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Water governance puzzle in Riau Province: uncovering key actors and interactions

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ABSTRACT

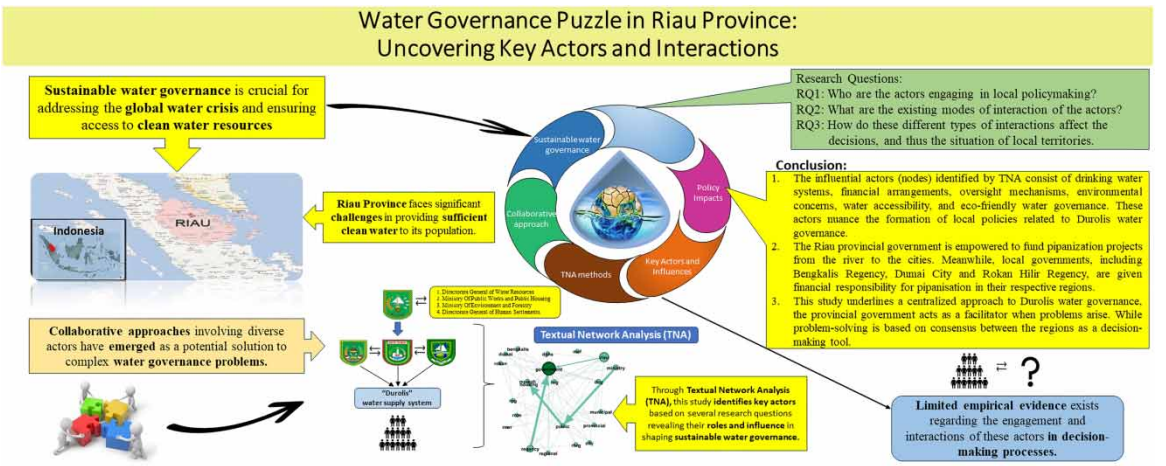
Sustainable water governance is crucial for addressing the global water crisis and ensuring access to clean water resources. In the Indonesian context, Riau Province faces significant challenges in providing sufficient clean water to its population. Collaborative approaches involving diverse actors have emerged as a potential solution to complex water governance problems. However, limited empirical evidence exists regarding the engagement and interactions of these actors in decision-making processes. This study focuses on Bengkalis Regency, Dumai City, and Rokan Hilir Regency, in Riau Province, using Textual Network Analysis (TNA) to identify key actors in local water governance. The findings of this study highlight: (1) The influential actors (nodes) identified by TNA consist of drinking water systems, financial arrangements, oversight mechanisms, environmental concerns, water accessibility, and eco-friendly water governance. These actors nuance the formation of local policies related to Durolis water governance. (2) The Riau provincial government is empowered to fund pipanization projects from the river to the cities. Meanwhile, local governments are given financial responsibility for pipanization in their respective regions. (3) Durolis water governance follows a centralized approach, with the provincial government acting as a facilitator when problems arise. Meanwhile, problem-solving is based on consensus between the regions as a decision-making tool.

Key words: Collaboration, Durolis Water Governance, Textual Network Analysis, Water governance

HIGHLIGHTS

- The paper highlights various problems in Riau Province.
- It gives recommendations for improving sustainable water governance in Riau Province at the micro-, meso-, and macro-levels.
- The TNA method suggests valuable information and new perspectives for sustainable water governance that other methods miss out.
- It provides empirical evidence of the key actors' identification into their roles in water governance decision-making.

GRAPHICAL ABSTRACT



1. INTRODUCTION

The emergence concept of New Public Management (NPM) became a pivotal point for the advancement of public administration thought. This idea permits public institutions to collaborate with other institutions beyond public entities to solve complex public problems (Hood, 1995). Accordingly, governments are adopting 'new' networked arrangements involving stakeholders in policy formulation, negotiation and implementation to overcome the complex problem (Rhodes, 1996; Klijn & Koppenjan, 2006). One of the prominent examples of complex problems that raise greater attention among scholars is to ensure the world's clean water resources. Indeed, the major causes of the water crisis are rapid growth in population density which corresponds to increased consumption of clean water (Lautze *et al.*, 2011), the complicated governance system (Ortega *et al.*, 2016; Uddin *et al.*, 2021), and the lack of complete knowledge about the interacting subsystems which led to the mismanagement of water resources (Nieminen *et al.*, 2021). Nonetheless, in the context of water governance, the kind of collaborating actors often seem unequal, whether and when their involvement in decision-making is often overlooked due to limited empirical cases.

This study begins with a preliminary observation of problematic situations related to water governance in Indonesia. Concern for the provision of safe drinking water has been a major topic in Indonesia since 1990 (Suyeno *et al.*, 2014). This is despite the fact that water management has been in place since the 1990s, and bolstered by Minister regulation and law Number 17 of 2019 concerning guidelines for water resources. There are still areas where clean water accessibility is insufficient (Suyeno *et al.*, 2014; Cahyaningsih, 2016), particularly on Sumatera Island (see Figure 1), one of which is Riau Province, which has the lowest percentage if compared to other provinces in the same areas. Riau Province has been identified as a laggard in clean water services (Harirah *et al.*, 2022). The scarcity of clean water in Riau Province is highly concerning (Harirah *et al.*, 2022), especially given the physical location of the province, which is situated on peatlands with low density and is prone to permanent drought.

Riau Province is predicted to face a prolonged clean water crisis, as evidenced by the unmet demand for clean water in its coastal areas (Harirah *et al.*, 2022). Furthermore, the low coverage of clean water services in both urban and rural regions is only approximately 13%, while drinking water accessibility in Riau remains at 30.36% in 2021 (Central Bureau of Statistics, 2023). The inability to process domestic and non-domestic waste

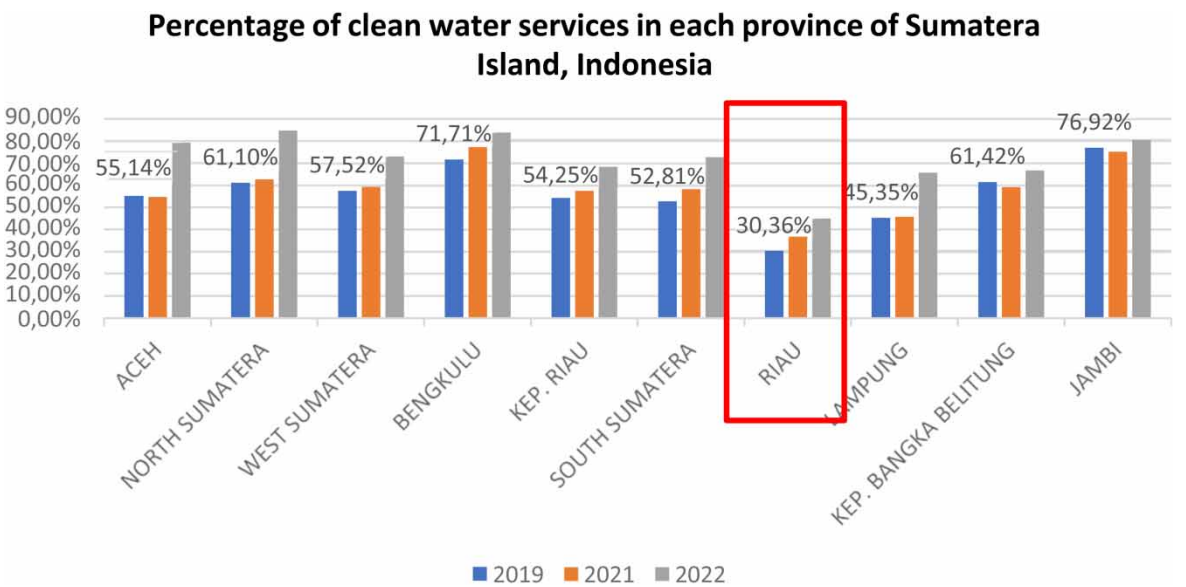


Fig. 1 | Percentage of clean water services in each province of Sumatera Island, Indonesia (*source:* Central Bureau Statistics, 2023).

is the primary reason for the variation in drinking water quality in Dumai City, Rokan Hilir Regency, and Bengkalis Regency. Furthermore, excessive land extraction by households and industry has been shown to threaten the availability of quantity and quality raw water in downstream areas, particularly when not in line with proper watershed management (Li & Mostafavi, 2021). The other issues are aggravated by the current status of urban drinking water supply systems, which overlap due to insufficient regulations and good management in supporting drinking water delivery.

Nevertheless, the local government has employed numerous approaches to overcome this issue through the collaborative strategy, namely inter-regional cooperation. The water supply system locally known as SPAM of 'Durolis' which refers to (Dumai City, Rokan Hilir Regency, and Bengkalis Regency) was projected as a result of this collaboration. Multiple new approaches are being developed regarding the complexity of water governance problems, for instance, polycentric governance (Frey *et al*., 2021; Diver *et al*., 2022; Pahl-Wostl & Knieper, 2023); community natural resource management (Tantoh & McKay, 2021; Pradhan *et al*., 2022); multi-level and collaborative governance (Moss & Newig, 2010; Hamilton & Lubell, 2018; Pacheco *et al*., 2022); network governance (Gatt, 2016; Kunz *et al*., 2017; Narayan *et al*., 2020; Fischer *et al*., 2022; Love *et al*., 2023); and adaptive governance (Pahl-Wostl, 2008; Cheng *et al*., 2019).

On the other hand, we agreed that collaboration provides an opportunity to address problems that cannot be tackled by any actor on their own. However, its promise is balanced by limited evidence that collaboration is able to produce better, more implementable, environmental solutions that have justified its use to date (Brisbois & de Loë, 2016; Nabiafjadi *et al*., 2021). Their success will be determined by the participation of a broader range of individuals and stakeholders involved in water-related decisions (Megdal *et al*., 2017; Yi *et al*., 2019; Hegga *et al*., 2020). Therefore, a key challenge for water governance is how to examine and demonstrate the interactions between each of the actors engaged in local decision-making. Some of the research questions are as follows: RQ1: Who are the actors engaging in local policymaking? RQ2: What are the existing modes of interaction of the

actors? RQ3: How do these different types of interactions affect the decisions, and thus the situation of local territories?

We approach the research questions in the empirical context of local water governance in Dumai City, Rokan Hilir Regency, and Bengkalis Regency, Riau Province, Indonesia. There are several reasons these areas are useful for this research. First, by considering these areas are located on peat soil, with a depth of 0–0.5 m plus the establishment of a large oil industry, which causes a dark color of water both in these three locations (Harirah *et al.*, 2022); indeed, it is essential to examine the management and water supply in these selected locations. Second, the rivers surrounding these locations, the Rokan river, Kampar-river, Kuantan Indragiri-river, and Siak river, have severe pollution levels, rendering the water unsafe for human consumption. However, the water utilized by the Durolis Regional SPAM comes from the Rokan River as the only source of raw water suitable for drinking water services in these areas. Third, the relatively large population growth in Riau is also one of the triggers for the government to immediately provide clean water for citizens. Fourth, inadequate accessibility of drinking water in the selected areas remains around 20% in 2021 (Central Bureau of Statistics, 2023). We based our understanding in the local context because we genuinely believed local issues offer a unique opportunity to observe how the different modes of governance operate in practice. The local level allows for more innovative arrangements to be developed as niches of experimentation (Nieminen *et al.*, 2021). Actors become more interrelated and more easily identifiable (Narayan *et al.*, 2020).

This study employs (Segev 2020) the Textual Network Analysis (TNA) paradigm as an analytical guide to investigate this phenomenon. TNA's primary notion is to concentrate on the interactions (ties, links, connections, or edges) that exist between nodes (actors or vertices) and the structures that they involve. TNA is based on the basis of word combinations that appear together and have distinct meanings. The words that appear often in the text are the actors in the network discussed in this study. We combined TNA based on government regulatory documents. Some attention has been drawn to network analysis of water governance in a variety of contexts, including stakeholder interactions in Malta (Gatt, 2016), water management in a mining company (Kunz *et al.*, 2017), decentralized wastewater (Narayan *et al.*, 2020), state roles in water governance (Brisbois & de Loë, 2016), and actors involved in water governance (Fischer *et al.*, 2022). Despite the fact that the majority of the researchers mentioned above employed social network analysis methods, none of them used TNA. While TNA can be used in government documentaries in assessing the complexities of governance situations. TNA provides the macro-, meso-, and micro-levels of the actor network, and shows the interaction involved based on government documentaries. Furthermore, this study aims to examine this phenomenon using the TNA technique to identify who the key actors are and gain insight into the role they play in water governance decision-making that has strong linkages with other relevant stakeholders. It also aims to describe and analyze the collaborative interaction of water governance networks regarding the scope of activity of actors who want to engage based on research questions.

2. THEORETICAL BACKGROUND

2.1. Water governance analysis

The primary questions of analytical water governance are likely to be 'who governs?', 'who owns the water?', and 'how to participate and decentralize practices' (José *et al.*, 2023). Using water as a focus for studying actors engaged in water governance of Riau Province is useful because water policy decisions take place at multiple sites and scales. These decisions are also subject to often contested overlapping legal, institutional and social structures (Fischer *et al.*, 2022). Existing research into collaborative water governance regarding the Durolis Drinking Water Supply System provides a strong theoretical foundation upon which to build an actor network

(Diver *et al*., 2022). In governance for water, collaboration can be used for a host of purposes including joint fact-finding, planning, conflict resolution, and decision-making (Pacheco *et al*., 2022). We are particularly concerned with how these different types of interactions affect the decisions at the local level in the form of macro-, meso-, and microlevels.

The emergence of the water governance concept has been disputed by practitioners and academics across interdisciplinary areas, particularly among public administrators (Jiménez *et al*., 2020). Previous studies conducted by Hegga *et al.* (2020), Lautze *et al.* (2011), and Wuijts *et al.* (2018) pointed out various definitions of water governance, they referred governance to the processes and institutions involved in decision-making rather than the outcome of decision-making. On the other hand, Eberhard *et al.* (2017) and Jiménez *et al.* (2020) emphasized that water governance entails utilizing attributes to achieve desired outcomes, shaped by the values and aspirations of individuals and organizations, as a means to an end. Despite this, a study conveyed by Zhou & Dai (2023) found a different viewpoint, determining the water governance as a system in a what, how, when and who has the right to water and related services and their benefits. Most academic literature focuses primarily on outcomes of products while the actual process of joint deliberation on whether and when actors engage and networks involved in water decision-making is often overlooked due to the limited empirical cases.

Collaboration among actors can take many forms, including the exchange of information, coordination of projects, or technical assistance, among other modes. Actors build trust and mutually-beneficial relationships through collaboration (Wuijts *et al*., 2018; Yi *et al*., 2019; Harirah *et al*., 2022) and are more likely to participate in forums that reduce transaction costs of collaboration (Yi *et al*., 2019). Cross-scale coordination is important for the governance of problems spanning multiple scales (Hamilton & Lubell, 2018) though cross-scale interactions are commonly dominated by more powerful and well-resourced organizations (Li & Mostafavi, 2021). Participation in, and engagement with, other actors and environmental issues are commonly modeled using network analysis. From the actor component, the studies sought to identify individuals and organizations involved in water governance and water policies. For the identification of the actor component to identify as empowerment of the actor linkage, participation cannot just be about validating decisions made elsewhere; it must include the ability to influence decision-making processes and outcomes (Zhou & Dai, 2023). Indeed, it can be addressed through TNA: the use of TNA based on government documentaries would be to visualize and summarize the interaction, the actors and the ability to influence decision-making processes of water governance in Riau Province.

TNA, in particular, has numerous major advantages for analyzing complex governance problems. At this point, TNA may support the identification and interpretation of specific responsibilities of certain actors in the governance network, such as gatekeeper or broker roles (Kunz *et al*., 2017; Fischer *et al*., 2022; Love *et al*., 2023). These actors can be critical for the spread of information and best practices, as well as the development of compromise solutions in governance networks. The process of acquiring TNA data has a positive effect on stakeholder participation and connection building (Segev, 2020), while also improving their awareness of other actors in the network.

3. METHODS

It is a kind of qualitative methodology that is conducted through TNA analysis at all three levels (macro-, meso-, and micro-levels) to discover the position of actors in the structural graph as conducted by Segev (2020) each relationship between the actors involved in the activities forms centrality in the network (nodes) that can be quantitatively compared. The performance of actors was measured based on the degree of centrality, while the activities were measured from betweenness centrality and actor engagement (Segev, 2020). The relationship

was interpreted as performance as well as position in a structural graph to differentiate between the performance of bureaucrats and users from outside organizations.

3.1. Study area

The study was conducted in three areas in Riau Province comprising (1) Dumai City, (2) Rokan Hilir Regency, and (3) Bengkalis Regency, Indonesia (See Figure 2). These locations are located in the coastal area of Riau province that is also marked as flooding-prone and high drought-prone. This is due to the huge magnitude of slightly critical to extremely critical land >7.9 million ha, leading to moderate sedimentation with an erosion value of 60–180 tonnes/ha/year. These selected locations are also surrounded by high oil and manufacturing industries that have stimulated increased demand for water. Meanwhile, the basin's peculiar geography, positioned upstream and downstream, has pitted river water consumers against one another and caused the unmet demand for clean water alongside Riau Province.

3.2. Data collection and analysis

According to Larran & Andrades (2015) TNA data taken from government documentaries are able to examine the actor network in the form of policies and regulations. Meanwhile, based on Segev (2020) TNA is believed to be a powerful and promising tool to identify patterns in any kind of text – from books, academic papers, social media, songs and films, to transcripts of an interview, or even government documentaries. It can be thought of as an X-ray of the text to reveal the structure of the content, the relationship between words and their overall position. Therefore, we based our TNA on government documentaries. **At the macrolevel**, the data collected were the Regulation of the Minister of Public Works and Public Housing Number 27/PRT/M/2016 Concerning the Implementation of a Drinking Water Supply System. **At the mesolevel**, the data collected were documents on technical rules for activities of Joint Agreement of the Directorate General of Water Resources (DGWR), Ministry

Fig. 2 | Location of selected areas of Riau Province, Indonesia (*source:* Research Output 2023).

of Public Works and Public Housing (MPWPH), together with the Directorate General of Human Settlement Karya and the Government of Riau Province, Dumai City, Rokan Hilir, and Bengkalis Regency in 2017. Meanwhile, **at the microlevel**, the analyzed narratives originate from the Drinking Water Supply System Master Plan (RISPAM) for Bengkalis Regency, Riau Province, part of the Bengkalis Regency Drinking Water System Development Master Plan, the Medium-term Investment Program Plan section of the Directions of the Regency/City Drinking Water Supply System Master Plan (RISPAM) Rokan Hilir Regency 2017–2025, and Environmental Management Document and Drinking Water System (SPAM) City of Dumai of the 2018–2024. Figure 3 demonstrates some of the data collection procedures adopted by TNA:

The first step we used is: (1) Define and refine the sample; the corpus sample is determined by analyzing documents at the macro-, meso-, and micro-levels. In this stage the sample documents are adjusted according to the research topics related to water governance in line with the research questions mentioned above, then the data are cleaned by removing all punctuation marks other than dots (.) and overall all conjunctions, and finally, the documents are converted to text format (txt). (2) Identify the network's primary actors; after getting the whole corpus, validation is performed on the main actors who become TNA nodes. (3) Clean and refine the list, limiting the number of words and types of terms by using a stopword list to verify the accuracy of the data utilized before performing the procedure on the Word. ij software.

The specified data samples were evaluated utilizing the TNA technique according to stages 4, 5, 6, 7, and 8 in the Gephi program (Segev, 2020). Moreover, TNA analysis combines Social Network Analysis (SNA) and content analysis by examining the quality and structure of word relationships to identify central words in the body of the text and clusters of words. Words are considered in this context as actors (corpus) who are connected through a network in the form of edges, with the focus point being how frequently the words being analyzed appear in one or more networks (co-appearance/co-occurrence) (Segev, 2020; Love *et al.*, 2023). The data were analyzed using Gephi software with a modularity technique to evaluate how much community networks are composed, the degree to determine the number of actor-to-other relationships, and betweenness centrality to determine an actor's influence or power over other actors.

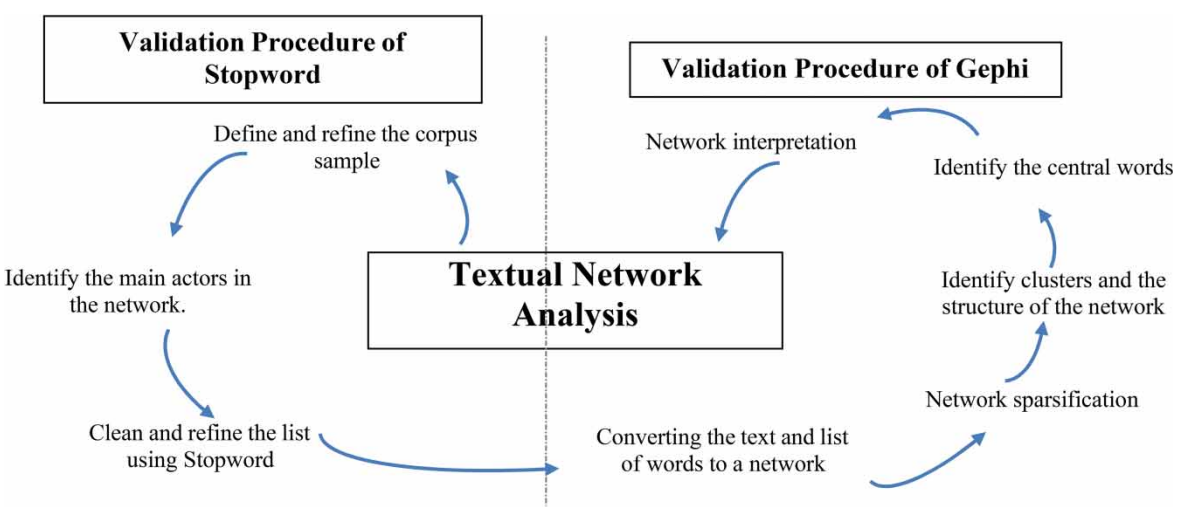


Fig. 3 | TNA stages (*source:* adopted of Segev (2020); Tala (2003).

4. RESULTS

4.1. Actors (nodes) engaging in local policymaking

Derived from the TNA processing above, the network of actors that directly influence the water governance process in Bengkalis Regency consists of 109 corpus (nodes), 276 edges (ties) and classified into six clusters that are linked together through a network bond. The network of actors in Dumai City consists of 166 corpus (nodes), and 562 edges (ties) and it is classified into seven clusters. And the network of actors gathered in Rokan Hilir Regency consists of 115 corpus (nodes), and 238 edges (ties) that are classified into seven clusters. Figure 4 presents the pre-validated network of actors in these selected areas.

The initial process yielded an incomplete network, on which pre-validated network graphs for the Bengkalis Regency, Dumai City, and Rokan Hilir Regency (Figures 4(a) and 4(c)) were built. Although these influencing and implementing actors may have been visually identified by different node features, the validated network graph clearly distinguishes them by their position in the core or periphery, as well as their node sizes, which represent their centrality metrics. During this stage, the most important performers were determined, and the unimportant actors were eliminated. As a result, the actors in the validated actor network have changed (see Figures 5(a) and 5(c)).

Figure 5(a) shows the network actors of Bengkalis Regency. It can be identified that the overall cluster remains different colors: (1) The brown cluster is an emphasis in the Durolis SPAM design relating to the development of the drinking water system. The key actor in this cluster is 'water', the discussions related to water have become quite extensive along with the high demand and its relation to planning as mentioned in the medium-term narratives. (2) The red cluster concerns clean water services from the SPAM Durolis schedule, ranging from distribution to capacity areas that can be flowing with clean water. (3) The dark green cluster represents the zoning flow by SPAM Durolis from Bengkalis Regency including the initial planning into the funding stage. (4) The orange cluster shows the need for clean water services of several areas in Bengkalis Regency. (5) Light green represents demand for a proper clean water in most villages in the Bengkalis Regency. (6) Purple indicates the zoning for water services.

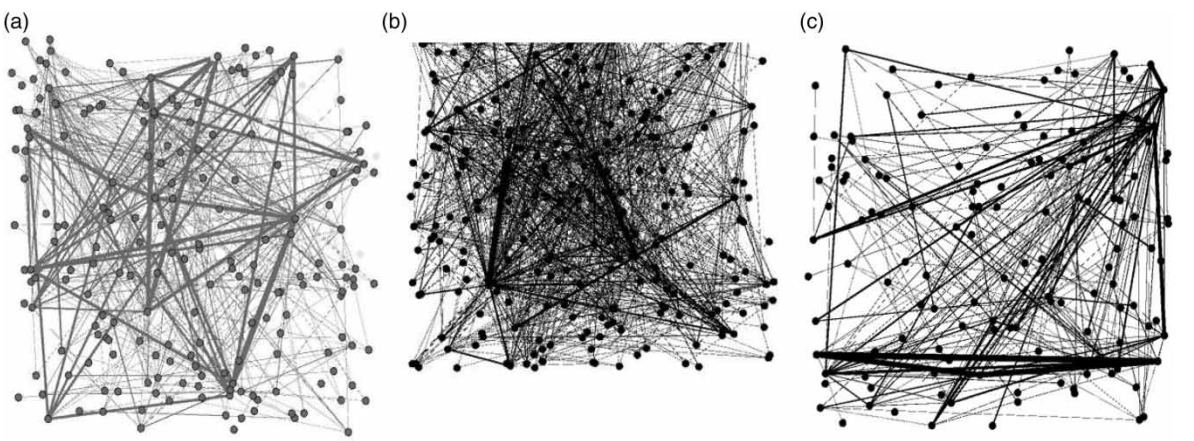


Fig. 4 | Pre-validated network actors presented: (a) Bengkalis Regency, (b) Dumai City, and (c) Rokan Hilir Regency (*sources:* Research Output 2023).

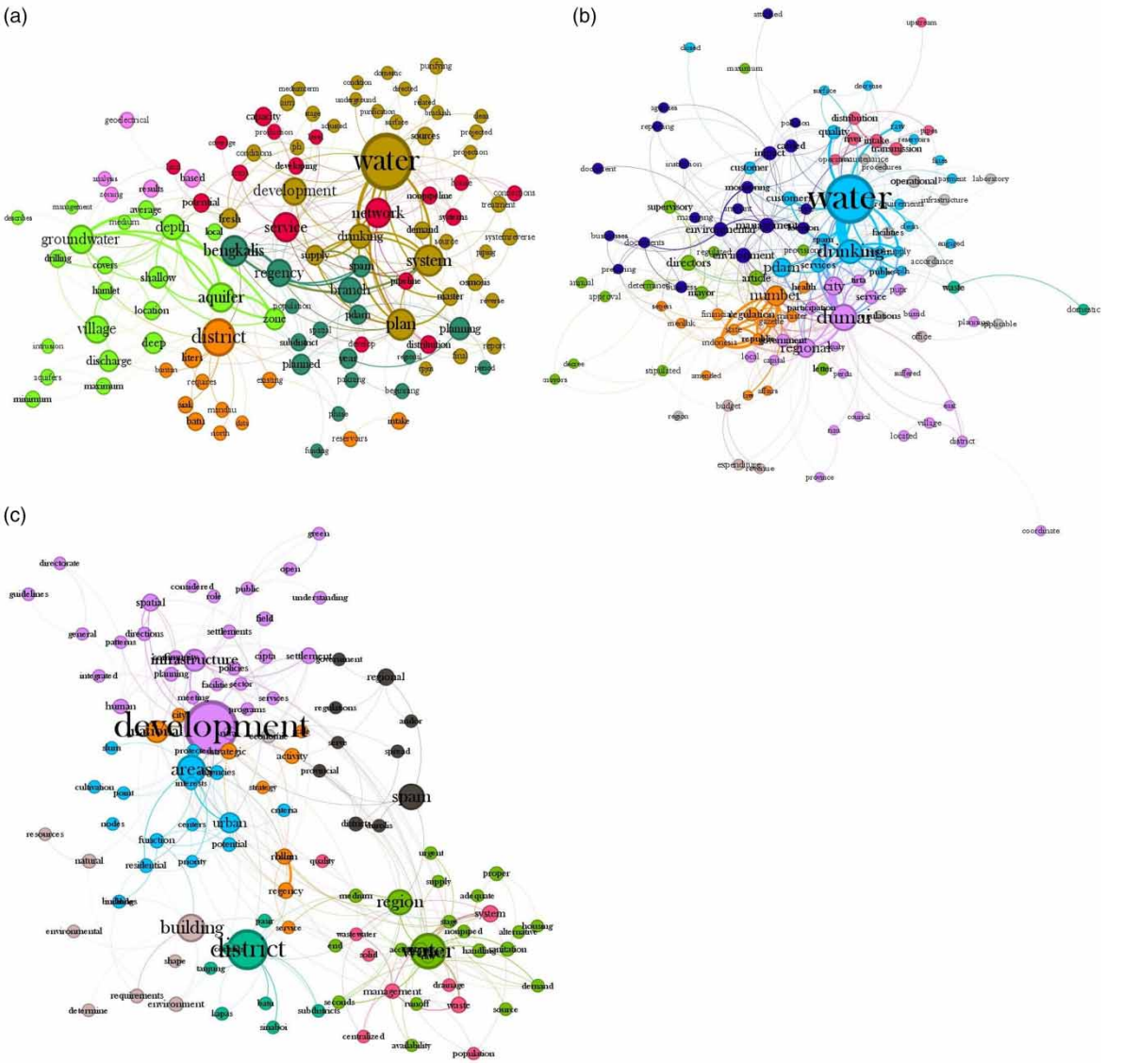


Fig. 5 | (a) Network graph of actors in Bengkalis Regency; (b) network graph of actors in Dumai City; and (c) network graph of actors in Rokan Hilir Regency.

The presented Figure 5(b) demonstrates the network actors in Dumai City. It can be seen that the clusters consist of different colors that represent a different power, the higher nodes indicate it has a powerful influence on the water governance strategies in these cities. (1) Light blue cluster highlights the urgency of addressing the demand for drinking water services, driven by the community's needs due to reservoir closures and limited surface land availability. This emphasizes the importance of implementing sustainable and resilient solutions to ensure an adequate and reliable water supply for the city's residents. (2) Purple cluster signifies the collaborative efforts between Dumai City, the Regional Province, and local participation in improving drinking water services.

This highlights the significance of stakeholder engagement and cooperation in developing effective water governance strategies that cater to the diverse needs and perspectives of the community.

(3) Orange color shows the financial regulations and allocations related to the Duralis SPAM projection. This underlines the importance of financial planning and resource allocation to support the implementation and sustainability of water management projects. (4) The green cluster indicates the supervisory mechanism in SPAM Durolis, emphasizing the role of governance and oversight in ensuring efficient and accountable water management practices that are directly carried out through the approval of the mayor. (5) Dark blue focuses on environmental management, highlighting the importance of considering and mitigating the potential adverse impacts of water management projects on the environment. This calls for the integration of environmental assessments and sustainable practices throughout the drilling and implementation stages. (6) The pink cluster represents a piping distribution and drilling process that does not adversely affect the environment. (7) The gray cluster discusses the facilities that support the implementation of Durolis SPAM based on the existing regulations. (8) The dark green cluster sheds light on the issue of poor water quality in Dumai City, primarily resulting from the substantial amount of domestic waste generated. This calls for comprehensive waste management strategies and water treatment measures to improve water quality and safeguard public health.

Meanwhile, Figure 5(c) can be identified as follows: (1) The purple cluster indicates the greater concern in Rokan Hilir Regency in 2017–2025 is the infrastructure development, which supports maximizing the clean water of Durolis SPAM. This policy also raises the need of public works officials to provide directions and guidelines to prevent conflict with the drinking water governance project through Durolis SPAM. (2) Green color shows the urgency of regional water accessibility. (3) The dark green cluster focuses on the zoning of water services in the most needed areas such as Tanjung Pasir District, Pasir district or other subdistricts. (4) The light brown cluster represents the need for eco-friendly water governance building. (5) The blue cluster indicates the characteristics of priority areas that should be flowed by Durolis SPAM. (6) The orange cluster focuses on the strategy for national water services through Durolis SPAM, particularly in Rokan Hilir Regency. (7) The gray cluster shows the Durolis SPAM as a regional regulation. (8) The pink cluster represents the need to improve the wastewater management system. In order to complete the information, we also presented in Table 1 the statistical distribution of TNA based on the large nodes of each network graph above.

Table 1 shows the density of TNA statistics which describes the activeness or proportion of all possible ties between actors actually present in Bengkalis, Dumai and Rokan Hilir water network. The smaller the density score, the fewer the number of bilateral and reciprocal connections, and the less extensive the inter-organizational cooperation (Huang *et al.* 2017). Therefore, it demonstrates the density of water drinking systems, water drinking quality, Dumai participation, environmental management, infrastructure development, water accessibility, and wastewater management become the most higher density scores. While the degree of centrality is high in several actors, it is lowest in the district actors, which is 26%. As argued by Huang *et al.* (2017), the nearer the degree centrality is to 1 (100%), the more the network is considered to have the highest centralization. In other words, the majority of connections within the network are formed with a small number of actors.

Being central to a network implies that a number of other actors have a direct link or a dependency and being in a central position can result in actor power. In attempting to define the centrality and power characteristic, we undertook the between centrality test. Betweenness measures the frequency with which a particular node falls in between the path which connects two actors. The higher the value, the higher the potential for exerting a controlling, or gatekeeping, influence on the flow of information between one actor and another. The first and second places water drinking system and national strategy betweenness centrality of 35 and 24%, respectively, while the government actor and SPAM rank low under 10%. This appears to make sense if the use of the drinking water system as a national strategy that collaborates

Table 1 | Statistical distributions of TNA.

Actors	Density	Degree centrality (%)	Betweenness centrality	Actor engaged
Bengkalis Regency				
Water drinking system	0.64	68	0.35	1.0
Water services	0.52	65	0.09	0.61
SPAM planning	0.45	58	0.03	0.31
Zoning	0.42	42	0.003	0.21
District	0.53	26	0.18	0.46
Groundwater	0.42	48	0.10	0.27
Dumai City				
Water drinking quality	0.60	72	0.15	1.0
Dumai participation	0.51	77	0.05	0.93
Financial regulation	0.32	60	0.002	0.13
Supervisory	0.33	67	0.07	0.44
Environmental management	0.70	55	0.04	0.79
Operational infrastructure	0.68	76	0.002	0.35
Pipes distribution	0.35	75	0.01	0.28
Waste domestic management	0.36	39	0.10	0.42
Rokan Hillir Regency				
Infrastructure development	0.88	74	0.10	0.63
Water accessibility	0.70	81	0.05	0.72
District	0.57	62	0.03	0.09
Environmental building	0.29	70	0.23	0.53
Priority area	0.30	33	0.002	0.09
National strategic	0.39	81	0.24	0.82
SPAM regulations	0.36	40	0.03	0.19
Wastewater management	0.60	61	0.7	0.77

Source: Research Output (2023).

with Bengkalis Regency, Dumai City, and Rokan Hilir Regency is based on societal demands that become government concerns in several years of governing.

4.2. Modes of interaction of the actors

This study identified several actors involved and interacting at the mesolevel. The network of actors that directly influence the water governance process of regional agreement of the DGWR, MPWPH together with the Directorate General of Human Settlement Karya and the Government of Riau Province, Dumai City, Rokan Hilir Regency, and Bengkalis Regency consists of 98 corpus (nodes), 190 edges (ties) and is classified into eight clusters.

At this stage, the TNA shows a water governance that focuses on the regional water implementation as represented in a light blue cluster. This implementation of regional water is also connected and identified by human actors related to their interaction in their agreement article as presented in a purple cluster (Figure 6).

At the provincial level, the decision-making power of the regional water implementation that is Durolis SPAM is much higher than ties in the state sector. The decision-making power of sustaining water governance strategies for drinking water supply services has become the responsibility of the central government. The central government presented in this case is the Ministry of Public Work and Public Housing, Riau Province, and The Municipality of Waterworks. More specifically, the Riau Provincial has the authority in funding related to piping from the river to these cities. Meanwhile, the local governments that consist of Bengkalis Regency, Dumai City and Rokan Hilir Regency are required to fully fund the pipanization in their regions to increase drinking water coverage.

4.3. The different types of interactions affect the decisions, and thus the situation of local territories

According to Figure 7, we identified several human actors that affect the decisions both in central and local government. The network of actors that directly influences Durolis SPAM on the sustainability water governance strategies in Riau Province of the scope component consists of 10 organizations.

Certain actors were found to play a directly influencing or implementing role in Durolis SPAM for these cities. Figure 7 shows how the actors in SPAM Durolis governance are directly connected. The actors involved through TNA as representatives of the central government are the MPWPH, the Ministry of Environment and Forestry (MEF). On the other hand, the Provincial represents the actors of Riau Provincial Government (RPG) and DGWR. At the municipal level, the actors consist of Municipal Waterwork of Riau (MWR), Riau Regional Owned Enterprises (RROE) or locally known as PDAM. Furthermore, the local levels of the actors involved are the Bengkalis Regency Government (BRG), Dumai City Government (DCG), and Rokan Hilir Regency Government (RHRG) (see Table 2).

Since their adjacency matrix with other actors varied highly, they were divided into two groups in thick and thin arrows as presented in Figure 7. Further, the main agency that directed the municipal governance is the RPG in the Durolis SPAM projection. This entity was found to play a bigger role in the smaller cities with respect to regional water governance. Most active ties come from the actors in the MPWPH that become supervisory with regard to this projection. The most central agency is no longer the DGWR/MWR, but the utility of the RPG. The regency government consists of BRG, DCG, and RHRG with the latter two playing bigger roles.

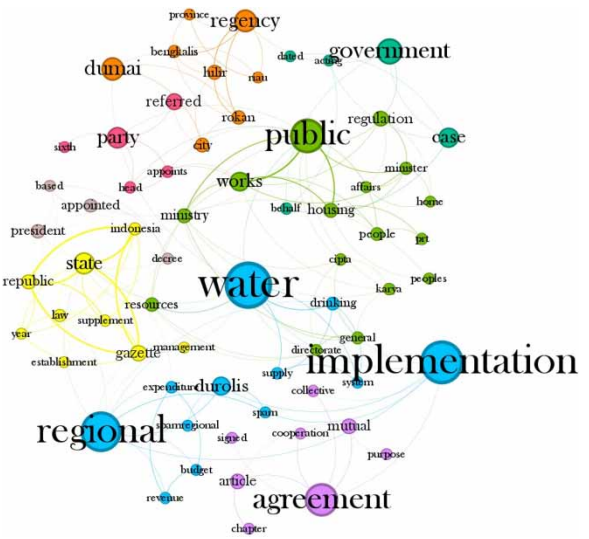


Fig. 6 | Network graph on the interaction of the actors.

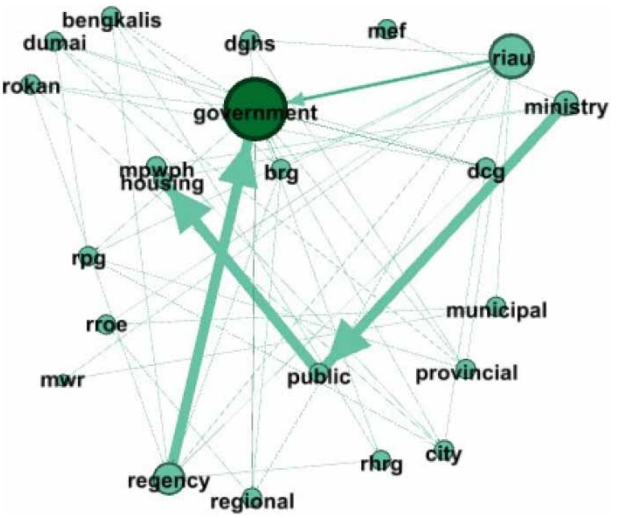


Fig. 7 | Network graph on the actors present.

Table 2 | List of human actors identified.

Level	Organization	Abbreviation
Central	Directorate General of Water Resources	DGWR
	Ministry Of Public Works and Public Housing	MPWPH
	Ministry Of Environment and Forestry	MEF
	Directorate General of Human Settlements	DGHS
Province	Riau Provincial Government	RPG
	Municipal Waterworks of Riau	MWR
	Riau Regional Owned Enterprises	RROE
Local	Rokan Hilir Regency Government	RHRG
	Bengkalis Regency Government	BRG
	Dumai City Government	DCG

5. DISCUSSION

The above results indicate that TNA could bring out useful information and new perspectives for sustainable water governance that other methods miss out. TNA can also corroborate key qualitative evidence while allowing for a systematic comparison of the governance networks in different cities. The structure of the actor network can have implications for power dynamics and the distribution of influence within water governance (Kunz *et al.*, 2017). Actors with larger node sizes or higher centrality measures are often considered more central in the network and may have greater control over decision-making processes (Narayan *et al.*, 2020). This study showed that the drinking water system is the main actor that influences local policymaking. This position as a key actor enables it to shape the flow of information, resources, and policies. The network actor analysis reveals different clusters within the Bengkalis Regency context; it becomes apparent that the Durolis SPAM project plays a crucial role in addressing the challenges of clean water supply in Bengkalis Regency. The clusters highlight the planning,

funding, zoning, and distribution aspects associated with the project. Various actors in Table 1 and Figure 5(a) provide valuable insights for understanding and managing the water-related challenges in the Bengkalis Regency.

The network actor of Figure 5(b) in Dumai City reveals various clusters representing different aspects of power and influence on water governance strategies. The most significant impact on water governance is water drinking quality as the main actor, Dumai participation and environmental management as the second and third significant actors. The visual representation enables policymakers to identify key areas of focus, prioritize interventions, and develop integrated approaches that address the complex challenges associated with water management. Additionally, the different clusters highlight the diverse dimensions and challenges associated with water governance, underscoring the need for a holistic approach to address these issues effectively. This is in line with the previous research conducted by Pahl-Wostl & Knieper (2023), while Zhou & Dai (2023) confirmed that understanding these clusters can aid policymakers, planners, and stakeholders in making informed decisions and formulating strategies to improve the clean water infrastructure and services.

On the other hand, the identified clusters of Figure 5(c) provide valuable insights into the Rokan Hilir Regency. This study showed that infrastructure development is the main actor that influences local policymaking. Infrastructure development as a primary concern aligns with the understanding that adequate and well-maintained infrastructure is essential for ensuring reliable access to clean water. Previous research conducted by Feldman, (2022b) has emphasized the significance of infrastructure investments in supporting water supply and distribution systems, particularly in regions facing water scarcity or inadequate water infrastructure (Narayan *et al*., 2020). The second actor that influenced the Rokan Hilir Regency is water accessibility. The recognition of water accessibility as the second actor that influenced the Rokan Hilir Regency to become an urgent priority resonates with studies by Pahl-Wostl & Knieper (2023) and Wuijts *et al.* (2018), which highlight the importance of ensuring equitable access to water resources for all communities. Unequal access to clean water can exacerbate social and economic disparities (Feldman, 2022a), and addressing water accessibility challenges (Eberhard *et al*., 2017) has been identified as a critical component of achieving the United Nations Sustainable Development Goals related to water and sanitation.

In this case, the water governance process in these cities at the actors (nodes) engaging in local policymaking mentioned above is influenced by the non-human actors. The status of non-human actors is based on each region's priorities, which clarifies our understanding of their influence on human actors' decisions (Fischer *et al*., 2022). Furthermore, the insights provided by TNA and the identification of key actors and clusters within the water governance networks can inform evidence-based decision-making processes. This finding also proved the reason why certain actors are more likely to engage in decision-making. Policymakers, planners, and stakeholders can leverage this information to develop targeted interventions and allocate resources effectively. However, it is important to note that the findings presented in this analysis are specific to the regions studied and the time frame considered. The dynamics and priorities of water governance can evolve over time, and the identified actors and clusters may change accordingly.

Furthermore, the analysis of modes of interaction in water governance provides support for the existing understanding of regional water implementation. The focus on regional water, as represented by the light blue cluster, aligns with previous studies conducted by Pahl-Wostl & Knieper (2023) and Zhou & Dai (2023) that have emphasized the importance of considering water management at the regional level. This finding reinforces the notion that addressing water-related challenges requires collaborative efforts among multiple stakeholders within a defined geographic area. The inclusion of human actors in the analysis underscores their role in decision-making processes and emphasizes the need for their active participation in developing and implementing water policies. The structure and dynamic of the actor network reveal the decision-making power dynamics between Durolis SPAM and the state sector at the provincial level. The higher decision-making power of Durolis

SPAM indicates its influence and authority in driving regional water implementation. This finding supports earlier studies by Bitterman & Koliba (2023), Hegga *et al.* (2020), Megdal *et al.* (2017), and Yi *et al.* (2019) that have emphasized the role of non-state actors in water governance and their ability to shape policies and strategies.

In terms of funding responsibilities, the study uncovers the distribution of financial obligations between the central government and local governments. The authority of Riau Provincial in funding piping from the river to cities, coupled with the requirement for local governments to fully fund pipanization in their regions, reflects the collaborative and shared financial commitments needed to improve drinking water coverage. This finding aligns with previous research of Lee *et al.* (2022) and Moss & Newig (2010) that has emphasized the need for multi-level governance approaches, involving both higher-level and local-level actors. By considering the importance of regional water implementation, stakeholder engagement, and the role of non-state actors, this study further contributes by revealing the power dynamics and funding responsibilities that influence decision-making and implementation processes. Understanding these dynamics is vital for developing inclusive and sustainable water governance strategies that can enhance drinking water coverage and address water-related challenges effectively.

Meanwhile, the network of actors in this study confirmed that the central government, represented by the MPWPH and the MEF, plays a crucial role in overseeing and supervising the Durolis SPAM project. This finding is consistent with the studies of Pahl-Wostl & Knieper (2023), the understanding that national-level entities often have the authority and resources to set the overall direction and policies for regional projects. Additionally, the RPG as the main agency directing municipal governance in the Durolis SPAM project builds upon previous studies that highlight the significance of regional or provincial governments in driving local-level decision-making. This finding reinforces the idea that regional actors possess a deeper understanding of local dynamics, challenges, and needs, making them better positioned to implement effective water management strategies (Zhou & Dai, 2023). The prominence of the MPWPH actors as supervisory actors corresponds to previous research emphasizing the regulatory and oversight roles of central government agencies in infrastructure projects. These actors are often responsible for ensuring compliance, quality control, and the alignment of local initiatives with national policies.

Looking in greater detail, the findings revealing the active ties and involvement of the regency governments, represented by BRG, DCG, and RHRG, in the latter two cities within the Durolis SPAM project align with research highlighting the importance of local governments in infrastructure development and service delivery. Local governments possess a deeper understanding of the specific needs and challenges faced by their communities, allowing them to play a more significant role in decision-making processes and implementation. Therefore, this study supports and adds depth to previous research by Fischer *et al.* (2022), Li & Mostafavi (2021) and Zhou & Dai (2023) that highlight the roles of different actors at various levels of governance in shaping the decisions and situation of local territories within the Durolis SPAM project. The findings reinforce the importance of multi-level and multi-actor approaches in regional projects, acknowledging the influence and involvement of central, provincial, municipal, and local actors. By building upon Bitterman & Koliba (2023) and Hegga *et al.* (2020), this study contributes to a more comprehensive understanding of the dynamics that influence decision-making and governance processes in regional water management projects.

6. CONCLUSION

The results of this study have contributed toward several practical implications. It confirmed the key actors and clusters within the microlevel of water governance networks in Bengkalis Regency, Dumai City, and Rokan Hilir Regency. In Bengkalis Regency, the Durolis SPAM project plays a crucial role in addressing the challenges of

clean water supply. In Dumai City, water drinking quality, Dumai participation, and environmental management are identified as significant actors. In the Rokan Hilir Regency, infrastructure development and water accessibility emerge as the main actors influencing local policymaking. The TNA based on the RQ1 of the actors engaged in local policymaking within Bengkalis Regency, Dumai City, and Rokan Hilir Regency has provided valuable insights into the complex dynamics of water governance in these regions.

In Bengkalis Regency, the network analysis revealed the presence of distinct clusters, each with its unique focus. These clusters range from the planning and development of drinking water systems to the demand for clean water services in different areas. This indicates a multifaceted approach to addressing water governance issues in the region. Moreover, the centrality metrics demonstrated that certain actors play pivotal roles in influencing water governance decisions, particularly those related to water quality and planning. Conversely, the network analysis of Dumai City highlighted the critical role of stakeholder engagement and cooperation in addressing the urgent need for water supply services. Several clusters emphasized the importance of sustainable solutions, financial arrangements, oversight mechanisms and environmental considerations. The analysis highlighted the delicate balance required when developing water management strategies in an urban context. Similarly, the Rokan Hilir Regency exhibited a diverse set of clusters, with a focus on infrastructure development, water accessibility, and eco-friendly water governance. Centrality metrics in this region also identified influential actors shaping policy decisions related to infrastructure and water accessibility. This reflects the region's commitment to enhancing water management infrastructure and service provision.

The interaction modes among actors as in RQ2 highlight a cooperative approach to regional water governance, with a clear delineation of roles and responsibilities between regional and central authorities. The RPG is granted the authority to fund piping projects from the river to the cities, emphasizing the importance of central support in critical infrastructure development. Meanwhile, local governments, including Bengkalis Regency, Dumai City, and Rokan Hilir Regency, are tasked with the financial responsibility of pipanization within their respective regions. This approach promotes local accountability and financial commitment to expanding drinking water coverage in these areas. This nuanced understanding of actor interactions can inform policy decisions and enhance the effectiveness of water governance strategies in these regions.

Furthermore, the diverse types of interactions as in RQ3 among various actors at both central and local government levels profoundly impact decision-making processes and consequently, the state of local territories, particularly in the context of Durolis SPAM and water governance strategies in Riau Province. At the central government level, the MPWPH and the MEF play significant roles in overseeing and implementing Durolis SPAM. These actors serve as representatives of the central government and are crucial in shaping the direction of water governance strategies. In contrast, the provincial government, represented by the RPG and the DGWR, exerts its influence on a broader scale. The RPG, in particular, emerges as a key agency directing municipal governance in Durolis SPAM. This suggests a centralized approach to regional water governance, where the provincial government plays a pivotal role in decision-making. While at the municipal level, entities such as the Municipal Waterwork of Riau (MWR) and RROE or PDAM are actively involved in water governance. These local actors are responsible for implementing and managing water supply services within their respective territories. The centralization of decision-making power in the hands of the provincial government, particularly the RPG, signifies a top-down approach to water governance in the region. The Provincial Government acts as a facilitator when problems arise, while problem-solving is based on consensus between the regions as a decision-making tool. As a result, the dynamics of local territories are shaped by the interactions and decisions of these actors.

However, it is important to recognize the limitations of this study. The findings are specific to the regions studied (Bengkalis Regency, Dumai City, and Rokan Hilir Regency) and may not be directly applicable to other contexts. The dynamics of water governance can vary across regions, and the identified actors and clusters

may differ accordingly. Further research and analysis are necessary to capture any changes in actor networks and power dynamics in water governance over time. Therefore, caution should be exercised when generalizing the findings to other locations. Additionally, longitudinal studies can provide a more comprehensive understanding of the evolving relationships and influences among actors, enabling policymakers, planners, and stakeholders to adapt their strategies accordingly.

DATA AVAILABILITY STATEMENT

The raw data was primarily sourced from the Provincial Government of Riau, Indonesia. For access to the data supporting our research findings, kindly contact the corresponding author, Suyeno, who will provide it upon request.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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