Water and Wastewater, Vol. 36, No. 6, pp:

# Text Mining Analysis of Strategic Alignment in Urban Water Supply and Demand within a Circular Economy Framework: a Systematic Approach

**Zahra Mousavi[1], Mehrdad Hosseini Shakib[2*], Seyed Javad Iranbanfard[3]**

1. PhD. Student, Dept. of Industrial Management, Faculty of Management and Economics, SR.C., Islamic Azad University, Tehran, Iran
2. Assoc. Prof., Dept. of Industrial Management, Ka.C., Islamic Azad University, Karaj, Iran (Corresponding Author) Mehrdad.shakib@kiau.ac.ir
3. Assoc. Prof., Dept. of Management, Shi.C., Islamic Azad University, Shiraz, Iran

https://doi.org/10.22093/wwj.2026.580026.3548 **Original Paper**

## Abstract

Sustainable management of urban water resources requires strategic alignment between supply and demand strategies, particularly within a circular economy perspective. Despite growing interest in both domains, few studies have systematically examined how supply and demand strategies can be aligned through an integrated, CE–oriented framework using computational text analysis methods. This study analysed 91 peer–reviewed articles published between 2015 and 2025, retrieved from international and local databases using 16 specialised keywords. Text mining methods were applied, including Latent Dirichlet Allocation for topic modelling, n–gram analysis for pattern identification, TextBlob–based lexical polarity analysis, and K–Means clustering for concept grouping. Data were preprocessed using NLTK and SpaCy libraries, reducing the corpus from 856,000 to 726,000 words after cleaning and stopword removal. Clustering analysis identified five main thematic clusters: resource and infrastructure management (28%), CE strategies (25%), demand and consumption management (20%), planning and policymaking (15%), and stakeholder participation and collaboration (12%). Silhouette coefficients exceeded 0.7 for all clusters, confirming the coherence and validity of the solution. Lexical polarity analysis revealed that 45% of texts carried positive orientations, 40% were neutral, and 15% were negative, reflecting cautious optimism about circular solutions alongside acknowledged implementation barriers. The findings demonstrated that successful urban water management required an integrated approach simultaneously addressing smart infrastructure, water recycling, demand management, coherent policymaking, and stakeholder participation. The study contributed a replicable text–mining framework for synthesising dispersed literature on water–CE alignment, offering evidence–based guidance for policymakers, water utilities, and future researchers.

**Keywords:**
Circular Economy of Water, Integrated Water Resource Management, Text Mining, Strategic Alignment, Water Demand Management, Sustainability of Urban Water Resources.

**Received: Dec. 20, 2025**
**Revised: Jan. 14, 2026**
**Accepted: Feb. 20, 2026**

**To cite this article:**
Mousavi, Z., Hosseini Shakib, M., Iranbanfard, S. J., 2026. Text mining analysis of strategic alignment in urban water supply and demand within a circular economy framework: a systematic approach. *Water and Wastewater*, 36(6), https://doi.org/10.22093/wwj.2026.580026.3548.

## 1. Introduction

The sustainable management of urban water resources has emerged as one of the most pressing challenges confronting modern cities in the twenty–first century. Rapid urbanisation, climate change, and escalating water demand exert mounting pressure on already – limited freshwater supplies (Kakwani and Kalbar, 2024). According to global projections, more than 70% of the world's population will reside in urban areas by 2050, posing significant challenges for sustainable urban water supply and infrastructure planning (Brglez et al., 2024). Global wastewater generation has reached approximately 359.4 billion m³ annually, yet only 52% is treated before discharge – a figure that underscores both the scale of the problem and the magnitude of recoverable resources being lost (Barua, 2026).

Traditional water resource management, which primarily focused on increasing supply through new infrastructure, is no longer adequate to address growing urban needs. This inadequacy has driven a paradigm shift toward innovative, systems – oriented management strategies that simultaneously address supply reliability, demand efficiency, and resource recovery (Bouramdane, 2023). The circular economy[1] has emerged as one of the most promising conceptual frameworks for this transformation. Rooted in the principle of keeping resources in continuous use through recycling, reuse, and closed–loop systems, the CE contrasts sharply with the conventional linear model of "extract, use, dispose" (Timm et al., 2023). In the water sector, CE principles involve rethinking the entire urban water cycle–from source management and distribution to wastewater treatment, nutrient recovery, and water reuse (Fatimah et al., 2024). Studies have shown that implementing CE principles in urban water management can reduce fresh water consumption by 30–40% and lower treatment costs substantially (Koseoglu–Imer et al., 2023).

However, recent scholarship has clarified that circularity alone is insufficient. Moallemi et al., (2026) argued that CE principles must be coupled with resilience to chronic and acute climate stresses to ensure reliable urban water services in an increasingly uncertain world. Their review of 25 leading global cases identified three operationalising strategies: building foresight through scenario – based adaptive approaches; balancing competing priorities through value–centred financing; and enabling coherent action through cross – sectoral collaboration and science – practice partnerships. Similarly, Madhavaraj et al., (2025) demonstrated that integrating CE principles into water distribution networks requires not only technical redesign but also nature–based solutions, inclusive governance, and targeted policy support. These findings point toward a more integrated conception of urban water management – one in which supply, demand, governance, and institutional dimensions are treated as interacting components of a single system rather than parallel silos.

A central dimension of this integration is the alignment of supply and demand strategies. The lack of such alignment has been identified as a primary cause of inefficiency in urban water systems (Koseoglu–Imer et al., 2023).

Kyriakopoulos, (2023) demonstrated that misalignment between supply and demand policies leads to resource wastage and increased operational costs, while Rodrigues et al., (2024) showed that the success of sustainable urban water management depends precisely on integrating these two dimensions. On the supply side, strategies have evolved from developing new water sources toward sustainably optimising existing infrastructure, with studies indicating that combining supply strategies with water recycling can enhance resource sustainability by up to 40% (Domenech and Borrion, 2022). On the demand side, successful management programmes – combining technical measures, economic incentives such as tiered pricing, and social awareness campaigns – have demonstrated reductions in consumption of 20 – 30% (Kyriakopoulos, 2023). Integrated water resource management, which coordinates these dimensions alongside land use and ecosystem considerations, has been shown to enhance the resilience of urban water systems to both climate change and population pressures (Rodrigues et al., 2024).

Smart technologies constitute another critical axis of contemporary urban water management. The application of the Internet of Things[2], artificial intelligence, and big data analytics enables real–time monitoring, demand forecasting, and intelligent network management, reducing water loss by up to 25% and increasing operational efficiency by 35% (Möslinger et al., 2023).

Fu et al., (2023) provided a comprehensive perspective on AI applications in future urban water infrastructures, while Xiang et al., (2021) explored the role of AI in sustainable environmental planning and water resource management more broadly. At the applied level, Moazezi Farhadifar and Tavakoli, (2025) demonstrated that self – organising map[3] neural networks can optimise the spatial deployment of emergency response teams during water crises, achieving significant reductions in incident response time – a finding that confirms the operational viability of AI – based decision support in urban water infrastructure management. The integration of smart technologies with CE strategies and demand management approaches is increasingly recognised as a prerequisite for next – generation urban water governance.

[1] Circular Economy (CE)

[2] Internet of Things (IoT)

[3] Self – Organising Map (SOM)

Beyond technical dimensions, the institutional and business model context of water utilities shapes how effectively any of these strategies can be implemented. Handayani and Fitriati, (2026) examined the transformation strategy of an Indonesian regional water utility, demonstrating that the integration of resource – based strategic assets with social innovation – including multi – stakeholder collaboration, hybrid public funding, and service digitalisation – underpins measurable performance gains.

Critically, Nimjerdi et al., (2026) empirically demonstrated, using panel data from 33 Iranian provincial water and wastewater companies, that business model innovation – measured through net asset turnover – has a significant positive effect on output alongside labour and capital. This finding is directly relevant to the present study, whose research population comprises urban water and wastewater companies, and suggests that business model innovation must be treated as an integral rather than peripheral component of urban water strategy.

Romero and Barquet, (2025) further showed that hybrid business models bridging formal and informal, centralised and decentralised, and public and private boundaries are central to navigating the heterogeneous infrastructure configurations characteristic of rapidly urbanising contexts.

The regulatory environment provides the broader institutional scaffolding within which these technical and business model innovations unfold. The present manuscript's Discussion identifies regulatory frameworks and incentive policies as critical enablers of CE adoption, a position strongly supported by recent empirical literature. Nimjerdi, (2026), analysing panel data from 27 EU countries over 2010–2023, found a U – shaped relationship between open innovation and environmental performance indicators – including municipal waste recycling rates and resource productivity – with environmental regulations significantly reinforcing this relationship.

Yuan, (2026) further clarified the dual role of regulation: as a driver of innovation and public participation when well–designed, but as a barrier when rigid, fragmented, or weakly enforced. Balsalobre–Lorente et al., (2025) showed that digital transformation and sustainable innovations, supported by appropriate environmental tax structures, can significantly reduce emissions in OECD economies, while Gariba and Arthur, (2026) demonstrated that the positive relationship between technological innovation and circular economy outcomes is moderated by regulatory environment, human capital, and technological capacity. These findings collectively indicate that regulatory coherence and innovation policy are not ancillary concerns but structural conditions for the adoption of CE principles in urban water management.

Despite this growing body of evidence, a systematic review of the research literature reveals a persistent fragmentation. Existing studies tend to be case–specific or focused on single dimensions – either supply or demand, either technology or governance – without providing a comprehensive mapping of how these dimensions interact within a CE framework. Studies such as those by Domenech and Borrion, (2022) and Arauzo–Carod et al., (2022) concentrated on demand management and regional CE policies respectively, while Sohal et al., (2022) focused on supply–side considerations. Business model innovation, regulatory moderation, and stakeholder participation have rarely been examined together with technical infrastructure dimensions in a unified analytical framework. Furthermore, no study has applied computational text mining methods specifically to synthesise and cluster the literature on supply – demand alignment in urban water management within a CE context.

The present study addresses this gap through a systematic text mining analysis of 91 peer–reviewed articles published between 2015 and 2025. The novelty of this research is threefold. First, it applies an integrated computational pipeline – combining Latent Dirichlet Allocation[1] topic modelling, n–gram pattern extraction, lexical polarity analysis, and K–Means clustering – to a dedicated corpus on urban water supply –demand alignment, a methodological approach not previously applied to this specific domain. Second, it synthesises supply–side, demand–side, smart technology, business model, and regulatory dimensions simultaneously within a CE framework, moving beyond single–dimension analyses. Third, it produces a validated cluster–based taxonomy of strategies that offers actionable, evidence–anchored guidance for the three principal audiences of this research: policymakers and urban managers seeking integrated frameworks for strategic planning; water and wastewater companies aiming to enhance operational and business model performance; and researchers requiring a structured synthesis of prevailing trends and identified gaps to inform future empirical work.

The primary research question addressed is: "**What are the key patterns and trends in urban water supply and demand strategies within the circular economy approach as identified in the literature***?"* The remainder of this paper is structured as follows. Section 2 describes the research methodology, including corpus construction, preprocessing procedures, and the text mining and clustering pipeline. Section 3 presents the results and discussion, integrating the findings from keyword analysis, pattern identification, lexical polarity analysis, and concept clustering with reference to prior literature. Section 4 presents the conclusions, limitations, and directions for future research.

[1] Latent Dirichlet Allocation (LDA)

## 2. Materials and methods

This study employed a systematic text mining approach to analyse the literature on urban water supply and demand alignment within a circular economy framework. The research was conducted in four sequential phases: corpus construction and article selection, data preprocessing, analytical procedures, and validation. Fig. 1 presents a flowchart of the overall methodological pipeline.

### 2.1. Corpus construction and article selection

The research corpus was constructed through a comprehensive search of reputable international databases – including Scopus, Web of Science, IEEE Xplore, and ScienceDirect – as well as Persian–language databases including Scientific Information Database[1], Magiran, Civilica, and Noormags. The search was restricted to publications from 2015 to 2025, reflecting a decade of accelerating scholarly output on urban water management and circular economy integration. Sixteen specialised keywords were used in both English and Persian, spanning the principal thematic domains of the study, as presented in Table 1.

**Table 1**. Keywords used for literature search

| No. | English keyword |
|---|---|
| 1 | Circular economy |
| 2 | Water resource management |
| 3 | Urban water supply |
| 4 | Water demand |
| 5 | Strategic alignment |
| 6 | Water consumption optimization |
| 7 | Water recycling |
| 8 | Integrated water resource management |
| 9 | Water resource sustainability |
| 10 | Water reuse |
| 11 | Water demand modeling |
| 12 | Water resource planning |
| 13 | Water productivity / Water efficiency |
| 14 | Water economics |
| 15 | Water supply strategies |
| 16 | Water demand strategies |

The article selection process followed a structured screening protocol consistent with systematic review standards. The initial database search returned 1,847 records. Following automated de–duplication, 1,203 unique records remained. Title and abstract screening against the inclusion criteria reduced this to 284 records, which were then assessed in full text. After applying all exclusion criteria, 91 articles were retained for final analysis. Fig. 2 presents the Preferred Reporting Items for Systematic Reviews and Meta – Analyses[2] flow diagram summarising inclusion and exclusion decisions at each stage.

Inclusion criteria were: (1) publication in English or Persian; (2) publication within the 2015–2025 timeframe; (3) substantive focus on strategies for urban water supply and/or demand management within a circular economy context; (4) relevance to urban water and wastewater companies or related management organisations; and (5) article type comprising original research articles, systematic reviews, or case studies. Articles were excluded if they focused exclusively on non–urban water systems, if the circular economy dimension was entirely absent, or if full text was unavailable. The corpus of 91 articles provides a sufficient documentary base for the Latent Dirichlet Allocation, n–gram, and K–Means analyses applied in this study: prior text mining studies in comparable environmental management domains have successfully applied these techniques to corpora of similar or smaller size (Möslinger et al., 2023; Rabbi and Amin, 2024), and the analytical focus on a tightly defined thematic domain – supply–demand alignment in urban water management – reduces the heterogeneity that would otherwise require a larger corpus.

### 2.2. Data preprocessing

All preprocessing was performed in Python (version 3.10) using the NLTK[3] (version 3.8.1) and SpaCy[4] (version 3.5.3) natural language processing libraries. Topic modelling was implemented using Gensim[5] (version 4.3.1), lexical polarity analysis using TextBlob[6] (version 0.17.1), and clustering using Scikit–learn[7] (version 1.2.2).

The preprocessing pipeline comprised three sequential steps applied uniformly to the full text of all 91 articles.

In the first step, **text cleaning** involved the removal of non–linguistic elements including HTML tags, reference list entries, figure captions, table headers, and special characters. This step reduced the raw corpus from 856,000 words to 822,000 words, confirming the successful removal of redundant and irrelevant material.

In the second step, **text normalisation** standardised all tokens to lowercase and resolved common

[1] Scientific Information Database (SID)

[2] Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)

[3] Natural Language Toolkit (NLTK)

[4] An Open-Source Library for Advanced Natural Language Processing (SpaCy)

[5] A Topic Modelling Library for Unsupervised Semantic Modeling (Gensim)

[6] A Python Library for Processing Textual Data And Lexical Analysis (TextBlob)

[7] A Machine Learning Library for Python (Scikit-learn)

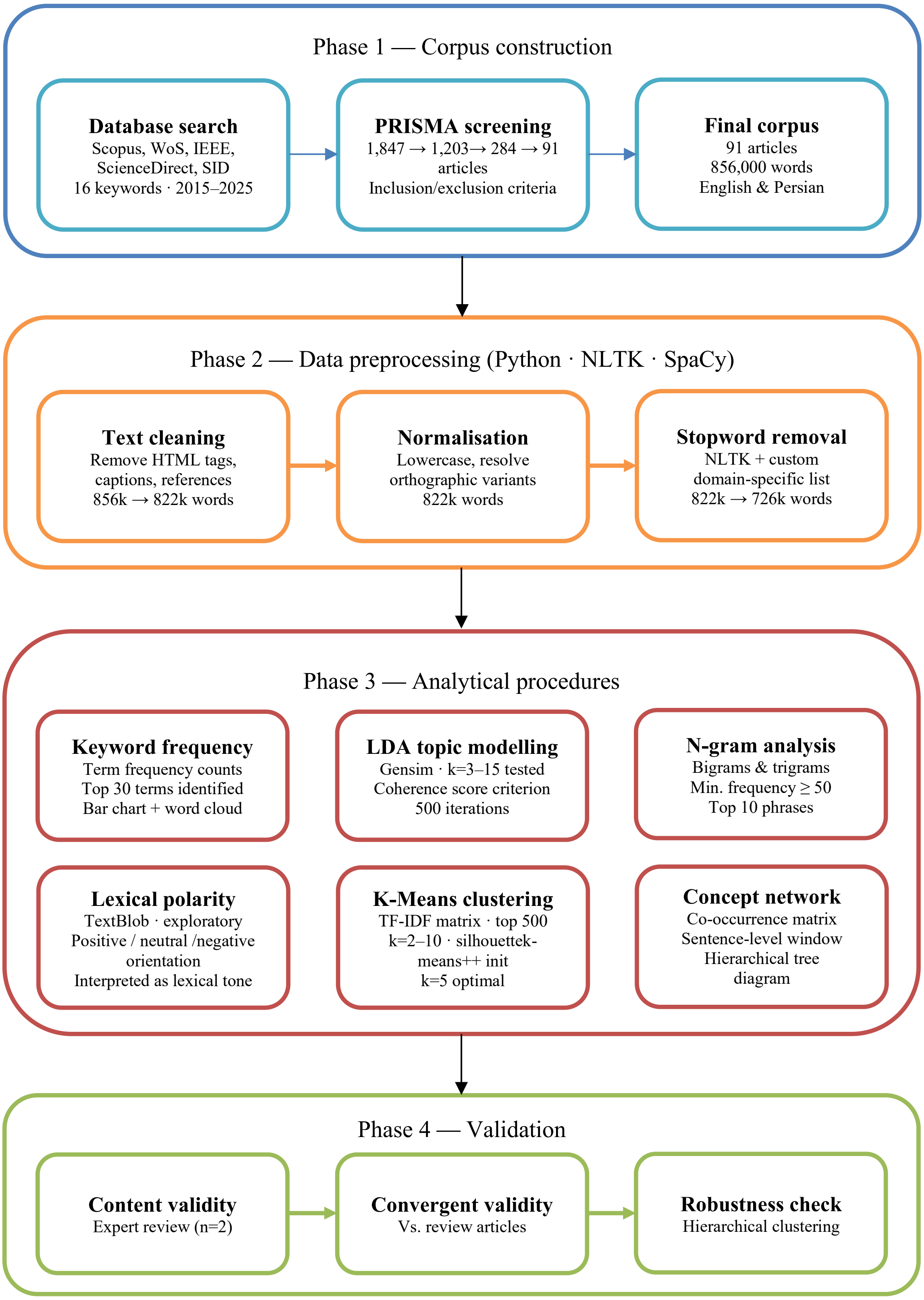


**Fig. 1**. Methodology flowchart

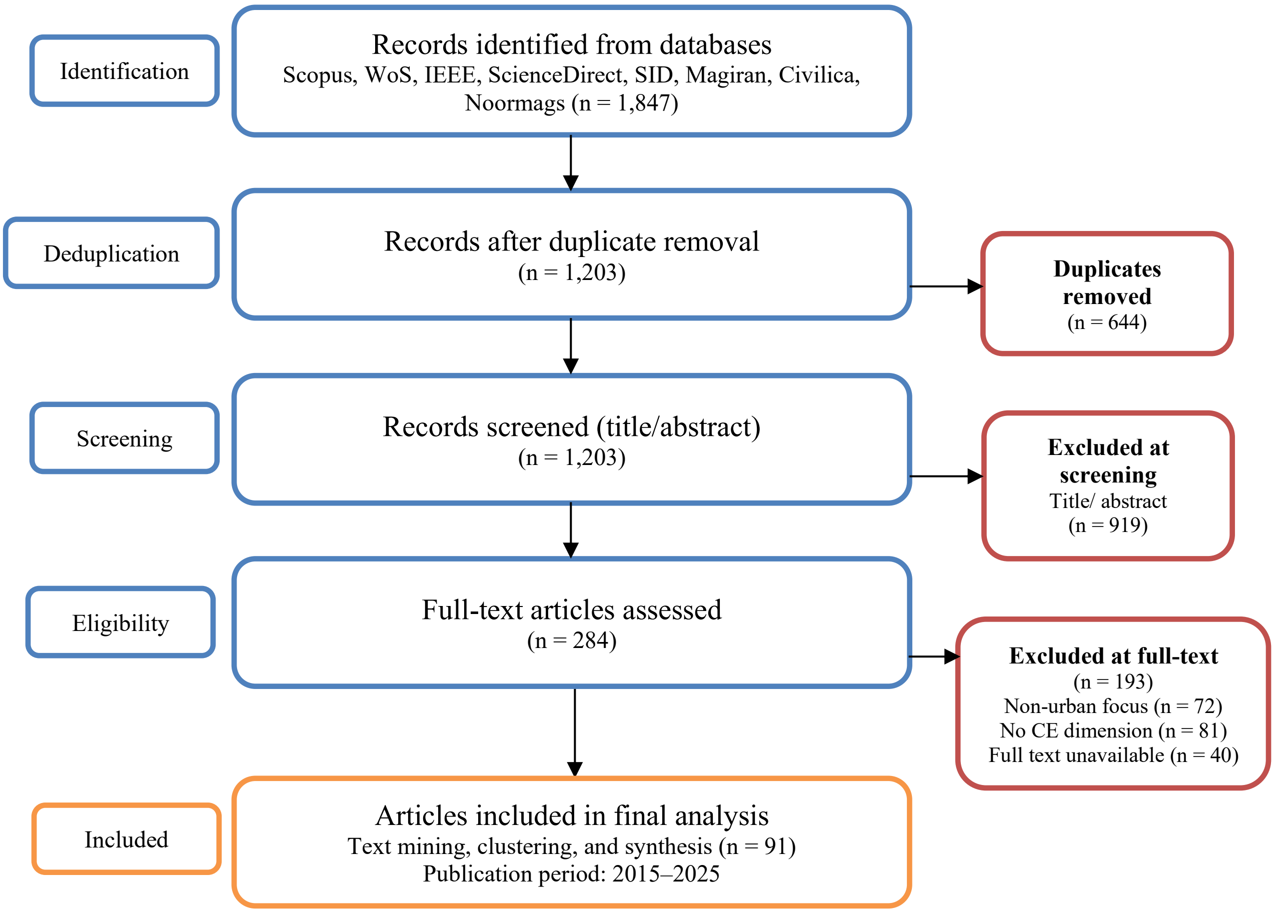


**Fig. 2**. PRISMA flow diagram

orthographic variants (e.g., "grey–water" and "greywater"), ensuring consistency across the corpus without altering word count.

In the third step, **stopword removal** eliminated high–frequency, low–information words using a combined stopword list drawn from NLTK's standard English list and a custom domain–specific extension developed for this study. Domain–specific stopwords included generic academic terms (e.g., "study," "paper," "result") that carry no thematic content in this context. This step reduced the corpus to 726,000 words, representing a 15% reduction from the post–cleaning volume. The outcomes of all preprocessing steps are summarised in Table 2.

**Table 2**. Results of text preprocessing

| Phase | Words before processing | Words after processing |
|---|---|---|
| Text cleaning | 856,000 | 822,000 |
| Text normalization | 822,000 | 822,000 |
| Stopword removal | 822,000 | 726,000 |

## 2.3. Analytical procedures

Following preprocessing, five analytical procedures were applied in sequence to achieve progressively deeper levels of content understanding.

**Keyword Frequency Analysis** was conducted using term frequency counts across the full preprocessed corpus. The thirty terms with the highest frequency and thematic relevance were identified and are reported in Section 3. Frequency distributions were visualised as bar charts and word clouds to facilitate pattern recognition.

**Topic Modelling via LDA** was implemented using the Gensim library. The number of topics was determined empirically by testing values of k ranging from 3 to 15 and selecting the value that maximised coherence score while preserving interpretive distinctiveness across topics. The LDA model was run with 500 iterations and a random seed to ensure reproducibility. The resulting topic–term distributions informed the subsequent clustering and thematic interpretation.

**N–gram Analysis** was applied to identify meaningful multi – word expressions and recurring conceptual phrases within the corpus. Bigrams and trigrams with a minimum frequency threshold of 50 co –

occurrences were retained, yielding the ten most salient phrases reported in Section 3. This technique provided contextual information about how key concepts were deployed and combined in the literature, complementing the single–term frequency analysis.

**Lexical Polarity Analysis** was conducted using the TextBlob library to explore the prevailing orientations of evaluative language in the corpus. It is important to note that TextBlob's polarity lexicon is calibrated for general – domain text rather than scientific writing; accordingly, the results of this analysis are interpreted as an exploratory characterisation of lexical tone – distinguishing texts that foreground achievements and potential (positive polarity) from those that foreground challenges and limitations (negative polarity) – rather than as a behavioural or attitudinal measure in the psychological sense. Sentences were classified as positive (polarity score > 0.1), negative (polarity score < −0.1), or neutral (−0.1 ≤ score ≤ 0.1).

**Clustering** was performed using the K–Means algorithm on a Term Frequency – Inverse Document Frequency[1] feature matrix constructed from the preprocessed corpus. Documents were represented as Term Frequency – Inverse Document Frequency vectors with a vocabulary limited to the top 500 terms by document frequency, following standard practice in text clustering pipelines (Möslinger et al., 2023). The optimal number of clusters was determined by computing the silhouette coefficient across values of k from 2 to 10; k=5 produced the highest average silhouette score and yielded the most interpretively coherent cluster solution. K–Means was initialised using the k–means++ strategy and run with 300 iterations and 10 random restarts to avoid local optima. To assess the robustness of the five–cluster solution, hierarchical agglomerative clustering with Ward linkage was applied to the same Term Frequency – Inverse Document Frequency matrix as a sensitivity check; the resulting dendrogram confirmed a natural partition into five primary groupings consistent with the K–Means solution, supporting the stability of the reported clusters.

**Concept Network Analysis** was conducted to visualise semantic relationships among the most frequent terms and phrases. A co–occurrence matrix was constructed based on terms appearing within the same sentence, and the resulting network was rendered as a hierarchical tree diagram to illustrate the structural organisation of concepts across the corpus.

### 2.4. Validation

The validity and reliability of the text mining results were ensured through multiple complementary measures. Content validity was established by screening all selected sources for academic credibility and relevance to the study's thematic focus. Two experienced experts in strategic urban water management independently reviewed the extracted concepts and cluster assignments; their assessments confirmed the accuracy and meaningfulness of the clustering logic, and any disagreements were resolved through discussion.

Convergent validity was verified by comparing the identified clusters and dominant themes against findings from recent review articles and industry reports on urban water management. The close alignment between the emergent cluster structure and the conceptual categories reported in prior literature confirmed the credibility of the results. Construct robustness was further assessed by comparing the K–Means solution against hierarchical clustering results, as described above. Cluster quality was quantified using the silhouette coefficient, which exceeded 0.7 for all five clusters - a threshold conventionally interpreted as indicating strong cluster cohesion and separation. Finally, all steps of the analysis pipeline, from preprocessing parameter settings to algorithm configurations, were fully documented to ensure reproducibility.

## 3. Results and discussion

### 3.1. Data preprocessing

The preprocessing pipeline was applied uniformly across the full corpus of 91 articles, following the three–step sequence described in Section 2: text cleaning (856,000 → 822,000 words), text normalisation (word count unchanged), and stopword removal (822,000 → 726,000 words), yielding a 15% reduction that substantially improved the signal–to–noise ratio for subsequent analyses. The outcomes of all preprocessing steps are summarised in Table 2. This sequence is consistent with established best practice in text mining applied to environmental management literature (Möslinger et al., 2023; Rabbi and Amin, 2024).

### 3.2. Keyword frequency analysis

Fig. 3 presents the frequency distribution of the 20 most common terms in the corpus in their original unordered sequence, while Fig. 4 displays the same terms ranked by descending frequency across the full set of 30 keywords identified through LDA analysis. Reading these two figures together is important: Fig. 3 reveals the relative prominence of terms as they emerge across the document collection without imposing a ranking, while Fig. 4 allows direct comparison of term weights and confirms the hierarchical dominance of core concepts.

The most frequent term across the corpus is "water" (n ≈ 4,850), followed by "management" (n ≈ 3,930), "resources" (n ≈ 3,670), "circular" (n ≈ 3,420), and "economy" (n ≈ 3,290). The dominance of these five terms jointly confirms that the corpus is tightly focused on the intersection of water resource management and

[1] Term Frequency–Inverse Document Frequency (TF-IDF)

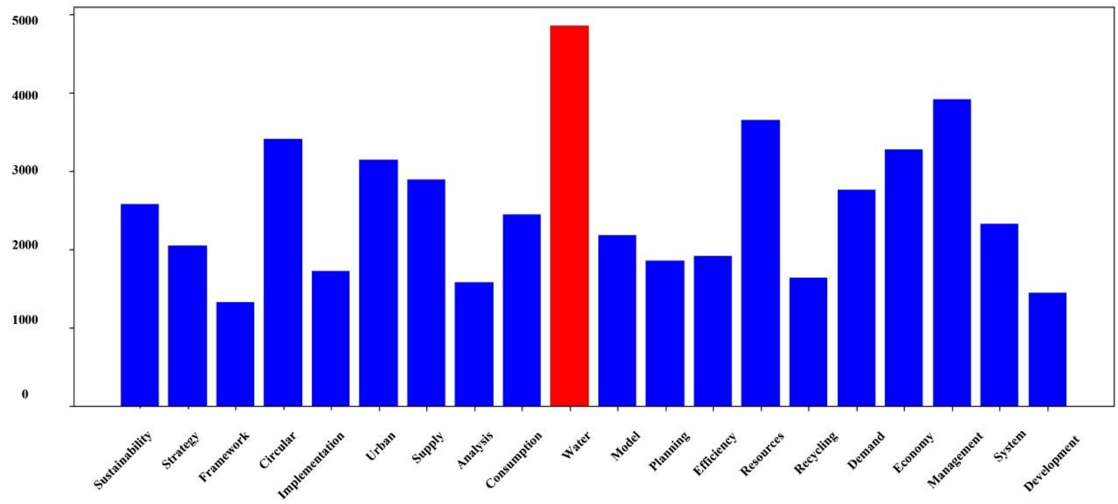


**Fig. 3.** Frequency distribution of the top 20 keywords in the analyzed texts

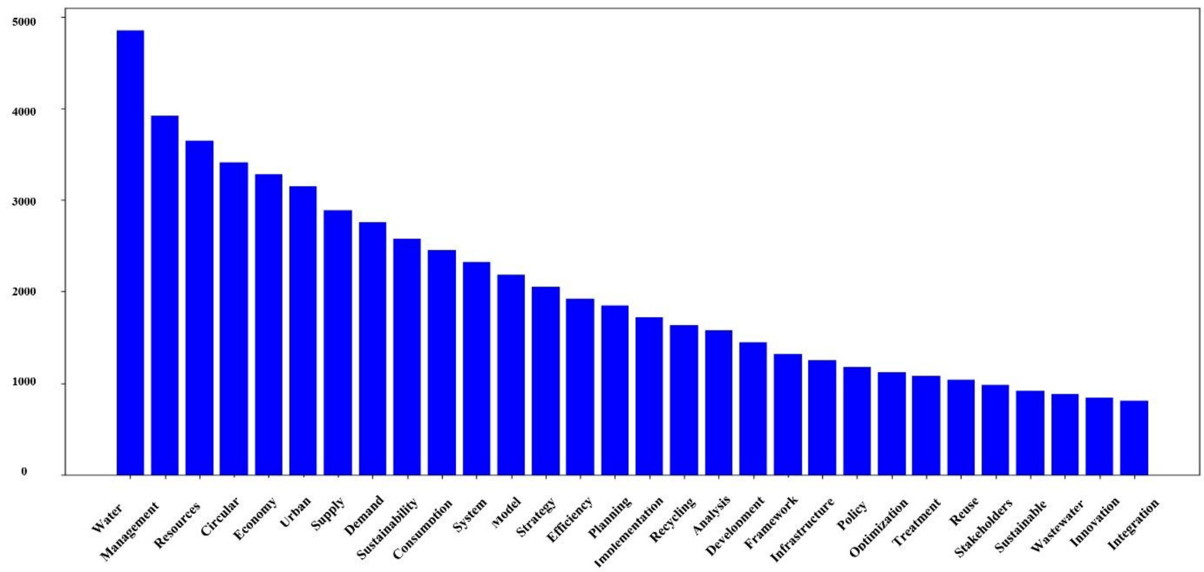


**Fig. 4**. The 30 most frequent keywords and their occurrences

circular economy thinking, validating the search strategy and corpus construction process. The co–prominence of "supply" (n ≈ 2,900) and "demand" (n ≈ 2,780) as near-equal–frequency terms is particularly significant: it indicates that the literature does not systematically privilege one side of the supply-demand equation over the other, suggesting an emerging disciplinary consensus around integrated approaches - a finding consistent with the argument of Rodrigues et al., (2024) that sustainable urban water management requires the simultaneous integration of both dimensions.

Beyond the five dominant terms, the sustained frequency of "sustainability" (n ≈ 2,600), "efficiency" (n ≈ 1,960), and "recycling" (n ≈ 1,620) reflects the literature's strong orientation toward performance improvement and resource conservation rather than merely descriptive documentation of current practice. The appearance of "stakeholders" (n ≈ 950), "policy" (n ≈ 1,060), and "integration" (n ≈ 820) among the lower-frequency terms in Fig. 4 is analytically meaningful: these governance and institutional concepts, though present, are less central to the corpus than technical and resource–oriented terms, pointing to a relative underrepresentation of participatory and regulatory dimensions in the literature - a gap that is further confirmed in the clustering analysis below, and one that aligns with recent empirical findings on the moderating role of regulatory environments in circular economy transitions (Nimjerdi, 2026; Yuan, 2026).

The word cloud (Fig. 5) provides a complementary visual synthesis of these frequency patterns. The dominant visual presence of "water," "management," "circular," "resources," and "economy" corroborates the quantitative frequency analysis. Notably, secondary terms visible in the cloud - including "hydrology," "resilience," "eco-friendly," "livelihoods," "equity," and "biodiversity" - do not appear among the top 30 LDA keywords but are present in the broader corpus, suggesting that while the literature is primarily oriented toward engineering and management solutions, a smaller but non–trivial strand of research engages with ecological and social justice dimensions of urban water governance. This observation is consistent with the call by Santos et al., (2023) for greater attention to socioeconomic and cultural dimensions in sustainable water management.

### 3.3. Identification of textual patterns

N–gram analysis identified ten dominant multi–word phrases in the corpus, presented in Table 3. The most frequent phrase, "urban water management" (n=485), confirms the centrality of the urban context across all 91 articles. The second–ranked phrase, "circular economy approach" (n=420), indicates that the CE framework is invoked not merely as background context but as an active analytical lens in a large proportion of the studies. The near–equal frequency of "water supply demand" (n=380) and "sustainable water resources" (n=345) again reinforces the integrated framing of supply and demand as co–dependent rather than competing concerns.

The semantic network diagram (Fig. 6) visualises the relational structure among these ten phrases, with "Urban Water Strategies Alignment" occupying the central hub position - a configuration that reflects the analytical focus of this study and confirms that the corpus is coherently organised around the strategic alignment problem. From this central node, connections radiate outward to phrases belonging to all five thematic dimensions subsequently identified in clustering: supply and demand management, circular economy approaches, resource planning, sustainability, and stakeholder engagement. The presence of "stakeholder engagement process" (n=255) as a peripheral node in the semantic network – connected to the hub but not cross–connected to other peripheral nodes – is structurally telling: it suggests that stakeholder participation is acknowledged as relevant across the literature but has not yet been deeply integrated with technical and strategic discourse in the way that, for example, "water reuse recycling" and "integrated water management" are mutually connected. This structural observation provides empirical grounding for the frequently made normative claim that participatory dimensions remain siloed from mainstream water management research (Tsatsou et al., 2023; Moallemi et al., 2026).

### 3.4. Lexical polarity analysis

The exploratory lexical polarity analysis, conducted using the TextBlob library, classified corpus texts as carrying predominantly positive (45%), neutral (40%), or negative (15%) orientations (Fig. 7). As noted in the methodology, these results are interpreted as characterisations of lexical tone rather than as measures of researcher sentiment in a psychological sense: texts classified as positive are those that foreground achievements, demonstrated benefits, and potential solutions, while those classified as negative foreground challenges, barriers, and unresolved problems.

Representative examples of sentences classified under each polarity category, together with their TextBlob polarity scores, are presented in Table 4.

The dominance of positive and neutral orientations (85% combined) reflects a literature that is primarily constructive and solution–oriented in its framing, consistent with the applied and policy–adjacent nature of the urban water management field. The 45% positive orientation is driven by language associated with demonstrated outcomes - phrases such as "significant progress," "improved efficiency," and "promising results" - which frequently appear in case study and empirical research articles describing implemented CE strategies or smart water technologies. This finding aligns with the broader optimism in the field regarding the potential of circular and smart approaches documented by Fu et al., (2023) and Barua, (2026).

The 15% negative orientation is concentrated in articles addressing implementation barriers, regulatory constraints, and infrastructure limitations. Representative negative–polarity statements include observations about "critical water shortages," "infrastructure limitations," and "institutional barriers" - language consistent with the challenges identified by Koseoglu–Imer et al., (2023) in their study of CE implementation in European water systems. The presence of this critical strand, while smaller than the positive orientation, is analytically valuable: it signals that the literature has not converged on uncritical optimism but maintains a realistic assessment of the conditions under which circular strategies can and cannot succeed. The thematic breakdown of these orientations, summarised in Table 5, reveals seven recurring attitudinal patterns: optimism about innovative solutions, concern over current water scarcity conditions, belief in collective participation, confidence in long-term sustainability goals, emphasis on systemic integration, awareness of implementation limitations, and enthusiasm for technological innovation.

### 3.5. Concept clustering

K-Means clustering of the Term Frequency – Inverse Document Frequency document–feature matrix identified five thematically coherent clusters, with the optimal solution at k=5 confirmed by the highest

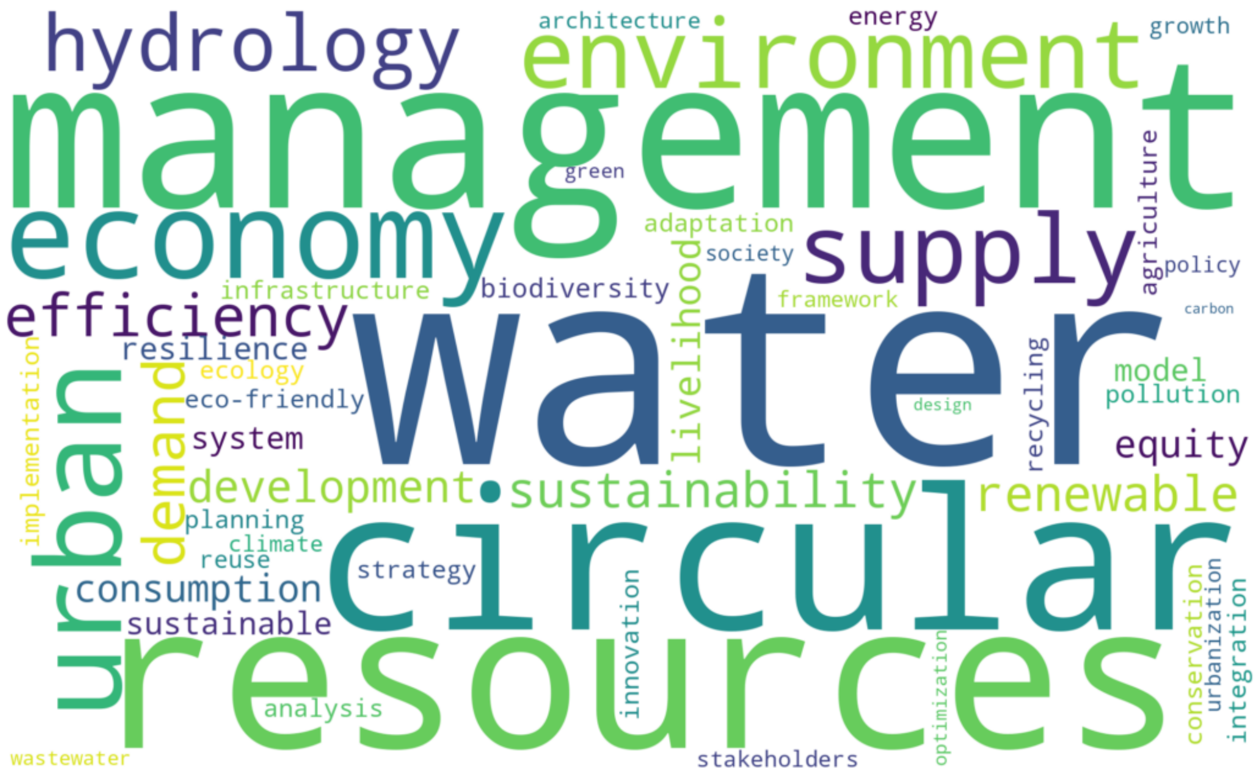


**Fig. 5**. Word cloud of the most frequent and important keywords in the analyzed texts

**Table 3**. Top 10 frequent phrases and their analysis

| No. | Frequent phrase | Frequency | Analysis |
|---|---|---|---|
| 1 | Urban water management | 485 | Reflects the core focus on managing urban water resources. |
| 2 | Circular economy approach | 420 | Emphasizes the circular economy as a key framework. |
| 3 | Water supply demand | 380 | Highlights simultaneous attention to supply and demand. |
| 4 | Sustainable water resources | 345 | Indicates the priority of sustainability in water management. |
| 5 | Water resource planning | 310 | Focuses on strategic planning for water resources. |
| 6 | Integrated water management | 290 | Demonstrates the importance of holistic approaches. |
| 7 | Water reuse recycling | 275 | Reflects emphasis on water recycling and reuse. |
| 8 | Strategic resource allocation | 265 | Highlights the importance of efficient resource use. |
| 9 | Stakeholder engagement process | 255 | Underscores the role of stakeholder participation. |
| 10 | Optimization water consumption | 250 | Focuses on optimizing water consumption patterns. |

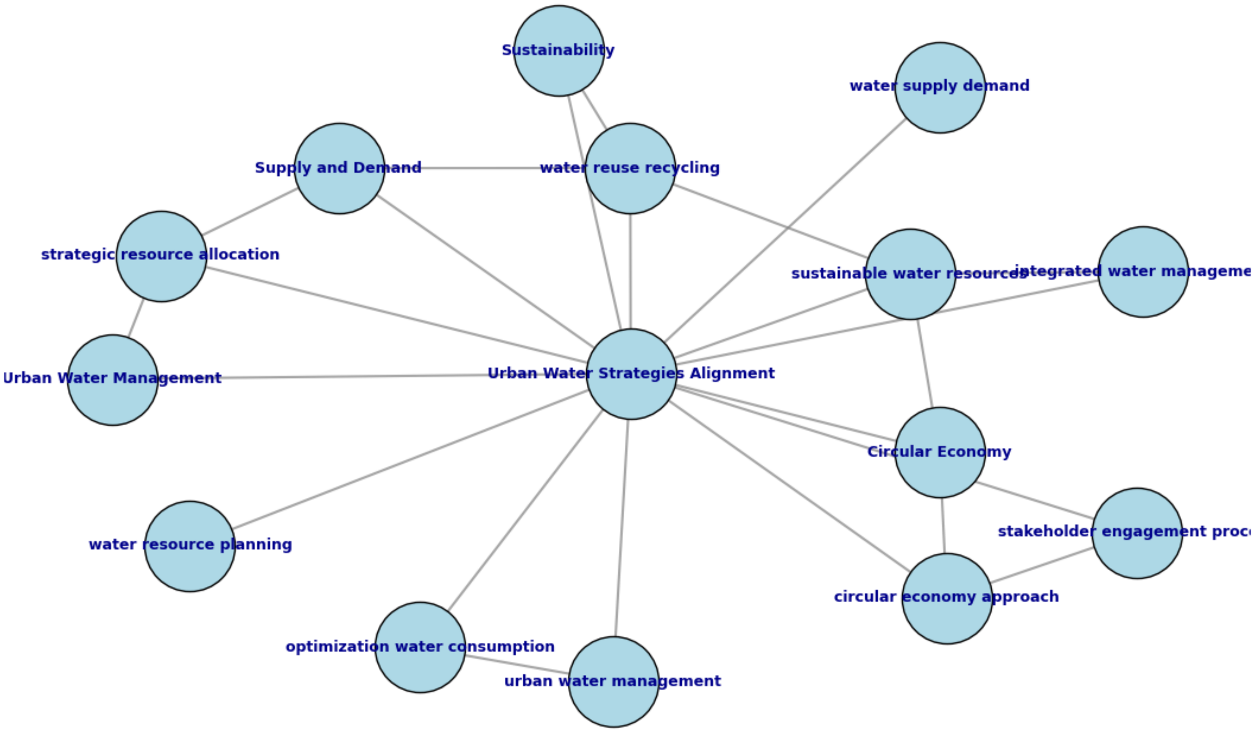


**Fig. 6**. Semantic tree diagram illustrating relationships between frequent phrases sentiment analysis

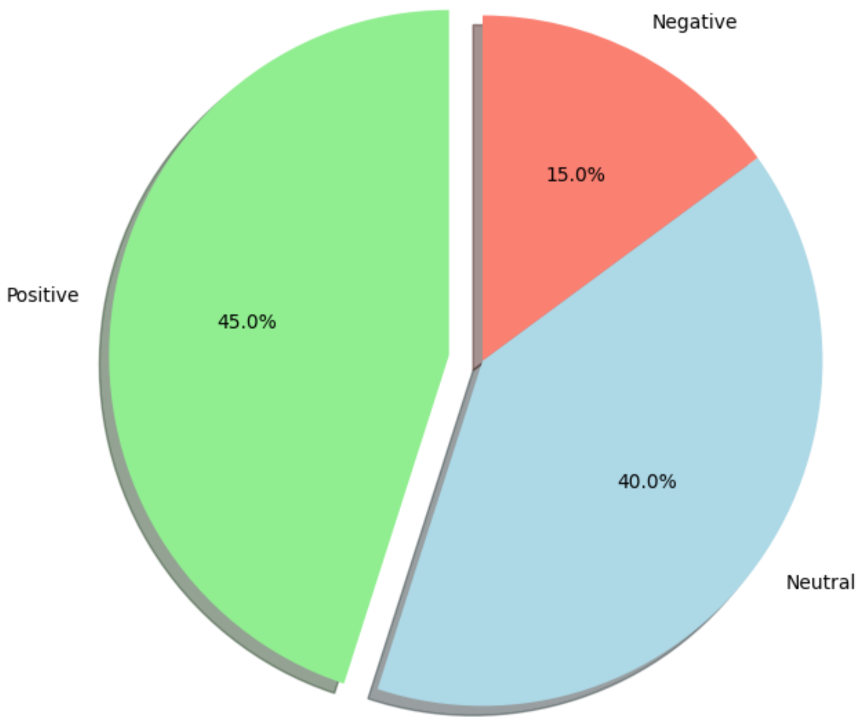


**Fig. 7**. Sentiment distribution in texts related to urban water management strategies

**Table 4**. Representative examples of sentences classified by lexical polarity, with TextBlob polarity scores

| Sentence | Sentiment | Score |
|---|---|---|
| "The innovative approach of the circular economy significantly improves water management efficiency." | Positive | 0.8 |
| "Water scarcity poses serious challenges to urban sustainability." | Negative | –0.6 |
| "The study examines water supply patterns in urban areas." | Neutral | 0.0 |
| "Successful implementation of water recycling strategies has led to significant progress." | Positive | 0.7 |
| "Critical water shortages threaten community welfare." | Negative | –0.7 |
| "The research analyzes methods for aligning supply and demand." | Neutral | 0.1 |
| "Sustainable water management practices show promising results." | Positive | 0.6 |
| "Incorporating stakeholder perspectives enhances project outcomes." | Positive | 0.5 |
| "Current infrastructure limitations hinder system efficiency." | Negative | –0.4 |
| "The model considers various consumption patterns." | Neutral | 0.0 |

**Table 5**. Thematic patterns of lexical orientation identified in the corpus

| No. | Attitude | Analysis |
|---|---|---|
| 1 | Optimism about innovative solutions | Strong belief in the ability of new technologies and innovative approaches to solve water issues. |
| 2 | Concern over the current situation | A deep understanding of current challenges and the negative consequences of water shortages. |
| 3 | Belief in collective participation | Emphasis on the importance of stakeholder collaboration and participatory approaches. |
| 4 | Hope for sustainability | Confidence in achieving sustainable management of water resources. |
| 5 | Emphasis on integration | Belief in the necessity of a systemic and integrated approach. |
| 6 | Caution regarding limitations | Awareness of existing barriers and limitations in implementing solutions. |
| 7 | Enthusiasm for innovation | Interest in discovering and implementing new solutions. |

**Table 6**. Clustering quality assessment using silhouette coefficient

| Cluster | Silhouette coefficient |
|---|---|
| Resource and infrastructure management | 0.82 |
| Circular economy strategies | 0.79 |
| Demand and consumption management | 0.78 |
| Planning and policy making | 0.83 |
| Stakeholder engagement | 0.76 |

average silhouette coefficient across the tested range of k=2 to k=10. The robustness of this solution was verified through hierarchical agglomerative clustering with Ward linkage, which produced a consistent five-group partition. Silhouette coefficients for all five clusters exceeded 0.7 (Table 6), indicating strong within-cluster cohesion and clear between–cluster separation. The scatter plot in Fig. 8 - which maps each concept according to its weight (x–axis, reflecting term frequency and centrality) and score (y-axis, reflecting thematic coherence within its cluster) - visually demonstrates this separation: the five cluster groupings occupy distinct regions of the feature space with minimal overlap, and within each cluster, points form recognisable concentrations rather than dispersed clouds.

Reading Fig. 8 in detail provides insights beyond the summary statistics. Concepts positioned in the upper–right quadrant (high weight, high score) – including "Urban Water Supply Systems," "Leakage Management," "Consumer Behavior," and "Networking" - are the most central and thematically coherent representatives of their respective clusters. Concepts positioned in the lower – left quadrant (lower weight, lower score) – including "Community Participation," "Closed Water Cycle," and "Stakeholder Communication" - are present in the corpus but less frequently and less consistently associated with their assigned cluster, suggesting they occupy boundary

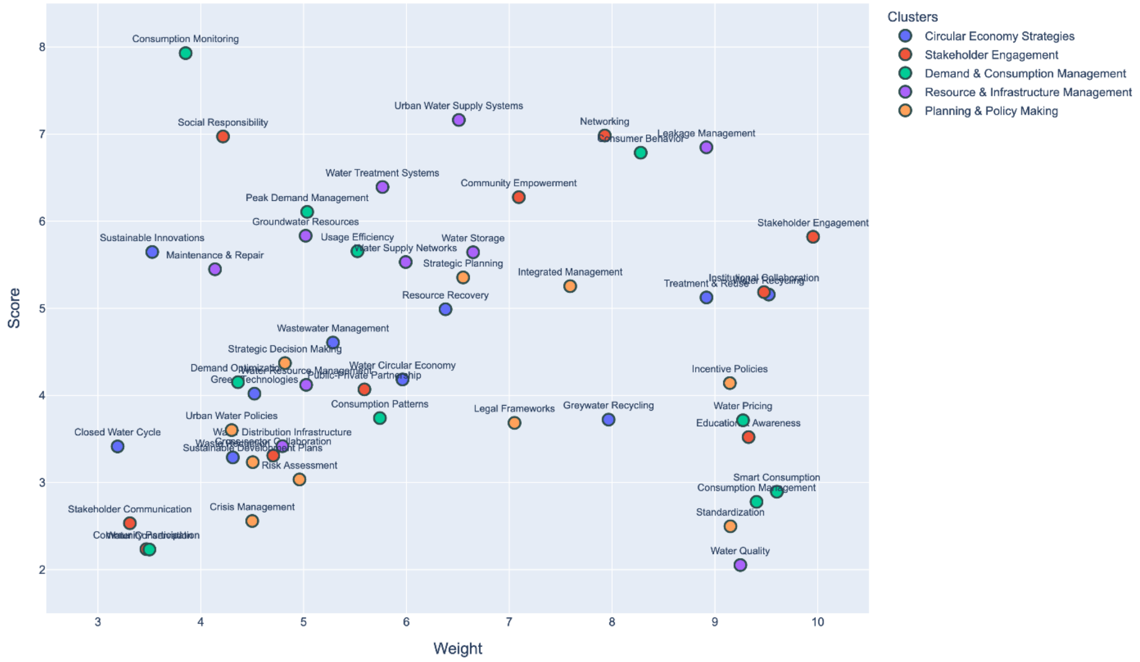

**Fig. 8**. Scatter plot of concept distribution in feature space based on scores and weights

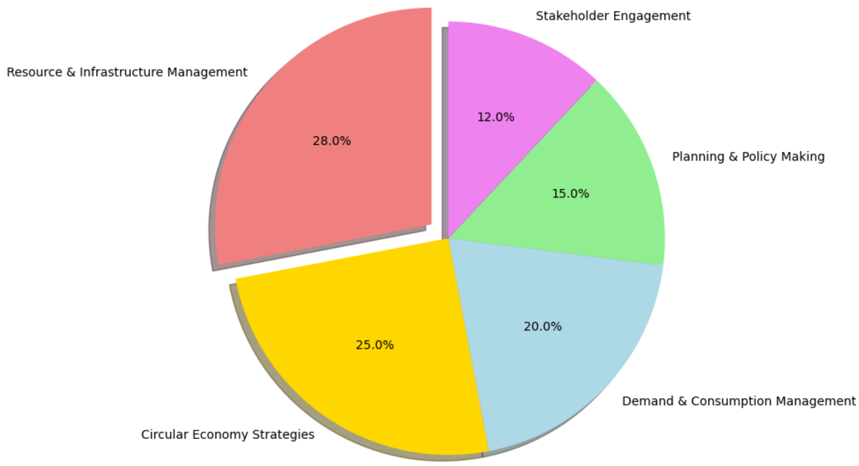

**Fig. 9**. Distribution of key concepts across the five clusters

positions between thematic domains. This distribution confirms that the five identified clusters are not equally dense: Resource and Infrastructure Management (28%) and Circular Economy Strategies (25%) are the most heavily populated, while Stakeholder Engagement (12%) is the most sparsely represented - a quantitative reflection of the qualitative imbalance in research attention noted throughout this analysis. The proportional distribution of concepts across the five clusters is illustrated in Fig. 9, with cluster sizes reflecting the relative volume of research attention devoted to each thematic domain.

The five clusters and their constituent concepts are presented in Table 7 and discussed below.

**Resource and Infrastructure Management (28%)** is the largest cluster, encompassing concepts related to water distribution networks, treatment systems, leakage reduction, water quality monitoring, and groundwater management. The dominance of this cluster reflects the infrastructural reality of urban water governance: before circular or demand–oriented strategies can be implemented, the physical systems through which water is captured, treated, and distributed must be functioning and efficiently managed. The cluster's prominent concepts – leakage management, maintenance and

**Table 7**. Clustering of concepts related to urban water supply and demand management strategies within a circular economy framework

| Cluster | Related concepts |
|---|---|
| Resource and infrastructure management | Urban water supply systems, water distribution infrastructure, water resource management, water treatment systems, water supply networks, maintenance and repair, leakage management, water quality, groundwater resources, water storage |
| Circular economy strategies | Water recycling, treatment and reuse, greywater recycling, wastewater management, green technologies, resource recovery, closed water cycle, water circular economy, sustainable innovations, waste reduction |
| Demand and consumption management | Consumption patterns, demand optimization, consumption management, usage efficiency, consumer behavior, water pricing, peak demand management, water conservation, consumption monitoring, smart consumption |
| Planning and policy making | Strategic planning, legal frameworks, integrated management, standardization, risk assessment, sustainable development plans, incentive policies, crisis management, urban water policies |
| Stakeholder engagement | Community participation, cross–sector collaboration, education and awareness, stakeholder engagement, social responsibility, public–private partnership, networking, stakeholder communication, community empowerment, institutional collaboration |

repair, smart distribution systems – align closely with the finding of Madhavaraj et al., (2025) that integrating CE principles into water distribution networks requires targeted infrastructure redesign as a prerequisite.

At the operational level, Salehi et al., (2024) demonstrated that the application of a Survival Analysis Model[1] to historical incident data from urban water distribution networks enables evidence – based prioritisation of renewal programmes – an approach that directly operationalises the infrastructure management strategies most prominently represented in this cluster. The transition toward smart infrastructure, identified as the dominant trend within this cluster (Table 8), is consistent with the broader trajectory documented by Fu et al., (2023) regarding AI and IoT applications in urban water systems.

**Circular Economy Strategies (25%)** encompasses water recycling, greywater reuse, wastewater management, green purification technologies, resource recovery, and closed–loop water cycle design. This cluster reflects the core theoretical framework of the study and confirms that CE principles have achieved substantial penetration in the urban water management literature over the 2015–2025 period. The emphasis on technological innovation Survival Analysis Model particularly advanced treatment trains and resource recovery systems Survival Analysis Model is consistent with Barua, (2026), who demonstrated that integrated CE systems combining nutrient recovery, energy generation, and water reuse can achieve lower life – cycle costs than conventional treatment over a 20–year horizon, despite higher upfront capital. The relatively high weight scores of "Water Circular Economy" and "Resource Recovery" in Fig. 8 further confirm that these concepts are not peripheral elaborations but central organising ideas within this cluster.

**Demand and Consumption Management (20%)** includes consumption pattern analysis, smart pricing strategies, peak demand management, domestic consumption programmes, and smart monitoring systems. This cluster confirms that demand–side management has achieved recognition as a co – equal strategic domain alongside supply and infrastructure management in recent literature – a notable evolution from earlier periods when supply–side expansion was the dominant paradigm. The presence of "Consumer Behavior" as a high–score concept within this cluster (visible in Fig. 8's upper–middle region) underscores the increasing recognition that technical efficiency measures alone are insufficient and must be coupled with behavioural insights, consistent with the findings of Kyriakopoulos, (2023) on the combined effectiveness of technical, economic, and social demand management tools.

**Planning and Policy Making (15%)** encompasses strategic planning frameworks, legal and regulatory structures, risk assessment, crisis management protocols, and incentive policy design. This cluster is the fourth largest and its concepts tend to occupy mid – range positions in Fig. 8 - neither the highest weights nor the lowest scores - suggesting they are present across a broad range of articles but rarely constitute the primary analytical focus. The prominence of "Integrated Management" and "Strategic Planning" as central concepts reflects the growing consensus that supply and demand strategies cannot be effectively aligned without

[1] Survival Analysis Model (SAM)

**Table 8**. Content and thematic analysis of the five clusters in strategic urban water management

| Cluster | Main topics | Key subtopics | Dominant trends |
|---|---|---|---|
| **Resource and infrastructure management** | – Integrated infrastructure management<br>– Optimizing distribution networks<br>– Resource quality management | – Renovating outdated networks<br>– Smart distribution systems<br>– Resource quality monitoring<br>– Leakage and waste management<br>– Development of green infrastructure | – Transition to smart infrastructure<br>– Focus on system sustainability<br>– Prioritizing the renewal of aging networks |
| **Circular economy strategies** | – Recycling and reuse<br>– Circular economy business models<br>– Innovative technologies | – Water recycling systems<br>– Resource and energy recovery<br>– Green purification technologies<br>– Circular business models<br>– Innovation in recycling | – Enhancing resource efficiency<br>– Reducing environmental impacts<br>– Developing sustainable technologies |
| **Demand and consumption management** | – Behavioral consumption patterns<br>– Optimizing consumption<br>– Peak demand management | – Consumer behavior analysis<br>– Smart pricing strategies<br>– Domestic consumption management<br>– Programs for consumption reduction<br>– Smart consumption monitoring systems | – Promoting sustainable consumption patterns<br>– Expanding smart monitoring systems<br>– Optimizing consumption through behavioral insights |
| **Planning and policy making** | – Strategic water policies<br>– Legal frameworks<br>– Long–term strategic planning | – Integrated policy development<br>– Supporting regulatory frameworks<br>– Strategic planning<br>– Risk management<br>– Incentive policies | – Integrated policies<br>– Strengthening legal frameworks<br>– Developing comprehensive plans |
| **Stakeholder engagement** | – Social participation<br>– Cross–sector collaboration<br>– Education and empowerment | – Encouraging public participation<br>– Institutional collaboration<br>– Educational programs<br>– Stakeholder networking<br>– Raising public awareness | – Increasing community engagement<br>– Strengthening cross–sector collaborations<br>– Developing educational initiatives |

overarching governance frameworks. This finding directly engages the empirical literature on the regulation–innovation nexus: Nimjerdi, (2026) demonstrated that environmental regulations significantly moderate the relationship between open innovation and circular economy outcomes in EU countries, while Yuan, (2026) showed that regulatory coherence is a structural condition for successful CE transitions. Complementing these findings, Zamany et al., (2025) showed that green research and development – encompassing green intellectual capital, design, and investment – exerts a significant positive influence on environmental pollution reduction, suggesting that innovation policy represents a direct lever for advancing the sustainability goals reflected in this cluster. The cluster's lower–scoring boundary concepts – including "Sustainable Development Plans" and "Risk Assessment" – suggest that long–term strategic planning and risk governance, while present in the literature, remain less operationally developed than shorter – term policy and pricing instruments.

**Stakeholder Engagement (12%)** is the smallest cluster, comprising community participation, cross–sector collaboration, educational programmes, public – private partnerships, institutional collaboration, and stakeholder communication. The relative smallness of this cluster – together with the predominantly low weight scores of its constituent concepts visible in Fig. 8's lower – left region – constitutes one of the most important substantive findings of this study. Participatory and collaborative dimensions of urban water governance are systematically underrepresented in the literature relative to technical and infrastructural dimensions, despite extensive normative argument for their centrality (Tsatsou et al., 2023; Moallemi et al., 2026; Chelvarforoush et al., 2024).

The latter study demonstrated, through a comparative – critical analysis of water governance legislation in the Baluchestan region of Iran, that participatory management models – combining legal reform, stakeholder involvement, and adaptive resource–use practices – are essential for resolving water crises in contexts where top–down regulatory frameworks have failed to account for local conditions. This imbalance has practical implications: Handayani and Fitriati, (2026) demonstrated that transformation strategies in water utilities that integrate multi – stakeholder collaboration and community – needs approaches with technical resource management achieve measurably superior performance outcomes compared with purely technical interventions. The underrepresentation of stakeholder engagement in the literature therefore does not reflect its unimportance but rather a research gap with direct operational consequences for water utility managers and urban planners.

Taken together, the five–cluster solution reveals a literature that is technically sophisticated and increasingly circular in orientation but unevenly developed across governance, behavioural, and participatory dimensions. The integrated approach required for effective urban water management – simultaneously addressing smart infrastructure, water recycling, demand behavioural change, coherent policy frameworks, and meaningful stakeholder participation – is articulated in principle across the corpus but implemented in full in relatively few of the 91 analysed studies. This gap between integrated aspiration and disciplinary fragmentation is the central substantive contribution of this analysis, and it provides the empirical foundation for the recommendations presented in Section 4.

## 4. Conclusions

This study employed a systematic text mining approach to analyse and cluster strategies for aligning urban water supply and demand within a circular economy framework, drawing on a corpus of 91 peer–reviewed articles published between 2015 and 2025. The analysis produced five validated thematic clusters – resource and infrastructure management (28%), circular economy strategies (25%), demand and consumption management (20%), planning and policymaking (15%), and stakeholder engagement (12%) – with silhouette coefficients exceeding 0.7 for all clusters, confirming the coherence and robustness of the solution.

Several substantive conclusions emerge from this analysis with direct implications for policymakers, water utility managers, and researchers.

For **policymakers and urban managers**, the findings demonstrate that effective urban water governance cannot be achieved through single – dimension interventions. The co – equal prominence of supply and demand terms in the corpus frequency analysis, combined with the multi – cluster structure of the concept space, provides empirical support for integrated policy frameworks that simultaneously address infrastructure modernisation, circular resource strategies, behavioural demand management, and cross–sectoral regulatory coherence. The Planning and Policymaking cluster confirms that legal frameworks and incentive policies are recognised as essential enablers in the literature; however, their relatively lower weight scores in the scatter plot (Fig. 8) indicate that the operationalisation of these frameworks remains underdeveloped compared to technical solutions. Policymakers should therefore prioritise the development of regulatory environments that explicitly moderate the relationship between innovation investment and circular economy outcomes – a mechanism empirically demonstrated by Nimjerdi, (2026) across EU countries and further supported by Yuan, (2026) – rather than relying on technical interventions alone.

For **water and wastewater utilities**, the business model dimension identified in the literature review and reflected in the Circular Economy Strategies and Resource and Infrastructure Management clusters warrants particular attention. Nimjerdi et al., (2026) demonstrated that business model innovation, measured through asset turnover efficiency, has a significant positive effect on output in Iranian provincial water companies – the same organisational type as the study's research population. This finding, combined with the cluster evidence that smart infrastructure and resource recovery are the dominant trends in the most heavily populated thematic areas, suggests that utilities should pursue simultaneous investment in physical infrastructure renewal and business model restructuring rather than treating these as sequential priorities. The underrepresentation of stakeholder engagement (12%) relative to technical clusters further indicates that utilities may be systematically under–investing in community participation and cross–sector collaboration – dimensions that Handayani and Fitriati, (2026) and Moallemi et al., (2026) identify as critical to sustained performance improvement.

For **researchers**, this study identifies three priority directions for future work.

First, quantitative assessments of supply – demand alignment strategies are needed: the present study maps the conceptual landscape of the literature but cannot assess the relative effectiveness of different strategic combinations – a gap that calls for comparative case study and econometric approaches.

Second, the operationalisation of circularity and resilience in water systems under deep uncertainty, as called for by Moallemi et al., (2026), requires further empirical development; the present corpus reveals that resilience thinking remains peripheral relative to circularity thinking despite strong theoretical arguments for their integration.

Third, AI – based predictive modelling for urban water demand – visible as an emerging thread in the corpus through terms such as "innovation," "model," and "optimization" – represents a high–potential research frontier that bridges the technical and governance dimensions identified across multiple clusters.

This study is subject to several limitations that should inform its interpretation. The corpus is restricted to English and Persian literature published between 2015 and 2025, potentially omitting relevant contributions from other linguistic contexts, particularly Spanish, Chinese, and Arabic–language scholarship on water management in water – stressed regions. The text mining pipeline, while systematic and validated, captures surface–level patterns in the literature and cannot fully recover the nuanced arguments, contextual dependencies, or methodological distinctions present in individual studies.

The lexical polarity analysis represents the most significant methodological limitation of this study. TextBlob's polarity lexicon is calibrated for general–domain consumer text and does not account for the characteristically hedged, passive, and nominally complex language of scientific writing. As a result, the classification of sentences as positive, neutral, or negative in this study reflects surface – level lexical tone rather than researcher attitude or document evaluative stance. Quantitative accuracy metrics cannot be computed without a manually annotated gold – standard corpus tailored to water management literature, which was beyond the scope of this study. Future research should validate polarity findings against domain – specific sentiment lexicons or transformer – based models (e.g., SciBERT) trained on scientific text.

A related limitation concerns the corpus size. Although 91 articles constitute a sufficient and comparable base for tightly focused text mining in a defined thematic domain –consistent with prior studies by Möslinger et al., (2023) and Rabbi and Amin, (2024) – this sample size approaches the lower boundary for robust LDA topic modelling. LDA is known to perform most reliably on larger corpora, and the relatively small corpus may have constrained the granularity of topic differentiation and reduced the generalisability of thematic findings to the broader international literature on urban water management. Expanding the corpus to include Spanish, Chinese, and Arabic–language publications in future work would substantially mitigate this limitation. Future research would benefit from incorporating mixed – methods designs that combine the breadth of computational text analysis with the depth of systematic qualitative synthesis.

Notwithstanding these limitations, this study makes a methodological and substantive contribution to the urban water management literature. Methodologically, it demonstrates the feasibility and validity of applying an integrated text mining pipeline – combining LDA topic modelling, n–gram extraction, lexical polarity analysis, and K–Means clustering with hierarchical validation – to a tightly defined corpus on supply – demand strategy alignment. Substantively, it provides a validated, evidence – based taxonomy of five strategic clusters that policymakers, utilities, and researchers can use as an organising framework for integrated urban water governance within the circular economy paradigm. The central finding – that the literature simultaneously affirms the necessity of integration and reflects persistent disciplinary fragmentation across technical, governance, and participatory dimensions – is both a diagnosis of the current state of knowledge and a call to action for the next generation of research and practice.

## 5. Acknowledgement

The authors would like to thank all experts who participated in this study for their valuable time and insights.

## References

Arauzo–Carod, J. M., Kostakis, I. and Tsagarakis, K. P., 2022. Policies for supporting the regional circular economy and sustainability. *The Annals of Regional Science*, 68(2), 255–262. https://doi.org/10.1007/s00168-022-01124-y.

Balsalobre–Lorente, D., Rong, N., Shah, S. A. R., Huseynova, R. and Abbas, N., 2025. Sustainable Innovation and the Circular Economy: Regulatory and Economic Drivers. In Singh, P., Daga, S., Yadav, K., Mishra, V., Eds. *Circular Economy and Sustainable Innovation: Pathways and Applications for a Greener Future, Volume 2*. Springer, Cham. pp. 67-87. https://doi.org/10.1007/978-3-032-00437-6-4.

Barua, S., 2026. Wastewater-based circular economy: water reuse in agriculture and industry-a comprehensive review. *International Journal of Research Publications in Engineering, Technology and Management (IJRPETM)*, 9(3), 1031-1046. https://doi.org/10.15662/IJRPETM.2026.0903004.

Bouramdane, A. A., 2023. Optimal water management strategies: paving the way for sustainability in smart cities. *Smart Cities*, 6(5), 2849–2882. https://doi.org/10.3390/smartcities6050128.

Brglez, K., Perc, M. and Lukman, R. K., 2024. The complexity and interconnectedness of circular cities and the circular economy for sustainability. *Sustainable Development*, 32(3), 2049-2065. https://doi.org/10.1002/sd.2766.

Chelvarforoush, H., Mortazavi, M. and Mosapour Negari, F., 2024. Water crisis and the need to reassess water ownership and utilization methods in Baluchestan (case study: Saravan). *Journal of Water and Wastewater*, 35(5), 39–58. (In Persian). https://doi.org/10.22093/wwj.2025.504673.3469.

Domenech, T. and Borrion, A., 2022. Embedding circular economy principles into urban regeneration and waste management: framework and metrics. *Sustainability*, 14(3), 1293. https://doi.org/10.3390/su14031293.

Fatimah, Y. A., Govindan, K., Sasongko, N. A. and Hasibuan, Z. A., 2024. The critical success factors for sustainable resource management in circular economy: assessment of urban mining maturity level. *Journal of Cleaner Production*, 469, 143084. https://doi.org/10.1016/j.jclepro.2024.143084.

Fu, G., Sun, S., Hoang, L., Yuan, Z. and Butler, D., 2023. Artificial intelligence underpins urban water infrastructure of the future: a holistic perspective. *Cambridge Prisms: Water*, 1, e14. https://doi.org/10.1017/wat.2023.15.

Gariba, M. I. and Arthur, E. E., 2026. Driving circular economy transformation through technological innovation: the moderating role of regulatory environment, human capital, and technological capacity. *Humanities and Social Sciences Communications*, 13, 225. https://doi.org/10.1057/s41599-025-06414-2.

Handayani, D. and Fitriati, R., 2026. Integrating resource–based view and social innovation for organizational transformation: evidence from a leading Indonesian water utility company. *Majapahit Journal of Islamic Finance and Management*, 6(1), 1431-1454. https://doi.org/10.31538/mjifm.v6i1.834.

Kakwani, N. S. and Kalbar, P. P., 2024. Prioritization of strategies for urban water circular economy using water circularity indicator. *Water Policy*, 26(5), 480–505. https://doi.org/10.2166/wp.2024.233.

Koseoglu–Imer, D. Y., Oral, H. V., Calheiros, C. S. C., Krzeminski, P., Güçlü, S., Pereira, S. A. et al., 2023. Current challenges and future perspectives for the full circular economy of water in European countries. *Journal of Environmental Management*, 345, 118627. https://doi.org/10.1016/j.jenvman.2023.118627.

Kyriakopoulos, G. L., 2023. Circular Economy and Sustainable Strategies: Theoretical Framework, Policies and Regulation Challenges, Barriers, and Enablers for Water Management. In Zamparas, M. G. and Kyriakopoulos, G. L., Eds. *Water Management and Circular Economy*. Elsevier, pp. 197-230. https://doi.org/10.1016/B978-0-323-95280-4.00014-X.

Madhavaraj, M., Ali, H. H. and Anjali, G., 2025. The Circular Economy in Water Supply Networking. In Bandh, S. A., Malla F. A. and Halog, A., Eds. *Water Use Efficiency, Sustainability and the Circular Economy*. Elsevier, pp. 35–58. https://doi.org/10.1016/B978–0–443–26749–9.00004-1.

Moazezi Farhadifar, M. and Tavakoli, I., 2025. Optimization of mobile emergency team deployment in water crises using neural networks (case study: Pakdasht, Varamin, Pishva and Qarchak Counties). *Journal of Water and Wastewater*, 36(3), 1-18. (In Persian). https://doi.org/10.22093/wwj.2025.544414.3513.

Moallemi, E. A., Xenarios, S., Wise, R. M. and Castonguay, A. C., 2026. Operationalising circular economy and resilience in water management systems in an increasingly uncertain world. *Current Opinion in Environmental Sustainability*, 81, 101648. https://doi.org/10.1016/j.cosust.2026.101648.

Möslinger, M., Ulpiani, G. and Vetters, N., 2023. Circular economy and waste management to empower a climate-neutral urban future. *Journal of Cleaner Production*, 421, 138454. https://doi.org/10.1016/j.jclepro.2023.138454.

Nimjerdi, A. H., 2026. The impact of open innovation on municipal waste recycling rate and resource productivity in the European Union countries: the moderating role of environmental regulations. *Sustainable Environment*, 12(1), 2655489. https://doi.org/10.1080/27658511.2026.2655489.

Nimjerdi, A. H., Sajadifar, S., Toopkanloo, M. I., Jafari, S., Shamloei, A. and Sami, A., 2026. The impact of business model innovation on productivity in Iranian water and wastewater companies. *World Water Policy*, 12(1), e70056. https://doi.org/10.1002/wwp2.70056.

Rabbi, M. F. and Amin, M. B., 2024. Circular economy and sustainable practices in the food industry: a comprehensive bibliometric analysis. *Cleaner and Responsible Consumption*, 14, 100206. https://doi.org/10.1016/j.clrc.2024.100206.

Rodrigues, P. M., Pinto, F. S. and Marques, R. C., 2024. A framework for enabling conditions for wastewater reuse. *Sustainable Production and Consumption*, 46, 355-366. https://doi.org/10.1016/j.spc.2024.02.022.

Romero, D. D. and Barquet, K., 2025. Business models for decentralized water services in urban and peri–urban areas. *Cleaner Water*, 4, 100138. https://doi.org/10.1016/j.clwat.2025.100138.

Salehi, S., Abiati, A., Rajabi, M. and Khandaie, M., 2024. Planning water distribution network renewal using the SAM model for data analysis of historical events. *Journal of Water and Wastewater*, 35(4), 88–112. (In Persian). https://doi.org/10.22093/wwj.2025.502364.3462.

Santos, E., Carvalho, M. and Martins, S., 2023. Sustainable water management: understanding the socioeconomic and cultural dimensions. *Sustainability*, 15(17), 13074. https://doi.org/10.3390/su151713074.

Sohal, A., Nand, A. A., Goyal, P. and Bhattacharya, A., 2022. Developing a circular economy: an examination of SMEs' role in India. *Journal of Business Research*, 142, 435-447. https://doi.org/10.1016/j.jbusres.2021.12.072.

Timm, J. F. G., Maciel, V. G. and Passuello, A., 2023. Towards sustainable construction: a systematic review of circular economy strategies and ecodesign in the built environment. *Buildings*, 13(8), 2059. https://doi.org/10.3390/buildings13082059.

Tsatsou, A., Pergar, P., Frantzeskaki, N., Malamis, S. and Atanasova, N., 2023. Planning nature–based solutions for water management and circularity in Ljubljana, Slovenia: examining how urban practitioners navigate barriers and perceive institutional readiness. *Urban Forestry and Urban Greening*, 89, 128090. https://doi.org/10.1016/j.ufug.2023.128090.

Xiang, X., Li, Q., Khan, S. and Khalaf, O. I., 2021. Urban water resource management for sustainable environment planning using artificial intelligence techniques. *Environmental Impact Assessment Review*, 86, 106515. https://doi.org/10.1016/j.eiar.2020.106515.

Yuan, L., 2026. Environmental regulation at the crossroads: a review of catalysts and barriers in circular economy transitions. *Business Strategy and the Environment*, 1–16. https://doi.org/10.1002/bse.70588.

Zamany, A., Khamseh, A. and Khamseh, A., 2025. Green innovation for sustainable development: the impact of research and development on environmental pollution reduction. *International Journal of Technological Learning, Innovation and Development*, 16(2), 139-161. https://doi.org/10.1504/IJTLID.2025.146725.