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A Neutrosophic Framework for Assessment of Distributed Circular Water to Give Neighborhoods Analysis to Prepare for Unexpected Stressor Events

Mohamed Abouhawwash [1,*], Mohammed Jameel [2] and Sameh S. Askar [3]

[1] Department of Computational Mathematics, Science, and Engineering (CMSE), College of Engineering, Michigan State University, East Lansing, MI 48824, USA; abouhaww@msu.edu.

[2] Department of Mathematics, Faculty of Science, Sana'a University, Sana'a 13509, Yemen; moh.jameel@su.edu.ye.

[3] Department of Statistics and Operations Research, College of Science, King Saud University, Riyadh 11451, Saudi Arabia; saskar@ksu.edu.sa.

* Correspondence: abouhaww@msu.edu.

Abstract: The global water issue is caused by a number of factors, including extreme weather, population increase, and industrial activity. One of the reasons we're running out of water as a planet is because of the outdated take-make-use-throw-away linear paradigm of handling water. It has been suggested that the circular economy may help alleviate water shortages by inspiring a fundamental change in municipal water infrastructure. Reduced consumption, recovered natural resources, and minimal waste are the three pillars of a circular water supply. A dispersed water supply is more adaptable and robust than a centralized one because it gives communities more time to be ready for emergencies. Nonetheless, there have been no extensive studies of the most important elements that influence the choice to build distributed water supplies. In order to better inform the planning process, this research seeks to identify critical selection factors that influence the evaluation of viable choices. This study proposed the triangular neutrosophic set with the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method to compute the weights of criteria. The neutrosophic set is used to deal with uncertain data.

Keywords: Triangular Neutrosophic Set; Water Management; Distributed Circular Water; DEMATEL Method.

1. Introduction

By 2020, 3.6 billion individuals will still be without availability to basic sanitation and 2 billion would be without safe drinking water. By 2030, the gap between global water needs and supply is expected to widen to 40 percent. This means that just 81% of people will have availability to clean drinking water by the year 2030, leaving an estimated 1.6 billion individuals in need. Global warming, population increase, and the demands of agriculture and industry all contribute to a global water crisis.

For instance, the water cycle is being impacted by climate change-related phenomena including rising global temperatures and severe weather occurrences. There will be a greater need for reliable water management systems when the world's population approaches 9.8 billion in 2050. Commercial operations, which account for 19% of global water usage, produce wastewater that may be dumped without sufficient therapy, further endangering the world's already dire water situation [1, 2].

Problems with water supply may have far-reaching effects on economies, ecosystems, and societies, making them critically important to people everywhere. Increasing urbanization brings with it a host of water-related difficulties that need a rethinking and rebuilding of urban water infrastructure. In light of the present water crisis, proponents of the sustainable economy have pushed for its implementation as a means of shifting the existing water policy mindset. A "take-make-use-dispose" linear framework is often used for the administration of water resources. To put it another way, it is already difficult to get access to securely managed water supplies using the conventional linear strategy since water is repeatedly removed without being replaced[3]–[5].

For both financial and ecological reasons, the linear fluid paradigm must be abandoned. However, a circular economy strategy may provide a more sustainable, egalitarian, resilient, and effective means of addressing water-related issues. Reducing waste, reusing materials, and cutting down on consumption are all positive outcomes that might result from implementing circular economy ideas into urban water supplies [6, 7].

There has been growing interest in studying circular water structures due to the potential advantages of adopting such a paradigm. Scientists have created a broad range of centralized and distributed circular water structures using state-of-the-art technology. Centralized water systems may meet more demand, but they are more expensive to set up and take longer to begin providing service.

Large-scale water infrastructure is less likely to replenish supplies and uses more power. In contrast, establishing decentralized water supplies takes less time and money and may be tailored to meet the specific requirements of a certain neighborhood or community. Cities may better prepare for stresses and shocks when dispersed systems continue to operate as intended even when a centralized system is disturbed. Therefore, the focus of this study is on the implementation of decentralized, closed-loop water systems on a community level [8, 9].

2. Water Systems

There have been enormous advantages to cities from the traditional, centralized approach of urban water management, which brings 'large pipes in' from numerous water supplies to urban areas and pushes 'huge pipes out' to discharge urban effluent. Cities across the globe benefit from this "hard path" of water in many ways, including a steady supply of clean water, better health care, more effective wastewater treatment, and streamlined administration. However, there are several risks and costs associated with this route, including ecological damage, societal interference, and high cost of capital.

Water availability is shifting rapidly as a result of the impact of global warming on various water source types as well as aging, increasingly vulnerable, large facilities inadequate leadership structures, limited financing possibilities for new infrastructure projects, and other factors. Threats on the supply side, such as growing urbanization, demographic shifts, and altered client behaviors, are frequently not handled by responsive policy adjustments [10, 11].

In light of this, urban areas are beginning to realize they must rethink their approach to water management and undertake a radical reimagining of their use of freshwater. As a substitute to the traditional linear management approach, which relies on a big central architecture and a limited number of decentralized water solutions applied at various spatial scales inside the city, a new, circular flow of water is envisaged.

Decentralized neighborhood-level measures are planned to supplement the distribution system with regional supplies like rainwater or the soil, and to regenerate wastewater to cover some of the urban demands, in addition to water-aware appliances used in individual homes to reduce individual demands. By integrating numerous distributed technological advances options, this circular urban water supply system decreases, recycles, and reclaims, as opposed to the traditional model of extracting, transporting, and disposing of wastewater. The proposed paradigm change is very reminiscent of bigger socio-economic shifts that attempt to achieve sustainability, like the development of a system of circular economy [12, 13].

This desired decentralization of urban fluid, however, will not come without difficulty, as it introduces a greater degree of network complexity and necessitates collaboration and co-design of efficient execution and uptake models among sectoral organizations, water utilities, neighborhoods, and businesses. Also, the complex interplay among various decentralized technologies at various scales and across various urban water cycle areas, like potable water, sewage, and stormwater, must be factored into decision support systems that were originally developed with the assumption of a centralized, outside-provided water system [14, 15].

3. Circular Water Economy

Water's significance as a public good essential to human survival and an essential human right cannot be emphasized. Agricultural output, energy generation, industrial output, and manufacturing output all rely on water to function. It is fundamental to equitable growth since it has roots in economic, ecological, and social variables. Conflicts and economic instability, particularly in sectors that supply essential services, may result from unchecked competition for water resources [16, 17].

The lack of water to cool thermal power stations has had a negative impact on the production and quality of crops. People expansion, increasing agricultural activity, urbanization (75% of Europe's population now resides in cities and metropolitan regions), and the variable weather induced by climate change have all contributed to a worldwide rise in the demand for water. Vanishing snow, increasing sea levels, and erratic rainfall patterns are all results of the hydrological cycle being altered by the greenhouse gas influence of global warming. The hydrological cycle demonstrates the cyclical nature of water; nevertheless, human actions over the last century have impeded the natural flow of the planet's water supply [18, 19].

4. Neutrosophic DEMATEL Method

The authors of this work utilize neutrosophic Decision-Making Trial and Evaluation Laboratory (DEMATEL) to calculate weights and create a causal diagram of causes impacting digitalization in distributed circular water. DEMATEL's use of neutrosophic numbers allows it to accommodate uncertainties brought on by human choice. However, grey theory and fuzzy logic are often used to deal with such issues. It is explained that fuzzy logic has problems with uncertainty and lack of membership. Cases in the actual world may be represented as neutrophilic sets, which are compilations of decision-making dimensions including truth, indeterminacy, and falsehood. utilized extensively in MCDM issues; pioneered the neutrosophic method. In addition, presented and used the neutrosophic DEMATEL technique for vendor choice. This research adds to the existing body of knowledge by taking a neutrosophic approach to distributed circular water using the DEMATEL technique [20]–[24]. Figure 1 shows the proposed method.

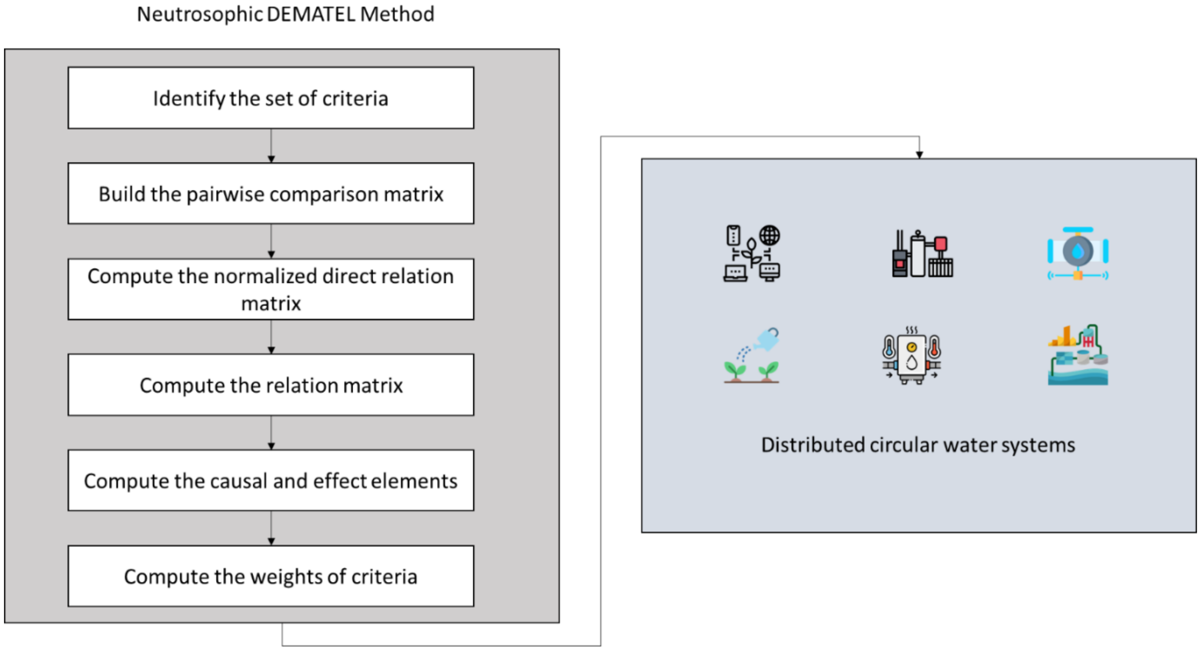

Figure 1. The neutrosophic DEMATEL method steps.

Step1. Identify the set of criteria.
Step2. Build the pairwise comparison matrix.
Step3. Compute the normalized direct relation matrix.

$$N = \frac{1}{\max \sum_{j}^{m} x_{ij}} \quad (1)$$

$$R = N * X \quad (2)$$

Where X refers to the pairwise comparison matrix.
Step4. Compute the relation matrix.

$$L = R(I - R)^{-1} \quad (3)$$

Where I refers to the Identity matrix.
Step5. Compute the causal and effect elements.

$$A = \left[\sum_{j=1}^{f} l_{ij}\right]_{f\times 1} \quad (4)$$

$$B = \left[\sum_{j=1}^{f} l_{ij}\right]_{1\times f} \quad (5)$$

Step6. Compute the weights of criteria

$$w_j = \sqrt{(A+B)^2 + (A-B)^2} \quad (6)$$

5. Results and Discussion

This section introduces the application of the neutrosophic DEMATEL method to compute the weights of criteria.

By recycling and reusing water on a local level, a distributed circular water system may help cut down on overall water use and waste. Instead of transporting water from a single location, this method recycles the water already present in a given region.

In the circular water system, wastewater from sources including irrigation systems, factories, and toilets is collected, purified, and reused for non-drinking needs. The water is cleansed and reused in a natural cycle after being returned to the environment.

The advantages of this method include: Less water is used because less freshwater is needed from a centralized source when water is reused on a local level. Less untreated water is released into the environment thanks to wastewater treatment and reuse, resulting in less pollution. The water security of communities is improved when they use water from nearby sources rather than depending on distant sources. Less energy is required to transport water from a central source when it can be treated and reused on a local level. Because it needs less infrastructure and maintenance, the dispersed circular water system may be less expensive than centralized water systems. As a whole, a distributed circular water system is an eco-friendlier and effective method of water management that may cut down on water waste and save money for communities.

These are some of the requirements for distributed circular water systems:

Rainwater, groundwater, and surface water are all good examples of local water supplies that might be tapped into by the system.

The system should be able to treat and recycle wastewater to a high enough level that the recycled water is of sufficient quality for its intended use.

The system needs a well-thought-out distribution network to provide clean water to residents quickly and easily.

Water supply and demand swings may be smoothed out if the system has enough storage space.

Water quality and quantity should be monitored in real-time, and the system should be controlled so that any problems can be addressed immediately.

Successful implementation of the system requires active community involvement. To make sure the community is aware of the system's advantages and is eager to participate, it must have an effective communication and engagement plan.

Considering the initial investment, continuing maintenance cost, and possible cost savings from decreased water usage and waste, the system should be economically viable and sustainable.

Water security can be improved, water consumption can be reduced, and environmental effects can be mitigated if a distributed circular water system is planned and built with these goals in mind. Also, social, technical, and ecological are criteria used in this paper.

Applying the steps of the triangular neutrosophic DEMATEL method. Table 1 presents the triangular neutrosophic numbers between criteria. Then compute the normalization direct relation matrix as shown in Table 2. Then compute the total relation matrix. Then compute the casual and effects elements. Then compute the weights of criteria as shown in Figure 2.

Table 1. Direct relation matrix

	DWC$_1$	DWC$_2$	DWC$_3$	DWC$_4$	DWC$_5$	DWC$_6$	DWC$_7$	DWC$_8$	DWC$_9$	DWC$_{10}$
DWC$_1$	1	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}
DWC$_2$	1/{(0,1,2); 0.30, 0.75, 0.70}	1	{(1,2,3); 0.80, 0.15, 0.20}	{(4,4,4); 1.00, 0.00, 0.00}	{(4,4,4); 1.00, 0.00, 0.00}	{(1,2,3); 0.80, 0.15, 0.20}	{(0,1,2); 0.30, 0.75, 0.70}	{(2,3,4); 0.90, 0.10, 0.10}	{(1,2,3); 0.80, 0.15, 0.20}	{(1,2,3); 0.80, 0.15, 0.20}
DWC$_3$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1	{(2,3,4); 0.90, 0.10, 0.10}	{(0,1,2); 0.30, 0.75, 0.70}	{(4,4,4); 1.00, 0.00, 0.00}	{(4,4,4); 1.00, 0.00, 0.00}	{(4,4,4); 1.00, 0.00, 0.00}	{(1,2,3); 0.80, 0.15, 0.20}	{(4,4,4); 1.00, 0.00, 0.00}
DWC$_4$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/ {(2,3,4); 0.90, 0.10, 0.10}	1	{(4,4,4); 1.00, 0.00, 0.00}	{(2,3,4); 0.90, 0.10, 0.10}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(4,4,4); 1.00, 0.00, 0.00}	{(0,1,2); 0.30, 0.75, 0.70}
DWC$_5$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1	{(0,1,2); 0.30, 0.75, 0.70}	{(2,3,4); 0.90, 0.10, 0.10}	{(1,2,3); 0.80, 0.15, 0.20}	{(0,1,2); 0.30, 0.75, 0.70}	{(2,3,4); 0.90, 0.10, 0.10}
DWC$_6$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/ {(2,3,4); 0.90, 0.10, 0.10}	1/{(0,1,2); 0.30, 0.75, 0.70}	1	{(1,2,3); 0.80, 0.15, 0.20}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}	{(0,1,2); 0.30, 0.75, 0.70}
DWC$_7$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(2,3,4); 0.90, 0.10, 0.10}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1	{(2,3,4); 0.90, 0.10, 0.10}	{(0,1,2); 0.30, 0.75, 0.70}	{(1,2,3); 0.80, 0.15, 0.20}
DWC$_8$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/{(2,3,4); 0.90, 0.10, 0.10}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(2,3,4); 0.90, 0.10, 0.10}	1	{(1,2,3); 0.80, 0.15, 0.20}	{(4,4,4); 1.00, 0.00, 0.00}
DWC$_9$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1	{(0,1,2); 0.30, 0.75, 0.70}
DWC$_{10}$	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(2,3,4); 0.90, 0.10, 0.10}	1/{(0,1,2); 0.30, 0.75, 0.70}	1/ {(1,2,3); 0.80, 0.15, 0.20}	1/ {(4,4,4); 1.00, 0.00, 0.00}	1/{(0,1,2); 0.30, 0.75, 0.70}	1

Table 2. Normalization direct relation matrix

	DWC_1	DWC_2	DWC_3	DWC_4	DWC_5	DWC_6	DWC_7	DWC_8	DWC_9	DWC_{10}
DWC_1	0.034187	0.010891	0.010891	0.010891	0.010891	0.010891	0.010891	0.010891	0.010891	0.010891
DWC_2	0.107313	0.034187	0.062818	0.15384	0.15384	0.062818	0.010891	0.103842	0.062818	0.062818
DWC_3	0.107313	0.018605	0.034187	0.103842	0.010891	0.15384	0.15384	0.15384	0.062818	0.15384
DWC_4	0.107313	0.007597	0.011255	0.034187	0.15384	0.103842	0.010891	0.010891	0.15384	0.010891
DWC_5	0.107313	0.007597	0.011255	0.007597	0.034187	0.010891	0.103842	0.062818	0.010891	0.103842
DWC_6	0.107313	0.018605	0.007597	0.011255	0.107313	0.034187	0.062818	0.010891	0.010891	0.010891
DWC_7	0.107313	0.107313	0.007597	0.011255	0.011255	0.018605	0.034187	0.103842	0.010891	0.062818
DWC_8	0.107313	0.011255	0.007597	0.011255	0.018605	0.107313	0.107313	0.034187	0.062818	0.15384
DWC_9	0.107313	0.018605	0.018605	0.007597	0.107313	0.107313	0.107313	0.018605	0.034187	0.010891
DWC_{10}	0.107313	0.018605	0.007597	0.107313	0.011255	0.107313	0.018605	0.007597	0.107313	0.034187

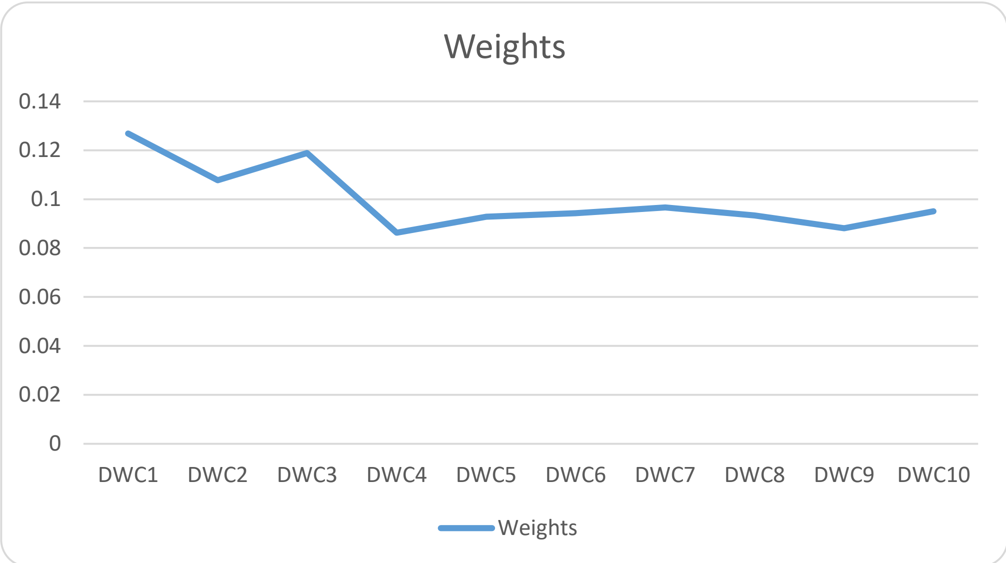

Figure 2. The weights of distributed circular water criteria.

6. Conclusion

The worldwide water crisis is becoming worse because of things like climate change, population growth, and industrial activity. The circular economy has been advocated as a solution to water shortage because it can help bring about a fundamental shift in the way water is managed. Eliminating waste, recovering assets, and cutting consumption are all possible results of incorporating circular economy ideas into urban water supplies. Greater resilience and greater service delivery versatility are provided by distributed water supply systems. Distributed systems continue to operate in the face of a failure at the central node, giving societies time to be ready for the unexpected. This paper used the triangular neutrosophic DEMATEL method to analyze the weights of water system criteria. We used the ten criteria in this study. We achieved the treatment capacity as the highest criterion. To ensure that recycled water is of sufficient quality for its intended use, a distributed circular water system must have sufficient treatment capacity. This is crucial because the quality of the recycled water is crucial to the system's performance, and contaminated water may have detrimental effects on human health and the surroundings.

Data availability

The datasets generated during and/or analyzed during the current study are not publicly available due to the privacy-preserving nature of the data but are available from the corresponding author upon reasonable request.

Conflict of interest

The authors declare that there is no conflict of interest in the research.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. S. Huma, W. Ahmed, M. Ikram, and M. I. Khawaja, "The effect of logistics service quality on customer loyalty: case of logistics service industry," South Asian J. Bus. Stud., vol. 9, no. 1, pp. 43–61, 2020.
2. Y.-C. Lee, F. Leite, and K. Lieberknecht, "Prioritizing selection criteria of distributed circular water systems: A fuzzy based multi-criteria decision-making approach," J. Clean. Prod., p. 138073, 2023.
3. M. S. Mauter and P. S. Fiske, "Desalination for a circular water economy," Energy Environ. Sci., vol. 13, no. 10, pp. 3180–3184, 2020.
4. J. Léonard, E. Perrier, and G. De Marsily, "A model for simulating the influence of a spatial distribution of large circular macropores on surface runoff," Water Resour. Res., vol. 37, no. 12, pp. 3217–3225, 2001.
5. Z. Sheikh and H. Bonakdari, "Prediction of boundary shear stress in circular and trapezoidal channels with entropy concept," Urban Water J., vol. 13, no. 6, pp. 629–636, 2016.
6. H. Rosenthal, "Fish behaviour in circular tanks: a video documentation on fish distribution and water quality," Int. Counc. Explor. Sea. Maric. Committee, C., p. F4, 1987.
7. M. Azgar and N. R. Smruthi, "Design of Circular Water Tank by Using STAAD PRO Software," Int. J. Sci. Eng. Technol. Res., vol. 6, no. 29, pp. 5642–5650, 2017.
8. D. Bouziotas, D. van Duuren, H.-J. van Alphen, J. Frijns, D. Nikolopoulos, and C. Makropoulos, "Towards circular water neighborhoods: Simulation-based decision support for integrated decentralized urban water systems," Water, vol. 11, no. 6, p. 1227, 2019.
9. J. Oca and I. Masalo, "Flow pattern in aquaculture circular tanks: Influence of flow rate, water depth, and water inlet & outlet features," Aquac. Eng., vol. 52, pp. 65–72, 2013.
10. R. C. Brears, Developing the circular water economy. Springer, 2020.
11. A. Malvandi and D. D. Ganji, "Brownian motion and thermophoresis effects on slip flow of alumina/water nanofluid inside a circular microchannel in the presence of a magnetic field," Int. J. Therm. Sci., vol. 84, pp. 196–206, 2014.
12. M. K. Agrawal and S. K. Sahu, "An experimental study on the rewetting of a hot vertical surface by circular water jet impingement," Exp. Heat Transf., vol. 29, no. 2, pp. 151–172, 2016.
13. A. Plevri et al., "Sewer Mining as a Distributed Intervention for Water-Energy-Materials in the Circular Economy Suitable for Dense Urban Environments: A Real World Demonstration in the City of Athens," Water, vol. 13, no. 19, p. 2764, 2021.
14. R. M. Lark, D. Clifford, and C. N. Waters, "Modelling complex geological circular data with the projected normal distribution and mixtures of von Mises distributions," Solid Earth, vol. 5, no. 2, pp. 631–639, 2014.
15. C. Wang, X. Wang, W. Shi, W. Lu, S. K. Tan, and L. Zhou, "Experimental investigation on impingement of a submerged circular water jet at varying impinging angles and Reynolds numbers," Exp. Therm. Fluid Sci., vol. 89, pp. 189–198, 2017.
16. F. Xu and M. S. Gadala, "Heat transfer behavior in the impingement zone under circular water jet," Int. J. Heat Mass Transf., vol. 49, no. 21–22, pp. 3785–3799, 2006.
17. H. Kitahata, Y. Koyano, R. J. G. Löffler, and J. Górecki, "Complexity and bifurcations in the motion of a self-propelled rectangle confined in a circular water chamber," Phys. Chem. Chem. Phys., vol. 24, no. 34, pp. 20326–20335, 2022.
18. [L. Zeng and T. J. Pedley, "Distribution of gyrotactic micro-organisms in complex three-dimensional flows. Part 1. Horizontal shear flow past a vertical circular cylinder," J. Fluid Mech., vol. 852, pp. 358–397, 2018.

19. T. Schaubroeck, T. Gibon, E. Igos, and E. Benetto, "Sustainability assessment of circular economy over time: Modelling of finite and variable loops & impact distribution among related products," Resour. Conserv. Recycl., vol. 168, p. 105319, 2021.
20. N. M. C. Martins and D. I. C. Covas, "Induced circulation by plunging and submerged jets in circular water storage tanks using CFD," Water, vol. 14, no. 8, p. 1277, 2022.
21. N. A. Nabeeh et al., "A Comparative Analysis for a Novel Hybrid Methodology using Neutrosophic theory with MCDM for Manufacture Selection," in 2022 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), IEEE, 2022, pp. 1–8.
22. A. Abdel-Monem and A. A. Gawad, "A hybrid Model Using MCDM Methods and Bipolar Neutrosophic Sets for Select Optimal Wind Turbine: Case Study in Egypt," Neutrosophic Sets Syst., vol. 42, no. 1, p. 1, 2021.
23. A. Abdel-Monem, A. A. Gawad, and H. Rashad, Blockchain Risk Evaluation on Enterprise Systems using an Intelligent MCDM based model, vol. 38. Infinite Study, 2020.
24. N. A. Nabeeh, A. Abdel-Monem, and A. Abdelmouty, "A novel methodology for assessment of hospital service according to BWM, MABAC, PROMETHEE II," Neutrosophic Sets Syst., vol. 31, no. 1, pp. 63–79, 2020.
25. H. S. Kilic and A. S. Yalcin, "Comparison of municipalities considering environmental sustainability via neutrosophic DEMATEL based TOPSIS," Socioecon. Plann. Sci., vol. 75, p. 100827, 2021.

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