RESEARCH ARTICLE OPEN ACCESS

Baileo: Jurnal Sosial Humaniora
Volume 1, Issue 3 | May 2024
https://ojs3.unpatti.ac.id/index.php/baileofisip

BAILEO JURNAL SOSIAL HUMANIORA
e-ISSN 3026-3468
p-ISSN 3026-2593

Article info
Received manuscript:
05/04/2024
Final revision:
22/05/2024
Approved:
26/05/2024

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

Ony Frengky Rumihin*
Universitas 17 Agustus 1945 Surabaya, Jalan Semolowaru No. 45, Surabaya 60118, Indonesia

*Correspondence E-Mail: ony.rumihin@gmail.com
DOI: https://doi.org/10.30598/baileofisipvol1iss3pp268-280

ABSTRACT

This article explores the implementation of public policy in water resources management on small islands, focusing on the development of the Nomaha Reservoir on Kisar Island, Maluku. The study aims to provide a comprehensive understanding of how water scarcity can be addressed through a synergistic approach that integrates technical, policy, and sociocultural dimensions. Employing a mixed-methods design, the research combines technical feasibility assessments, policy analysis through document reviews, and field observations of the island's topographic, hydrological, and environmental characteristics. The findings reveal that the Nomaha Reservoir project reflects a strategic response to water scarcity, supported by spatial planning regulations at the national, provincial, and district levels. The study highlights the importance of local community participation in water management efforts, showing increased public awareness, behavior change in water use, and the incorporation of local wisdom—particularly the customary environmental regulation known as Sasi. The novelty of this study lies in its integration of engineering solutions with policy frameworks and indigenous practices, offering a model for sustainable water governance in small island contexts. This article contributes to the social sciences and humanities by emphasizing the value of participatory, multi-level, and culturally grounded approaches to environmental management, particularly in geographically and ecologically vulnerable regions.

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

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), the provincial government introduced the concept of Cluster Island Development as a strategic framework for managing its archipelagic territory. Given Maluku's abundant natural resources and varied comparative advantages, this spatial planning model divides the province into four distinct Characteristic Clusters to optimize resource utilization and support regional integration. Characteristic Cluster 1, comprising Ambon City, Buru Regency, South Buru Regency, and West Seram Regency, emphasizes urban development and the richness of natural resources. Cluster 2 includes Central Maluku and East Seram Regencies, known for their agricultural and mining potential. Cluster 3 covers Tual City, Southeast Maluku, Tanimbar Islands, and Aru Islands Regencies, highlighting the tourism potential shaped by their unique island geographies. Meanwhile, Cluster 4, consisting of Southwest Maluku Regency, focuses on the wealth of fisheries resources. The development of these strategic areas is considered vital to

improving community welfare by ensuring more effective spatial planning, encouraging regional economic growth, and fostering interconnected development across Maluku's island clusters.

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.

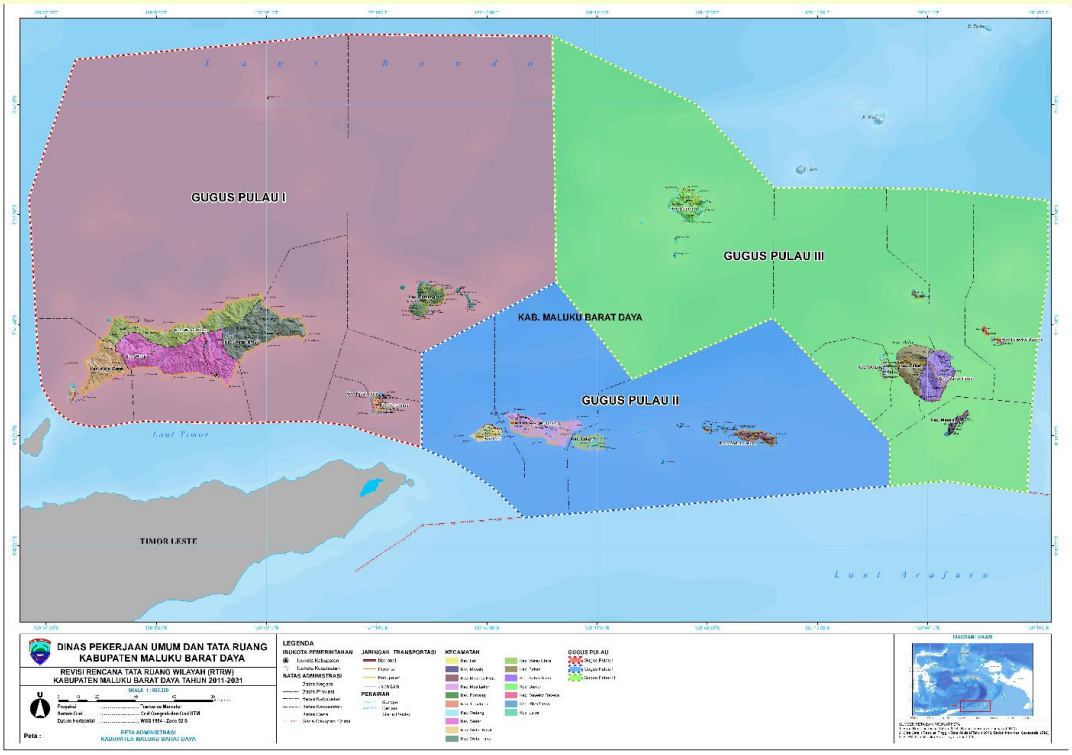

Figure 1 Map of Southwest Maluku Strategic Area
Source: RTRW Maluku Regency

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 Tepa 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.

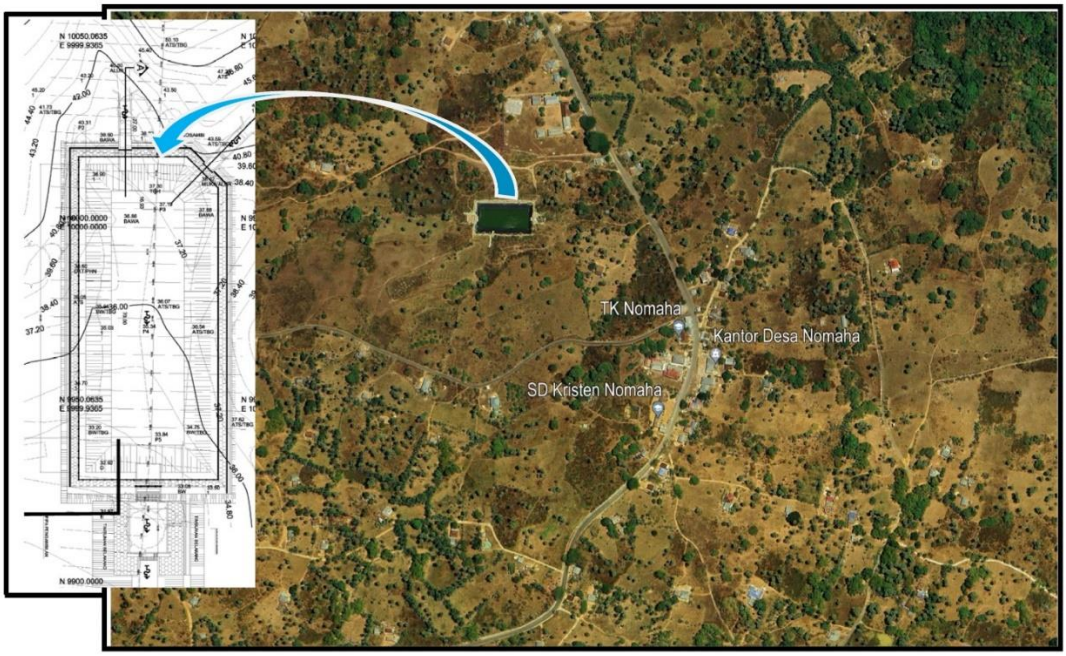

Figure 2 Nomaha Reservoir Design, Kisar Island
Source: The Results of the Researcher's Technical Analysis

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.

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.

ETHICAL STATEMENT AND DISCLOSURE

This study was conducted in accordance with established ethical principles, including

informed consent, protection of informants' confidentiality, and respect for local cultural values. Special consideration was given to participants from vulnerable groups to ensure their safety, comfort, and equal rights to participate. No external funding was received, and the authors declare no conflict of interest. All data and information presented were collected through valid research methods and have been verified to ensure their accuracy and reliability. The use of artificial intelligence (AI) was limited to technical assistance for writing and language editing, without influencing the scientific substance of the work. The authors express their gratitude to the informants for their valuable insights, and to the anonymous reviewers for their constructive feedback on an earlier version of this manuscript. The authors take full responsibility for the content and conclusions of this article.

REFERENCES

Ahmed, F., Johnson, D., Hashaikeh, R., & Hilal, N. (2023). Barriers to Innovation in Water Treatment. *Water*, *15*(4), 773. https://doi.org/10.3390/w15040773

Algaba, M. H.-P., Huyghe, W., Van Leeuwen, K., Koop, S., & Eisenreich, S. (2024). Assessment and Actions to Support Integrated Water Resources Management of Seville (Spain). *Environment, Development and Sustainability*, *26*(3), 7347–7375. https://doi.org/10.1007/s10668-023-03011-8

Ali, N., Bilal, M., Khan, A., Ali, F., & Iqbal, H. M. N. (2020). Design, engineering and analytical perspectives of membrane materials with smart surfaces for efficient oil/water separation. *TrAC Trends in Analytical Chemistry*, *127*, 115902. https://doi.org/10.1016/j.trac.2020.115902

Biggs, R., De Vos, A., Preiser, R., Clements, H., Maciejewski, K., & Schlüter, M. (2021). *The Routledge handbook of research methods for social-ecological systems*. Taylor & Francis. https://doi.org/10.4324/9781003021339

Ferry, D. (2019). Local wisdom based water resources conservation for environmental sustainability. *Scientiae Educatia: Jurnal Pendidikan Sains*, *8*(2), 220–230. https://doi.org/10.24235/sc.educatia.v8i2.2538

Gunnarsdottir, M. J., Gardarsson, S. M., Schultz, A. C., Albrechtsen, H.-J., Hansen, L. T., Bergkvist, K. S. G., Rossi, P. M., Klöve, B., Myrmel, M., & Persson, K. M. (2020). Status of risk-based approach and national framework for safe drinking water in small water supplies of the Nordic water sector. *International Journal of Hygiene and Environmental Health*, *230*, 113627. https://doi.org/10.1016/j.ijheh.2020.113627

Habiyaremye, A. (2020). Water innovation in South Africa: Mapping innovation successes and diffusion constraints. *Environmental Science & Policy*, *114*, 217–229. https://doi.org/10.1016/j.envsci.2020.08.011

Hardika, S. A., Fasni, A., & Dewata, I. (2020). Pengelolaan sumber daya air di masa pandemi covid-19 dalam perspektif kearifan lokal. *Jurnal Kependudukan Dan Pembangunan Lingkungan*, *1*(3), 33–41.

Haryadi, J., & Nastiti, A. S. (2020). Fisheries technology innovation supports the Citarum Harum program. *IOP Conference Series: Earth and Environmental Science*, *521*(1), 12010. https://doi.org/10.1088/1755-1315/521/1/012010

Heinke, J., Lannerstad, M., Gerten, D., Havlík, P., Herrero, M., Notenbaert, A. M. O., Hoff, H., & Müller, C. (2020). Water use in global livestock production—opportunities and constraints for increasing water productivity. *Water Resources Research*, *56*(12), e2019WR026995. https://doi.org/10.1029/2019WR026995

Kuriqi, A., Pinheiro, A. N., Sordo-Ward, A., Bejarano, M. D., & Garrote, L. (2021). Ecological impacts of run-of-river hydropower plants—Current status and future prospects on the brink of energy transition. *Renewable and Sustainable Energy Reviews*, *142*, 110833. https://doi.org/10.1016/j.rser.2021.110833

Kurniawati, E., & Aliman, M. (2020). Participation of green environmental group and ulur-ulur local wisdom on buret lake ecotourism management in karst area of tulungagung, Indonesia. *Geo Journal of Tourism and Geosites*, *30*, 889–895. https://doi.org/10.30892/gtg.302spl15-519

Leal Filho, W., Totin, E., Franke, J. A., Andrew, S. M., Abubakar, I. R., Azadi, H., Nunn, P. D., Ouweneel, B., Williams, P. A., & Simpson, N. P. (2022). Understanding responses to climate-related water scarcity in Africa. *Science of the Total Environment*, *806*, 150420. https://doi.org/10.1016/j.scitotenv.2021.150420

Lee, W.-J., & Mwebaza, R. (2021). Digitalization to achieve technology innovation in climate technology transfer. *Sustainability*, *14*(1), 63. https://doi.org/10.3390/su14010063

Marlina, S., Astina, I. K., Utomo, D. H., & Kurniawati, E. (2022). Ecotourism Management Based On Local Wisdom For Optimizing The Function Of Cave Water Resources As A Prevention Of Floods And Droughts In Wakatobi Regency, Indonesia. *Geojournal of Tourism and Geosites*, *44*(4), 1222–1232. https://doi.org/10.30892/gtg.44406-938

Mendrofa, B. F., Rahman, S. A., Utami, H. S., Fariz, T. R., & Heriyanti, A. P. (2023). Bentuk Kearifan Lokal dalam Pengelolaan Sumber Air di Taman Lele, Kota Semarang. *Proceeding Seminar Nasional IPA*.

Mishra, R. K. (2023). Fresh water availability and its global challenge. *British Journal of Multidisciplinary and Advanced Studies*, *4*(3), 1–78. https://doi.org/10.37745/bjmas.2022.0208

Moyle, B. D., Weaver, D. B., Gössling, S., McLennan, C., & Hadinejad, A. (2022). Are water-centric themes in sustainable tourism research congruent with the UN Sustainable Development Goals? *Journal of Sustainable Tourism*, *30*(8), 1821–1836. https://doi.org/10.1080/09669582.2021.1993233

Mycoo, M., Wairiu, M., Campbell, D., Duvat, V., Golbuu, Y., Maharaj, S., Nalau, J., Nunn, P., Pinnegar, J., & Warrick, O. (2022). Small islands. *IPCC WGII Sixth Assessment Report*.

Nhemachena, C., Nhamo, L., Matchaya, G., Nhemachena, C. R., Muchara, B., Karuaihe, S. T., & Mpandeli, S. (2020). Climate change impacts on water and agriculture sectors in Southern Africa: Threats and opportunities for sustainable development. *Water*, *12*(10), 2673. https://doi.org/10.3390/w12102673

Pakmehr, S., Yazdanpanah, M., & Baradaran, M. (2020). How collective efficacy makes a difference in responses to water shortage due to climate change in southwest Iran. *Land Use Policy*, *99*, 104798. https://doi.org/10.1016/j.landusepol.2020.104798

Phong, N. T., & Van Tien, H. (2021). Water resource management and island tourism development: insights from Phu Quoc, Kien Giang, Vietnam. *Environment, Development and Sustainability*, *23*(12), 17835–17856. https://doi.org/10.1007/s10668-021-01417-w

Raizada, P., Sudhaik, A., Patial, S., Hasija, V., Khan, A. A. P., Singh, P., Gautam, S., Kaur, M., &

Nguyen, V.-H. (2020). Engineering nanostructures of CuO-based photocatalysts for water treatment: current progress and future challenges. *Arabian Journal of Chemistry*, *13*(11), 8424–8457. https://doi.org/10.1016/j.arabjc.2020.06.031

Ratnasari, D., Sidiq, F., & Saputra, J. (2023). Local Wisdom, Environmental Management and Sustainable Traditions in Naga Village, Tasikmalaya Regency. *International Journal of Ethno-Sciences and Education Research*, *3*(4), 116–120. https://doi.org/10.46336/ijeer.v3i4.504

Rosa, L., Chiarelli, D. D., Rulli, M. C., Dell'Angelo, J., & D'Odorico, P. (2020). Global agricultural economic water scarcity. *Science Advances*, *6*(18), eaaz6031. https://doi.org/10.1126/sciadv.aaz6031

Rumihin, O. F., Makarim, C. A., & Pranoto, W. A. (2024). Analysis of Rainwater Harvesting Methods for Optimizing Small Island Areas: A Case Study in Selaru Island, Indonesia. *West Science Interdisciplinary Studies*, *2*(01), 22–35. https://doi.org/10.58812/wsis.v2i01.556

Shahzad, A., Ullah, S., Dar, A. A., Sardar, M. F., Mehmood, T., Tufail, M. A., Shakoor, A., & Haris, M. (2021). Nexus on climate change: Agriculture and possible solution to cope future climate change stresses. *Environmental Science and Pollution Research*, *28*, 14211–14232. https://doi.org/10.1007/s11356-021-12649-8

Sharan, A., Lal, A., & Datta, B. (2021). A review of groundwater sustainability crisis in the Pacific Island countries: Challenges and solutions. *Journal of Hydrology*, *603*, 127165. https://doi.org/10.1016/j.jhydrol.2021.127165

Tan, N. P. B., Ucab, P. M. L., Dadol, G. C., Jabile, L. M., Talili, I. N., & Cabaraban, M. T. I. (2022). A review of desalination technologies and its impact in the Philippines. *Desalination*, *534*, 115805. https://doi.org/10.1016/j.desal.2022.115805

Tariq, M. A. U. R., Alotaibi, R., Weththasinghe, K. K., & Rajabi, Z. (2022). A detailed perspective of water resource management in a dry and water scarce country: the case in Kuwait. *Frontiers in Environmental Science*, *10*, 1073834. https://doi.org/10.3389/fenvs.2022.1073834

Thamrin, H., Ridho, H., Sinaga, R. P. K., Ritonga, F. U., Nasution, F. A., & Purwanto, C. P. (2022). Local wisdom in natural resources management of freshwater fish In Lau Teba. *IOP Conference Series: Earth and Environmental Science*, *1115*(1), 12104. https://doi.org/10.1088/1755-1315/1115/1/012104

Tzanakakis, V. A., Angelakis, A. N., Paranychianakis, N. V, Dialynas, Y. G., & Tchobanoglous, G. (2020). Challenges and opportunities for sustainable management of water resources in the island of Crete, Greece. *Water*, *12*(6), 1538. https://doi.org/10.3390/w12061538

Wang, J., Meng, Q., Zou, Y., Qi, Q., Tan, K., Santamouris, M., & He, B.-J. (2022). Performance synergism of pervious pavement on stormwater management and urban heat island mitigation: A review of its benefits, key parameters, and co-benefits approach. *Water Research*, *221*, 118755. https://doi.org/10.1016/j.watres.2022.118755

Weningtyas, A., & Widuri, E. (2022). Pengelolaan sumber daya air berbasis kearifan lokal sebagai modal untuk pembangunan berkelanjutan. *Volksgeist: Jurnal Ilmu Hukum Konstitusi*, 129–144. https://doi.org/10.24090/volksgeist.v5i1.6074

Yuliana, E., Yusuf, M., Nirmalasary, T. N., Amri, N. H., Erlyn, P., Hariani, P. L., & Hidayat, B. A. (2021). Natural resources and environment Management for the development of local wisdom. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, *4*(4), 8248–8254.

Zakar, M. Z., Zakar, D. R., & Fischer, F. (2020). Climate change-induced water scarcity: a threat to human health. *South Asian Studies*, *27*(2).