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An Advancements of Sustainable Water Management through Multi-Criteria Decision Making: A Comprehensive Study

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Abstract

This study explores the advancements and applications of Multi-Criteria Decision Making (MCDM) in the context of sustainable water management. Recognizing the increasing complexities and challenges associated with water resource allocation, water quality management, and strategic planning, MCDM emerges as a powerful tool to navigate these intricate decision landscapes. We systematically investigate the fundamental principles of MCDM and its relevance to sustainable water management. The review encompasses studies highlighting successful applications of MCDM, particularly in water resource allocation and water quality improvement. Additionally, the integration of MCDM with emerging technologies and its role in adaptive management are explored. By elucidating the current state of the art and identifying future opportunities, this review aims to contribute to the ongoing discourse on leveraging MCDM for resilient and sustainable water management practices.

Keywords: Sustainable water management; Water quality management; Multi-criteria decision making; Water quality improvement; Smart water technologies

Introduction

The provision, usage, and conservation of water resources present several challenges. Sustainable water management takes a comprehensive approach to tackling these issues while maintaining the resilience and well-being of human communities and ecosystems. Fundamentally, sustainability in water management recognizes the interdependence of environmental, social, and economic variables and aims to strike a balance between the limited supply of water and the growing demand for it. This paradigm entails distributing water optimally among various users, such as home requirements, industry, and agriculture, all the while preserving ecosystems and biodiversity. Ensuring the long-term health of aquatic ecosystems, reducing pollution, and maintaining water quality are the top priorities in sustainable water management. To deal with the uncertainties brought on by population expansion and climate change, it also requires implementing adaptive strategies. Efficient use of water resources, incorporating cutting-edge technology, involving stakeholders, and developing regulations that support fair access and responsible usage are essential elements of sustainable water management. Sustainable water management seeks to ensure water supply for current and future generations by promoting a balance between human requirements and environmental health, encouraging resilience in the face of changing circumstances. The element of life, water, is a vital resource where the social, ecological, and economic systems converge. The need for sustainable water management is more important than ever in light of the world's mounting problems, including population expansion, climate change, and growing water shortages. To achieve sustainability in water management, one must possess both a thorough grasp of intricate hydrological systems and efficient frameworks for making decisions that can handle a variety of difficult issues. Water management sustainability requires a multimodal strategy that incorporates social, environmental, and economic factors. First and foremost, it's critical to practice effective water conservation and usage. Water resources may be optimized by putting into practice technologies like rainwater collecting, smart irrigation, and effective water distribution systems.

a) In order to foster agreement and guarantee that a variety of viewpoints are taken into account during the decision-making process, stakeholder involvement is essential. Developing inclusive and equitable water management policies entails collaborating with local businesses, governments, and communities.

b) Sustainable water practices require the guidance of strategic policies and laws. Standards for water quality, equal access, and environmental conservation should all be covered by these rules. Long-term sustainability depends on integrated water resource management, which takes into account how groundwater and surface water are interrelated.

Initiatives for education and awareness help create a society that is mindful of water. Encouraging water literacy increases public support for sustainable water management techniques while encouraging responsible consumption behaviours. To guarantee the long-term resilience and health of water systems, attaining sustainability in water management essentially necessitates a coordinated strategy that combines technical innovation, efficient governance, stakeholder collaboration, and community involvement.

The use of cutting-edge technologies is essential. The effective management of water resources is made possible by remote sensing, data analytics, and real-time monitoring, which offer prompt insights into use trends and any problems.

This introduction lays the groundwork for a thorough examination of how MCDM becomes a crucial instrument for negotiating the complexities of sustainable water management and provides a route to resilient and well-informed decision-making.

Review of Literature

Issues to make Sustainable Water Management: The complicated nature of water systems, socioeconomic issues, and environmental factors provide some obstacles to the implementation of sustainable water management. The growing need for water worldwide due to urbanization, industry, and population expansion is one of the main challenges. Water supplies are under increasing strain, so finding smart ways to distribute, use, and preserve water is essential. Climate change is making water shortage worse, which is a serious problem that affects both quantity and quality. These difficulties are made worse by the unequal distribution of water supplies between regions and periods, which raises concerns about sufficiency and accessibility. In addition, inefficiencies and losses in the water supply chain are caused by insufficient infrastructure and wasteful water consumption. Water source pollution is another serious issue. Freshwater bodies are contaminated by industrial discharges, agricultural runoff, and inappropriate waste disposal, endangering human health and ecosystems. Sustainable water management has always faced the challenge of striking a balance between the requirement for environmental preservation and economic growth. Making decisions is made more difficult by the dynamics of stakeholders and conflicting interests. Managing competing priorities is necessary to maintain ecosystems while balancing the demands of people, industry, and agriculture. Overcoming this obstacle requires effective water governance, which entails comprehensive stakeholder participation and transparent decision-making. Climate change-related uncertainties pose a dynamic challenge. Variations in precipitation patterns, increased frequency and severity of floods or droughts, and temperature increases affect the distribution and accessibility of water resources. Strategies for adaptation need to be adaptable and sensitive to these shifting circumstances. It also costs a lot of money to implement sustainable water management in terms of infrastructure, technology, and education. Some areas, especially in poorer nations, struggle to implement cutting-edge water management techniques due to a lack of funding.

In conclusion, attaining sustainable water management necessitates a thorough comprehension of interrelated problems. It entails dealing with problems related to pollution, inequality in distribution, stakeholder disputes, scarcity, climatic uncertainty, and budgetary limitations. To overcome these obstacles and ensure future water security, creative problem-solving, teamwork, and a dedication to striking a balance between human needs and environmental stewardship are necessary.

The effects of climate change, population increase, and intense rivalry for water from the agricultural, industrial, municipal, and energy sectors are making water management increasingly difficult [1,2]. To achieve sustainable development, water demand and supply management is the main emphasis of integrated water resources management. One limited resource that is necessary for society to survive and operate is water. Because of this, implementing integrated water resources management is crucial to addressing shortages, the problems caused by climate change, and the rising water demand from growing economies [3]. A theoretical model that combined the views of integrated landscape management (ILM) and institutional design principles (IDP) was used to assess cooperative initiatives from wastewater from agriculture that involved water suppliers and agricultural stakeholders [4]. A nationwide evaluation of the danger of drought for agricultural areas was presented [5], accounting for the intricate interactions between many risk factors. According to studies, there are effective ways to improve agricultural water, including crop diversification, crop pattern management, and conjunctive (i.e., surface water and groundwater) water management [6].

Complex water demand and supply systems of today are managed by evaluation models that include social,

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economic, environmental, and climate variables. Using the idea of risk, a model was created by determining exposure, vulnerability, and hazards [7]. The vulnerability was divided into two categories: the human environment and the natural/built environment. The categories were sensitivity and adaptive capability. To manage water in agricultural regions, a geographic information system modelling and satellite data were created. The irrigation water demand was modulated based on many vegetation indices [8]. The water allocation regulations were assessed by water user groups in France [9], taking into account environmental, social, and economic, factors about water used by agricultural user groups. To evaluate the activities under various climatic scenarios, the Soil and Water Assessment Tool (SWAT) and the Adaptation Pathways methodology were combined [10].

Strong organizational strength is necessary for conjunctive management, and this may be attained through regional planning that is founded on a solid comprehension of how groundwater and surface water interact [11]. Strategic planning based on sustainable development principles is necessary for basins with established water supply and drainage networks to be sustainable [12]. The pursuit of sustainable growth satisfies the requirements of future generations while meeting existing economic, environmental, and social demands. It was mentioned [13] that there is a lack of strategic vision for sustainability objectives and actions. A SWOT analysis is a methodical strategic planning process that evaluates a system's strengths (S), weaknesses (W), opportunities (O), and threats (T) to determine its current state [14]. A SWOT analysis-based evaluation of the literature was published [15]. SWOT analysis was used to manage water resources strategically in Africa [16]. To assist the scalability and replication of watershed regional planning instruments in flood-prone areas, tactical planning techniques were investigated in Austrian food-risk management [17]. Prioritizing local and regional scale conservation efforts in diverse environments was made possible by the development of a raster-based regional preservation planning and action tool [18].

To enhance irrigation benefits in the setting of global water administration, a regionally dispersed crop water usage model, cellular automaton (CA), and crop suitability (CS) were implemented in a global optimization model of agricultural consumption of water [19]. Deficits in irrigation networks and corrective actions were identified through research that was published [20].

A subfield of research into operations called multi-criteria decision-making offers techniques for selecting options that are rated according to several criteria. In a variety of multi-criteria decision-making circumstances, the Analytic Hierarchy Process (AHP) is a commonly used decision-making technique [21]. This study uses the mean of the non-principal eigenvalue as an expression to define and quantify the consistency of the pairwise comparison matrix. Thorough a study and systematic classification of the literature on the techniques have been conducted [22]. A presentation [23] reviewed the TOPSIS approach to decision-making. To ascertain the criteria weights in decision-making situations, a novel step-wise weight assessment ratio analysis was presented [24]. The Decision-Making Trial and Evaluation Laboratory (DEMATEL) and the Best Worst Method (BWM) were two of the weighing techniques used in the decision-making process that were combined to accomplish the importance of supplier criteria [25]. Under uncertainty, a model combining the Additive Ratio Assessment (ARAS) approach was presented [26]. In a supplier selection challenge during the pandemic, a novel combinative distance-based assessment method and a categorical-based evaluation methodology were used to measure attractiveness, leading to the development of a new decision-making strategy [27]. The real score measures of the image fuzzy numbers were used to build the in a fuzzy environment [28]. To solve a real-world difficult decision-making problem in social science study, a unique modification of an established MCDM method referred to as the preference ranking based on the ideal-average separation approach in a fuzzy environment was used [29]. Three MCDM frameworks were used to compare the supply chain performance of top Indian healthcare firms [30]. The following lists the steps of the entropy approach [31-35] that were used to determine the criteria's weights.

An extended fuzzy lambda-tau and fuzzy MCDM approach was used to undertake an analysis of uncertainty [36]. Based on the additive ratio evaluation techniques and the removal of criteria, the integrated Fermatean fuzzy based on information decision-making approach was developed and applied to the problem of choosing a food waste treatment system [37]. Research was done on a fuzzy multi-criteria group decision-making model for managing ecological risk in watersheds [38]. Planning water for agriculture, food, energy, and crop area maintenance was made possible with the development of a scenario-based fuzzy interval programming technique [39]. Game theory was used to address issues with decision-making. Game theory may be used to help decision-making in a competitive context, as proven by the application of the technique to building site selection [40].

Issues for Making Sustainable Water Management

The primary concern in attaining sustainable water management pertains to the intricate and interrelated obstacles presented by population expansion, climatic variability, and the escalating requirement for water reserves. The pressure on water supplies brought on by urbanization and an increasing world population is one of the main problems. There is tremendous demand for water supplies due to rapid urban growth, which causes over-extraction from aquifers and depleting surface water resources. This problem is made worse by climate change, which also creates uncertainty in precipitation patterns, intensifies extreme weather events, and modifies the availability and timing of water supplies. The effect on hydrological cycles that follow is a major obstacle to sustainable water management. Pollution is yet another serious issue. Water quality is lowered by industrial

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discharges, agricultural runoff, and poor sanitation systems into water sources, which impacts ecosystems and public health. It becomes a difficult task to strike a balance between the need for environmental preservation and economic development. Unfair water distribution is a recurring problem where some areas struggle with a shortage of water while others deal with an overabundance of water that causes flooding. Planning strategically is necessary to address this mismatch, taking into account local and regional viewpoints.

The problem is made worse by antiquated water management techniques and ineffective infrastructure, which both lead to losses in the supply chain. Unskilled labour combined with outdated infrastructure makes it difficult to provide communities with clean water. Collaboration and effective governance are crucial components of sustainable water management that are frequently absent. The implementation of comprehensive and long-term remedies is impeded by inadequate regulation, enforcement, and cooperation among diverse parties. Finally, changing social attitudes and practices is necessary to ensure sustainable water management. Due to a lack of knowledge and instruction, practices including over-extraction, excessive water consumption, and inappropriate pollution disposal continue. To tackle these complex issues, a comprehensive strategy is essential. This entails implementing strong legislation, embracing nature-based solutions, integrating cutting-edge technologies, and encouraging community involvement. A paradigm change is necessary to achieve sustainable water management, where efficiency, equity of access, and conservation become essential elements of a broad and flexible approach.

Asses Smart Water Technologies

The process of evaluating smart water technologies is a methodical assessment of how well they manage water resources, increase productivity, and improve sustainability in general. This is a brief manual for evaluating smart water technologies:

a) Performance measurements: Establish precise performance measurements that are in line with certain objectives, including leak detection, water conservation, or system resilience. Evaluate the technology's suitability for these requirements.

b) Data Accuracy and Reliability: Assess the technology-generated data's accuracy and dependability. For effective water management and well-informed decision-making, trustworthy data is essential.

c) Capabilities for Integration: Examine how well the technology integrates and works with the current water management and infrastructure. Integrity throughout guarantees a comprehensive strategy for water management.

d) Scalability: Take into account how scalable the technology is. Evaluate its flexibility in managing water at many levels, ranging from small-scale systems to more extensive municipal or regional uses.

e) Cost-Benefit Analysis: To determine if deploying the technology will be economically feasible, perform a thorough cost-benefit analysis. Take operating and upfront investment costs into consideration and long-term savings.

f) Energy Efficiency: Assess Smart Water Technologies' energy usage. The least amount of environmental effect may be achieved by optimizing technology to increase energy efficiency.

g) Resilience and Security: Evaluate the cybersecurity safeguards and the technology's ability to withstand disturbances. It is essential to guarantee both the system's continued functioning and data security.

h) User-Friendliness: Take into account how user-friendly and simple the technology is to utilize. The technology works better when it has an easy-to-use interface and simple functioning.

i) Environmental Impact: Assess the technology's effects on the environment by taking into account the materials used, the amount of waste produced, and sustainability in general. Environmental conservation should benefit from smart water technologies.

j) Adaptability to Changing Circumstances: Evaluate how well the technology adjusts to alterations in the environment, such as variations in the climate or changes in the population. Over time, sustained efficacy is ensured via a flexible system.

k) Regulatory Compliance: Verify that the Smart Water Technology conforms to all applicable laws and guidelines. Respecting regulations is essential for moral and legal reasons.

l) Comments from Stakeholders: Get input from all relevant parties, such as community members, end users, and experts in water management. Their viewpoints offer insightful information about the applicability and real-world impact of the technology.

Stakeholders may embrace and apply Smart Water Technologies more wisely by methodically assessing these factors, which will ultimately lead to the development of resilient, sustainable, and effective water management systems.

Water Quality Improvement

A comprehensive strategy that incorporates treatment, preventive, and sustainable practices is necessary to enhance the quality of the water. First, create riparian buffer zones and land-use plans to safeguard water sources by keeping contaminants out of bodies of water. Use efficient wastewater treatment techniques to get rid of impurities before releasing the water. Precision farming and buffer strips are two examples of sustainable agriculture techniques that reduce fertilizer and pesticide runoff. Utilizing green infrastructure, stormwater management aids in runoff control and pollutant load reduction. Issues are quickly identified

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by routine testing and monitoring of water quality measures. Campaigns for public awareness encourage ethical conduct, and laws and regulations guarantee that water quality regulations are followed.

The health of ecosystems is influenced by preventing erosion and maintaining natural habitats. Nutrient contamination may be avoided by strategic nutrient management, which limits inputs of phosphorus and nitrogen. Last but not least, participation in clean-up campaigns and community engagement allows people to contribute to the preservation of water quality. Combining these actions with innovation and research support creates a strong plan to improve water quality, guaranteeing clean and sustainable water supplies for ecosystems and human use. A mix of treatment procedures, sustainable practices, and preventative measures are used to improve the quality of the water. Key tactics to improve the quality of water are as follows:

a) **Protection of Source Water:** Take action to prevent pollution of water sources by managing industrial discharges, regulating runoff from agricultural regions, and maintaining natural ecosystems surrounding water bodies.

b) **Wastewater Treatment:** To ensure that contaminants are removed before being released into water bodies, invest in efficient wastewater treatment facilities. Wastewater treatment facilities, both municipal and industrial, fall under this category.

c) **Best Practices for Agriculture:** Encourage and put into practice sustainable farming methods to reduce fertilizer, pesticide, and sediment runoff into water sources. Agribusiness's negative effects on water quality can be mitigated with the use of practices like cover crops and precision farming.

d) **Riparian Buffer Zones:** Establish and maintain vegetative buffer zones along water bodies. These buffer zones help filter pollutants, reduce erosion, and provide habitat for aquatic life.

e) **Stormwater Management:** To prevent pollutants from entering aquatic bodies, lower the amount and velocity of stormwater runoff by using stormwater management measures like permeable pavements and rain gardens.

f) **Programs for Education:** Create and carry out educational initiatives to enlighten the public, business leaders, and farming communities on the value of clean water and to promote ethical conduct.

g) **Frequent Testing and Monitoring:** To quickly detect and resolve any possible problems, regularly monitor and test the parameters of water quality. Testing for contaminants such as microorganisms, nutrients, heavy metals, and new pollutants is part of this process.

h) **Land Use Planning:** To avoid unsuitable development close to water bodies, incorporate water quality factors into land use planning. Proper land-use and zoning laws can contribute to the preservation of water quality.

i) **Erosion Control:** To stop soil erosion, use erosion control techniques like terracing and growing plants. Controlling sediment is essential to preserving the quality of the water and stopping the movement of contaminants.

j) **Management of Phosphorus and Nitrogen:** Use strategies including prudent fertilizer use, nutrient management plans, and the encouragement of sustainable farming methods to control nutrient inputs, particularly phosphorus and nitrogen.

k) **Community Involvement:** Take part in projects aimed at improving the quality of the local water supply. Inspire community participation in cleanup campaigns, stream monitoring initiatives, and other initiatives that cultivate a feeling of accountability for water resources.

Encourage innovation and research in the management of water quality. Examine novel approaches and technology for identifying and managing newly developing pollutants. Water quality may be considerably improved and maintained for the benefit of ecosystems and human populations by implementing a thorough and integrated strategy that incorporates technical advancements, community involvement, and regulatory measures.

Strategic Planning for Water Management by MCDM

MCDM strategic planning for sustainable water management calls for a thorough and progressive strategy to handle the intricacies of water-related problems. First, taking into account the various facets of sustainability, MCDM establishes essential criteria including water quality, availability, and social equality. Strategic planning reflects stakeholder preferences and societal ideals by using MCDM approaches to weigh these criteria according to their relative relevance. By use of scenario analysis, MCDM facilitates the examination of diverse future situations and evaluates the resilience of suggested tactics in varying scenarios. This makes it easier to choose robust and adaptive water management strategies that can resist unforeseen events like population expansion and climate unpredictability. Furthermore, MCDM makes it easier to incorporate new technologies into strategic plans, guaranteeing that data analytics, sensor networks, and smart water technologies progress hand in hand with sustainable water management methods. Involving stakeholders and incorporating their varied viewpoints into decision-making is an essential component. The legitimacy of selected strategies is increased by MCDM's transparent and inclusive strategic planning process. In general, MCDM offers a dynamic and organized framework for strategic planning in sustainable water management, encouraging flexibility, resilience, and the long-term health of communities and water resources.

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Conclusion

The element of life, water, is a vital resource where the social, ecological, and economic systems converge. The need for sustainable water management is more important than ever in light of the world's mounting problems, including population expansion, climate change, and growing water shortages. To achieve sustainability in water management, one must possess both a thorough grasp of intricate hydrological systems and efficient frameworks for making decisions that can handle a variety of difficult issues. This study was designed to solely examine how MCDM provides a valuable solution to negotiate the complexities of sustainable water management and make flexible and well-informed decisions. Based on the study we make the following decision.

a) The Complexity of Water Management Challenges: Water managers face an unparalleled combination of cross-border issues in the twenty-first century. Growing populations, urbanization, and industrialization put more strain on water supplies, while climate change makes precipitation patterns unpredictable and exacerbates extreme weather events. Simultaneously, declining water quality adds to the complexity and puts ecosystems and human health at risk. Faced with such complex difficulties, the conventional method of isolated, single-criteria decision-making is insufficient. Therefore, a paradigm change that incorporates integrated, holistic methods is necessary, and here is where MCDM comes into play.

b) The Function of MCDM in Sustainable Water Management: Based on operations research and decision science, multi-criteria decision-making provides an organized and methodical approach to solving choice issues involving several, sometimes contradictory, criteria. Its applicability to sustainable water management stems from its capacity to take into account the wide range of variables present in situations where decisions are made on water. Decision-makers can use MCDM to create adaptive management plans, prioritize water quality improvement methods, or optimize water allocation among conflicting users. It offers a complete framework to help them traverse the complexity.

c) Principles of MCDM: Understanding the principles of MCDM is crucial for understanding its function in sustainable water management. Common concepts are shared by MCDM techniques, such as the Analytic Hierarchy Process (AHP) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). To arrive at the best or most acceptable answers, these techniques entail organizing decision issues, outlining criteria and alternatives, gathering preferences, and combining all of these inputs. These standards may include social justice, environmental effect, economic efficiency, and technological viability in the context of water management, indicating the necessity for an equitable, multidisciplinary approach.

d) Applications of MCDM in Water Resource Allocation: The wise distribution of water among diverse users and purposes is essential to the sustainable management of water resources. In this context, MCDM excels by making it easier to assess trade-offs between competing goals. We will examine situations where MCDM has revolutionized the optimization of water distribution by examining aspects including ecological requirements, urban water supply, and agricultural demands via case studies and practical applications. An integrated water allocation plan is promoted by the nuanced approach provided by MCDM, which enables decision-makers to balance societal equality and environmental sustainability against economic rewards.

e) Improvements in MCDM-Assisted Water Quality Management: An essential component of sustainable water practices is managing water quality, which calls for sound decision-making about contaminants, sources of pollution, and ecosystem health. In this situation, MCDM's ability to manage several criteria and preferences comes in rather handy. We will examine research that demonstrates how MCDM may be effectively applied to prioritize solutions for improving water quality while taking into account societal acceptability, environmental impact, and cost-effectiveness. The potential of MCDM to guide proactive and adaptive water quality management strategies is further enhanced by its interaction with new technologies, such as sensor networks and data analytics.

f) Integration with Emerging Technologies and Smart Water Management: As the world grows more networked, there is a strong case to be made for the integration of MCDM with emerging technologies. Sensors, real-time data analytics, and the Internet of Things (IoT) enable smart water management, which works in perfect harmony with MCDM. This convergence provides rapid, data-driven insights to decision-makers and for the ongoing monitoring of water systems. We will investigate how MCDM, in conjunction with these technologies, supports dynamic, adaptive water management, guaranteeing a flexible response to changing circumstances.

g) Prospects and Difficulties for the Future: Although MCDM has a lot of potential, there are obstacles when using it for sustainable water management. Significant obstacles include the complexity of decision settings, data uncertainty, and the requirement for stakeholder interaction. The difficulties and restrictions that come with using MCDM in water management will be carefully covered in this introduction, highlighting the areas that need improvement and creativity. In addition, the story will present potential future paths and prospects, imagining a scenario in which MCDM develops into an even more powerful instrument for the goal of sustainable water management.

Future Opportunities for Sustainable Water by MCDM

Promising and diverse prospects exist for the use of MCDM in Sustainable Water Management. By offering real-time data analysis and predictive modelling for more adaptable and effective

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water management, the integration of artificial intelligence and machine learning with MCDM can improve decision support systems. When used with MCDM, blockchain technology may improve water management transactions' security, traceability, and transparency while guaranteeing fair resource distribution and lowering the possibility of corruption. IoT may be used by MCDM to enhance data collecting and monitoring. Making better decisions is made possible by the real-time data that smart sensors and Internet of Things (IoT) devices can offer on infrastructure issues, consumption trends, and water quality. By giving local communities more influence over water management choices, participatory MCDM techniques may increase community involvement and promote a feeling of accountability and ownership for sustainable practices. With the uncertainties and difficulties brought on by climate change in mind, MCDM may be used to create water management plans that are climate resilient. This entails making plans for severe weather, changing precipitation patterns, and rising sea levels. By encouraging the reuse and recycling of water resources and reducing waste output, MCDM may help bring circular economy ideas into water management. Water management systems may function at their best when conventional infrastructure is integrated with natural solutions under the direction of MCDM.

Permeable surfaces and wetlands are examples of green infrastructure that can enhance engineered solutions. To construct sustainable water infrastructure, public-private partnerships may be evaluated and established with the help of MCDM. This entails evaluating the viability, dangers, and advantages of working together to enhance water services. The creation of creative policies for sustainable water management can benefit from the use of MCDM. To promote wise water usage, this involves implementing financial tools like water price schemes. MCDM may be used to create educational programs and capacity-building projects that will raise stakeholders' knowledge and comprehension of sustainable water management techniques. Cooperation between states and regions that share water resources can be facilitated by MCDM. It offers a methodical way to handle problems with transboundary water management and to negotiate fair water-sharing agreements. The incorporation of MCDM with new trends will continue to open doors as technology and methods advance, making it a vital instrument for influencing the direction of sustainable water management in the future.

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