

Adaptive management for coastal sanitation governance in Jakarta, Indonesia: Bridging community resilience and the 100-0-100 development

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Abstract— Coastal urban areas in Indonesia, particularly in Jakarta, face complex sanitation challenges due to rapid urbanization, environmental vulnerability, and the persistence of informal settlements. While national programs like the 100-0-100 initiative and the KOTAKU (Kota Tanpa Kumuh) program aim to achieve universal sanitation access and slum eradication, implementation in flood-prone coastal zones remains constrained by rigid infrastructure models, fragmented governance, and limited community engagement. This study employs a narrative review approach to examine how principles of adaptive management can enhance the effectiveness, inclusiveness, and resilience of coastal sanitation systems. Drawing on literature from urban planning, environmental governance, and participatory development, the study synthesizes insights across five core dimensions of adaptive management: assets, flexibility, organization, learning, and agency. The resulting framework highlights the importance of leveraging local knowledge, enabling flexible planning and financing, promoting inter-agency collaboration, institutionalizing learning mechanisms, and strengthening community leadership. By aligning technical solutions with social realities and environmental dynamics, adaptive management offers a pathway to improve sanitation governance while supporting Indonesia's broader sustainable development and climate adaptation goals. The study concludes with policy recommendations to integrate adaptive approaches into the design and evaluation of urban sanitation programs, ensuring that no community is left behind in the pursuit of inclusive and resilient urban futures.

Keywords— Adaptive management; coastal sanitation; community resilience; urban governance; KOTAKU program; 100-0-100 initiative; participatory planning; Jakarta; slum upgrading; environmental health

I. INTRODUCTION

Sanitation remains a critical challenge in many rapidly urbanizing areas across the Global South, especially in coastal megacities where environmental vulnerability intersects with socio-economic inequality and governance fragmentation [1], [2], [3]. In Indonesia, the capital city of Jakarta exemplifies this convergence. With over ten million residents and significant portions of the population living in informal settlements near the coast, Jakarta is continuously confronted by chronic flooding, land subsidence, sea-level rise, and increasing environmental pollution [4], [5], [6]. These threats severely compromise the ability of public agencies to deliver safe, inclusive, and resilient sanitation systems [7], [8]. To address urban infrastructure deficits and improve the quality of life for marginalized populations, the Indonesian government launched the 100-0-100 initiative, aiming to provide 100 percent access to safe drinking water, achieve zero percent slum areas, and ensure 100 percent access to adequate sanitation [9].

This ambitious policy framework aligns with Indonesia's commitment to achieving Sustainable Development Goals (SDGs), particularly Goal 6 (clean water and sanitation) and Goal 11 (sustainable cities and communities). Within this framework, the KOTAKU program, or "Kota Tanpa Kumuh" (Cities Without Slums), has emerged as a national flagship initiative that integrates infrastructure upgrading [10], community-based planning, and inter-agency collaboration to improve conditions in urban informal settlements.

However, while KOTAKU and 100-0-100 have made significant strides in aligning development goals with infrastructure delivery, their implementation in coastal areas like North Jakarta has revealed critical shortcomings. The majority of sanitation interventions under these initiatives are still guided by top-down decision-making [11], standardized engineering models, and rigid performance indicators. These approaches often ignore the socio-spatial heterogeneity of coastal communities and the unpredictability of environmental systems [12]. In many cases, sanitation systems such as communal septic tanks or small-scale wastewater treatment plants are installed without sufficient attention to local flooding patterns, groundwater levels [13], or community willingness and capacity to maintain the infrastructure [7]. As a result, infrastructure deteriorates quickly, becomes underutilized, or is abandoned altogether. These implementation gaps are exacerbated by the specific ecological and governance conditions in coastal areas. Settlements near Jakarta's shoreline are

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frequently informal or semi-formal, lacking secure land tenure and formal service access [14], [15]. The risk of tidal flooding, known locally as “rob,” makes conventional infrastructure approaches unfeasible without major adaptation [16]. Moreover, these communities are often socially and politically marginalized, which limits their ability to engage with public agencies and influence decision-making processes. The convergence of environmental, technical, and institutional challenges creates a complex landscape where linear planning and one-size-fits-all solutions no longer suffice.

In light of these challenges, this study argues for a shift toward adaptive management in the governance of coastal sanitation systems. Adaptive management is a dynamic, learning-oriented approach that has been widely used in natural resource management and increasingly applied in urban governance contexts [17], [18], [19], [20]. Rather than following a fixed blueprint, adaptive management emphasizes continuous monitoring, stakeholder feedback, flexible planning, and iterative adjustment in response to change. It recognizes that complex socio-ecological systems such as those found in Jakarta’s coastal zones require governance models that can deal with uncertainty, encourage innovation, and promote local agency. Applying adaptive management to sanitation governance means designing systems that are flexible enough to accommodate hydrological variability, modular enough to be implemented incrementally, and inclusive enough to reflect community needs and aspirations. It also means rethinking how success is measured not only through infrastructure coverage, but through outcomes such as system longevity, local ownership, environmental resilience, and social equity. Adaptive management enables sanitation programs to become more than infrastructure projects; they become platforms for collaboration, experimentation, and empowerment [21].

Although the principles of adaptive management have been acknowledged in various sectors, their application in sanitation policy and practice in Indonesia remains limited. Community participation, a central tenet of the KOTAKU initiative, is often restricted to surface-level involvement, such as mobilizing residents for construction labor or attending socialization meetings [22]. Rarely are communities involved in more substantive roles such as co-designing infrastructure, co-managing maintenance, or participating in impact evaluation. Moreover, the governance structures that oversee sanitation planning typically fragmented across multiple agencies often lack the institutional capacity or incentive to integrate adaptive processes such as feedback loops, learning platforms, or community-driven innovation [23], [24], [25], [26].

This study responds to these challenges by developing a conceptual and applied framework for adaptive sanitation governance in Jakarta’s coastal areas. Through a narrative review of existing literature, policy documents, and case studies, the research explores how adaptive management can be operationalized across five interrelated dimensions: assets, flexibility, organization, learning, and agency [23], [24], [25]. These dimensions reflect not only technical and institutional requirements,

but also the cultural, environmental, and political contexts that shape sanitation outcomes. Assets refer to the physical infrastructure, local knowledge, social capital, and natural resources that can be mobilized to support adaptive interventions. Flexibility captures the ability of sanitation technologies, financing mechanisms, and regulatory frameworks to respond to changing conditions. Organization involves the alignment and coordination of stakeholders across sectors and scales. Learning emphasizes the role of monitoring, reflection, and knowledge exchange in guiding continuous improvement. Agency focuses on empowering communities to take leadership in sanitation planning, implementation, and advocacy. The narrative review methodology allows the study to synthesize insights from diverse disciplines environmental planning, public health, urban governance, and community development while grounding the analysis in the specific conditions of coastal Jakarta. It does not attempt to provide a definitive solution or technical design, but rather a conceptual roadmap and operational strategies for embedding adaptive principles into sanitation programming. This approach is especially important in the context of climate change, which is expected to intensify many of the existing risks facing coastal settlements, including sea-level rise, extreme rainfall, and waterborne diseases.

II. METHOD

A. Research Design and Objective

This study adopts a narrative review approach to explore the conceptual and practical applications of adaptive management in coastal sanitation governance, particularly within the framework of Indonesia’s KOTAKU (Kota Tanpa Kumuh) program and the national 100-0-100 development target. A narrative review is well-suited for synthesizing knowledge across diverse sources, providing both a descriptive and interpretive understanding of a complex topic that spans infrastructure, environmental health, urban governance, and community participation. Unlike systematic reviews, which focus on exhaustive coverage and rigid inclusion criteria, the narrative approach allows for flexibility in identifying, selecting, and analyzing literature and empirical evidence, especially when the goal is to integrate knowledge from policy documents, case studies, and conceptual frameworks within a socio-political context. The research is designed as an exploratory, interpretive review guided by the principles of adaptive governance, social-ecological systems thinking, and participatory urban planning. The overarching aim is to critically examine how adaptive management principles can be integrated into coastal sanitation programming in Indonesia, with a focus on five key dimensions: assets, flexibility, organization, learning, and agency. These dimensions were identified a priori through a preliminary scan of literature on adaptive governance and were used to structure the subsequent stages of data collection and analysis. This study does not attempt to evaluate a single intervention or case study. Instead, it builds a broader conceptual framework, supported by empirical insights, that can inform more effective and inclusive sanitation governance in urban coastal contexts.

B. Thematic Analysis

Sanitation in coastal cities like Jakarta presents challenges that are technical (e.g., system design, drainage), social (e.g., informal settlements, inequality), environmental (e.g., tidal flooding, water pollution), and institutional (e.g., fragmented governance, low enforcement capacity). These dimensions cannot be fully understood through a singular disciplinary lens or methodology. Therefore, a narrative review approach is chosen to allow for the integration of:

- Peer-reviewed academic literature
- Policy documents and government regulations
- Grey literature from development organizations and NGOs
- Case studies and technical reports related to KOTAKU, 100-0-100, and urban WASH (Water, Sanitation, and Hygiene) programs

The flexibility of the narrative review permits the researcher to engage critically with different types of evidence and to develop an adaptive, context-sensitive analytical model rather than a fixed set of conclusions. A purposive search strategy was employed to identify relevant literature published between 2010 and 2024, ensuring both recency and relevance to current policy debates. The following databases and repositories were used:

- Scopus
- Google Scholar
- ScienceDirect
- ProQuest

Search terms were structured using Boolean operators and keyword combinations such as:

- “adaptive management” AND “urban sanitation” AND “Indonesia”
- “KOTAKU program” AND “coastal resilience”
- “community-based sanitation” OR “participatory governance”
- “100-0-100 sanitation target” AND “Jakarta slums”
- “climate change adaptation” AND “urban water infrastructure”

C. Data Extraction

Data were extracted manually using a coding matrix aligned with the five adaptive management dimensions:

1. Assets – utilization of local knowledge, infrastructure, and environmental systems.
2. Flexibility – technological and financial adaptability, responsive regulation.
3. Organization – institutional arrangements and governance coordination.
4. Learning – monitoring, feedback, and iterative improvement.
5. Agency – empowerment and representation of local communities.

Within each dimension, sub-codes were developed inductively to capture recurring themes, including

modular infrastructure, policy flexibility, community-led monitoring, gender-inclusive sanitation groups, climate vulnerability, and cross-sectoral alignment. NVivo software was used for organizing and visualizing the codes, but analysis was conducted manually to maintain a close interpretive connection with the text. Key findings were not simply aggregated but synthesized into a conceptual model (see Table 2 and Figure 1) that maps the interaction of adaptive principles within real-world sanitation programming. This synthesis enabled both within-theme insights (e.g., characteristics of financial flexibility) and cross-theme linkages (e.g., how local agency improves monitoring outcomes).

III. RESULTS AND DISCUSSION

Table 1 presents a comprehensive framework for applying adaptive management to the design and implementation of a coastal sanitation program in Jakarta. Adaptive management is increasingly recognized as a necessary strategy in complex and uncertain socio-environmental systems particularly in urban settings vulnerable to climate risks, infrastructural deficits, and socio-economic inequality [27], [28], [29]. In Jakarta’s northern coastal areas, rapid urbanization, tidal flooding (rob), land subsidence, and aging or absent sanitation infrastructure have led to chronic environmental degradation and heightened public health risks. Conventional infrastructure-focused solutions have often failed in these environments due to their rigidity, lack of community input, and poor alignment with local needs. Adaptive management offers a viable alternative by promoting iterative, inclusive, and flexible approaches to governance and program implementation [17], [18], [19], [20]. It emphasizes the importance of working with uncertainty, leveraging local knowledge and existing resources, and building systems that can evolve in response to feedback and changing conditions [30]. Table 1 organizes this approach into five core dimensions: assets, flexibility, organization, learning, and agency, each of which is critical for enabling a responsive and sustainable sanitation program in Jakarta’s coastal context.

The first dimension, assets, focuses on identifying and utilizing existing strengths [31], such as community-based organizations (e.g., youth groups, PKK, and fisher groups), communal wastewater systems (IPAL Komunal), green infrastructure like mangroves, and detailed local knowledge of tides, drainage, and flooding. These resources provide an important foundation for building context-sensitive and cost-effective interventions. Recognizing and mobilizing such assets helps to reduce dependency on external inputs and encourages local stewardship of sanitation infrastructure.

The second dimension, flexibility, is vital for dealing with Jakarta’s dynamic coastal environment, which is affected by sea-level rise, seasonal flooding, and shifting urban patterns. Technological flexibility includes the use of decentralized systems such as modular IPALs, bio-septic tanks, and constructed wetlands that can be adapted to spatial and hydrological constraints. Financial flexibility refers to combining funding from local government (APBD), private sector (CSR), and community contributions, including micro-financing

tailored to household capacity. Policy and regulatory flexibility, meanwhile, allows for real-time revisions and the piloting of new sanitation models through supportive

local regulations. Without flexibility, programs risk failure when conditions change or when initial assumptions prove inaccurate [32], [33].

Table 1. Comprehensive framework for applying adaptive management to the design and implementation of a coastal sanitation program in Jakarta

Dimension	Sub-Dimension	Description
1. Assets	Social and community assets	- Active community-based organizations: youth groups, women's groups (PKK), fisher associations, local environmental volunteers. - Local values and traditional knowledge that support clean and healthy living behavior (PHBS).
	Infrastructure assets	- Existing communal wastewater treatment systems (IPAL Komunal) in several neighborhoods. - Drainage networks and coastal barriers that can be optimized for wastewater management.
	Environmental assets	- Coastal mangroves and green spaces offering natural biofiltration and pollution reduction.
	Local knowledge assets	- Community insights on tidal cycles, flood-prone areas, and seasonal changes are essential for resilient sanitation planning.
2. Flexibility	Technological flexibility	- Use of decentralized systems: bio-septic tanks, small-scale wetlands, modular IPAL for flood-prone areas. - Modular technologies allow phased and adaptive implementation.
	Financial flexibility	- Funding mix from APBD, CSR, village funds, and community contributions. - Micro-financing tailored to household affordability.
	Policy and regulatory flexibility	- Development of local regulations (e.g., mayoral decrees) supporting innovation and piloting. - Mechanisms to revise policies based on real-time monitoring and feedback.
3. Organization	Multi-stakeholder coordination	- Coordination among city government, Environmental Agency, Health Department, Bappeda, and subdistrict offices. - Collaboration with NGOs, academia, and private sector for capacity building.
	Community-based management units Cross-program integration	- Formation of "Coastal Sanitation Management Groups" at RW level for facility management and education. - Alignment with slum upgrading (KOTAKU), disaster risk reduction, and climate resilience programs.
4. Learning	Participatory monitoring and evaluation Pilot projects and test beds	- Community involvement in monitoring water quality, septic systems, and IPAL performance using digital tools or reporting systems. - Sanitation pilots in selected neighborhoods to test innovations, identify technical issues, and gather feedback.
	Feedback loops for adaptive planning Capacity building and training	- Regular planning reviews (quarterly/annually) to adjust strategies based on outcomes and inputs. - Training for local IPAL operators and sanitation cadres.
		- Certification for community sanitation facilitators to validate local expertise.
5. Agency	Community ownership and co-design	- Residents involved from the beginning through participatory mapping and planning. - Community-led site selection and system design.
	Strengthening local capacity	- Sanitation education for women, youth, and vulnerable groups. - Development of local champions to lead awareness and behavior change.
	Representation and advocacy	- Community representation in formal decision-making platforms at subdistrict/city level. - Support for local leaders to advocate for improved sanitation services.

The third dimension, organization, addresses institutional arrangements and governance coordination [34], [35]. Coastal sanitation requires multi-level collaboration between government agencies (e.g., DLH, Dinas Kesehatan, Bappeda), NGOs, universities, and private sector actors. Formal structures like community-based sanitation management groups (Kelompok Pengelola Sanitasi Pesisir) can help bridge top-down policy and bottom-up practice. Cross-program integration ensures that sanitation is aligned with broader urban development goals [36], climate adaptation, and slum upgrading initiatives (e.g., KOTAKU) which reduces redundancy and maximizes impact.

The fourth dimension, learning, ensures that program implementation is informed by evidence, feedback, and experience [37], [38], [39], [40]. This involves regular

participatory monitoring and evaluation of system performance (e.g., water quality, septic tank status), the use of pilot projects to test context-appropriate technologies, and the establishment of feedback loops to iteratively adjust planning and resource allocation. Capacity-building efforts, including training for sanitation cadres and local IPAL operators, are essential to ensure knowledge retention, operational sustainability, and system resilience [41]. Learning mechanisms should be embedded within the institutional structure, not treated as one-off events. Finally, the fifth dimension, Agency, focuses on empowering local communities as co-creators of sanitation solutions [42]. Too often, communities are seen merely as beneficiaries rather than active participants. Adaptive sanitation governance requires community ownership through participatory

design, needs mapping, and localized decision-making. Special attention should be given to the inclusion of women, youth, and vulnerable populations whose voices are frequently excluded from formal processes. Local champions and grassroots leaders must be supported to advocate for equitable access, shape policy discussions, and monitor service delivery. Agency ensures that sanitation systems are not only technically functional but socially embedded and politically legitimate [43].

Figure 1 illustrates an adaptive management framework designed to strengthen the implementation of the KOTAKU initiative (Kota Tanpa Kumuh) within the national target of 100-0-100, which aims to achieve 100% access to clean water, 0% slum areas, and 100% access to adequate sanitation. This framework integrates five core dimensions of adaptive management assets,

flexibility, organization, learning, and agency to address the complexity and multi-scalar nature of urban upgrading in Indonesia's informal settlements. Given the dynamic challenges of rapid urbanization, climate vulnerability, land tenure issues, and institutional fragmentation, traditional top-down approaches are often insufficient to ensure long-term sustainability and inclusiveness in slum upgrading programs. The KOTAKU program requires an approach that can adjust to diverse local contexts, empower communities, and support continuous innovation [44]. The adaptive management model presented in Figure 1 addresses this need by embedding resilience thinking and participatory governance into every phase of the program cycle.

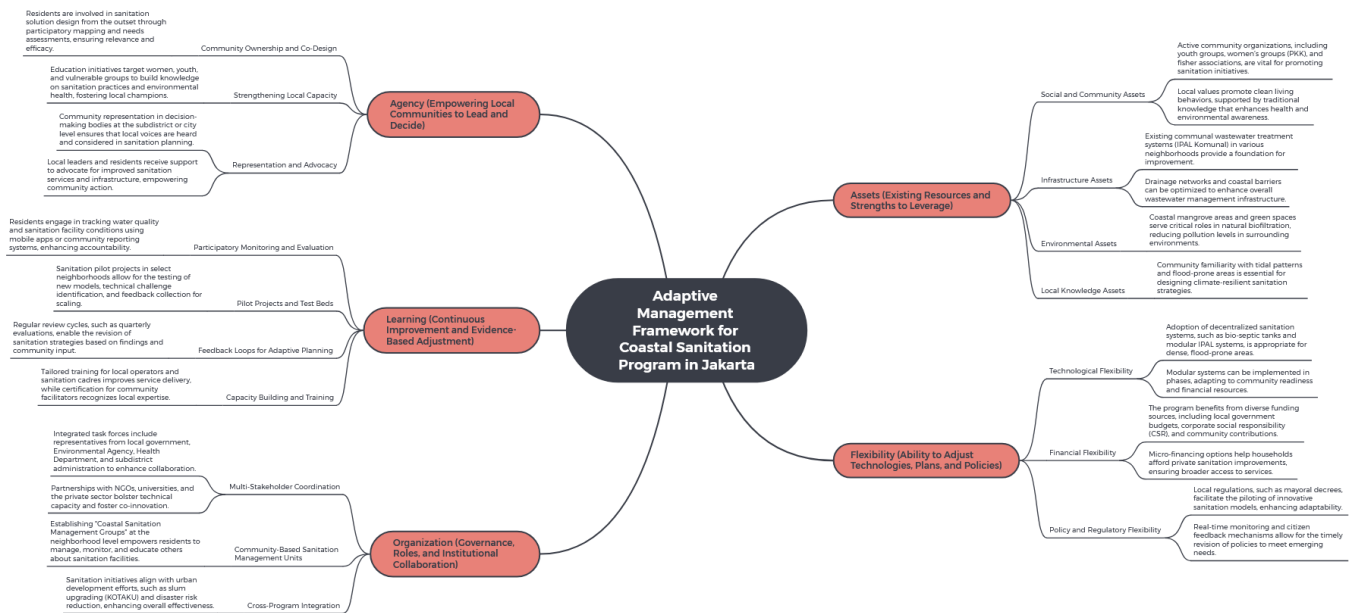


Figure 1. Adaptive management framework designed to strengthen the implementation of the KOTAKU initiative

To address these complexities, Table 2 provides an adaptive management framework that operationalizes five key dimensions. These dimensions are mapped across three critical layers: (1) Program approach how government and stakeholders design and implement interventions; (2) Community participation the specific roles local residents play in shaping and sustaining sanitation initiatives; and (3) Involved community actors the individuals, groups, and institutions embedded in the social fabric of coastal communities. Unlike conventional sanitation models that focus solely on infrastructure provision, this adaptive framework advocates for a systems-based and socially grounded approach. It reflects global best practices in urban governance, resilience theory, and environmental health management, which stress the importance of locally embedded, flexible, and participatory strategies in fragile ecosystems [45], [46], [47].

The first dimension assets emphasizes the importance of building on what already exists within the community. This includes physical infrastructure (e.g., existing communal waste treatment units or drainage), social capital (e.g., community groups, traditional leaders), and

natural resources (e.g., mangroves and wetlands that offer ecological services). Communities can play a vital role in identifying underutilized or overlooked resources and co-developing plans to leverage these assets. The second dimension flexibility underscores the need for technological, financial, and policy responsiveness. Sanitation infrastructure in coastal areas must be modular and adaptive to changing land conditions, sea-level rise, and seasonal variability. Similarly, financing must be flexible enough to combine sources such as government funding (APBD), corporate social responsibility (CSR), microfinance, and community contributions.

Organization represents the institutional arrangements and governance capacity required to operationalize sanitation programs. Effective coordination among city governments, environmental and health departments, NGOs, and community-based organizations is essential. More importantly, the establishment of community-level management units enables decentralized decision-making, localized monitoring, and faster service delivery. The learning dimension is central to adaptive management. It integrates participatory monitoring and

evaluation (M&E) systems, iterative piloting of sanitation technologies, and structured feedback loops that allow continuous improvement. Communities not only benefit from these learning mechanisms but also contribute knowledge that may otherwise go undocumented or underappreciated in formal systems. Finally, agency refers to the empowerment of local

stakeholders. Through co-design processes, community-led planning, and institutional representation, residents become active decision-makers. Women, youth, and marginalized groups often disproportionately affected by poor sanitation must be given space and support to advocate for their own needs [48], [49], [50].

Table 2. Adaptive management dimensions and community roles in coastal sanitation programs

Dimension	Program approach	Community participation	Involved community actors
Assets	Mapping and leveraging existing social, environmental, and infrastructure resources (e.g., IPAL, mangroves, community groups).	Communities help identify local assets and contribute knowledge about flood risks, seasonal waste trends, and spatial sanitation needs.	Community groups (Karang Taruna, PKK), RT/RW leaders, local NGOs, coastal environmental activists.
Flexibility	Use of modular and decentralized sanitation systems adaptable to local conditions; flexible financing (CSR, APBD, swadaya).	Community selects preferred sanitation models based on land space, affordability, and cultural appropriateness.	Local cooperatives, micro-finance institutions, informal settlements' associations.
Organization	Formation of a multi-stakeholder task force; establishment of community-based sanitation management units.	Community participates in daily operation, maintenance, and local-level decision-making structures.	Sanitation Cadres (Kader Sanitasi), Coastal Sanitation Management Groups (RW level), Subdistrict facilitators.
Learning	Regular participatory monitoring & evaluation (M&E); piloting sanitation prototypes in high-risk neighborhoods.	Community members collect and analyze data; participate in training and reflection sessions.	Local universities, youth groups, citizen science volunteers, training centers.
Agency	Empowerment through co-design and shared governance; local leadership in sanitation advocacy.	Communities need assessments, help design solutions, and engage in public consultations and feedback mechanisms.	Community leaders, women's groups, sanitation champions, vulnerable and low-income household representatives.

IV. CONCLUSION

This study has demonstrated the critical importance of integrating adaptive management principles into the governance of coastal sanitation systems in Indonesia, particularly within the implementation frameworks of the KOTAKU initiative and the 100-0-100 national development target. Coastal urban environments, such as those in North Jakarta, present unique and evolving challenge—from tidal flooding and land subsidence to high population density and socio-economic exclusion that demand more than conventional, infrastructure-focused approaches. Sanitation governance in these contexts must navigate uncertainty, institutional fragmentation, and dynamic social-ecological conditions. Through a narrative review and synthesis of empirical evidence and theoretical insights, the study identified five interconnected dimensions assets, flexibility, organization, learning, and agency that form the foundation for an adaptive sanitation framework. This framework emphasizes the use of locally embedded knowledge, modular and context-sensitive technologies, flexible financing, inclusive governance structures, continuous learning loops, and meaningful community participation. Taken together, these dimensions support a more resilient, equitable, and sustainable approach to urban sanitation development.

The findings suggest that adaptive management is not merely a technical or procedural enhancement, but a transformative governance shift—one that repositions local communities as co-creators of sanitation solutions rather than passive beneficiaries. By grounding sanitation programs in adaptive practices, policymakers and practitioners can bridge the gap between national development aspirations and on-the-ground realities, ensuring that investments in infrastructure are both socially embedded and ecologically viable. As Indonesia continues to pursue its urban transformation agenda, the incorporation of adaptive management into sanitation policy and practice will be essential to realizing inclusive and climate-resilient cities. The study provides a strategic starting point for this shift, offering both a conceptual roadmap and actionable recommendations for improving the effectiveness and legitimacy of coastal sanitation interventions.

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