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Analysis of Clean Water Infrastructure Development Towards Fulfillment of the Needs of The Dumai City Community

Topo Yudhoyono H[1*], Lubna Salsabila[2], Karol teovani Lodan[3], Timbul Dompak[4]
[1-4] Department of Public Administration, Universitas Putera Batam, Batam, Indonesia
**Corresponding author: topoyudhonh@gmail.com*

Abstract: *This study aims to examine the development of clean water infrastructure in Dumai City to fulfill the community's clean water requirements. The clean water infrastructure possessed by the City of Dumai has failed to satisfy the comprehensive needs of the population. Consequently, the government addresses this issue by developing air infrastructure and implementing additional measures to resolve it. This scientific endeavor employs a descriptive qualitative method and the researcher's observation. The study's findings reveal that PDAM Tirta Dumai Bersemai in Dumai City has failed to satisfy the water requirements of its residents. Consequently, development is requisite via multiple initiatives, including the establishment of a Drinking Water Supply System (SPAM) through Public Private Partnership (PPP), the National Urban Water Supply Project (NUSWP), and Regional SPAM Development via DUROLIS Regional SPAM (Dumai - Rokan Hilir – Bengkalis).*

Keywords: *Clean Water, Development, Infrastructure Development, Sustainable Development.*

1. INTRODUCTION

Humans depend on water as an essential requirement for daily existence, which is also vital for other facets of life, including animals and plants. Without water, life on Earth would be unsustainable. Water is essential for human health as a substance that enhances well-being. Humans include 60% of their body weight in water, rendering them unable of surviving without it for extended periods. Water is utilized not only for consumption but also for daily human activities, including bathing, cooking, and industrial purposes. Water is an essential human necessity that is indispensable. The sole positive component of the average human quality of life is access to potable water. Nonetheless, numerous Indonesians currently lack access to this resource. Due to the intricate topographical conditions in Indonesia, water quality will undoubtedly differ among regions. For instance, mountainous regions abundant in water resources derive their supply straight from mountain springs. Additional conditions encompass lowland regions where groundwater serves as a supply of potable water. In contrast to regions characterized by peat or marshy soil conditions, the water quality in that location will be inferior to that of other regions, such as those with black soil. This does not imply that the accessible water is contaminated; it merely indicates that it possesses a different composition and remains usable.

Indonesian individuals access clean water sources often located in springs, groundwater from excavated or drilled wells, surface water bodies such as reservoirs, lakes, rivers, and rains. In 2019, 28% of Indonesians lacked access to clean water. The allocation of clean water has

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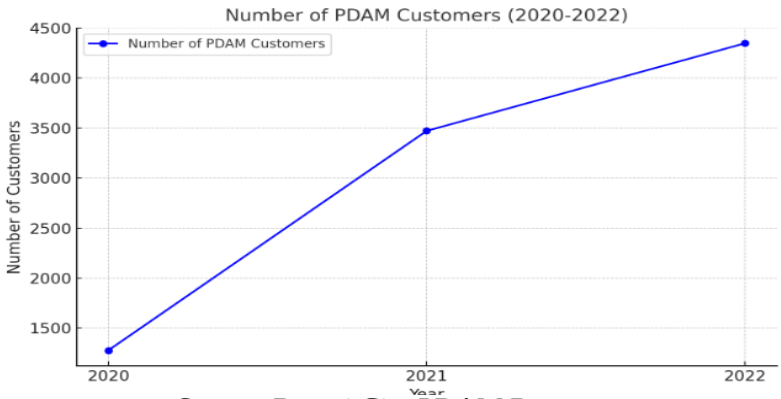
not been optimized despite Indonesia's economic expansion. The Central Statistics Agency (BPS) reported that 33.4 million Indonesians lack access to clean water, indicating a clean water access attainment rate of 72.55%.

Indonesia has failed to meet the Sustainable Development Goals (SDGs) on universal access to clean water for all its citizens. The issue of clean water scarcity is not solely attributable to variations in geographical conditions. This shortage also arises from human conduct that contaminates or alters clean water sources, rendering them unsuitable for proper usage. The issue resembles the act of discarding refuse into a river, contaminating it with organic or industrial trash. Water contamination is challenging to eliminate if individuals do not modify their behavior and rely solely on artificial water sources for access to clean water.

The government is endeavoring to supply clean water amenities specifically for the underprivileged. Water can also be procured through community-operated enterprises that sell water sourced from their own supplies to individuals in need. This imposes a hardship on the underprivileged, since they must allocate funds to obtain clean water. The less fortunate, middle class, and the entire community will be burdened if they expend resources to acquire clean water sourced from community sales. Consequently, a method for the community to obtain clean water is through the enhancement of basic infrastructure in metropolitan areas, ensuring its adequate availability.

The community can receive clean water through infrastructure established for its provision, which is acquired as a public service by the government. The supply of clean water may be administered by private sector entities, like the Drinking Water Company (PAM) or the Regional Drinking Water Company (PDAM). The provision of clean water is a demand for the government to address the issue of water scarcity in the community. Via distribution, business-oriented management, or community empowerment. This study addresses the issue of water infrastructure by proposing research solutions focused on the distribution and management of clean water in each community. Dumai City is situated on Sumatra Island inside Riau Province. This city encompasses an area of 1,727.38 hectares, with a water area of 71,393 hectares. The physical composition of this city comprises two soil types that constitute the earth's surface: typic tropaquepts or fluvisol gleik, and hydric trophemis or humic histosol. The second type of soil is inextricably created from the peat soil layer, which transforms into the predominant soil type in the Dumai City region. This region's peat soil possesses distinct properties.



Source: Dumai City PDAM Data

Based on the statistics presented above, it can be observed that the number of consumers of Dumai City PDAM has increased over the course of three years. This provides an explanation for why the number of individuals who are able to reap the benefits of the infrastructure is growing from one year to the next. Beginning in the year 2020, which began with 1277 customers, there was an increase of 2,195 additional consumers registered in the year 2021. A similar trend may be observed in 2022, as the number of clients has climbed to 4348 from 3472 in 2021. However, this accomplishment did not meet the target in previous years. In 2019, the Dumai City PDAM aimed to add 4,000 additional customer connections through the drinking water development program. However, this achievement did not meet the target. In order to meet the ever-increasing demand for clean water in Dumai City, the government ought to encourage the development of clean water infrastructure through programs and programs that are capable of resolving this issue. As a result, the objective of this study is to investigate the process of constructing clean water infrastructure in Dumai City in order to fulfill the requirements of the community in terms of clean water.

2. LITERATURE REVIEW

Sustainable Development Goals (SDGs)

The United Nations' Sustainable Development Goal 6 underscores the essential importance of water and sanitation in attaining sustainable development. It delineates particular objectives, including universal and equitable access to safe and inexpensive drinking water, enhancement of water quality through pollution reduction, and the execution of integrated water resource management at all levels. This paradigm emphasizes the imperative of infrastructure development that satisfies the criteria of cost and efficiency while simultaneously conforming to environmental sustainability objectives, hence enhancing resistance to climate change and other ecological concerns. Theory of urban

water management offers a holistic framework for tackling the intricacies of water service delivery in metropolitan regions. It underscores the amalgamation of engineering solutions, environmental sustainability, and social equality to guarantee enduring efficacy. Demand management encompasses techniques including water pricing, usage limitations, and awareness initiatives to enhance consumption efficiency. Resource optimization emphasizes improving the efficacy of water distribution systems, minimizing losses using sophisticated monitoring devices, and reprocessing effluent. Stakeholder engagement is essential for promoting collaboration among governments, business entities, and local communities, ensuring that varied perspectives are integrated into decision-making and that infrastructure development meets the population's requirements.

Institutional theory offers a comprehensive framework for analyzing the interaction between policies, governance structures, and organizational behavior in the development of water infrastructure. It highlights the impact of statutory regulations, informal conventions, and organizational practices on decision-making processes and project results. In Dumai City, institutional alignment entails synchronizing national, regional, and municipal policies to establish a cohesive regulatory framework that facilitates infrastructure investments. Collaboration among stakeholders is essential, necessitating active involvement from governmental entities, commercial investors, and community organizations. Institutional theory emphasizes the importance of clear communication and common goals among stakeholders to mitigate bureaucratic inefficiencies and promote the sustainability of water infrastructure projects.

Challenges in Clean Water Infrastructure Development

Studies have documented the profound challenges that rapid urbanization imposes on water infrastructure systems. As cities like Dumai expand rapidly, existing water supply networks often struggle to keep pace with growing demand, leading to issues such as water shortages, reduced service reliability, and unequal distribution. Furthermore, the surge in urban populations accelerates the deterioration of aging infrastructure, as systems originally designed for smaller populations become overburdened. Insufficient capacity results in increased operational stresses, while inadequate maintenance exacerbates leakage, contamination risks, and service disruptions. Addressing these challenges requires a proactive approach, including capacity expansion, modernization of infrastructure, and the adoption of smart water management technologies to improve resilience and efficiency.

Climate change intensifies water scarcity and adversely impacts water quality, posing issues for urban water management. Increasing global temperatures result in extended droughts, diminishing freshwater supply and exacerbating resource competition. Research by Smith et al. (2020) identifies particular vulnerabilities in coastal communities such as Dumai, including saltwater intrusion into freshwater aquifers caused by increasing sea levels and recurrent flooding, which contaminates water sources and compromises infrastructure. These effects require adaptive methods, including the establishment of resilient water infrastructure, investment in desalination technologies, and enhanced flood management approaches. Furthermore, incorporating climate risk evaluations into infrastructure planning helps alleviate long-term impacts and ensure sustainable water resources.

Decentralized water systems have arisen in rural and peri-urban regions of India as an effective response to the limitations of centralized infrastructure. These systems, frequently comprising municipal water treatment facilities, community-managed distribution networks, and rainwater gathering programs, ensure dependable access to clean water for marginalized groups. They are engineered to function autonomously or in collaboration with bigger centralized systems, facilitating adaptability and scalability according to community requirements. Decentralized solutions improve affordability and sustainability by utilizing renewable energy sources like solar-powered pumps and implementing cost-effective maintenance measures. For Dumai, using analogous strategies might reduce strain on centralized infrastructure while enhancing access to clean water in remote or swiftly growing metropolitan areas.

3. METHODS

The appropriate procedure is essential for data collecting in a study. The appropriately selected approach will accomplish the study's aims and objectives. This scientific endeavor employs a descriptive qualitative approach and researcher observation. The problem analysis method employs a qualitative approach grounded in references from several sources, including journals and scholarly articles. Qualitative research is characterized by its descriptive nature and frequently employs analytical methodologies. Qualitative research prioritizes the process and significance. This research establishes a framework for actions related to the gathering of library data through reading and recording, subsequently processed into research material. This research method involves utilizing a library, mostly through the examination of references such as books and other source materials, which are subsequently compiled. Gathering and

examining research materials, including journals, scientific articles, and papers, to facilitate processing and derive conclusions.

4. RESULTS

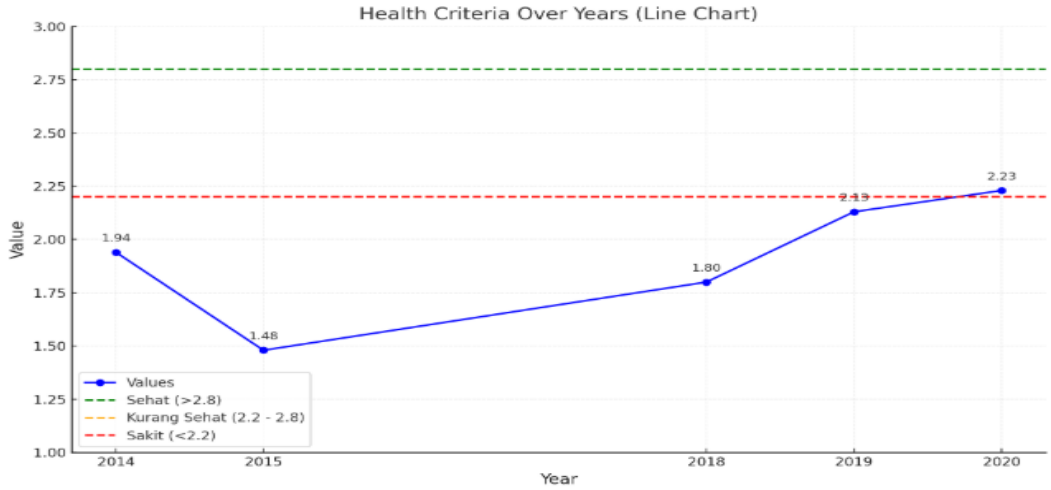
The fundamental component in any water distribution infrastructure is the necessity of water, as it acts as the primary indicator of the system's efficacy. The forecast of water demand relies on several elements, including the local population, per capita water usage, and both domestic and non-domestic water requirements. The lack of water in the production or distribution system also affects this projection. Unmet demand, enhanced service quality, and water requirements on peak days are critical factors in the development of a water delivery system. The rising rate of water use, correlated with the improving standard of living within the society, significantly influences the forecast of water demand.

Every water delivery system must be designed and constructed to fulfill three primary objectives: quantity, quality, and continuity. Consequently, the design of the city's water distribution system must adhere to stable conditions and comply with relevant planning regulations. The government, via the Ministry of Public Works and Public Housing (PUPR), has undertaken multiple initiatives to enhance access to potable water for the residents of Dumai City by constructing a piping network. This initiative is executed through the Government and Business Entity Cooperation Scheme (KPBU), which incorporates private sector investment as a financial innovation to mitigate elevated investment costs in the development of the Drinking Water Supply System (SPAM).

The PUPR Ministry's provisions for Dumai City's clean water infrastructure are executed through collaboration between PDAM Tirta Dumai Bersemai and PT. Dumai Tirta Persada in the advancement of the water delivery system. This collaboration seeks to facilitate rapid infrastructure development without imposing financial strain on the APBN/APBD. Data from 2018 indicates that of the 391 PDAMs in Indonesia, approximately 57% exhibit satisfactory performance, while 25% are deemed unsatisfactory, 13% demonstrate inadequate performance, and 5% have not undergone performance evaluation. The Dumai City Government-owned PDAM, PDAM Tirta Dumai Bersemai, is classified as "less healthy." In Riau Province, there are six PDAMs; according to the 2021 performance evaluation, four PDAMs are classified as "less healthy," while two PDAMs exhibit poor performance.

The assessment of PDAM performance encompasses the overall state of the PDAM, which must be robust to enhance the quality and coverage of drinking water services. The Drinking Water Supply System (SPAM) must be managed successfully and efficiently with

robust internal governance. The success of PDAM is evaluated based on four dimensions: financial, service, operational, and human resources. In 2020, the Ministry of PUPR evaluated the health level of PDAM, indicating an enhancement in PDAM Tirta Dumai Bersemai. This PDAM attained a score of 2.23, categorizing it as "less healthy," an enhancement from its prior



classification of "bad." This indicates an assessment and enhancement across all facets of the company's performance, anticipated to elevate the quality of clean water services in Dumai City.

The data analyzes health criteria trends from 2014 to 2020, classified into three health statuses: Sehat (Healthy), Kurang Sehat (Less Healthy), and Sakit (Unhealthy). The criteria for these categories are as follows: Values exceeding 2.8 are classified as "Sehat," values ranging from 2.2 to 2.8 as "Kurang Sehat," and values below 2.2 as "Sakit." This analysis aims to evaluate annual trends and measure overall success. Between 2014 and 2015, the health criterion had a dip, with the value decreasing from 1.94 to 1.48, signifying a deterioration in the "Sakit" category. Between 2015 and 2018, there was a modest improvement, with the value rising to 1.80, however it continued to fall inside the "Sakit" category. A substantial enhancement transpired between 2018 and 2019, with the value increasing to 2.13, indicating a discernible upward trend. The most notable milestone occurred in 2020, with the health value rising to 2.23, resulting in a status change from "Sakit" to "Kurang Sehat." This marked the inaugural instance during the studied period in which the health criteria transitioned from the "Sakit" category.

Notwithstanding the enhancement, none of the years examined attained the "Sehat" (Healthy) classification, which necessitates a value exceeding 2.8. This signifies that although advancements have occurred, additional efforts are required to attain optimal health conditions. The increasing trajectory from 2018 to 2020 indicates that actions and recovery efforts during this period were beneficial and should be perpetuated to maintain and enhance health standards.

The data indicates a favorable trend in health metrics from 2014 to 2020, culminating in a notable advancement to the "Kurang Sehat" category in 2020. Nonetheless, attaining the "Sehat" classification continues to be an objective for the future. It is advisable to concentrate on maintaining this upward trajectory, tackling the issues that led to previous declines, and executing strategic measures to significantly improve health outcomes in the coming years.

The enhancement of drinking water infrastructure in Dumai City aims to expand service coverage through various initiatives, including the Development of the Drinking Water Supply System (SPAM) via Government Cooperation with Business Entities (KPBU) at a capacity of 250 liters per second, the Development of SPAM through the National Urban Water Supply Project (NUSWP) with a capacity of 50 liters per second, and the Development of Regional SPAM through the Regional DUROLIS (Dumai - Rokan Hilir - Bengkalis) with a capacity of 150 liters per second. This expansion is anticipated to enhance the Dumai City Drinking Water Supply System, achieving a service coverage of 68%, comprising 36% piped drinking water network and 32% non-piped supply. The three developments are distributed across multiple sub-districts and villages in Dumai City: Durolis Development encompasses 3 sub-districts and 11 villages, KPBU Development includes 4 sub-districts and 11 villages, and NUWSP Development comprises 4 sub-districts and 7 villages.

At present, the clean water supplied by PDAM in Dumai City amounts to around 318,387 m² annually, which fails to satisfy the overall needs of the Dumai City population. This has prompted the community to pursue other solutions by constructing drilled wells or sourcing water from other avenues. Consequently, the Dumai City government is endeavoring to strategize the development of SPAM as a supplier of potable water, to be facilitated by PDAM Tirta Dumai Bersemai, with various initiatives aimed at achieving 25,000 household connections (SR) by 2024.

5. CONCLUSION

The demand for potable water in Dumai City is escalating in tandem with population increase and accelerated economic activity. Access to clean water is an essential necessity for the community; therefore, the presence of sufficient infrastructure is crucial to fulfill these requirements. Currently, the circumstances in Dumai City indicate that the Regional Drinking Water Company (PDAM) has failed to fulfill the community's need for clean water. The constrained budget of the Dumai City government is the primary impediment to the advancement and enhancement of clean water management infrastructure.

Innovative and sustainable solutions are required to address this issue and fulfill the community's clean water needs. One strategy that might be employed is the execution of multiple Drinking Water Supply System (SPAM) development initiatives. Potential programs for implementation include:

a. SPAM development via Government Collaboration with Business Entities (KPBU): This initiative enables the government to partner with the corporate sector in the creation and management of clean water infrastructure. This system enables more effective finance, development, and operations, hence optimally addressing clean water requirements.
b. The SPAM National Urban Water Supply Project (NUSWP) seeks to enhance the ability for clean water management in urban regions through a collaborative strategy including the central government, regional authorities, and international stakeholders. Dumai City anticipates enhancing clean water processing outcomes and expanding the distribution network through NUSWP, hence increasing access to clean water for a greater number of residents.
c. Establishment of DUROLIS Regional SPAM (Dumai - Rokan Hilir - Bengkalis): This regional SPAM initiative aims to foster collaboration among regions in the provision of potable water. Through the collaborative sharing of resources and infrastructure, regions like Dumai, Rokan Hilir, and Bengkalis can equitably address the community's clean water requirements.

These initiatives are anticipated to deliver a viable long-term resolution to the clean water concerns in Dumai City. The coordinated construction and administration of SPAM enables the residents of Dumai City to have more equal, high-quality, and sustainable access to clean water. The government must provide effective oversight of the execution of these programs to ensure that the benefits are maximally experienced by the entire community.

LIMITATION

The research on clean water infrastructure in Dumai City highlights several limitations that need to be addressed. One significant limitation is the resource constraint, as the limited budget of the Dumai City Government restricts the scale and speed of development projects, hindering comprehensive and efficient implementation. Additionally, the institutional capacity of PDAM Kota Dumai to meet the increasing demand for clean water remains a challenge, reflecting difficulties in managing resources, expanding service coverage, and maintaining operational efficiency. The geographic and environmental context further limits the research's

applicability, as the findings primarily focus on Dumai City and the DUROLIS region, making them less relevant to areas with different conditions.

Moreover, while initiatives like SPAM KPBU, NUSWP, and DUROLIS offer potential solutions, the research does not thoroughly address the challenges associated with implementing these programs, such as regulatory hurdles, stakeholder coordination, and technological compatibility. Another limitation is the reliance on public-private partnerships, which may introduce risks like dependency on private investors, potential conflicts of interest, or delays caused by complex negotiations. Lastly, the discussion emphasizes institutional and programmatic solutions but lacks a focus on community perspectives. The exclusion of community feedback and participation could undermine the equity and sustainability of the proposed outcomes. These limitations highlight the need for a more holistic approach that considers financial, institutional, and community aspects to ensure effective and inclusive solutions for Dumai City's clean water infrastructure challenges.

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