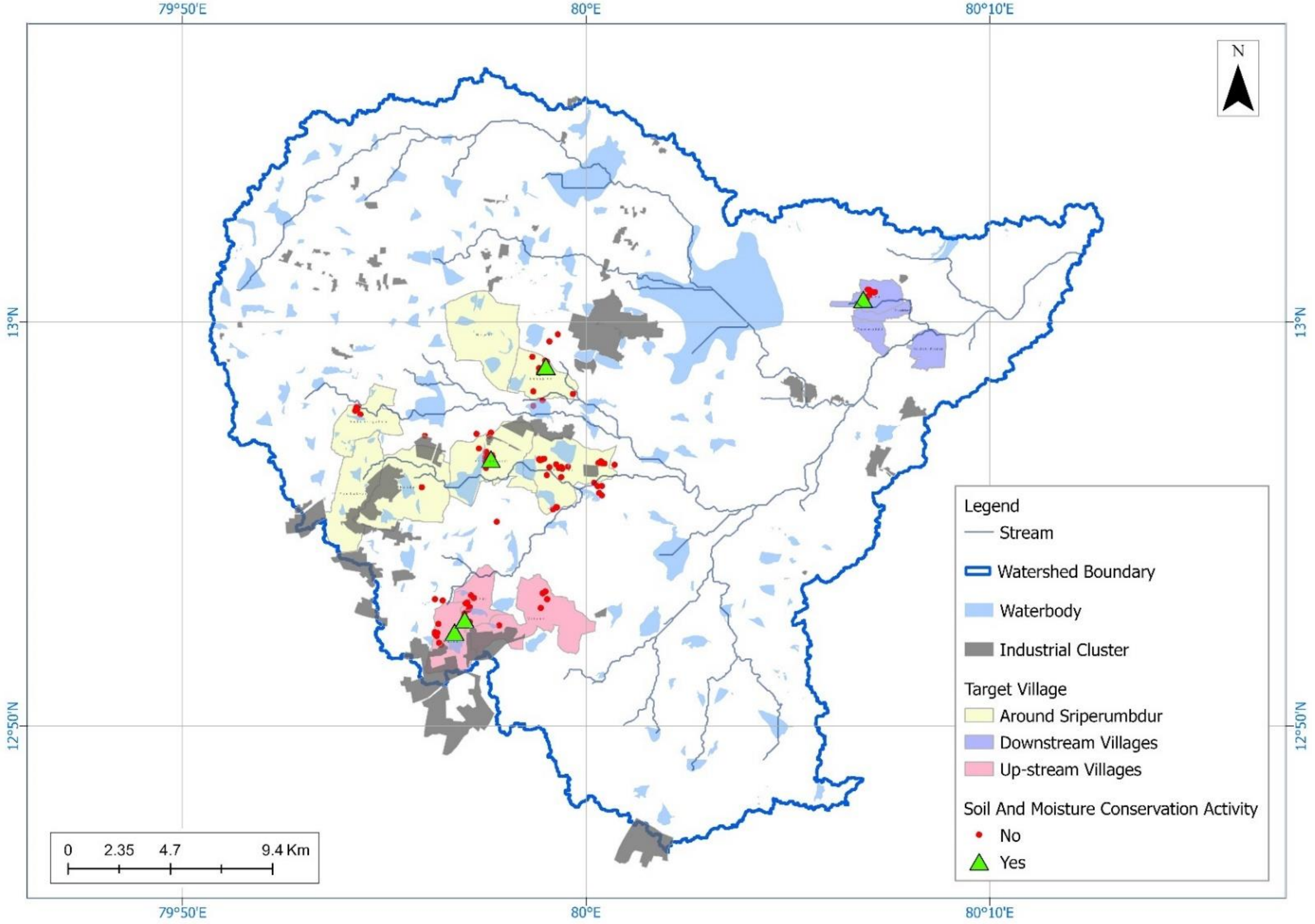


Figure 35 Spread of Soil and Water Conservation Activities.

HOUSEHOLD SURVEY

For household survey, data was collected from 300 respondents across 12 villages. Pondhur had the highest number of responses (40), while Eraiyur, Pillaipakkam, Polichalur, and Vaipoor had the fewest (15 each).

Sr	Village Name	Sample Size
1	Eraiyur	15
2	Kolathur	35
3	Kovur	20
4	Mambakkam	20
5	Mathur	35
6	Nemeli	35
7	Pennalur	25
8	Pillaipakkam	15
9	Polichalur	15
10	Pondhur	40
11	Vadamangalam	30
12	Vaipoor	15
Grand Total		300

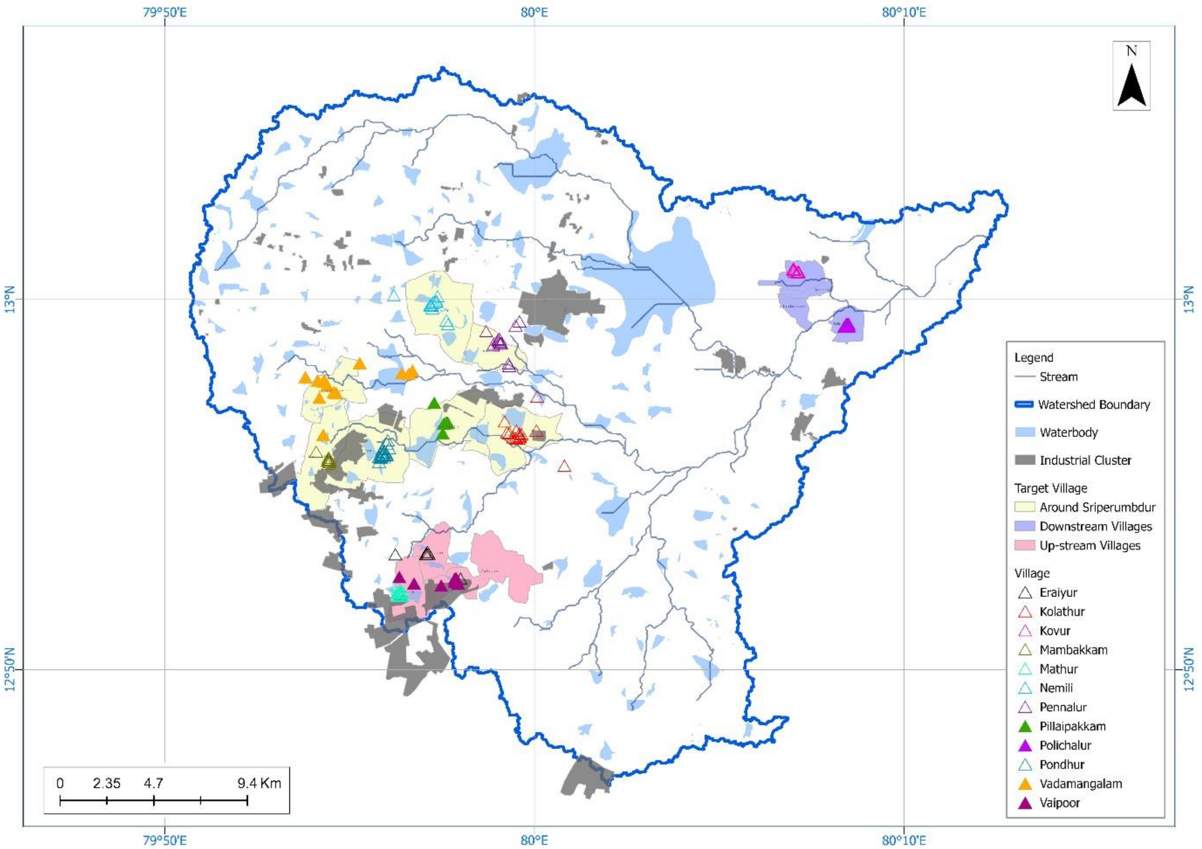


Figure 36 Household survey spread

1. Occupations: The majority (70%) of respondents are engaged in daily wage work (Agriculture). Other occupations include salaried jobs (16.5%) and work in local factories or cities (13.5%). Only one respondent from Vaipoor reported farming as their primary occupation.
2. Housing Ownership, Roof Type and area: 93.33% of respondents own homes, while 6.67% live in rented spaces. Notably, no respondent from Eraiyur or Vaipoor was living in rented housing. In these households around 81.33% of respondents have concrete roofs, while 18.67% have other types. As per rooftop area classification 82.33% have roofs larger than 100 sq. m. A small percentage have roofs between 100-500 sq. m., and only 0.33% have roofs larger than 500 sq. m. The ownership patterns are likely to impact the potential for rainwater harvesting in this area.

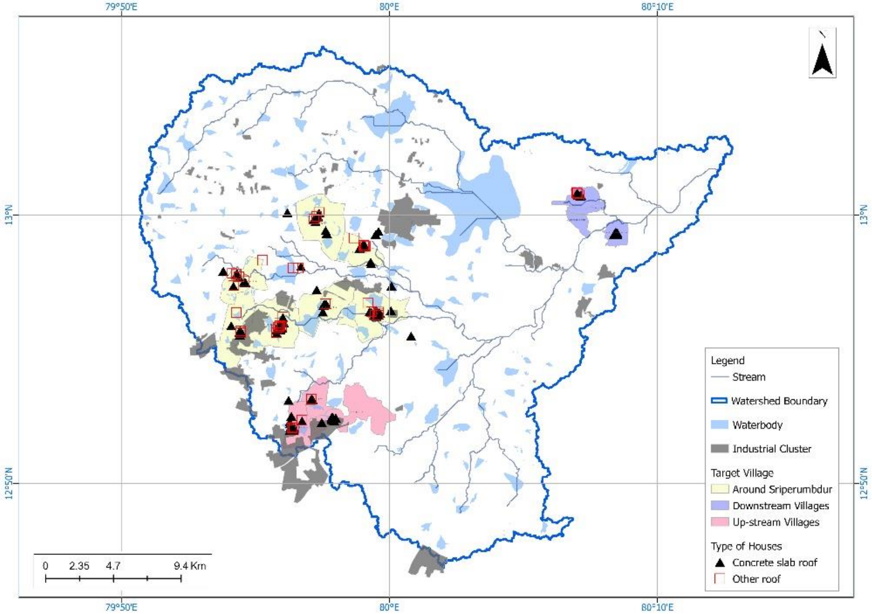


Figure 37 Type of house

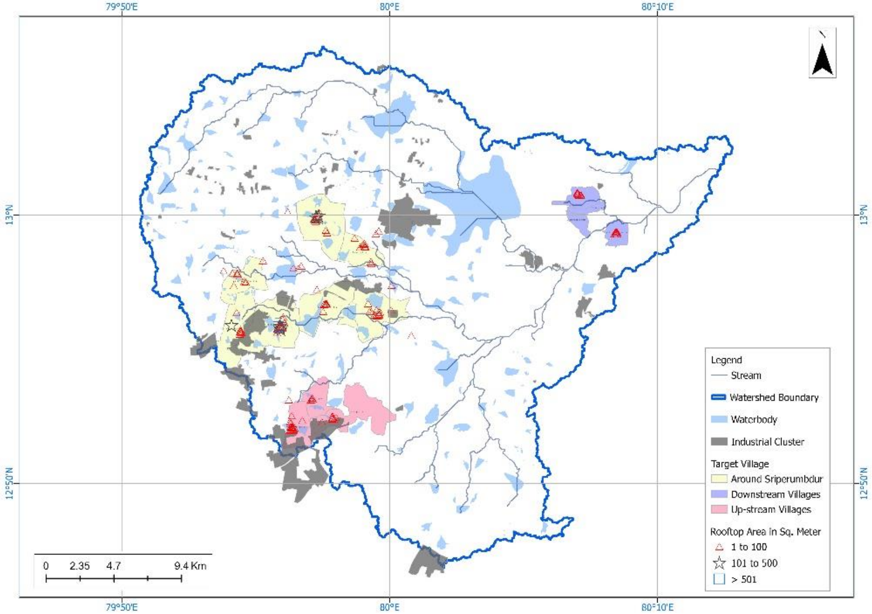


Figure 38 Rooftop area

3. Drinking Water Sources: 74.67% use municipal piped water, while 19% use RO water, and 1.67% rely on groundwater. As per water consumption data majority of respondents (96%) use less than 1000 liters of water daily. A small portion uses between 1000-2000 litres, and a few exceed 2000 liters in their daily water consumption. Around 77.67% report no issues with water quality, but 22.33% experience problems like salty taste or turbidity.

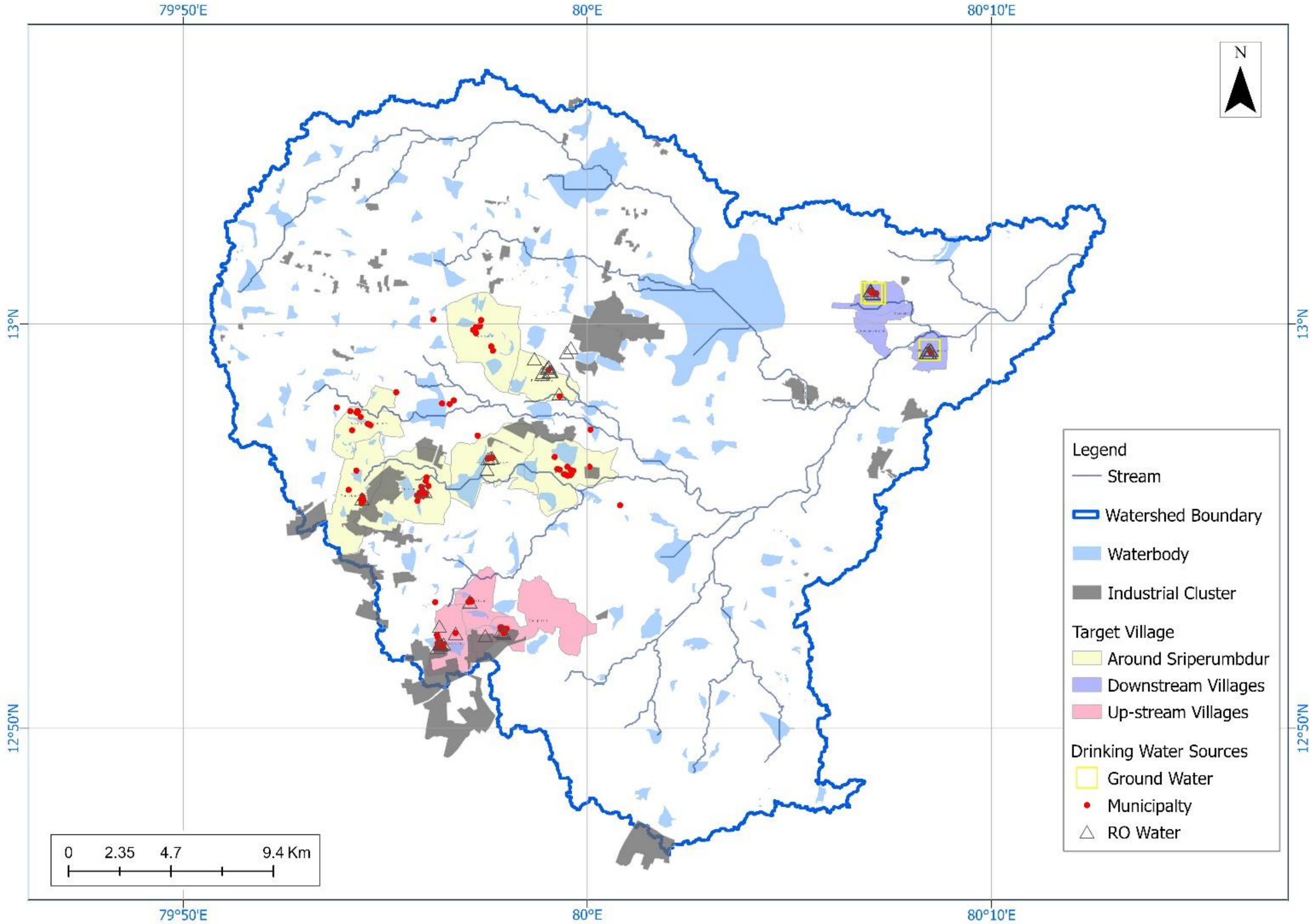


Figure 40 Drinking water sources

4. RO Systems: Only 9.67% of respondents have installed RO systems. Most do not have these systems, especially in villages with reported water quality issues.

5. Water conservation activities in these household is majorly rainwater harvesting, where around 30% of respondents have adopted rainwater harvesting systems, with a small fraction using the harvested water domestically. Another activity is water meter installation which is installed by only 4% to measure water usage. The majority do not use meters.

6. Self-Help Groups and Water Awareness Programs: 56.67% of respondents are members of self-help groups, with all respondents from Mambakkam being part of such groups. On water awareness programs around 14.67% have attended water use or quality awareness programs. The remaining 85.33% have not participated in any such programs.

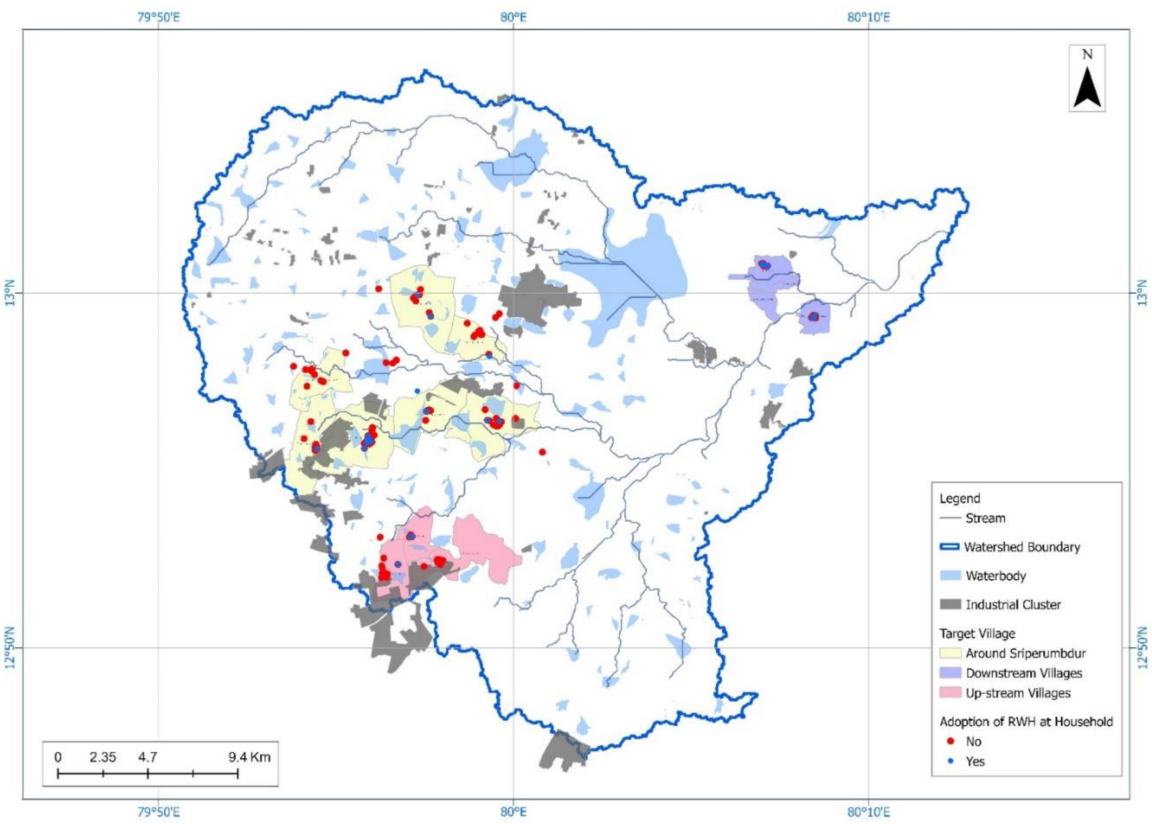


Figure 41 Status of rainwater harvesting activity

Major Inferences

Basis all the analysis provides key insights into water resource management across three distinct areas.

1. **Negative Water Gap Areas**: These regions are experiencing significant stress as demand exceeds supply, leading to declining groundwater levels and a heightened risk of severe water scarcity. Urgent conservation measures are essential, making these areas top priorities for intervention.
2. **Marginal Gap Areas**: Groundwater levels in these areas show fluctuating trends, indicating potential for further decline without timely intervention. They are currently in a transitional state and require close monitoring.
3. **Neutral or Positive Water Balance Areas**: In these regions, groundwater levels are stabilizing or slightly increasing, making them less susceptible to scarcity. However, they face the risk of inundation during heavy rainfall due to low soil absorption capacity.

Given the diverse challenges across these watersheds, tailored, area-specific intervention strategies are critical for effective water management. Thus, targeted, differentiated strategies are essential for managing water resources effectively across these diverse watershed conditions.

Water Allocation Definition, Principle And Framework

Definition

Water allocation refers to the systematic distribution of water resources among various users based on scientific assessments and the balancing of current and future demands. The framework for allocation considers hydrology, ecological needs, and community requirements, ensuring that water is managed as a shared public resource in a sustainable and equitable manner.

Principles for Allocation Planning:

The image illustrates the concept of **water allocation** within a multidimensional framework, highlighting the interplay between different dimensions—ecological, social, policy, and scientific—that influence water distribution.

Four key principles:

1. **Sustainability**: ensuring water use supports long-term ecosystem and resource health.
2. **Equity**: promoting fair distribution of water resources among all stakeholders.
3. **Adequacy**: ensuring there is enough water to meet the needs of different sectors and communities.
4. **Advocacy**: In the context of climate change and increasing water scarcity, advocacy pushes for policies that prioritize long-term water security, conservation, and fair access to water for agriculture, industry, and domestic use. Ultimately, advocacy in water allocation helps balance competing demands, protect ecosystems, and ensure that water is managed as a shared and sustainable resource for all.

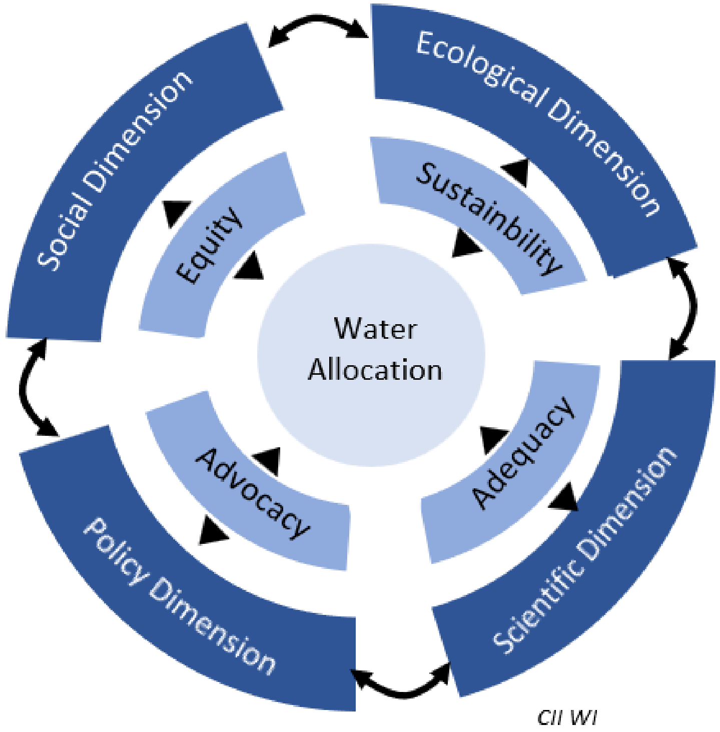


Figure 42 Water Allocation Principles

Surrounding these principles are the four dimensions:

1. **Ecological Dimension** – concerned with the environmental impact and the role of ecosystems in water management.
2. **Social Dimension** – emphasizes the societal aspects, ensuring that water allocation benefits communities equitably.
3. **Policy Dimension** – focuses on the regulatory frameworks and governance required to manage water resources effectively.
4. **Scientific Dimension** – relates to the data, research, and technical understanding needed to ensure sound water management practices.

The interconnectedness of these dimensions highlights the interactions and dependencies that make water allocation a dynamic process, involving various stakeholders and complex considerations. The **scientific dimension** is central to this framework, providing the data and insights that influence policies and drive equitable and sustainable water distribution. This comprehensive framework of water allocation principles seeks to balance environmental, social, and economic needs in an integrated and effective manner.

Framework of Water Allocation

The water allocation is based on the principle that water resources are a shared public resource that need to be managed sustainably and fairly. This means that all water users have a right to access water resources in a manner that balances their needs with the needs of the environment and the broader community.

The framework sets out how water is to be shared between:

1. **Consumptive uses**: These refer to water uses that remove water from a source, such as domestic, agriculture and industrial activities.
2. **Non-consumptive uses**: These include activities that do not significantly deplete water sources, such as recreational activities and some ecological functions like environmental or cultural uses.

The framework distinguishes between environmental flows (needed for ecosystems) and non- environmental flows, emphasizing the importance of maintaining ecological health. The key components include:

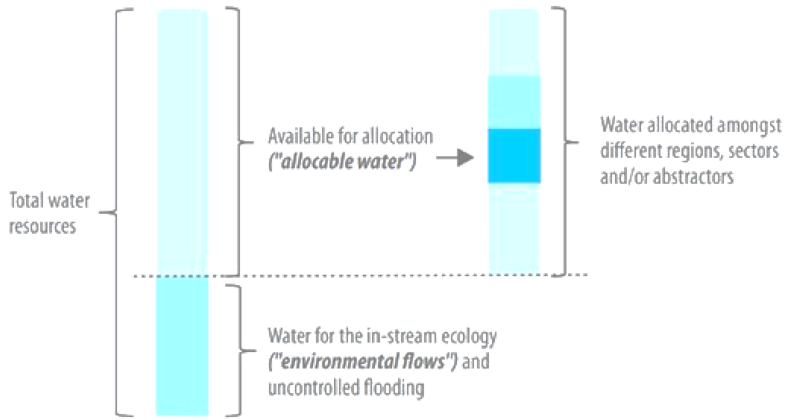


Figure 43: Total water resources, and allocable water.

(Figure Source: Basin water allocation planning principles, procedures, and approaches for basin allocation planning | PDF (slideshare.net)

1. Environmental Flow Considerations: A critical aspect of the framework is allocating 15-25% of total water resources to meet ecological and environmental needs.
2. Targeted Allocations based on land use as.
   a) Built-Up Areas: Receive 10-15% allocation due to their artificial nature.
   b) Natural Areas: Higher allocations (up to 25%) are designated to support green spaces and ecosystems.
   c) Irrigated Areas: Receive significant allocations to support agricultural needs, reflecting the balance between various demands.

Water Allocation Plan for the Study Area

Water allocation planning assesses the available water within a basin or region and determines how it should be distributed among regions, sectors, or users. It involves actions that enable water users to receive water for beneficial purposes based on a system of rights and priorities (UNESCAP, 2000). Given water's time-varying characteristics and its importance to society, alongside the complex relationships between climate, hydrology, economics, and sustainable development, water allocation is a challenging task.

The planning process is grounded in scientific research and stakeholder consultation. Allocation limits are set by balancing hydrological and ecological data with current and future water demand. These plans regulate groundwater and surface water extraction, ensuring long-term sustainability and consistency in water licensing while protecting resources and water-dependent environments for the future. The water allocation plan comprises of three essential steps.

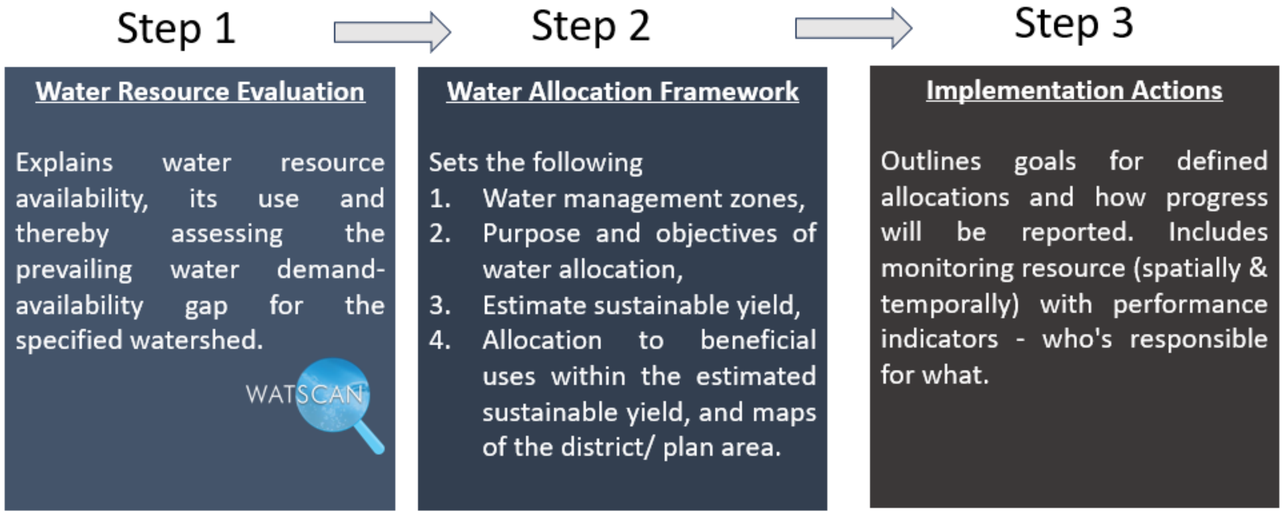
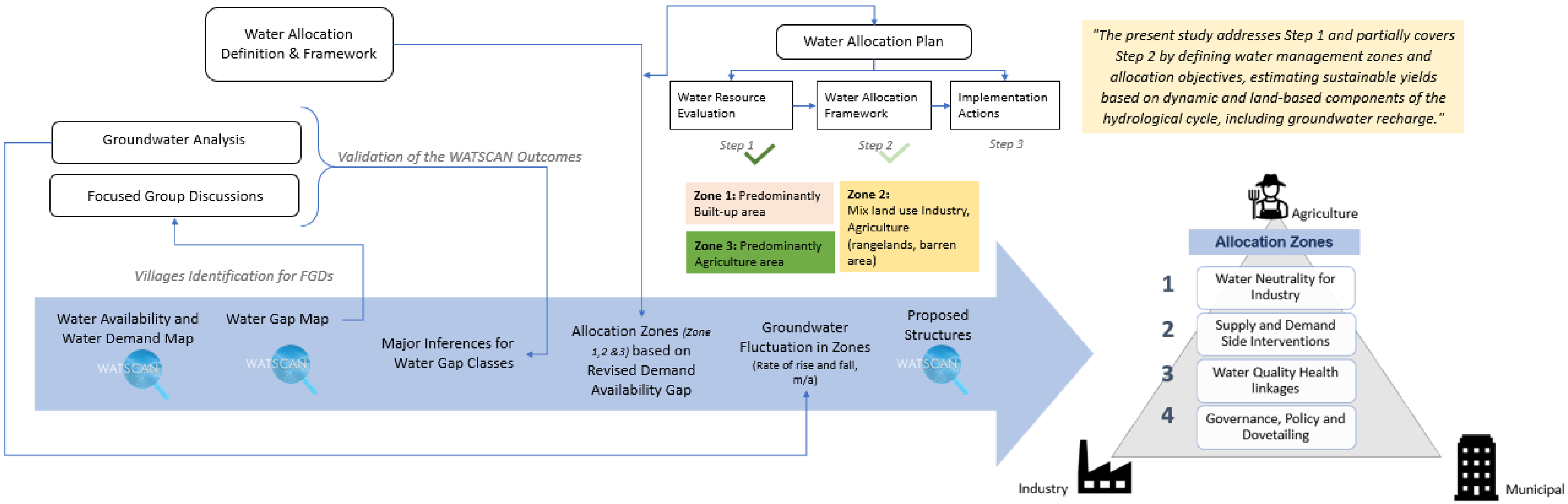


Figure 44 Step wise Water Allocation Plan

First, it evaluates water resources, assessing their availability and utilization while focusing on the gap between demand and supply within the watershed. Second, it establishes a water allocation framework that defines management zones and outlines the objectives of water allocation, including estimating sustainable yields and mapping the planning area for beneficial uses. Lastly, the plan details

implementation actions, which specify goals related to water allocations and outline monitoring methods, including spatial and temporal assessments and performance indicators for stakeholders.
The current study primarily focuses on evaluating water resources and partially explores the allocation framework by defining water management zones and objectives, as well as estimating sustainable yields based on dynamic hydrological factors like groundwater recharge and land use.

Re-emphasizing on the approach followed for the study figure 42 presents a framework for water allocation within a watershed, highlighting key processes and outcomes. The steps include defining the water availability and water demands followed by understanding the water gaps, engaging in focused group discussions, groundwater analysis.



Collaborative watershed management initiatives led by multiple industries aim to optimize water allocation, enhance livelihoods, and promote sustainable development in the region.

Figure 45 Project Approach and Way Forward

ALLOCATION ZONES BASED ON REVISED DEMAND AVAILABILITY GAP

Based on the revised demand-availability gap, the watershed can be strategically divided into three distinct allocation zones (Refer fig 43). This zoning approach facilitates targeted management strategies, ensuring that water resources are allocated efficiently to meet the specific needs and challenges of each zone, ultimately promoting sustainability within the watershed.

A medium allocation is assigned to mixed land use areas, reflecting a balance between development and green spaces. This structured approach helps ensure that water resources are allocated effectively, fostering both human and ecological well-being.

The allocation strategy is developed within the WATSCAN framework of water availability, which integrates the revised demand-supply scenario to optimize water availability while supporting ecological integrity. (Referring to the principles)

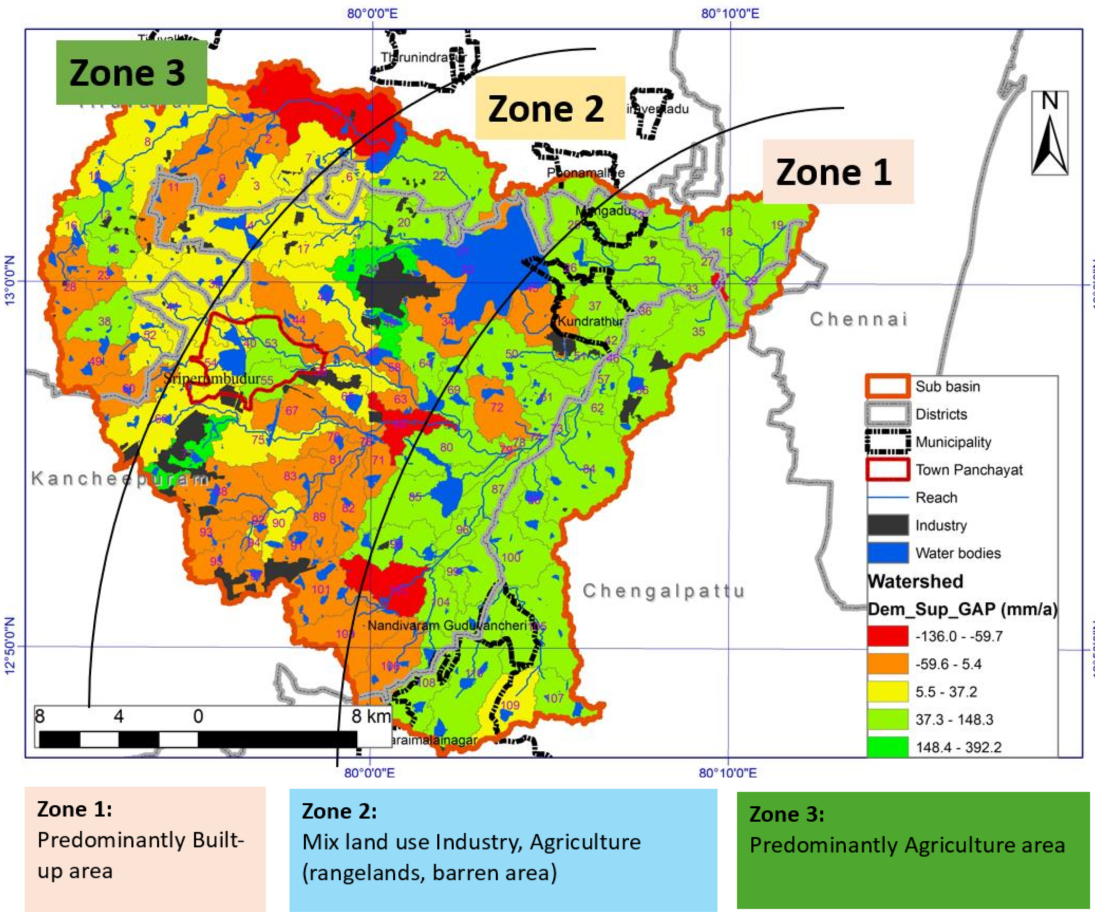


Figure 46 Demand-Supply gap as per allocation zones.

Zone 1: Predominantly Built-up area /High demand areas

Characteristics: These areas experience significant water demand that exceeds availability, often due to high population density or intensive agricultural practices.

Allocations:

1. Prioritize sustainable water use for essential domestic and agricultural needs.
2. Implement strict conservation measures to reduce waste and improve efficiency.
3. Allocate resources for infrastructure improvements to enhance supply.

Zone 2: Mix land use Industry, Agriculture (rangelands, barren area)

Characteristics: These regions have a balanced demand and supply situation, but with potential for future increases in water demand.

Allocations:

1. Maintain current water use levels while planning for gradual increases in allocations for agriculture and industry.
2. Focus on educational programs for water conservation and sustainable practices.
3. Designate a portion of water for ecological needs to preserve local ecosystems.

Zone 3: Predominantly Agriculture area

Characteristics: These zones have low water demand relative to available resources, often comprising natural landscapes or less developed areas.

Allocations:

1. Allocate a higher percentage of water to environmental and ecological uses, ensuring the health of local ecosystems.
2. Support recreational and conservation activities, promoting biodiversity.
3. Plan for potential future development while safeguarding existing water resources.

GROUNDWATER FLUCTUATION

Another critical element that added clarity to the study was the detailed assessment of groundwater levels, which played a key role in validating the zoning and water gap map.

By aligning groundwater data with the water gap map, it became easier to pinpoint areas experiencing significant water deficits, enabling more targeted interventions and strategic water management. This step reinforced the overall water allocation framework by ensuring both surface and groundwater resources were accounted for during the zoning process.

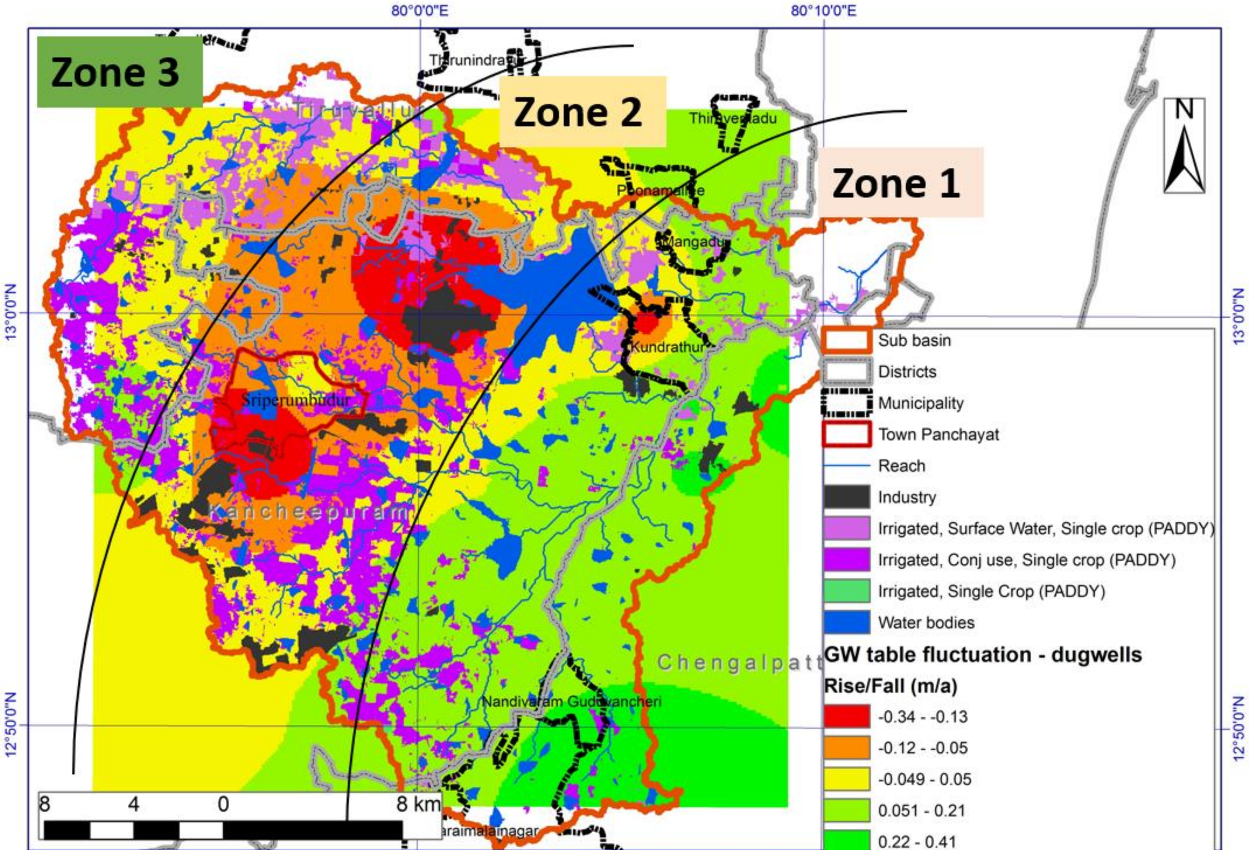


Figure 47 Groundwater Fluctuations

Referring to Figure 44, groundwater levels over the past 15 to 20 years have shown notable fluctuations across various zones, indicating either rising or declining trends. Zone 2 stands out as a highly contentious area where industrial activities and irrigation demands are creating immense pressure on water resources. **Groundwater levels in Zone 2 are declining at alarming rates**, due to the competing demands exerted by industrial and agricultural activities.

Zone 3, on the other hand, maintains a healthier balance between groundwater use and irrigation, indicating less strain on water resources. These insights underscore the pressing need for effective management strategies to address groundwater depletion and mitigate conflicts in water usage across these zones.

EXISTING AND PROPOSED STRUCTURES

The depleting groundwater levels and action stated in step – 3 of water allocation plan, assessment of existing structures was done. This involves evaluating existing structures implemented by the state government in the area. Five structures have been identified and

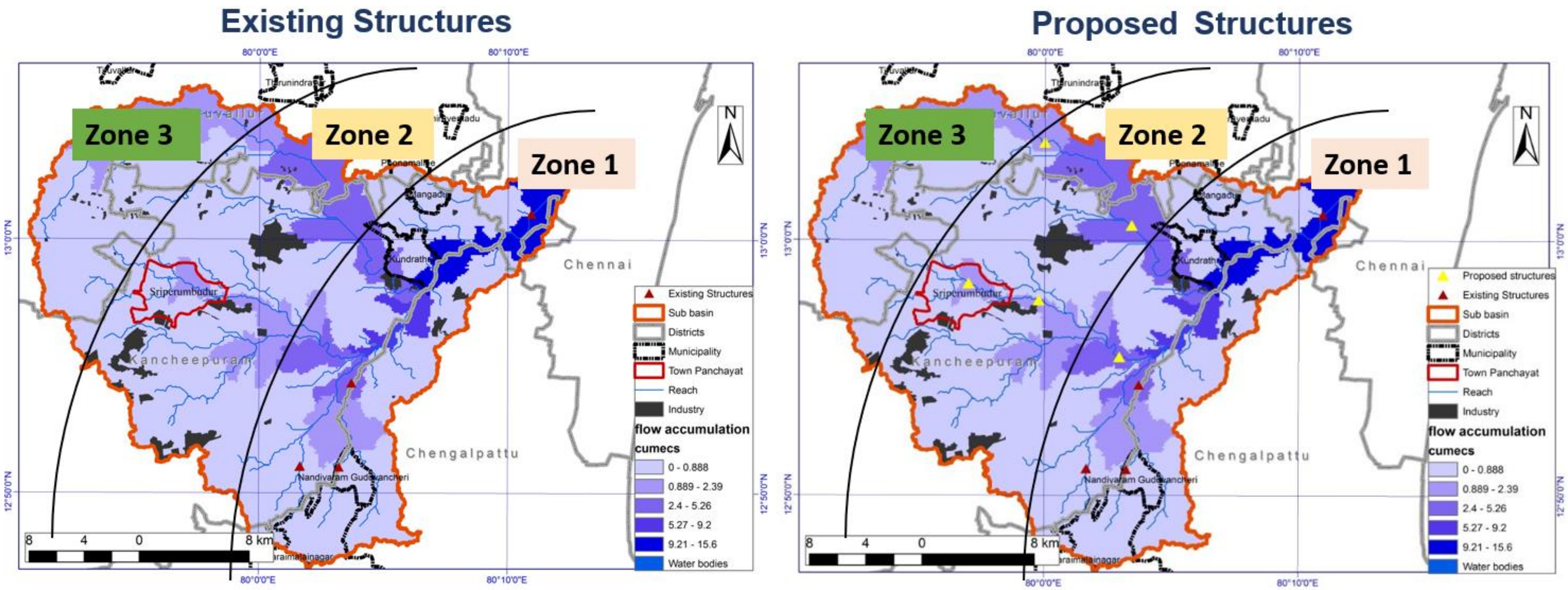


Figure 48 Existing and proposed (Suggested through WATSCAN) structures in the Sriperumbudur watershed.

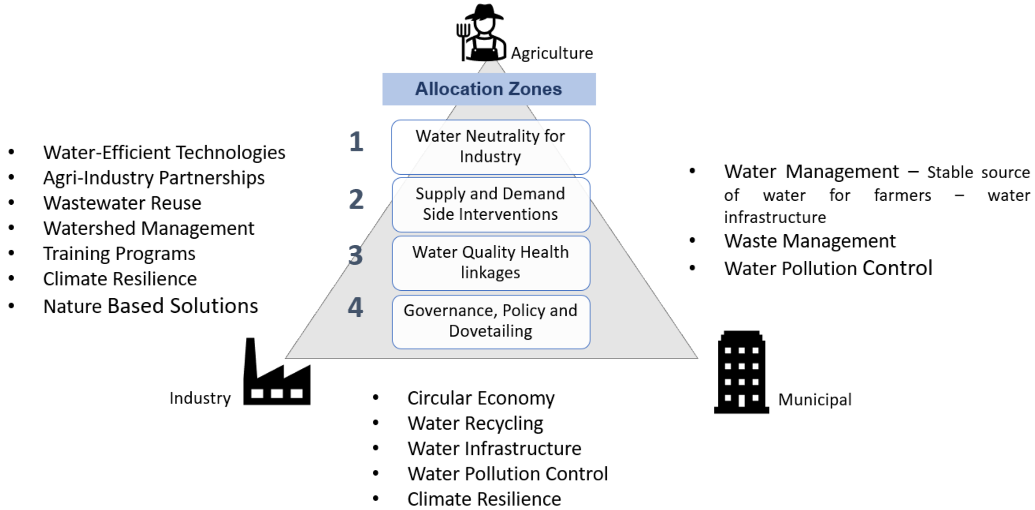
mapped, with their locations primarily concentrated in Zone 1. Zone 1, where these structures are located, was previously less developed, suggesting that historical land use has changed significantly over time.

The current state of Zone 1 is fully built-up, indicating substantial urban development since the time the structures were placed. Zone 1 now contrasts with Zone 2, which retains a mix of irrigation systems, suggesting ongoing changes in land use and water management dynamics.

The proposed structures are strategically designed to enhance groundwater recharge and improve overall groundwater conditions, particularly in Zones 2 and 3, where depletion is a concern. Located primarily within the Sriperumbudur municipal boundary and positioned along the river system, these structures are optimally placed to support effective groundwater replenishment. In addition to groundwater protection, they are intended to meet the increasing irrigation needs in Zone 3, ensuring sufficient water availability for farmers as irrigation intensities rise, ultimately supporting agricultural productivity.

WAY FORWARD

The rapid land use transformation in the region, particularly in Zone 1, where built-up areas are expanding, and in Zone 2, where industrial growth is competing with agricultural needs, is leading to increased water demand and conflict. Farmers are shifting from single cropping to more intensive methods, such as double paddy cultivation, reflecting a broader trend toward conjunctive water use—combining surface and groundwater to meet varying water availability. This shift, coupled with increasing water stress, inundation, and declining water quality, underscores the need for urgent intervention. Environmental concerns, including pollution from untreated sewage and sedimentation, are further exacerbating the situation, making water quality assessments a critical priority. The water allocation plan for Sriperumbudur identifies three distinct zones: Zone 1 (built-up areas), Zone 2 (transitional areas under rapid change), and Zone 3 (agricultural zones). Ensuring a balance between industrial development and agricultural sustainability, particularly in Zones 2 and 3, is essential.



Collaborative watershed management initiatives led by multiple industries aim to optimize water allocation, enhance livelihoods, and promote sustainable development in the region.

Moving forward, the proposed strategy emphasizes the construction of protective structures in Zones 2 and 3 to enhance groundwater recharge and sustain regional water availability. These structures, strategically placed along the river system, aim to optimize groundwater replenishment while supporting increasing agricultural demands. Key recommendations include encouraging industries in Zone 2 to adopt water-neutral practices and promoting the use of municipal water for industrial needs to reduce pressure on local resources. Nature-based solutions are also suggested to protect water bodies and manage flooding, particularly in urbanizing areas.

The overarching goal is to ensure equitable water distribution and community welfare, with a focus on monitoring water productivity and efficiency aligned with Sustainable Development Goal (SDG) indicators. The way forward involves initiating Phase Two, which will focus on collective stakeholder engagement to refine water management strategies and ensure sustainable development over the next 10 to 20 years.