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**WATER RESOURCES MANAGEMENT IN SMALL ISLANDS:
A REVIEW OF PUBLIC POLICY IMPLEMENTATION IN THE
DEVELOPMENT OF NOMAHA RESERVOIR, KISAR ISLAND**

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ABSTRACT

Water scarcity in small island regions, including Kisar Island in Maluku, presents a pressing issue due to inadequate water resource management. This article aims to describe a holistic approach to addressing the challenges of water resource management and water scarcity on Kisar Island, Maluku. The research methodology employed is a mixed-method approach, combining technical feasibility studies for reservoir technology, policy analysis through literature reviews, and field assessments to evaluate the topographic, hydrological, and environmental conditions of Kisar Island. In the technical context, the article analyzes reservoir technology as a solution to address water issues, supported by the topographic and hydrological characteristics of Kisar Island. Additionally, the article examines relevant public policies, such as Government Regulation No. 7 of 2013 on National Spatial Planning, Provincial Regulation No. 16 of 2013 on Provincial Spatial Planning in Maluku, and District Regulation No. 1 of 2023 on District Spatial Planning in Maluku Barat Daya. Through this review, the article highlights the crucial role of policy in establishing a supportive framework for water resource management. Furthermore, the importance of local community participation in water resource management on Kisar Island is emphasized, asserting that active engagement from the local community is key to achieving success in sustainable water management efforts.

Keywords: *Water Resources Management; Small Island Regions; Water Scarcity; Public Policy Implementation; Local Community Participation*

INTRODUCTION

Small islands as geographical entities often face serious challenges in managing water resources (Mycoo et al., 2022; Phong & Van Tien, 2021; Tzanakakis et al., 2020). As integral parts of the global ecosystem, small islands provide unique habitats for biodiversity and serve as centers of life for local communities (Mycoo et al., 2022). However, their presence in confined environments makes them vulnerable to various issues, including significant water resource shortages (Algaba et al., 2024; Tariq et al., 2022). Water scarcity on small islands has become an increasingly urgent issue in recent decades. Various studies and reports have highlighted that small islands often face serious water crises, both in terms of quantity and quality. This water scarcity not only affects the daily lives of local residents but also hampers agricultural efforts, leading to decreased food production and threatening local food security (Algaba et al., 2024; Sharan et al., 2021).

According to the World Health Organization (WHO), approximately 1 in 3 residents of small islands struggle to access safe drinking water for their daily needs (Gunnarsdottir et al., 2020; Mishra, 2023). The lack of clean water is not only a health issue but also an economic and social welfare concern (Tan et al., 2022). Additionally, rapid population growth and unpredictable climate change further exacerbate this situation (Shahzad et al., 2021; Zakar et al., 2020). Furthermore, water scarcity also has a negative impact on the agricultural and livestock sectors (Heinke et al., 2020; Nhemachena et al., 2020). Limited water resources hinder farmers' ability to irrigate and practice sustainable agriculture, while livestock farming often struggles to obtain adequate water supplies to meet the needs of the animals (Leal Filho et al., 2022; Pakmehr et al., 2020; Rosa et al., 2020).

Moyle et al. (2022) focus on studying water availability within the domain of water resource management and water scarcity in small islands by conducting an in-depth identification and analysis of water availability in small islands, both in terms of quantity and quality. Similarly, Kuriqi et al. (2021) and Wang et al. (2022) conducted comprehensive reviews considering various factors influencing water availability, including rainfall, evaporation rates, and water resource sustainability. Furthermore, the analytical focus in the research by Kuriqi et al. (2021), Moyle et al. (2022) and Wang et al. (2022) directs towards studies in the field of water engineering. This implies that the research not only seeks to understand theoretical aspects related to water availability but also applies technical and engineering principles to evaluate potential solutions and water management strategies. Additionally, Rumihin et al. (2024) emphasize that the field of water engineering enables exploration of various technologies and infrastructures that can be utilized to improve water availability in small islands.

In addition, Ahmed et al. (2023), Habiyaremye (2020), Haryadi & Nastiti (2020), Lee & Mwebaza (2021) have conducted in-depth studies on water resource management in small islands with an approach focusing on the development of innovative water technology and infrastructure. The main focus of these studies is to introduce and optimize various technological solutions that can be well-adapted to the unique conditions of small islands. Among the solutions researched are desalination technologies, aimed at converting seawater into freshwater that can be widely utilized (Lee & Mwebaza, 2021). Additionally, Ahmed et al. (2023) also emphasize the development of efficient rainwater management systems, smart water distribution systems capable of allocating water resources optimally (Haryadi & Nastiti, 2020), and innovative water storage technologies such as reservoirs and underground tanks (Habiyaremye, 2020). Furthermore, the research also covers the development of efficient irrigation technologies, aimed at enhancing agricultural productivity while minimizing water wastage.

Furthermore, several previous studies have highlighted the importance of a participatory approach involving local communities and stakeholders in water resource management on small islands (Hardika et al., 2020; Mendrofa et al., 2023; Ratnasari et al., 2023; Weningtyas & Widuri, 2022; Yuliana et al., 2021). Ratnasari et al. (2023) and Yuliana et al. (2021) emphasize the importance of active involvement and participation of local communities in decision-making

processes related to water management. Various approaches have been identified to enhance the participation of local communities, including efforts in education and raising awareness about the importance of sustainable water management (Hardika et al., 2020; Mendrofa et al., 2023). Additionally, community participation can be enhanced by providing opportunities for them to be directly involved in decision-making processes related to water resource management, whether through participatory forums, discussion groups, or public consultation mechanisms (Weningtyas & Widuri, 2022). Collaborative water management also becomes the focus of Marlina et al. (2022) and Thamrin et al. (2022) studies, where local communities work together in managing and maintaining water resources collectively. Furthermore, supervision and monitoring by local communities can be vital instruments in maintaining the sustainability of water management (Ferry, 2019). Kurniawati & Aliman (2020) also highlight the importance of developing and utilizing traditional technologies that have proven to be effective in water management by local communities over the years.

Unlike previous studies, this article outlines a holistic approach to water resource management on small islands, which integrates water techniques and technologies, public policies, and local community participation. Unlike approaches that consider only one aspect, this holistic approach is considered more effective in addressing the complex challenges related to water resources and water scarcity on small islands. This approach has several significant advantages, including a more comprehensive understanding of the issues, synergy between various aspects, adaptation to local contexts, as well as broad engagement and sustainable support from the local community. By actively involving the local community, the resulting solutions become more relevant and sustainable, supported by local understanding and community backing.

The aim of this article is to describe the holistic approach to addressing the challenges of water resource management and water scarcity on Kisar Island, Maluku. The main focus of this article is on the proposed water techniques and technologies, especially reservoir technology which has been proven effective in water management in small island environments. Additionally, the article also analyzes several relevant public policies, including Government Regulation No. 7 of 2013 concerning the National Spatial Plan, Maluku Provincial Regulation No. 16 of 2013 concerning the Spatial Plan of Maluku Province, and West Southeast Maluku District Regulation No. 1 of 2023 concerning the Spatial Plan of West Southeast Maluku District. Through this review, the article attempts to highlight the importance of policy roles in creating a supportive framework for water resource management. Furthermore, the article emphasizes the crucial role of local community participation in water resource management on Kisar Island, clarifying that active involvement of the local community is a key element in achieving success in sustainable water management efforts.

RESEARCH METHOD

This study employs a mixed-methods approach that integrates various methods to obtain a comprehensive understanding of the researched issue. The approach consists of three main components: policy analysis studies, technical feasibility studies, and field observations (Ali et al., 2020; Biggs et al., 2021; Raizada et al., 2020). Technical feasibility studies and field observations aim to evaluate reservoir technology as a potential solution to address water scarcity issues on Kisar Island. The technical feasibility evaluation includes an analysis of the technical aspects of reservoir technology, such as design, construction, operation, and sustainability. This method involves literature studies, expert consultations, and technical modeling to assess the performance of reservoir technology in the geographical and environmental context of Kisar Island.

In the technical feasibility testing method for reservoir technology, structured steps are fundamental in evaluating whether reservoir technology is an appropriate solution to address water scarcity on Kisar Island. The first step involves collecting primary and secondary data related to the island's geographical, hydrological, and environmental conditions. Subsequently, an analysis of water needs and potential water resources is conducted, which includes assessing water requirements for various purposes and evaluating the potential of natural water sources. The next stage is conducting an in-depth literature review on reservoir technology, including its design principles, construction, operation, and performance evaluation of existing reservoir in similar geographical contexts. This is followed by technical modeling, where the collected data is used to predict water availability, storage, and distribution on Kisar Island. Finally, expert consultations are conducted to ensure the accuracy and reliability of the analyses conducted.

Furthermore, policy analysis through literature studies is conducted with the aim of analyzing various relevant public policies related to water resource management on Kisar Island. Policy analysis is conducted through literature studies to identify, collect, and evaluate policies related to water management at the national, provincial, and district levels. The data obtained from these literature studies are then analyzed to understand the existing policy framework and its potential influence on the implementation of water management solutions on Kisar Island.

In the policy analysis method through literature studies, the initial step involves careful identification of relevant public policies, involving in-depth study of various policy documents from the national to the local level. This includes collecting policy literature such as Government Regulation No. 7 of 2013 concerning the National Spatial Plan, Maluku Provincial Regulation No. 16 of 2013 concerning the Spatial Plan of Maluku Province, and West Southeast Maluku District Regulation No. 1 of 2023 concerning the Spatial Plan of West Southeast Maluku District. This is followed by a thorough analysis of these documents to reveal their objectives, scope, and implementation strategies. In this process, in-depth evaluation is conducted to measure the effectiveness and relevance of policies in responding to the specific challenges faced by Kisar Island in the context of water resource management. This assessment not only includes the policy's capacity to address water scarcity issues but also its potential impact on environmental

sustainability and the well-being of local communities. Subsequently, the synthesis of literature analysis findings provides deep and detailed insights into the policy direction needed to address these challenges, while also highlighting policy gaps that need to be addressed or refined.

RESULTS AND DISCUSSION

Public Policy Analysis in the Development of Nomaha Reservoir on Kisar Island

Through national policies, as mandated in the Omnibus Law with derivative regulations such as Government Regulation No. 21 of 2021 on Spatial Planning, concrete efforts are made to achieve integration in planning for marine and terrestrial management. In the context of the Maluku Province, development planning holds strategic significance, particularly in providing sustainable economic benefits to the community. For instance, Presidential Decree No. 6 of 2017 emphasizes that Maluku, as one of the border regions of the country, holds a strategic position that cannot be overlooked. The presence of Maluku as part of the Unitary State of the Republic of Indonesia underscores the importance of optimizing the potential of this archipelagic region.

The designation of strategic national areas in the Maluku islands, as stipulated in Government Regulation No. 13 of 2017 concerning the National Spatial Plan (RTRWN), is a key step in formulating the direction of sustainable development. Areas such as Dobo, Saumlaki, and Ilwaki are identified as regions with significant economic potential, particularly in the maritime and tourism sectors. However, the management of water resources also requires serious attention. The development of integrated water management plans is crucial, especially considering the geographic and socio-economic complexity of the Maluku region. Water resource management policies in Maluku are closely linked to national efforts, which also include the Ambon-Seram River Basin and the Yamdena-Wetar River Basin. In other words, collaboration and coordination between national and regional institutions are key to ensuring the effectiveness of these policies. Through this holistic approach, a supportive framework for sustainable water resource management in Maluku will be established.

Through Regional Regulation Number 16 of 2013 concerning the Spatial Plan of Maluku Province (RTRWP Maluku), Maluku Province, which is one of the archipelagic provinces, introduces the concept of Cluster Island Development. With its abundant natural resources and diverse comparative advantages, Maluku Province requires effective spatial planning and utilization. The RTRWP Maluku organizes its territory into four distinct Characteristic Clusters. Characteristic Cluster 1 consists of Ambon City, Buru Regency, South Buru Regency, and West Seram Regency. This cluster highlights the potential for significant urban development as well as the diversity of natural resources. Characteristic Cluster 2 includes Central Maluku Regency and East Seram Regency, which have considerable potential in agriculture and mining. Characteristic Cluster 3 encompasses Tual City, Southeast Maluku Regency, Tanimbar Islands Regency, and Aru Islands Regency. This area is characterized by its unique geographical island characteristics and promising tourism potential. Characteristic Cluster 4, comprising Southwest Maluku Regency, is

known for its richness in fisheries resources.

The development of strategic areas is a crucial aspect of efforts to improve the welfare of the community in Maluku Province. Regional Regulation No. 16 of 2013 concerning the Spatial Plan of Maluku Province (RTRWP Maluku) has proposed the concept of cluster island development, which views the provincial territory as a series of characteristic clusters. The development of cluster islands aims to optimize the utilization of diverse natural resources and high economic potential in each cluster, while also enhancing the integration of development across the entire region.

In the context of water resource management, policies regarding water resource network systems are the primary focus. Strengthening irrigation network systems, such as the River Basin Areas in the Ambon-Seram River Basin, Yamdena-Wetar River Basin, and Kei-Aru River Basin, is a priority in enhancing agricultural productivity in Maluku Province. Additionally, the development of clean water network systems is also a serious concern, especially in areas facing difficulties in accessing clean water. The pipelining of clean water and the increase in the number of shallow and deep wells, supported by renewable energy-powered pumping facilities, are proposed solutions.

The use of desalination technology to convert saltwater into freshwater is also an important strategy in addressing water crises in remote islands. Locations with potential for implementing this technology have been identified, such as Osi Island, Tiga Island, Tam Island, Tayando Island, and several other islands. Through this approach, it is hoped to ensure an adequate supply of clean water for household, agricultural, and other sectors' needs in Maluku Province. Besides the direct benefits to communities in meeting their clean water needs, these policies are also expected to have a positive impact on economic growth. Better access to clean water will support the growth of economic sectors reliant on water resources, such as agriculture, fisheries, and tourism.

Through Regional Regulation No. 1 of 2013 concerning the Spatial Plan of Southwest Maluku District, strategies to improve the quality and coverage of clean water infrastructure services have been formulated. These strategies encompass several key steps aimed at enhancing community access to clean water and supporting sustainable development in the district. Firstly, this strategy proposes the provision of clean water sources by utilizing groundwater and/or surface water sources that can be used as raw water sources. This step is directed towards serving the clean water needs in urban and rural settlement centers. With the provision of adequate water sources, it is expected to address the frequent clean water shortages experienced by communities in Southwest Maluku District.

Furthermore, this strategy also emphasizes the development of clean water infrastructure to support the development of food crop farming and plantations in potential areas. In this regard, the development of clean water infrastructure is intended not only to meet the consumption needs of the community but also to support the agricultural sector in enhancing productivity and sustainability. Finally, this strategy includes the development and improvement

of the quality of clean water infrastructure, as well as efforts to realize the integration of clean water network systems. By enhancing the quality of clean water infrastructure and integrating various network systems, it is hoped that an efficient and sustainable clean water distribution system can be created. Through the implementation of this strategy, Southwest Maluku District has the potential to address the challenges of clean water shortages and improve the quality of life for its residents.

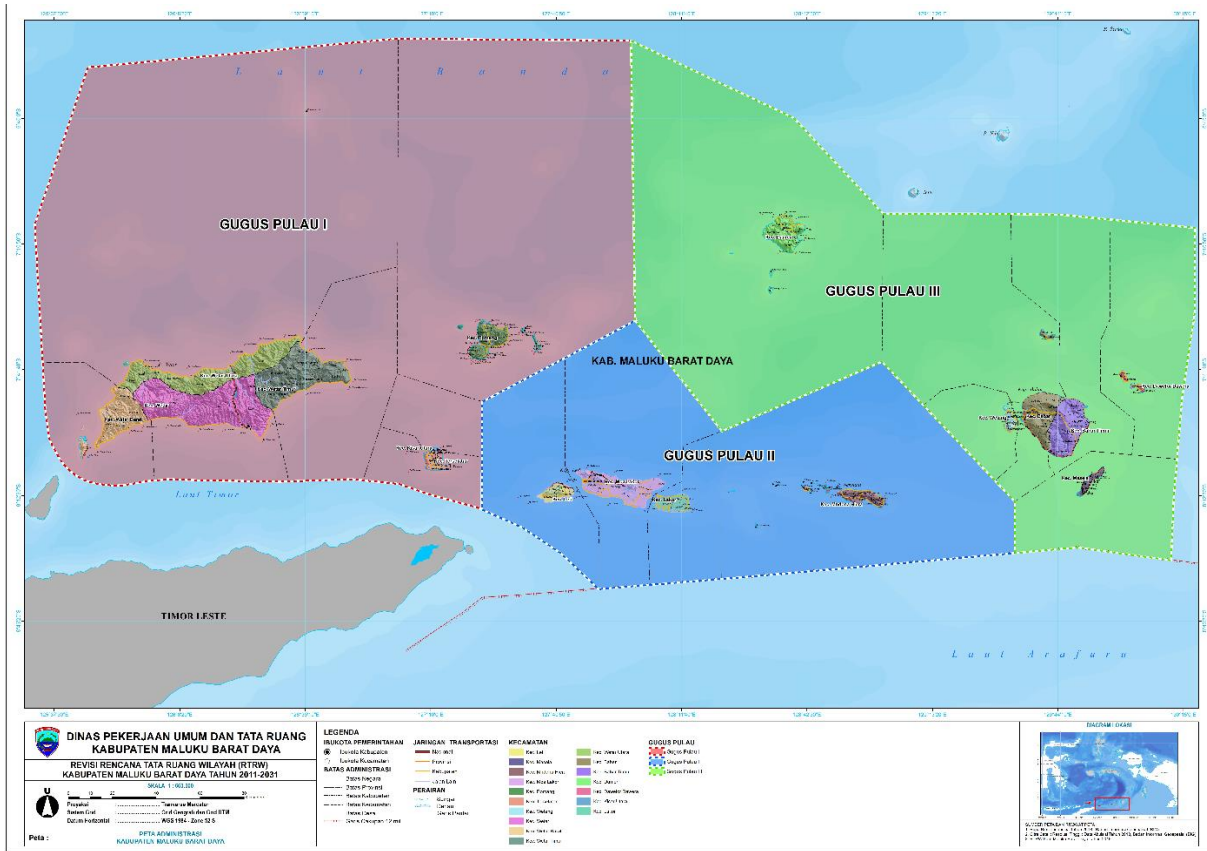


Figure 1 Map of Southwest Maluku Strategic Area
 Source: RTRW Maluku Regency

The water resources development plan encompasses several important aspects aimed at meeting the need for clean water and supporting sustainable water resource management. Water resource infrastructure refers to the infrastructure built to optimize the use of surface water and groundwater sources, with the main goal of meeting various community needs.

Management of national strategic river areas focuses on providing raw water for national strategic areas, National Activity Centers, and/or flagship areas. One of the river areas of concern is the Yamdena - Wetar Islands River Basin Area, which includes Wetar Island as a flagship area. The development of irrigation infrastructure is a key step in ensuring an adequate water supply, including the construction and improvement of reservoirs and the development of irrigation infrastructure at various strategic locations such as Luang Island Reservoir, Klis Reservoir, Tutukey

Reservoir, Ilwaki Reservoir, Kisar Reservoir, Lirang Reservoir, and Masela Reservoir. Furthermore, plans for the construction and maintenance of irrigation infrastructure, such as the Tapa and Wetar dams, are also an integral part of the water resources development strategy.

Furthermore, the water resources management plan includes the development of water resource infrastructure involving all raw water sources from reservoirs, dams, and rivers whose water can be directly utilized for various purposes. River Basin Utilization Zones are divided based on their typology, and the determination of water resource management zones is carried out according to the characteristics of the river basin area. The importance of protecting protected area zones is also recognized by not allowing the use of water resources for cultivation or mining functions.

Technical Analysis in Development of Nomaha Reservoir on Kisar Island

One of the main challenges in providing clean water in the Kisar Island Area, South Islands District, Southwest Maluku Regency, Maluku Province, is the limited availability of reliable clean water sources, both in terms of quantity and quality. Especially during the dry season, communities often have to purchase clean water, while others, especially those with economic constraints, are forced to use water that does not meet health standards. Although lacking surface water sources, this area has potential raw water sources that can be processed, including 7 reservoirs scattered across Kisar Island. These reservoirs play a crucial role in ensuring the availability of water to meet raw water needs on Kisar Island.

This study aims to evaluate the potential availability of water in the catchment area, identify water needs in the reservoir service area, and analyze the water balance in the Abusur reservoir. The results of the study indicate that the fluctuation of water volume in the existing conditions of the Abusur reservoir experiences a surplus of water, or excess water remaining in the reservoir pond until the end of the dry season. In November, there is a remaining water storage of 32,363.9 m³, while the total discharged water in the form of overflow reaches 59,370.5 m³. Considering these findings, optimization of reservoir utilization is conducted by adding a 10% increase in demand. Thus, the water volume in November becomes 30,618.5 m³, with a decrease in overflow by 1.48%.

From the analysis, it was found that the percentage of water demand for households is 31.9%, vegetable garden areas is 47.9%, and livestock is 20.3%. Meanwhile, the components of water balance, including evaporation, reach 15.12%, various water needs account for 32.8%, runoff is 17.48%, and infiltration is 34.52%. These data provide a clear picture of water distribution and usage on Kisar Island, laying the foundation for more precise policymaking in water resource management in the area. The construction of the Nomaha reservoir on Kisar Island is a technical step to address water shortages during the dry season. This effort is crucial to meet the water needs in the region. In its planning, the Nomaha reservoir has met the required technical specifications for reservoir construction in the Kisar Island area.

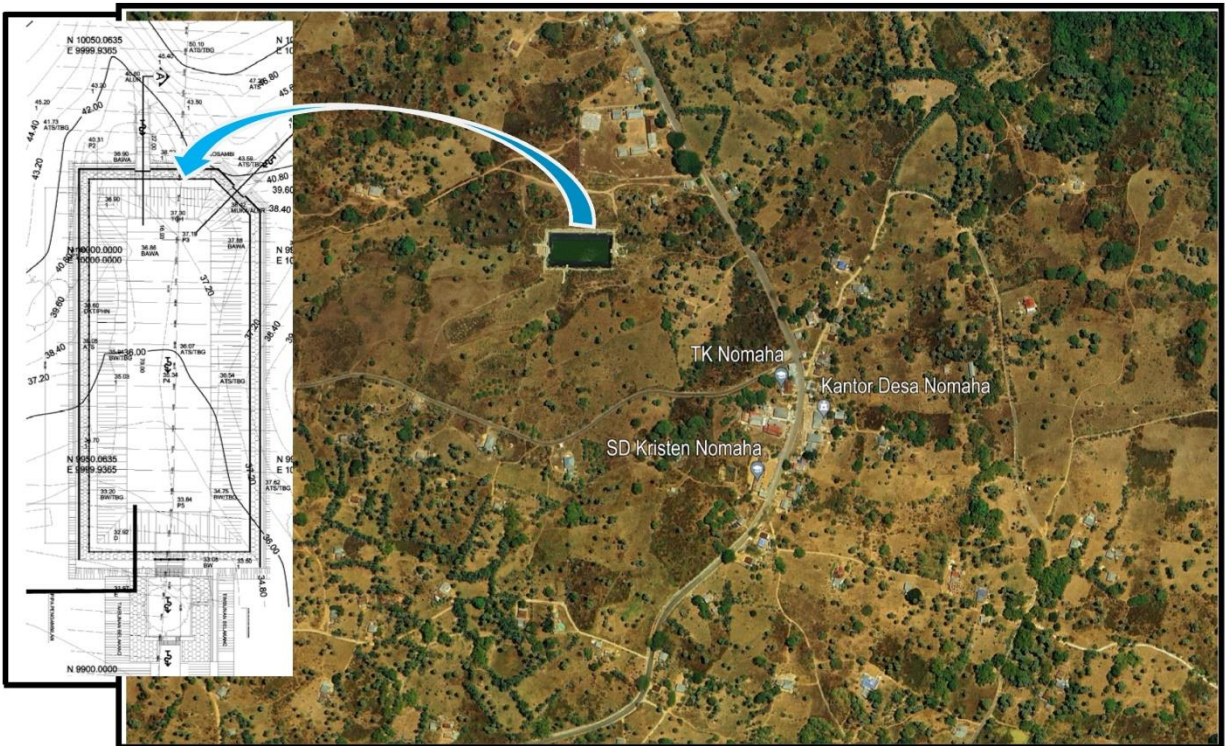


Figure 2 Nomaha Reservoir Design, Kisar Island
Source: The Results of the Researcher's Technical Analysis

The Role and Participation of Local Communities in Development of Nomaha Reservoir on Kisar Island

The participation of local communities in the construction of the Nomaha Reservoir on Kisar Island is aimed at raising awareness about the importance of sustainable water resource management. This includes efficient water use in households and agriculture, as well as proper waste management to prevent water pollution on Kisar Island. Additionally, conserving land and vegetation on Kisar Island is crucial in maintaining the water cycle and water quality. Participation in water conservation programs, education, and training conducted by the local village government aims to enhance community awareness and knowledge about water issues. The impact of these training programs is evident in the community's understanding that water resources are valuable assets that must be preserved. Communities can change their behavior to be more environmentally conscious, adopting water-saving practices at home, such as fixing pipe leaks and reducing water usage during washing or bathing.

This reality aligns with the statement from the Resident Supervisor (SOR) of Kisar Island, indicating that after participating in water conservation programs, education, and training conducted by the village government, community awareness and knowledge about water issues significantly increased. One of the impacts felt by the SOR is a deeper understanding that water resources are valuable assets that must be preserved. The SOR realizes that small actions like

fixing pipe leaks and reducing water usage during washing or bathing can have significant positive impacts on environmental preservation. Furthermore, the SOR reveals that awareness of the importance of sustainable water resource management also opens up new economic opportunities for the community. By reducing water wastage and optimizing the use of water resources, communities can save on operational costs and infrastructure maintenance. This can also enhance productivity in the agricultural and industrial sectors, providing significant positive impacts on the overall economic well-being of the community. The SOR asserts that water conservation programs and awareness of the importance of sustainable water resource management have brought about positive changes in the behavior and perspectives of the community regarding environmental and economic issues. The SOR hopes that these efforts can continue to be encouraged and expanded to create a better and more sustainable environment for future generations.

In addition to being part of the construction of the Nomaha Reservoir on Kisar Island, the participation of local communities also reflects efforts to preserve and uphold local wisdom, such as the Sasi tradition in Maluku customs. The concept of Sasi is a crucial aspect of traditional Maluku society, regulating the management and protection of natural resources. Sasi consists of a series of prohibitions and permissions governing how to wisely manage the environment and natural resources. As part of tradition, Sasi holds legal power binding on indigenous communities, ensuring that natural resource management is conducted sustainably and in accordance with local knowledge.

In the context of Maluku customs, Sasi also holds profound and sacred symbolic meanings. Sasi aims to preserve the sustainability of vital natural resources, thus maintaining the balance of the natural ecosystem. The impact of implementing Sasi is highly positive, strengthening social ties among community members. The practice of Sasi makes people more obedient to established rules, reduces violations, and fosters harmonious relationships between humans and nature. However, violations of Sasi are not overlooked. Individuals who violate the rules established in Sasi will face moral and magical sanctions inherent in Maluku's traditional customs. Thus, the participation of local communities in the construction of the Nomaha Reservoir not only yields positive impacts in terms of conserving natural resources but also strengthens the cultural values and inherited local wisdom.

CONCLUSION

The development of the Nomaha Reservoir on Kisar Island represents a strategic step in addressing the water scarcity issue in the area. Through a holistic approach involving various stakeholders, including the participation of local communities, reservoir technology, and public policies, this project can provide sustainable solutions in water resource management. In facing the challenge of water scarcity, the active participation of local communities plays a key role. Awareness of the importance of sustainable water resource management has increased among

the population, both through educational programs and training organized by village governments. This is reflected in changes in people's behavior to conserve water in households and adopt environmentally friendly practices. Additionally, the application of local wisdom in the form of Sasi practices also makes a significant contribution to maintaining environmental sustainability and natural resources. Sasi is not only a legal instrument but also a symbol of the community's commitment to maintaining harmony between humans and nature. In other words, the construction of the Nomaha Reservoir on Kisar Island is not just a technical solution to water scarcity but also reflects the importance of integration between modern technology, public policies, and local values in efforts to preserve environmental sustainability.

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