Palestine Journal of Mathematics

Vol 14(1)(2025) , 628–641

Enhanced Water Quality Analysis Using AHP and PROMETHEE-II: A Comprehensive Evaluation Approach

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Communicated by Ayman Badawi

MSC 2010 Classifications: 90B50, 91B76.

Keywords and phrases: AHP, Net outranking flow, PROMETHEE, WQI, Spearman's Rank correlation.

The authors would like to thank the reviewers and editor for their constructive comments and valuable suggestions that improved the quality of our paper. The authors are thankful to the TNPCB for their necessary support and facility

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Abstract: Holistic water resource management aims to identify rivers with potential for effective development, considering factors like land use, economy, water quality, and quantity. Using the PROMETHEE method for river flow and Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI) for water quality. Analytic Hierarchy Process (AHP) may structure criteria. Spearman's rank correlation assesses the relationship between PROMETHEE rankings and WQI ratings, indicating their strength and direction. The comparison involves evaluating rankings against water quality standards to identify rivers suitable for sustainable development. The integrated use of AHP, PROMETHEE, CCME-WQI, and Spearman's rank correlation provides a robust framework. Quantitative data includes correlation coefficients, efficiency metrics, and CCME-WQI scores. Qualitative evidence, such as stakeholder feedback, case studies, and comparative analysis, supports the framework's effectiveness in ensuring efficient water systems and sustainability. The study introduces a novel approach by integrating AHP, PROMETHEE, and CCME-WQI, providing a comprehensive strategy for water resource management. This innovative framework enhances decision-making and sustainability in water management through multi-criteria analysis and preference ranking.

1 Introduction

Water pollution is still a major problem in the world today, having a significant impact on ecosystems, biodiversity, and public health [1]. Even with coordinated attempts to lessen its effects, problems still exist, especially in areas with high population density where poor sewage treatment makes river contamination worse. Although the Water Quality Index (WQI) and Multi-Criteria Decision Making (MCDM) methodologies have been utilised in these endeavours, deficiencies persist, necessitating the adoption of more flexible and all-encompassing methods [2]. In order to evaluate water quality, previous research frequently use techniques like the Analytic Hierarchy Process (AHP) [3] and the Preference Ranking Organisation Method for Enrichment Evaluation (PROMETHEE) [4]. These methods are criticised, meanwhile, for their intrinsic judgmental inconsistencies and poor capacity to adjust to unforeseen circumstances. This study suggests an integrated strategy that incorporates Spearman's rank correlation, the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI) [5], and AHP-PROMETHEE II in response to these drawbacks.

Our study aims to provide a more resilient and flexible framework for water resource management by combining these approaches. By means of an extensive assessment of the intricate relationships present in river systems, our objective is to promote sustainable development of water resources and enhance our knowledge of the dynamics of water quality. Our study is innovative because it can solve the issues raised by earlier research, providing a comprehensive framework that goes beyond the constraints of specific techniques.

In the end, this study hopes to offer insightful information for upcoming environmental evaluations, highlighting the significance of an all-encompassing strategy in tackling water pollution and preserving the health of human populations as well as ecosystems.

2 Study Area

The Cauvery, Thamirabharani, and Bhavani are three prominent rivers that are present in the research region. The Cauvery River is extremely significant to the area's history, culture, and ecology. Thamirabharani River has long served as a cherished water source for many religious rituals. The Bhavani River, which rises in the Nilgiri highlands, contributes to the rich plains it traverses by being an essential irrigation system and by supporting vegetation and fauna.

2.1 River Bhavani

The Bhavani River shown in (Figure. 1) rises in Kerala's Silent Valley National Park before flowing back into Tamil Nadu. Its source is the Western Ghats in the Nilgiris District. It is a 217 km long perennial river that receives most of its water from the southwest monsoon and additional water from the northeast monsoon. It is Tamil Nadu's second-largest river.

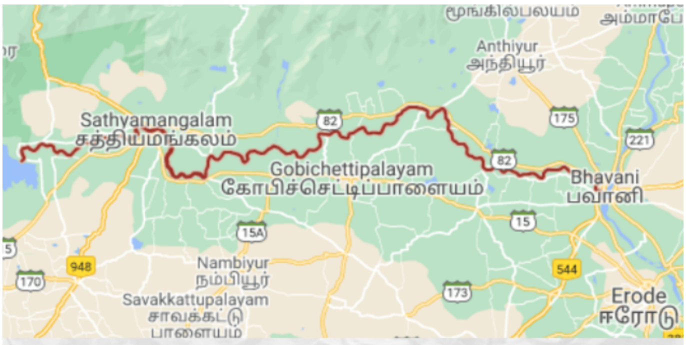

Figure 1. River Bhavani Map

2.2 River Thamirabharani

It rises at the well-known Agastyarkoodam mountain in the Western Ghats hills above Papanasam in the Ambasamudram taluk and runs through the Tamil Nadu districts of Tirunelveli and Tuticorin in southern India. In the past, it was known as the Tamraparni River (Figure. 2) and was linked to Sri Lanka. The river is around 125 kilometres long in total, from source to sea. At an elevation of 1,725 metres above sea level, the Tamirabharani River rises from the summit of the Pothigai hills, which are part of the Western Ghats' eastern slopes.

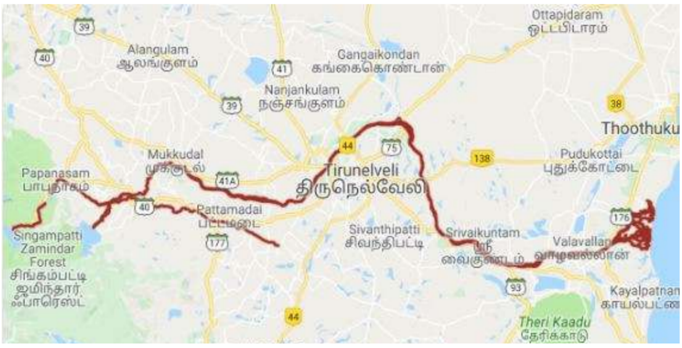

Figure 2. River Thamirabharani Map

2.3 River Cauvery

The Cauvery River represented in (Figure. 3) is a sizable river in India. The river's source is believed to be in the Karnataka Western Ghats in Talakaveri, Kodagu. With numerous rivers involving Mettur, Pallipalayam, Komarapalayam, Seerampalayam, Pugalur, Vairapalayam, P. Velur, Mohanur, Thirumukkudalur the Cauvery basin is thought to encompass 27,700 square miles (72,000 km2). It begins in the southwest of Karnataka and travels about 475 miles (765 km) southeast before entering the Bay of Bengal.

Figure 3. River Cauvery Map

3 Methodology

In the realm of decision-making, the Multi Criteria Decision Making (MCDM) approach emerged in the early 1970s as a systematic method to navigate through conflicting criteria, contributing to more nuanced and methodical decision-making processes. The continuous refinement of theories and models over time has paved the way for enhanced frameworks. MCDM techniques, widely employed in diverse fields such as engineering and environmental sciences, address challenges related to planning and decision-making where multiple criteria are involved. This study seeks to advance the MCDM process by introducing the integrated AHP-PROMETHEE II approach. This approach is exemplified through its application in decision hierarchies, criteria weight determination using AHP, and alternative ranking through PROMETHEE II.

Key steps in the MCDM process include:

- Identifying Decision Issues: This involves defining the problem, understanding objectives, and considering relevant guidelines and constraints. For instance, choosing an automobile may involve factors like price, fuel economy, comfort, safety, and brand reputation.

- Generating Alternatives: Viable solutions are enumerated and detailed once the decision problem is defined. This could encompass various car models from different manufacturers in the context of selecting an automobile.

- Weighting Criteria: Decision-makers assign weights to criteria based on their significance. These weights reflect the relative importance of each criterion concerning decision objectives, aligning with decision-makers' preferences. For example, if fuel economy outweighs pricing, a higher weight is assigned to it.

- Evaluating Alternatives: Criteria and their weights determined, alternatives are assessed based on objective or subjective performance data.

- Ranking and Aggregation: Alternatives are finally ranked based on their overall acceptability or preference, with various aggregation techniques applicable.

These approach not only refines the MCDM process but also provides a structured and robust methodology for decision-makers.

3.1 Analytic Hierarchy Process (AHP):

The Analytic Hierarchy Process (AHP), a well-known method for handling multiple criterion decision-making problems, was introduced by Thomas L. Saaty in 1977 [6]. AHP largely facilitates the process of ranking options based on the significance of each criterion. Its three core components are deconstruction (dividing issues into a hierarchical structure), synthesis (converting local priorities into universal priorities), and evaluation (comparing components pairwise) [7]. AHP frames decision-making challenges through the identification of goals, standards, and alternatives. The Saaty nine-point scale, which establishes alternate priorities, is used for pairwise comparisons. Next, the alternatives' weight coefficients are sorted according to their significance for the AHP outcomes. As illustrated in Figure. 4, AHP monitors the whole decision-making process to effectively identify abnormalities and give quantitative evidence to support judgements.

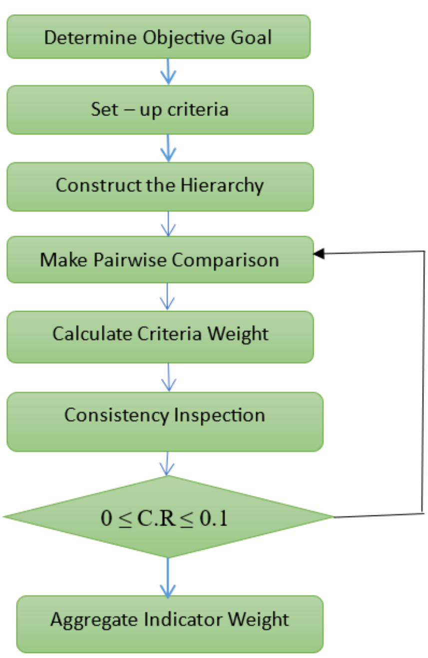

Figure 4. Working of AHP

3.2 PROMETHEE - II:

Introduced by J.P. Brans in 1982, PROMETHEE is a multifaceted technique with three categories: PROMETHEE I (partial ranking), PROMETHEE II (full ranking), and PROMETHEE III (interval ranking). PROMETHEE II, known for its effectiveness, requires specific information to comprehensively rank alternatives based on net outranking flow values [8]. Despite its swiftness and accuracy, the method lacks a defined procedure for weight derivation, posing a limitation. Nevertheless, PROMETHEE II is extensively used for computing preorders, enabling nuanced water quality assessment and supporting decision-making through strategic scores. The method's operational principle, determining net flow for a complete ranking, is depicted in Figure 5, emphasizing its practicality in multicriteria decision-making.

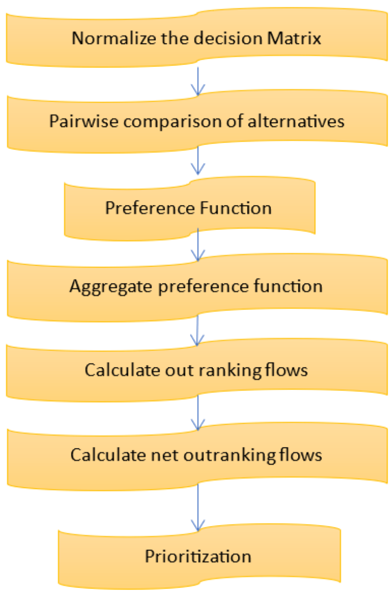

Figure 5. Working of PROMETHEE

Step 1: Determine the criteria (j=1,2,3......k) and the set of possible alternatives in a decision problem.

Step 2: Satisfy the weight W_j of the criteria by

$$\sum_{j=1}^{k} W_j = 1 \tag{3.1}$$

Step 3: Normalize the decision matrix by

$$R_{ij} = \frac{[x_i j - min(x_i j)]}{[max(x_i j) - min(x_i j)]} \tag{3.2}$$

where $x_i j$ is the evaluation values provided by decision makers (i=1,2,3......n) and number of criteria (j=1,2,3......k)

Step 4: Determination of difference by pairwise comparison

$$d_j(a, b) = g_j(a) - g_j(b) \tag{3.3}$$

where d_j (a,b) denotes the difference between the evaluations of a and b on each criterion, where g_j (a) be the value of a criterion j for a decision a and g_j (b) be the value of a criterion j for a decision b.

Step 5: Define the preference function

$$P_j(a,b) = F_j[d_j(a,b)] \tag{3.4}$$

where P_j (a,b) represents the function of the difference between the evaluations of alternative a regarding alternative b on each criterion into a degree ranging from 0 to 1.

Step 6: Determine the multi criteria preference index

$$\pi(a,b) = \sum_{j=1}^{k} P(a,b)W_j \tag{3.5}$$

Step 7: Determine the positive and negative outranking flows

$$\phi^+(a) = \frac{1}{n-1}\sum_{x\epsilon A}\pi(a,x) \tag{3.6}$$

$$\phi^-(a) = \frac{1}{n-1}\sum_{x\epsilon A}\pi(x,a)$$

Where ‘A’ be the set of possible decisions and ‘n’ the number of possible decisions.
Step 8: Calculate the net flow values and rank them accordingly

$$\phi(a) = \phi^+(a) - \phi^-(a) \tag{3.7}$$

4 Results and Discussions:

The assessment of water quality in the three rivers, Cauvery, Thamirabharani, and Bhavani, utilizes two distinct methodologies: Analytic Hierarchy Process (AHP) and PROMETHEE. Dissolved oxygen (DO), biological oxygen demand (BOD), and faecal coliform (FC) serve as the primary indicators for evaluating water quality. PROMETHEE initiates its assessment based on the initial values to rank the water quality of the three rivers. However, the details regarding the specific data and actions involved in this process are not explicitly provided. On the other hand, the AHP [10] approach outlines a comprehensive decision-making process, encompassing:

- Calculation of Criteria Weight: AHP establishes criteria weights to measure the relative importance of each criterion in the decision-making process, ensuring consistency with the sum of weights equaling one.
- Normalized Decision Matrix: Data normalization in the decision matrix aids in comparing and evaluating options and criteria.
- Comparative Analysis: Decision-makers perform pairwise comparisons to determine the relative significance or preference scales of criteria, enhancing the precision of criteria weights.
- Preference Function: A preference function is formulated to assess how well each alternative performs concerning criteria, quantifying preferences and satisfaction [11].
- Function of Aggregated Preference: This function combines performance evaluations across categories, providing an overall assessment of option desirability.

- Preference Index for Multi-Ratio: This index indicates the degree of desirability for each choice across all parameters, contributing to the overall ranking [15].

- Outranking Flow, Positive and Negative: Values indicating how one alternative outranks or is outranked reflect the degree of preference.

- Net Outranking Flow: Determining the overall ranking of alternatives by considering the balance between positive and negative outranking flows [16]-[19].

- Data and Area Considerations: Utilizing data from the Tamil Nadu Pollution Control Board (TNPCB) for 2021, the decision-making process incorporates specific river sites, enhancing the depth and context of AHP's decision-making.

In conclusion, while PROMETHEE provides a ranking based on initial values, AHP [12]-[14] employs a comprehensive approach, including criteria weight computation, pairwise comparison, preference function, and net outranking flow, to thoroughly assess water quality in the three rivers. The incorporation of specific data sources and locations enriches the depth and context of the AHP method's decision-making process.

Table 1. NOF of Cauvery River

Area	**Jan**	**Feb**	**Mar**	**Apr**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Mettur	-2.5589	-2.4902	-2.3405	-1.0118	-1.1703	-3.2106	-3.1311	-2.2758	-2.7826	-3.3701	-2.6650
Pallipalayam	-0.4308	-1.4854	-2.5033	-1.4063	-0.9617	-1.3845	0.2379	-2.1115	-1.9742	-1.9025	-3.0983
Komarapalayam	-2.3779	-1.2079	-0.9607	0.0981	0.4227	-1.1289	-1.6409	-3.1392	-2.4050	-2.5477	-1.8842
Seerampalayam	-2.3476	-2.2755	-3.2985	-3.0265	-1.1960	-1.8414	-2.6394	-2.3224	-4.0716	-2.6109	-1.9785
Pugalur	0.1036	-0.4047	-0.1420	0.2818	-1.8358	0.2036	-0.1199	-0.7990	-0.9584	-1.4329	-0.1830
Vairapalayam	-2.1157	-2.6683	-4.3509	-2.2316	-1.2333	-2.9728	-3.0824	-1.6449	-2.3701	-2.1113	-2.1064
P. Velur	-1.1863	-1.7713	-0.6674	-0.8770	-2.1089	-0.3525	-0.7404	-1.1584	-0.7564	-0.3760	-0.9971
Mohanur	-0.5854	-1.9926	-0.8632	-0.9000	-1.7763	-0.2121	-0.0228	-0.3200	-0.1154	-0.9197	-0.2623
Thirumukkudalur	0.8400	4.8761	3.9695	-0.4996	-0.6850	0.1694	-0.3088	1.9080	2.2451	3.3860	0.5753

Table 2. NOF of Thamirabharani River

Area	Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Papanasam	-1.1073	0.1793	-1.6857	-1.6469	-1.5297	-1.3450	-1.3389	-1.5740	-1.3466	-1.6215	-1.1439
Cheranmadevi	-1.0603	-1.3204	-1.4350	-1.3753	-0.5719	-1.8076	-1.7738	-0.7231	-1.4948	-0.8997	-1.3753
Kokirakulam	-0.5825	0.5355	0.8186	0.9742	1.3572	0.6645	-0.1904	0.9327	-0.5080	0.2736	0.2495
Murapanadu	-1.2427	-0.8467	-0.8572	0.1598	-0.8452	-0.5491	-0.5449	-0.7403	-0.4717	-1.3496	-1.0161
Thiruvidaimarudur	-0.8226	-0.0361	-1.0019	-1.0825	-1.2241	-0.8152	-0.9227	-1.2352	-1.1718	-1.2035	-1.3956
Ambasamudram	3.0577	2.4749	2.1440	0.6522	2.5045	1.9876	3.1708	1.8033	2.3292	2.5498	1.1537
Authoor	2.3240	2.6551	4.1074	3.1657	2.5600	1.4726	4.0433	2.5556	4.8828	2.8161	1.2280
Eral	0.2788	-0.6959	0.5473	0.0749	-1.0368	-0.5085	-0.2821	-0.9255	-0.1349	-0.6067	0.1122
Kallidakurichi	0.6992	0.5584	1.3733	0.9129	0.5411	1.7925	1.0712	2.8812	1.8164	2.3680	2.0830
Srivaikuntam	-0.7185	-1.1145	-0.9399	-0.1507	-0.1547	1.0336	-0.2280	-0.3250	-0.7158	-0.1489	0.2779
Vellakovil	-0.1464	-1.1305	-1.6853	-0.4045	-0.4650	-0.2934	-1.7585	-1.3737	-1.8812	-0.7869	1.0338
Seevalperi	-0.6793	-1.2591	-1.3857	-1.2799	-1.1353	-1.6322	-1.2460	-1.2759	-1.3036	-1.3906	-1.2073

Table 3. NOF of Bhavani River

Area	Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bhavanisagar	-0.3315	-0.7716	-0.6557	-0.6194	-0.0137	-0.2756	-0.9016	-0.7786	-0.9360	-0.5914	-0.2930
Bhavani	0.3284	0.6364	0.8340	0.8208	0.3942	0.5584	0.9303	0.8524	0.5302	0.8893	0.1454
Sathyamangalam	0.0031	0.1352	-0.1783	-0.2014	-0.3805	-0.2828	-0.0287	-0.0738	0.4058	-0.2979	0.1476

Figure. 6 shows the rankings of the nine locations along the river Cauvery, with rank one assigned to areas with good quality and nine to poor quality. The quality of the water varies. Thirumukkudalur has good-quality water, and Mettur has bad quality.

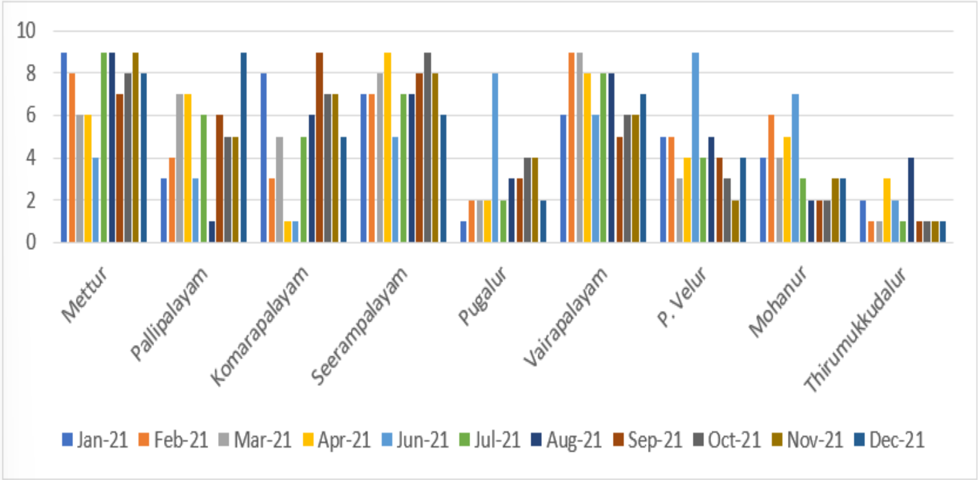

Figure 6. Rank Graph of Cauvery River

The classification of the twelve locations along the river Tamirabharani is shown in Figure. 7. One represents the greatest value on the scale, and twelve represents the lowest value. The quality of the water changed in various places over the ensuing months. Author's water is of high grade, in contrast to Papanasam's poor output.

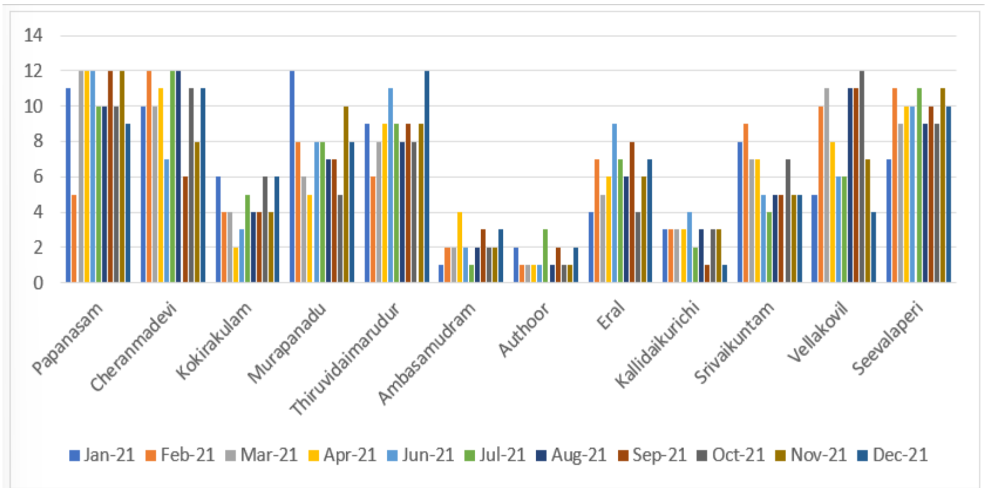

Figure 7. Rank Graph of Thamirabharani River

Figure. 8 ranks the three locations along the river Bhavani, with the highest rank being one and the lowest with rank 3. The quality of the locations in the following months is as follows: Bhavani has the excellent quality, while Bhavanisagar has poor quality.

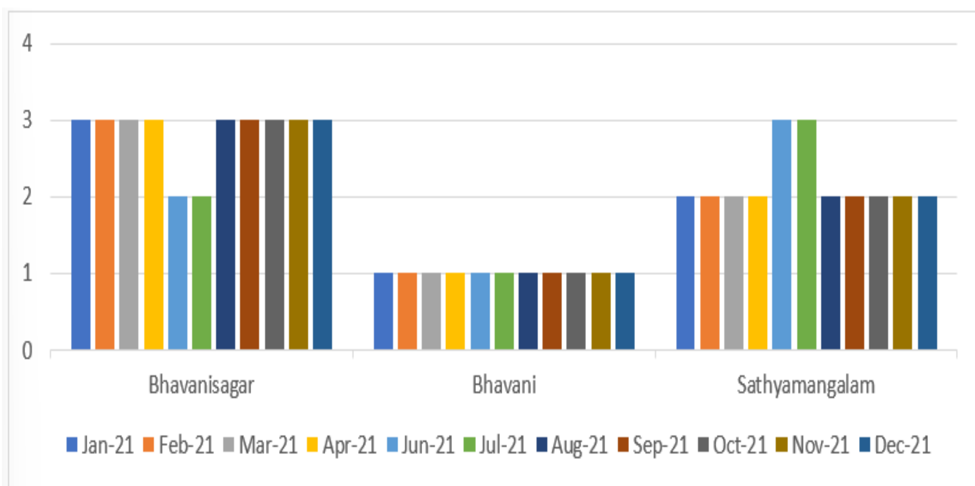

Figure 8. Rank Graph of Bhavani River

5 Water Quality Index (WQI)

The Water Quality Index (WQI) quantifies various aspects of water quality, assigning significance to each indicator based on intended water use [9]. Set limits for different pollutants are outlined by standards such as those of the Indian Council of Medical Research (ICMR), European Economic Community (EEC), World Health Organisation (WHO), Indian Standard Institution (ISI), and United States Public Health Services (USPHS) [9]. Graphical representations of the rivers' water quality indicators are illustrated in Figures 9, 10, and 11. The CCME (Canadian Council of Ministers of the Environment) devised a globally applicable WQI, distinct from traditional index aggregation methods, drawing inspiration from the British Columbia WQI [9]. Instead of subindices and variable weighting, the CCME WQI evaluates the scope, frequency, and amplitude of unmet targets to provide a unitless number representing overall water quality. The index output ranges from zero to one hundred, where one hundred signifies optimal water quality [20]. For ease of communication, the data is categorized into five groups. When compared to the total number of parameters evaluated, F1 (Scope) represents the percentage of parameters (failed parameters) that at least once during the time frame under consideration failed to meet their standards. The terms "target values" and "objectives" are interchangeable with "guidelines."

$$F_1 = \left(\frac{No.\ of\ Failed\ Parameter}{Total\ no.\ of\ Parameter}\right) \times 100 \tag{5.1}$$

The frequency of individual tests that don't meet requirements is indicated by the term F2 (Frequency). A test is a one-on-one comparison between a parameter's value from a particular sampling campaign and the parameter's related guideline.

$$F_2 = \left(\frac{No.\ of\ Failed\ tests}{Total\ no.\ of\ tests}\right) \times 100 \tag{5.2}$$

Three stages are required to calculate F3 (Amplitude), which displays how far test results that failed are from the norm. The number of times a particular concentration exceeds (or falls below, if the guideline is a minimum) the guideline is referred to as an excursion and is represented as follows: When the objective (guideline) of the jth parameter cannot be exceeded by the ith test value:

$$excursion_i = \left(\frac{Failed\ test\ value_i}{objective_j}\right) - 1 \tag{5.3}$$

For situations when the test value must not be lower than the objective (guideline):

$$excursion_i = \left(\frac{objective_j}{Failed\ test\ value_i}\right) - 1 \tag{5.4}$$

The overall amount by which individual tests are out of compliance is determined by adding up their deviations from the standards and dividing by the total number of tests (both those that adhere to the standards and those that do not). The normalised sum of excursions (nse), often known as this parameter, is calculated as

$$nse = \frac{\sum_{i=1}^{n} excursion_i}{Total\ no.\ of\ tests} \tag{5.5}$$

After scaling the normalised sum of the excursions from the guidelines (nse) to produce a range between 0 and 100, an asymptotic function calculates F3.

$$F_3 = \left(\frac{nse}{0.01nse + 0.01}\right) \tag{5.6}$$

After obtaining the factors, the index can be determined by adding the three factors together as follows:

$$CCME - WQI = 100 - \left[\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right] \quad (5.7)$$

The resultant values are normalised to a range between 0 and 100 using the divisor 1.732, where 0 denotes the "worst" water quality and 100 denotes the "best" water quality.
The rankings of the nine places along the Cauvery River are shown in Figure. 9, with rank one designating areas of good quality and rank nine designating areas of poor quality. Vairapalayam has poor water quality, while Mohanur has acceptable water quality.

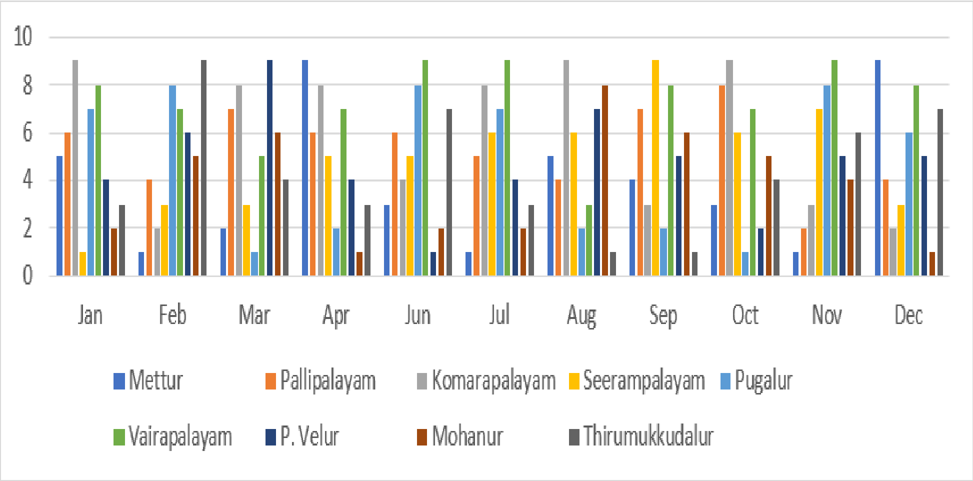

Figure 9. WQI - Rank Graph of Cauvery River

In Figure. 10, the twelve places along the river Thamirabharani are categorised. On the scale, one corresponds to the highest value and twelve to the lowest. Over the subsequent months, the water's quality changed in a number of locations. Seevalaperi's water is of low quality, while Ambasamudram's is of great quality.

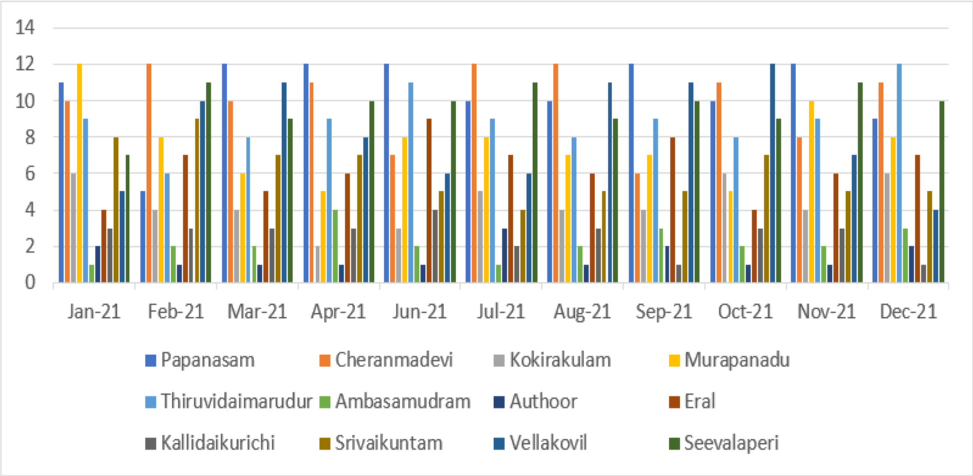

Figure 10. WQI - Rank Graph of Thamirabharani River

Figure. 11 classifies the three locations along the Bhavani River, with one being the highest and three being the lowest. Following are the locations' qualities for the upcoming months: Sathyamangalam has bad quality, while Bhavanisagar has great quality.

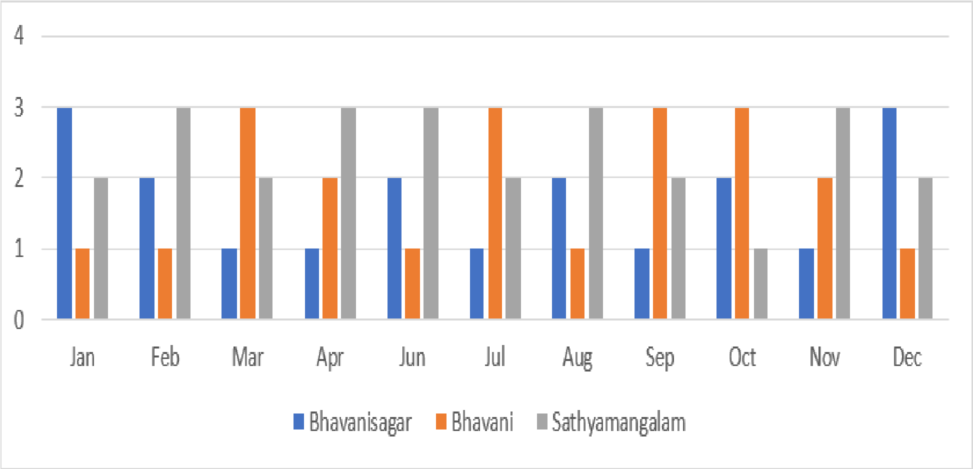

Figure 11. WQI - Rank Graph of Bhavani River

6 Spearman's Rank Correlation Coefficient

The statistical dependency between two variables can be assessed using a non-parametric metric called Spearman's Rank correlation coefficient [20]. It measures how well their relationship is captured by a monotonic function. In the area of water quality, Spearman correlations were used as a statistical test; a coefficient close to 0 denotes a weak association, while values close to -1 or 1 imply a significant negative or positive linear connection. The following formula is used to determine the Spearman's Correlation between PROMETHEE rankings and the Water Quality Index (WQI):

$$\rho = 1 - \frac{6 \sum d_i^2}{n\left(n^2 - 1\right)} \tag{6.1}$$

ρ – represents Correlation; n – represents no. of terms;
d_i – difference between the rank of PROMETHEE and WQI
The correlation can be found in the PROMETHEE and WQI rankings and is given in Table 4. The Cauvery River has a negative correlation in February, June, and November 2021, but a positive correlation in other months. There is correlation between the PROMETHEE and WQI rankings. Only January shows a negative correlation for the Thamirabharani River; the other months show a positive correlation. There is a correlation between PROMETHEE and WQI ranks. For every month, River Bhavani exhibits a positive association.

Table 4. Correlation Coefficient

Area	**Jan**	**Feb**	**Mar**	**Apr**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Cauvery	0.1000	-0.4333	0.0333	0.2333	-0.1833	0.1167	0.0833	0.3833	0.3667	-0.2500	0.1500
Thamirabharani	-0.2098	0.2098	0.1399	0.2378	0.0280	0.0769	0.3636	0.5105	0.3566	0.3007	0.0909
Bhavani	1.0000	0.8333	0.3333	0.5000	1.0000	0.5000	0.8333	0.3333	0.5000	0.5000	1.0000

7 Conclusion

Using cutting-edge analytical methods, we conducted a thorough evaluation of the water quality in the Cauvery, Thamirabharani, and Bhavani rivers in this large study. A thorough assessment of the dynamics of water quality was made possible by the combination of the Analytic

Hierarchy Process (AHP), the PROMETHEE method with Net Outranking Flow (NOF), and the Canadian Council of Ministers of the Environment Water Quality Index (CCME-WQI). By demonstrating connections between PROMETHEE rankings and CCME-WQI and identifying particular months with negative correlation patterns—particularly noteworthy in the Bhavani River—Spearman's rank correlation significantly improved our comprehension.
Our research relied on complete, high-quality data from monitoring stations that were evenly distributed, guaranteeing the accuracy and dependability of our conclusions. Our commitment to producing precise and significant results is demonstrated by our adherence to data uniformity. Crucially, our work shows the value of interdisciplinary approaches while also clarifying complex aspects of water quality. We provide a solid paradigm for environmental assessment research by combining several approaches. Moreover, our research provides new correlation patterns, which is a noteworthy development in the field.
In contrast to conventional methods, the suggested technique demonstrated significant advancements and produced more complex insights into the dynamics of water quality. A more thorough grasp of the assessment of water quality is made possible by the holistic framework that is made possible by the combination of AHP, PROMETHEE, CCME-WQI, and statistical correlations.
It's important to recognise the limitations of our research, though. Even with our meticulous methodology, some elements like spatial and temporal fluctuations might have affected our outcomes. Future studies can concentrate on resolving these issues and looking into other variables that might affect the quality of the water.
In summary, our work highlights the value of interdisciplinary approaches in environmental research while also advancing our understanding of the assessment of water quality. Our study lays the groundwork for future water resource management tactics that will be more successful by offering a sound methodology and revealing fresh insights.

Authors' Contributions

The authors have read and approved the final version of the manuscript. The authors contributed equally to this work.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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Received: 2024-03-19
Accepted: 2024-06-27