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Research Paper

The Role of Basic Infrastructure to Strengthen Economic Security in Eastern Indonesia

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Abstract

This study aims to analyze the role of water infrastructure in supporting the development of leading commodities in Maluku and Papua, Indonesia. The 2020 Gross Regional Domestic Product (GRDP) dataset will be analyzed using the Location Quotient (LQ) technique to determine the leading sectors/base commodities with comparative advantages in the Maluku and Papua Provinces. Based on the Location Quotient (LQ) analysis results, it will be combined with a spatial approach to provide an overview of water resources and infrastructure. The results of this study show that water resource infrastructure is related to the housing settlement sector and agricultural commodities in Maluku and Papua. Increasing agricultural productivity has positive implications for Indonesia's food and economic security. Investment in water infrastructure development is needed to support leading sectors.

Keywords: water infrastructure; leading commodities; location quotient (LQ).

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1. Introduction

Water plays a vital role in every aspect of human existence, influencing various aspects of our daily lives. Recent studies have revealed a concerning pattern of rising human water needs and decreasing per-capita access to freshwater for domestic, agricultural, and industrial purposes (Huang et al., 2021; Islam & Hyland, 2019; Ogou et al., 2021). By 2050, water demand is expected to surge by 55%, with approximately 40% of the global population residing in areas of severe water scarcity (Boretti & Rosa, 2019). Factors contributing to these trends include population growth, rising living standards, and climate change (Tuyishimire et al., 2022; Valipour et al., 2020). At the same time, the United Nations set the 2030 Sustainable Development Goals (SDGs), of which water security and infrastructure investment are integral components, so it is necessary to develop water infrastructure. Specific targets in the SDGs related to water infrastructure include achieving universal access to electricity and boosting renewable energy sources, enhancing the population's access to safely managed water, sanitation and hygiene, supplying effective agricultural and flood control systems, and protecting water-related ecosystems (United Nations, 2015). The 2030 Agenda for Sustainable Development emphasizes the integrated nature of development and the need to balance economic, social, and environmental considerations. In addition, there is a need to mitigate trade-offs and maximize harmony between the SDGs and their policy domains (Naylor et al., 2016). Economic growth is a good thing, but sustainability must be considered. Economic sustainability involves the advancement of wealth and its equitable distribution, which improves the quality of life for a larger segment of the global population (Van Niekerk, 2020).

Several studies examine the impact of water infrastructure on the economy in several countries. investments in basic infrastructure (water, sewerage, and local roads) can significantly enhance the local economy of rural communities in Romania (Pavel et ail., 2018). One additional increase in water infrastructure investment has a higher impact on economic growth (Dangui & Jia, 2022). Water supply infrastructure investment has direct and indirect effects, or spillover effects, on economic development in Asian countries (Yoshino et al., 2020). Large dams built primarily for hydroelectricity, irrigation, and water supply promote GDP growth on a global and national scale (Shi et al., 2019). The growth of water infrastructure has a positive effect on economic development, primarily because it enhances human health, which in turn improves education (Palei et al., 2015). Investment in water-saving irrigation infrastructure has enormous economic, social, and ecological benefits, making it a crucial decision for decision-making (Wang & Zhao, 2022). In the context of Indonesia, water supply infrastructure significantly affects per capita output in South Sumatra, as well as the agriculture, manufacturing, and trade sectors (Ambarita et al., 2024).

Inter-regional inequality in Indonesia is one of the big challenges in national economic development. Currently, the gap between Indonesia's western and eastern regions is relatively high, for example, in terms of water access. Water and sanitation remain a pressing public issue in Indonesia with broad economic and development implications. Disparities in water infrastructure still exist between regions in Indonesia, causing unequal access to water across regions. Studies show that districts in Java-Bali reported the highest levels of access to improved drinking water and sanitation. In contrast, districts in the Maluku Islands presented the lowest levels of access to improved drinking water, and districts in Papua presented the lowest levels of access to improved sanitation (Afifah et al., 2018).

Economists often use indicators to explain a country or region's economic conditions using Gross Domestic Product (GDP) or Gross Regional Domestic Product (GRDP). GRDP can be used to evaluate the economic development performance of a region in a certain period, both based on current prices and the basis of constant prices. GRDP is the amount of added value produced by all business units in a certain region or the total value of final goods and services produced by all regional economic units. The GRDP value can represent the economic growth of a region. Indonesia has a GDP of US$1.2 trillion, making it the 16th largest economy in the world and a member of the G-20 group of 20 countries with large GDPs (Sudaryat, 2024). However, Indonesia's GDP contribution distribution is not evenly distributed across all regions. Infrastructure inequality between regions in Indonesia is closely related to equal economic development between regions in Indonesia. This is proven by the contribution of Indonesia's Gross Domestic Product (GDP), which the group of provinces in Java and Sumatra still dominates. Eastern regions of Indonesia, such as Maluku and Papua, do not significantly contribute to Indonesia's GDP. The Central Statistics Agency (BPS) stated that Java contributed 57.05% of Indonesia's GDP in 2023. Other contributors were Sumatra at 22.01%, Kalimantan at 8.49%, Sulawesi at 7.10%, Bali-Southeast Nusa at 2.77%, and Maluku-Papua at 2.58% as shown in Figure 1 (Santika, 2024). With the minimal contribution

of eastern Indonesia to the economy, the government needs to formulate policies to increase Maluku-Papua's contribution to the national economy. Economic equality is an agenda that the government must prioritize to ensure no inequality for all levels of society. However, optimizing the regional economy's role must consider the economic region's leading commodities.

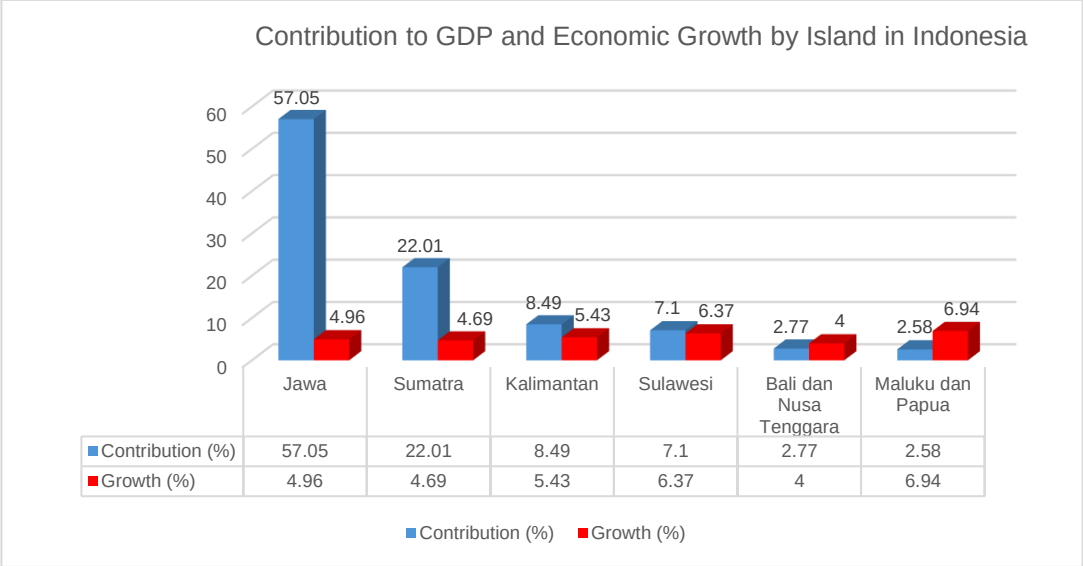

Figure 1. *Contribution to GDP and Economic Growth by Island in Indonesia (Santika, 2024)*

The development of regional economic potential is intended to accelerate growth and empower communities based on leading commodities. Developing local leading commodity-based potential is sought to increase the added value and competitiveness of leading commodities. In Maluku and Papua, the housing settlement sector and agricultural commodities are the region's leading sectors/base commodities that are related to water infrastructure. Developing regional economic potential will have positive implications for economic security. Economic security is the ability of the regional socio-economic system to ensure sustainable economic growth, social development of territories, and a high quality and standard of living for the population under the negative impact of various factors (Sverdan, 2015). On the other hand, the country's economic security should be understood as a condition of the national economy, which makes it possible to provide a high level of protection for the interests of each of its people from the negative impact of external and internal threats (Vladyslav, 2019). Enhanced economic security fosters private investment and growth in developing countries (Zaman et al., 2021)

Water infrastructure and economic security in Eastern Indonesia are deeply intertwined, with significant gaps posing challenges to the region's development. Eastern Indonesia, known for its abundant natural resources such as fisheries, agriculture, and minerals, faces considerable obstacles due to inadequate water infrastructure. Poor water supply systems, insufficient irrigation facilities, and lack of proper water management have hindered the full potential of these leading commodities. For instance, the fisheries sector, which is a vital source of income for many coastal communities, suffers from insufficient clean water for fish processing and preservation, leading to reduced product quality and market value. Similarly, the agriculture sector, heavily reliant on consistent water supply, often experiences reduced yields due to inefficient irrigation practices, affecting both food security and local livelihoods.

The economic security of Eastern Indonesia is closely linked to the performance of its leading commodities, and the gaps in water infrastructure exacerbate the vulnerabilities of this relationship. Without robust water infrastructure, the region struggles to attract investment and sustain economic growth. The mining sector, another key economic driver, requires substantial water for operations and is often hampered by the lack of reliable water sources, impacting productivity and environmental sustainability. Addressing these gaps is crucial for enhancing economic resilience and stability in Eastern Indonesia. Investment in water infrastructure development, including modern irrigation systems, clean water supply, and efficient water management practices, is essential to unlock the full economic potential

of the region's natural resources, ensuring long-term economic security and improved quality of life for its inhabitants. Based on the results of studies on the role of water infrastructure in the country's economy, further studies are needed to analyze the role of water infrastructure in supporting leading regional commodities, especially in the Maluku and Papua provinces. Accordingly, this study aims to analyze the role of water infrastructure in supporting the development of leading commodities in Maluku and Papua, Indonesia.

2. Methods

This paper used quantitative analysis combined with a spatial approach. Quantitative analysis was used in this paper because the data used in this paper is obtained from statistical data which is used to determine the concentration of economic activity in Maluku and Papua Provinces using the Location Quotient (LQ) method. Based on the Location Quotient (LQ) analysis results, it will be combined with a spatial approach to provide an overview of water resources and infrastructure in Maluku and Papua Provinces.

2.1 Analysis

The research paper analyses the 2020 Gross Regional Domestic Product (GRDP) dataset from the Maluku and Papua Provinces, which the Central Statistics Agency collected. The GRDP dataset will be analyzed using the Location Quotient (LQ) analysis technique to determine the leading sectors/base commodities with comparative advantages in the Maluku and Papua Provinces. Location Quotient (LQ) is a very useful analytical tool for identifying regional competitive advantages in various economic sectors. One of the main advantages of the Location Quotient method compared to other methods is its simplicity. LQ is easy to calculate and interpret because it only requires limited data, namely employment or output data from a particular sector in a region compared with total employment or output from that region and a reference region (for example, national level). With this simplicity, LQ can provide a quick overview of which sectors are more prominent in one region compared to other regions. This is very helpful in economic planning and policy making because it can identify sectors that have the potential to become the focus of further development.

Apart from its simplicity, the LQ method also provides deep insight into the economic specialization of a region. By using LQ, analysts can identify economic sectors that have a high concentration in a region, which may not be visible with other analysis methods. For example, if a region has an LQ of more than 1 for a particular sector, this indicates that the region has a higher concentration in that sector compared to the national average, indicating the existence of a comparative advantage. This information is invaluable for the development of regional development strategies and resource allocation, as it can indicate which sectors could become centres of economic excellence in the future. Compared to other methods that may be more complex or require more detailed data, LQ offers an efficient and effective tool for regional economic analysis (Franconi et al., 2024). The Location Quotient value is a coefficient number that shows the level of relative superiority of a regional sector compared to other regions. The Location Quotient coefficient determines the comparative base sector in an area, namely the sector whose potential can be relied upon compared to surrounding areas.

The approach used compares the relative function of the Gross Regional Domestic Product (GRDP) of a sector/production of a commodity in a region and the relative function of the magnitude of GRDP of a sector/production of a commodity at the regional level above. Mathematically, LQ can be formulated with the equation (Nowar, 2015):

$\boldsymbol{LQ_i} = (\boldsymbol{ei}/\boldsymbol{e})/(\boldsymbol{Ei}/\boldsymbol{E})$, where

Location Quotient *i* = Location Quotient value for sector *i* in the analysis district

$\boldsymbol{ei}$ = GRDP sector *i* in the analysis district

$\boldsymbol{e}$ = GRDP of all sectors in the analysis district

$\boldsymbol{Ei}$ = GRDP sector *i* in the analysis district province

$\boldsymbol{E}$ = GRDP of all sectors in the analysis district province

The Location Quotient coefficient ranges from 0 to positive finite, which can be interpreted as follows:

- A Location Quotient coefficient of less than 1 means that the sector/commodity in question does not have a comparative advantage.
- A Location Quotient coefficient equal to 1 indicates that the sector in question has the same relative advantage as the average for all regions.
- A Location Quotient coefficient greater than 1 means that the sector in question has a higher comparative advantage than the average.

Based on the Location Quotient (LQ) analysis results, it will be combined with a spatial approach to provide an overview of water resources and infrastructure in Maluku and Papua Provinces. The spatial approach in Location Quotient (LQ) analysis has significant advantages compared to other methods in several aspects. First, LQ provides a clear picture of the concentration of an industry or economic sector in a region compared to other regions. By using spatial data, LQ can identify areas that have competitive advantages or specialization in certain sectors. This is very useful for economic planning and regional development, as it allows policymakers to allocate resources more efficiently and support sectors that have high growth potential. Through Quantum Geographic Information System (QGIS) software, cartographic visualization will be carried out, making it easier for the government to understand the condition of water infrastructure and formulate appropriate policies to support the development of leading commodities.

3. Results and Discussion

Water infrastructure in Eastern Indonesia, particularly in the Maluku and Papua regions, plays a crucial role in enhancing economic security and development. This region has abundant natural resource potential, but its management is often hampered by limited access to clean water and adequate infrastructure. Providing clean water and good sanitation is very important to support public health and economic productivity. Investments in water infrastructure can help reduce waterborne diseases, improve quality of life, and enable local communities to participate more actively in economic activities. In addition, better access to clean water can also encourage growth in the agricultural and fisheries sectors, which are the backbone of the local economy in Maluku and Papua. These regions are characterized by their remote locations, challenging geographical terrains, and diverse archipelagic landscapes, making the provision and maintenance of water infrastructure both vital and complex. Investments in water infrastructure, including the development of clean water supply systems, irrigation for agriculture, and sanitation facilities, are essential for improving public health, supporting local agriculture, and enabling sustainable economic activities. Enhanced water infrastructure ensures reliable access to clean water, which is fundamental for the well-being of communities and the productivity of local economies. In Maluku, known for its fisheries and maritime activities, and Papua, rich in natural resources, robust water infrastructure supports industrial processes, boosts tourism, and fosters overall economic resilience. By addressing water-related challenges and improving infrastructure, these regions can better harness their natural potential, reduce poverty, and achieve more balanced national development.

Water resources infrastructure related to the housing settlement sector and agricultural commodities in Maluku is presented in Figure 2. Based on Figure 2, it can be seen that the infrastructure distribution in the Maluku region has few dams. The infrastructure supporting the drinking water supply system is spread throughout the Maluku region, located close to settlements, but is widely spread in the Seram area. The residential area in Maluku is 27,961,567 ha, most of which is spread across Ambon City.

Table 1. Result of LQ Analysis in Maluku Province

Regency /City	Agriculture, Forestry and Fisheries	Mining and Excavation	Processing Industry	Procurement of Electricity and Gas	Water Supply, Waste Management, Waste and Recycling	Construction	Wholesale and Retail Trade; Car and Motorcycle Repair	Transportation and Warehousing	Provision of accommodation and food and drink	Information and Communication	Financial Services and Insurance	Real Estate	Company Services	Government Administration, Defense and Mandatory Social Security	Education Services	Health Services and Social Activities	Other services
Kab. Buru	1.82	0.09	1.20	0.20	1.77	1.09	0.44	0.44	0.63	0.37	0.53	2.10	0.20	1.29	1.17	1.93	1.48
Kab.Buru Selatan	2.06	0.10	0.35	0.03	0.10	1.31	0.49	0.40	0.27	0.17	0.21	3.25	0.05	1.48	1.45	2.83	1.18
Kab. Kepulauan Tanimbar	0.26	0.05	0.03	7.86	0.72	0.59	2.03	3.74	4.90	0.16	2.16	0.33	0.23	0.47	0.23	0.46	0.23
Kab. Maluku Barat Daya	2.27	0.48	0.08	0.03	0.02	1.51	0.39	0.23	0.26	0.06	0.25	3.00	0.06	1.42	1.44	2.21	1.16
Maluku Tengah	1.34	0.08	1.19	0.14	0.94	1.00	0.85	0.43	0.70	0.39	0.65	1.51	2.40	1.17	2.59	0.65	1.77
Maluku Tenggara	1.60	0.06	0.13	0.21	1.55	1.72	0.80	0.44	1.20	0.34	1.15	1.01	0.72	1.44	1.36	1.67	1.44
Seram Bagian Barat	1.86	0.19	0.50	0.16	0.37	1.73	0.56	0.53	0.41	0.39	0.76	2.33	0.50	1.32	0.75	1.74	1.79
Seram Bagian Timur	1.50	3.40	0.13	0.04	0.35	1.11	0.45	0.41	0.26	0.22	0.49	2.06	0.29	1.06	0.74	1.40	1.35
Kota Tual	1.92	0.06	0.15	0.15	1.75	1.37	0.89	0.52	0.55	0.58	0.60	2.23	0.57	1.06	1.83	1.80	1.22
Kota Ambon	0.26	0.04	0.34	0.37	3.51	0.79	1.34	1.48	1.61	2.43	1.79	1.52	3.32	1.48	1.50	0.54	1.84
Kepulauan Aru	3.04	0.11	0.29	0.07	0.73	1.12	0.49	0.18	0.23	0.30	0.23	1.20	0.28	0.88	0.68	1.16	0.78

Source: Processed Data (2023)

The leading sectors in Maluku Province are Agriculture, Forestry, and Fisheries, with an area of 21,038,213 Ha of rice fields and 637,256,918 Ha of agricultural land. Coverage of clean water capacity in Maluku is supported by 2 lakes/reservoirs/sites, and river flows spread throughout the region. Farming areas requiring the greatest irrigation water support are West Seram Regency, Southeast Maluku, and Southwest Maluku. Based on an analysis that considers water needs for rice commodities and household clean water needs, Maluku Province is experiencing a water supply capacity deficit.

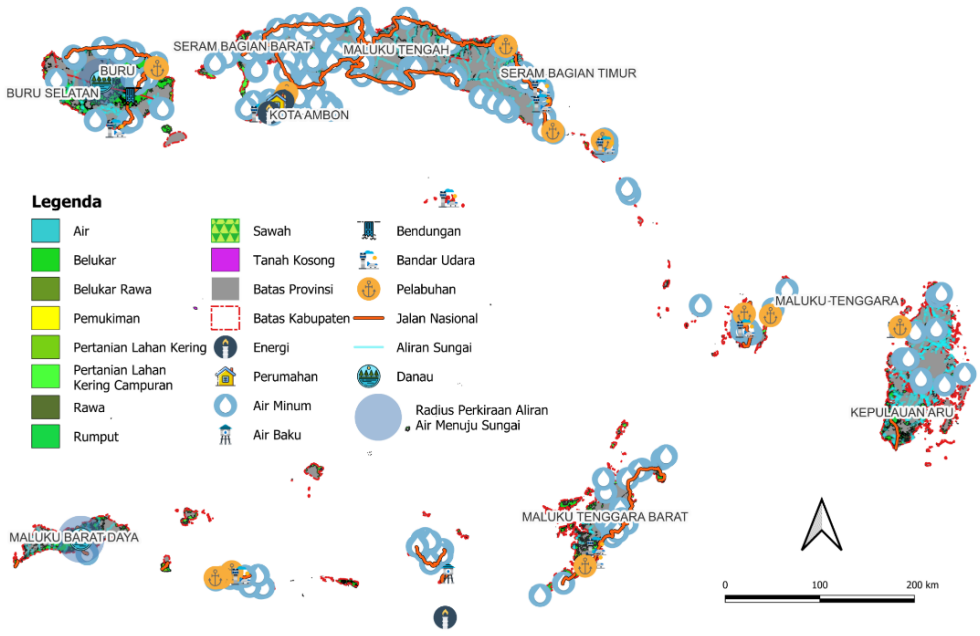

Figure 2. *Infrastructure and Agricultural Production Value Chain in Maluku (Processed Data, 2023)*

Water resources infrastructure related to the housing settlement sector and agricultural commodities in North Maluku is presented in Figure 3. Based on Figure 3, it can be seen that the infrastructure distribution in the North Maluku region does not have dams. The infrastructure supporting the drinking water supply system is widely spread in the Maluku region, which is generally located close to residential areas in North Maluku, covering an area of 23,132,306 Ha, most of which is in Ternate City.

Table 2. Result of LQ Analysis in North Maluku Province

Regency /City	Agriculture, Forestry and Fisheries	Mining and Excavation	Processing Industry	Procurement of Electricity and Gas	Water Supply, Waste Management, Waste and Recycling	Construction	Wholesale and Retail Trade; Car and Motorcycle Repair	Transportation and Warehousing	Provision of accommodation and food and drink	Information and Communication	Financial Services and Insurance	Real Estate	Company Services	Government Administration, Defense and Mandatory Social Security	Education Services	Health Services and Social Activities	Other services
Halmahera Barat	1.95	0.01	0.44	0.26	0.90	0.84	0.99	0.31	0.13	0.97	0.72	0.42	0.32	1.34	0.87	1.42	0.42
Halmahera Tengah	0.33	3.19	4.90	0.03	0.03	0.72	0.26	0.07	0.04	0.17	0.19	0.07	0.04	0.35	0.19	0.26	0.06
Halmahera Timur	0.99	4.51	0.31	0.09	0.02	1.47	0.79	0.23	0.11	0.68	0.32	0.36	0.50	0.79	0.52	0.51	0.28
Halmahera Selatan	0.91	2.19	3.44	0.10	0.40	0.62	0.71	0.19	0.09	0.40	0.31	0.28	0.11	0.38	0.49	0.80	0.22
Halmahera Utara	1.21	3.58	0.29	0.20	0.46	1.12	0.81	0.30	0.17	0.88	0.43	0.37	0.21	0.84	0.79	1.04	0.44
Kepulauan Sula	2.12	0.01	0.51	0.20	0.30	1.70	0.96	0.33	0.10	0.61	0.50	0.46	0.27	0.97	1.04	0.78	0.39
Pulau Morotai	2.41	0.01	0.37	0.24	0.06	1.59	1.18	0.31	0.08	0.42	0.39	0.60	0.20	0.57	1.04	0.85	0.55
Pulau Taliabu	2.62	2.45	0.13	0.05	0.04	0.59	0.87	0.16	0.04	0.19	0.13	0.26	0.05	0.47	0.37	0.42	0.23
Kota Ternate	0.19	0.01	0.24	0.35	0.37	1.17	1.44	1.79	0.62	3.00	1.99	1.25	1.45	1.17	1.24	1.97	2.01
Kota Tidore Kepulauan	1.20	0.01	0.24	0.48	0.66	1.10	0.67	0.51	0.10	1.08	0.65	0.46	0.64	2.50	1.08	1.20	0.53

Source: Processed Data (2023)

The leading sectors in North Maluku Province are Agriculture, Forestry, and Fisheries, with an area of 9,545,523 Ha of rice fields and 743,871,008 Ha of agricultural land. The coverage of clean water capacity is supported by two lakes/reservoirs/sites and river flows spread across the North Maluku region. Farming areas that require the greatest irrigation water support are in the West Halmahera and North Halmahera Regencies because they have large agricultural areas. Based on an analysis that considers water needs for rice commodities and clean water needs for households, North Maluku Province is experiencing a water supply capacity deficit. Previous findings in regions with similar agricultural profiles have highlighted the critical importance of water management. For instance, studies have shown that in areas where agriculture is predominant, sustainable water resources management is essential to balance the competing needs of agricultural and household water consumption (Hargrove et al., 2023).

Moreover, the phenomenon of water scarcity in agricultural regions has been extensively documented. Research by Cao et al. (2021) emphasizes that water productivity improvements are crucial for meeting the dual challenges of food security and sustainable water use. This is especially relevant in North Maluku, where the water needs for rice cultivation—a highly water-intensive crop—compete with the water requirements of households. Empirical studies in other regions have also shown that the introduction of efficient irrigation technologies and practices can mitigate water scarcity. For example, the adoption of drip irrigation and the use of drought-resistant crop varieties have been successful in reducing water consumption while maintaining agricultural productivity (Bhatt et al., 2019; Suna et al., 2023). The current findings from North Maluku align with these broader theoretical and empirical insights, reinforcing the need for integrated and efficient water management strategies. Addressing the water supply deficit will require a multifaceted approach, combining technological innovations, policy reforms, and community engagement to ensure sustainable water use that supports both agricultural productivity and household needs.

Water availability from various water resources is generally still sufficient to meet the population's needs in Maluku. However, it should be noted that the condition of green open space must be maintained. Efforts must be made to conserve water resources by regulating unfriendly human behaviour, building rainwater and runoff control infrastructure, and law enforcement efforts related to watershed maintenance and the behaviour of communities around water resources so that water availability is guaranteed throughout the year (Kunu et al., 2021). The availability of water sources in Maluku should be managed well and supported by adequate water infrastructure so that the water supply capacity can meet the community's needs and support the leading sectors in the Maluku and North Maluku Provinces.

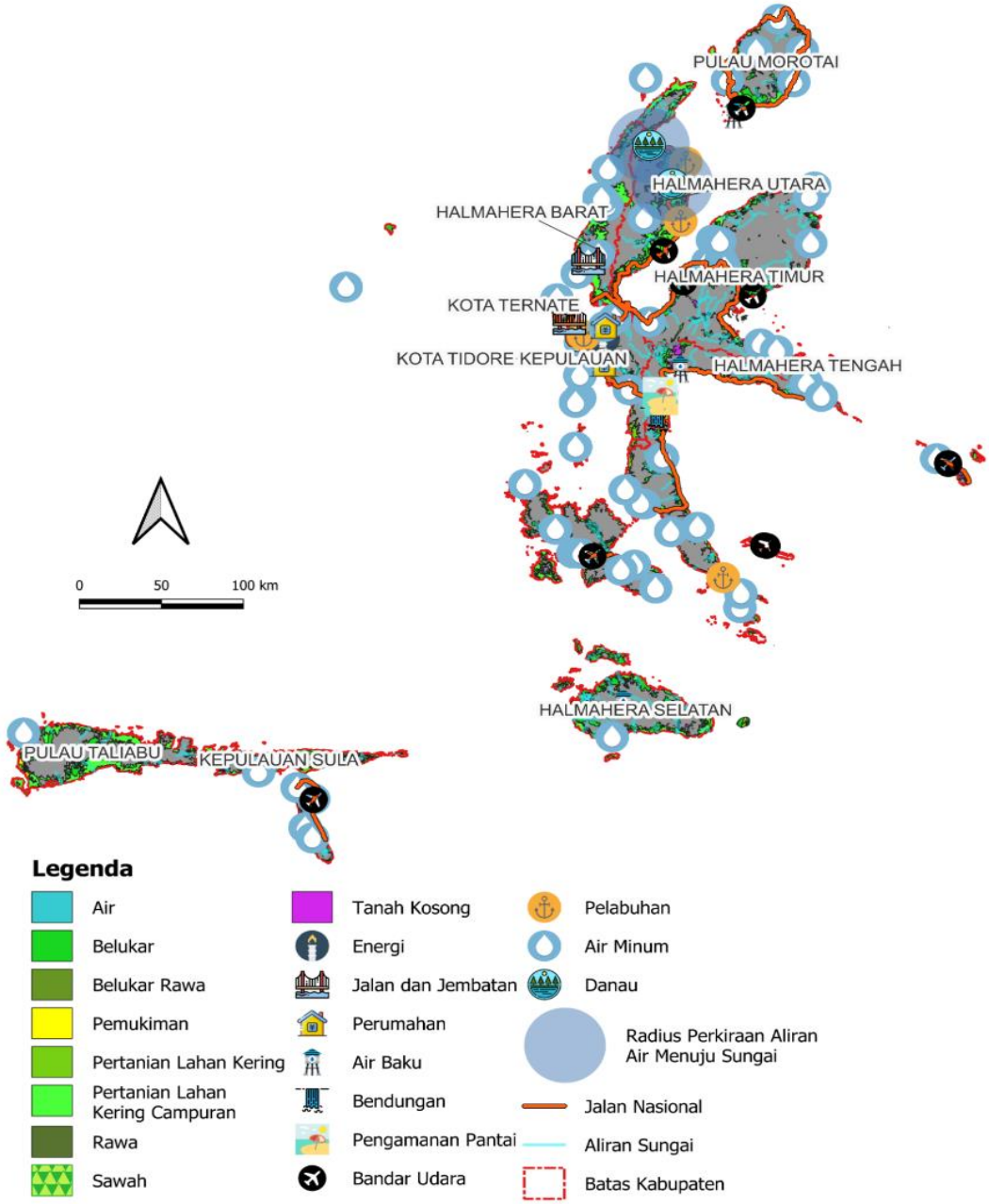

Figure 3. *Infrastructure and Agricultural Production Value Chain in North Maluku (Processed Data, 2023)*

Water Resources Infrastructure related to the Housing Settlement Sector and Agricultural Commodities in Papua is presented in the picture below on Figure 4. Based on this image, it can be seen that the distribution of infrastructure in the Papua region has 2 dam units located in Nabire and Boven Digoel Regencies. Supporting infrastructure for Drinking Water Supply Systems (SPAM) is widely spread in the Southern region. The residential area in Papua has an area of 89,683,141 ha, the largest of which is in Jayapura City.

Table 3. Result of LQ Analysis in Papua Province

Regency/City	Agriculture, Forestry and Fisheries	Mining and Excavation	Processing Industry	Procurement of Electricity and Gas	Water Supply, Waste Management, Waste and Recycling	Construction	Wholesale and Retail Trade; Car and Motorcycle Repair	Transportation and Warehousing	Provision of accommodation and food and drink	Information and Communication	Financial Services and Insurance	Real Estate	Company Services	Government Administration, Defense and Mandatory Social Security	Education Services	Health Services and Social Activities	Other services
Kab.Biak Numfor	2.04	0.03	0.41	6.64	2.44	0.49	1.92	2.05	1.16	1.10	3.41	1.91	2.47	1.99	1.26	1.40	1.13
Kab.Jayapura	1.86	0.07	0.49	1.03	2.53	1.23	1.64	3.44	1.81	1.76	1.00	2.00	2.26	0.95	1.06	1.13	1.79
Kab.Keerom	2.81	0.04	0.56	1.04	0.00	2.10	0.95	0.31	1.48	0.30	0.79	0.69	0.05	1.46	1.36	1.38	1.27
Kab.Kepulauan Yapen	2.06	0.02	0.42	2.03	2.13	0.49	2.21	2.20	1.26	1.17	2.24	2.45	1.38	1.52	1.74	1.64	2.86
Kab.Mamberamo Raya	1.82	0.08	0.03	0.00	0.00	1.65	1.27	0.92	1.08	0.00	0.05	0.77	0.18	2.45	3.48	2.70	3.06
Kab.Sarmi	2.74	0.05	0.22	1.05	0.98	1.48	1.18	1.64	1.05	0.87	0.77	1.33	0.59	1.51	1.57	1.51	1.68
Kab.Supiori	2.64	0.01	0.06	2.15	0.00	2.20	0.44	0.09	0.42	0.19	0.66	1.06	0.09	1.93	2.96	2.38	3.10
Kab.Waropen	2.40	0.03	0.12	0.72	0.21	2.36	0.81	0.44	0.36	0.16	0.33	2.24	0.26	1.64	2.80	0.88	1.89
Kota Jayapura	0.49	0.01	0.25	1.49	2.07	1.57	1.92	1.32	2.59	2.78	2.88	2.16	3.36	1.50	2.06	2.68	2.53
Kab.Merauke	2.26	0.06	0.38	1.79	1.93	1.30	1.73	1.90	1.93	2.45	1.42	1.18	1.46	0.96	1.07	1.18	1.22
Kab.Asmat	1.88	0.00	0.25	0.24	0.71	2.29	0.76	0.74	0.43	0.16	0.14	0.79	0.52	2.23	3.62	2.32	1.08
Kab.Mappi	2.02	0.01	0.07	0.19	0.02	2.49	0.86	0.56	0.35	0.15	0.48	0.70	0.09	2.49	1.72	1.73	1.01
Kab.Boven Digoel	2.30	0.05	2.33	0.15	0.07	1.92	0.69	0.56	0.36	0.09	0.64	0.57	0.17	1.02	0.93	1.10	0.70
Kab.Yahukimo	1.88	0.03	0.06	0.37	0.00	1.72	0.63	1.33	0.50	0.33	0.25	1.41	0.28	2.97	2.92	1.84	1.52
Kab.Tolikara	2.26	0.02	0.02	0.36	0.04	1.58	0.69	1.79	0.53	0.34	0.10	1.00	0.23	2.73	2.68	2.31	1.24
Kab.Pegunungan Bintang	1.80	0.04	0.01	0.30	0.00	2.35	0.48	0.68	0.53	0.20	0.84	0.55	0.24	3.17	1.67	1.44	1.09
Kab.Yalimo	2.21	0.02	0.01	0.00	0.00	1.51	1.38	0.92	0.13	0.00	0.00	0.45	0.09	2.95	2.16	1.98	2.55
Kab.Lanny Jaya	1.86	0.06	0.01	0.00	0.00	1.75	1.26	1.01	0.09	0.00	0.00	1.78	0.08	2.30	3.20	3.32	1.40
Kab. Puncak	1.79	0.00	0.00	0.15	0.04	2.24	1.37	0.13	0.34	0.03	0.03	0.97	0.17	3.58	0.22	0.27	0.25
Kab.Jayawijaya	1.21	0.05	0.22	2.52	0.62	1.09	2.17	3.97	1.05	1.92	1.00	2.79	2.00	1.33	1.33	1.47	1.55
Kab.Mamberamo Tengah	0.00	0.06	0.01	0.00	0.00	2.58	0.00	2.40	0.04	0.00	0.04	1.14	0.15	4.01	3.33	3.13	2.91
Kab.Nduga	2.05	0.01	0.01	0.00	0.00	2.06	1.39	0.36	0.12	0.00	0.00	1.17	0.11	2.21	2.62	2.61	2.49
Kab.Nabire	1.51	0.71	0.16	1.68	0.60	0.97	2.19	1.32	0.74	0.84	1.42	1.31	1.03	0.92	1.08	1.21	1.42
Kab.Paniai	0.83	1.34	0.04	0.13	0.10	2.09	0.39	0.65	0.32	0.16	0.11	0.50	0.32	1.11	0.77	0.80	0.72
Kab.Deiyai	2.07	0.04	0.04	0.48	0.00	2.44	1.00	0.23	0.08	0.01	0.10	0.79	0.07	2.39	1.96	2.32	1.08
Kab Dogiyai	2.41	0.09	0.01	0.10	0.02	0.85	1.48	0.32	0.48	0.12	0.00	4.06	0.00	3.22	0.32	1.44	0.43
Kab.Intan Jaya	2.10	0.01	0.03	0.00	0.00	2.54	0.88	0.30	0.03	0.00	0.00	0.14	0.08	2.83	1.47	1.18	1.50
Kab.Mimika	0.20	2.68	0.02	0.48	0.19	0.28	0.37	0.32	0.51	0.66	0.39	0.38	0.58	0.21	0.12	0.17	0.35
Kab. Puncak Jaya	2.26	0.04	0.06	0.23	0.00	2.24	0.86	0.75	0.36	0.21	0.11	0.84	0.20	2.26	1.67	2.41	1.37

Source: Processed Data (2023)

The majority of leading sectors in Papua Province are Government Administration, Defense and Mandatory Social Security based on the results of LQ analysis calculations from GRDP. The area of rice fields is 51,979,707 Ha and agricultural land is 960,557,434 Ha. Coverage of clean water capacity in West Papua is supported by 6 lakes/reservoirs/situations and also river flows spread across the Papua region. The agricultural area that requires the greatest support for irrigation water is in Merauke Regency. Based on the results of an analysis that takes into account water needs for rice commodities and clean water

needs for households, Papua Province is experiencing a water supply capacity deficit. The current deficit in water supply, when compared to the agricultural demands and household needs for clean water, suggests an urgent need for improved water management and infrastructure. This finding aligns with the theories of water resource management that emphasize the critical role of efficient allocation and infrastructure in supporting agricultural and domestic needs (Garrick et al., 2020; Nyam et al., 2021). Previous studies have highlighted similar challenges in other regions with large agricultural areas but limited water resources, stressing the importance of integrated water resource management (Cao et al., 2021). The situation in Papua Province underscores the necessity of addressing water supply issues to sustain agricultural productivity and meet the population's needs.

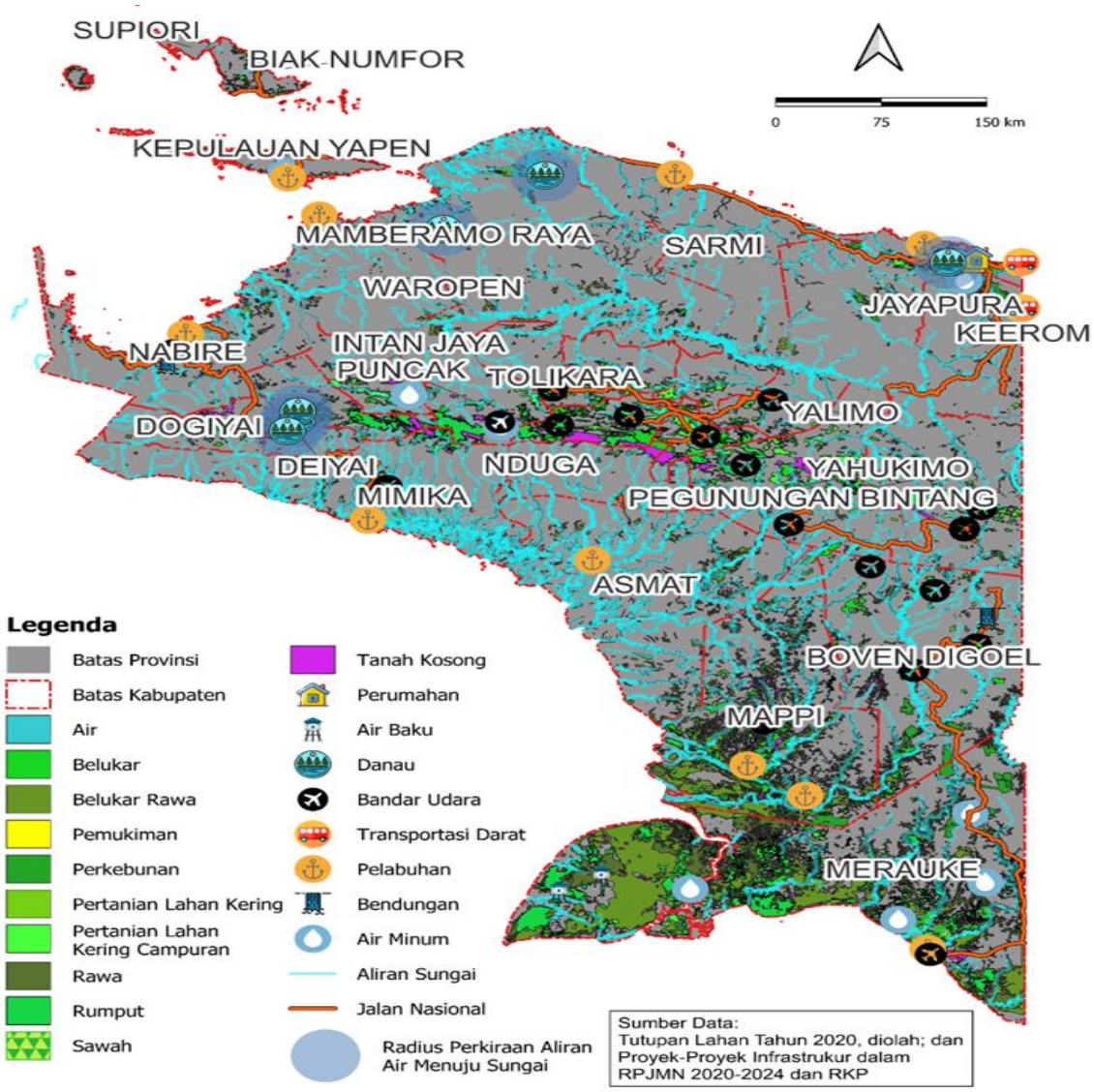

Figure 4. *Infrastructure and Agricultural Production Value Chain in Papua (Processed Data, 2023)*

Water resources infrastructure related to the housing settlement sector and agricultural commodities in West Papua is presented in Figure 5. Based on Figure 5, it can be seen that the distribution of infrastructure in the West Papua region still needs dams, but there are many lakes, reservoirs, and other situations. The infrastructure supporting the drinking water supply system is widely spread in the Sorong area, which is located close to residential areas. The residential area in West Papua has an area of 40,678,913 ha spread over two areas, namely Sorong City.

Table 4. Result of LQ Analysis in West Papua Province

Regency/City	Agriculture, Forestry and Fisheries	Mining and Excavation	Processing Industry	Procurement of Electricity and Gas	Water Supply, Waste Management, Waste and Recycling	Construction	Wholesale and Retail Trade; Car and Motorcycle Repair	Transportation and Warehousing	Provision of accommodation and food and drink	Information and Communication	Financial Services and Insurance	Real Estate	Company Services	Government Administration, Defense and Mandatory Social Security	Education Services	Health Services and Social Activities	Other services
Kab.Fakfak	1.55	0.04	0.39	1.41	3.44	1.98	1.53	1.55	1.69	0.99	1.11	0.97	0.18	1.83	2.44	0.89	0.33
Kab.Kaimana	2.51	0.04	0.63	2.00	0.81	1.44	1.37	1.45	1.17	0.59	1.09	0.84	0.08	1.98	0.97	0.54	0.47
Kab.Monokwari	1.30	0.09	0.49	2.79	5.98	1.38	1.73	1.29	2.55	1.27	2.82	1.34	0.23	1.99	2.08	1.34	0.64
Kab.Monokwari Selatan	5.23	0.02	0.17	3.54	0.62	0.27	0.15	0.78	0.55	0.07	0.65	0.12	0.08	2.36	1.63	0.86	1.06
Kab.Pegunungan Arfak	2.89	0.01	0.01	4.51	0.00	0.68	0.01	0.02	0.21	0.01	0.13	0.16	0.00	5.30	1.64	0.73	0.31
Kab.Teluk Bintuni	0.22	1.12	5.56	0.04	0.03	0.47	0.05	0.03	0.04	0.01	0.12	0.06	0.00	0.17	0.11	0.04	0.00
Kab.Wondama	3.05	0.04	0.25	0.48	0.74	1.32	0.93	0.72	0.63	0.14	0.78	0.64	0.06	2.71	1.55	0.42	0.20

Source: Processed Data (2023)

The majority of leading sectors in West Papua Province are Agriculture, Forestry and Fisheries, with an area of 5,435,824 Ha of rice fields and 132,976,477 Ha of agricultural land. The coverage of clean water capacity in West Papua is supported by ten lakes, reservoirs, and sites, as well as river flows spread across the West Papua region. The agricultural area that requires the greatest support for irrigation water is the Maybrat Regency. Based on the results of an analysis that takes into account water needs for rice commodities and clean water needs for households, West Papua Province is experiencing a water supply capacity deficit. Previous studies and theories have consistently highlighted the challenges faced by regions with extensive agricultural activities in managing water resources. For instance, Srivastav et al. (2021) emphasized the importance of sustainable water management practices in regions with significant agricultural demands. Similarly, Al-Shammary et al. (2024) noted that the efficiency of water use in agriculture is crucial for addressing water scarcity issues. In the context of West Papua, the current findings align with these theories, demonstrating that despite having natural water resources, the province struggles to meet its water demand due to the extensive agricultural requirements and household needs.

The observed water supply capacity deficit in West Papua Province can be compared with similar findings in other regions with intensive agricultural activities. For example, studies on water resource management in the Indo-Gangetic Plain (Kingra & Kukal, 2024) and the North China Plain (Kang et al., 2017) have reported similar challenges in balancing agricultural water demand with available water resources. These studies emphasize the need for integrated water management approaches that consider both agricultural and domestic water needs to ensure sustainable water supply.

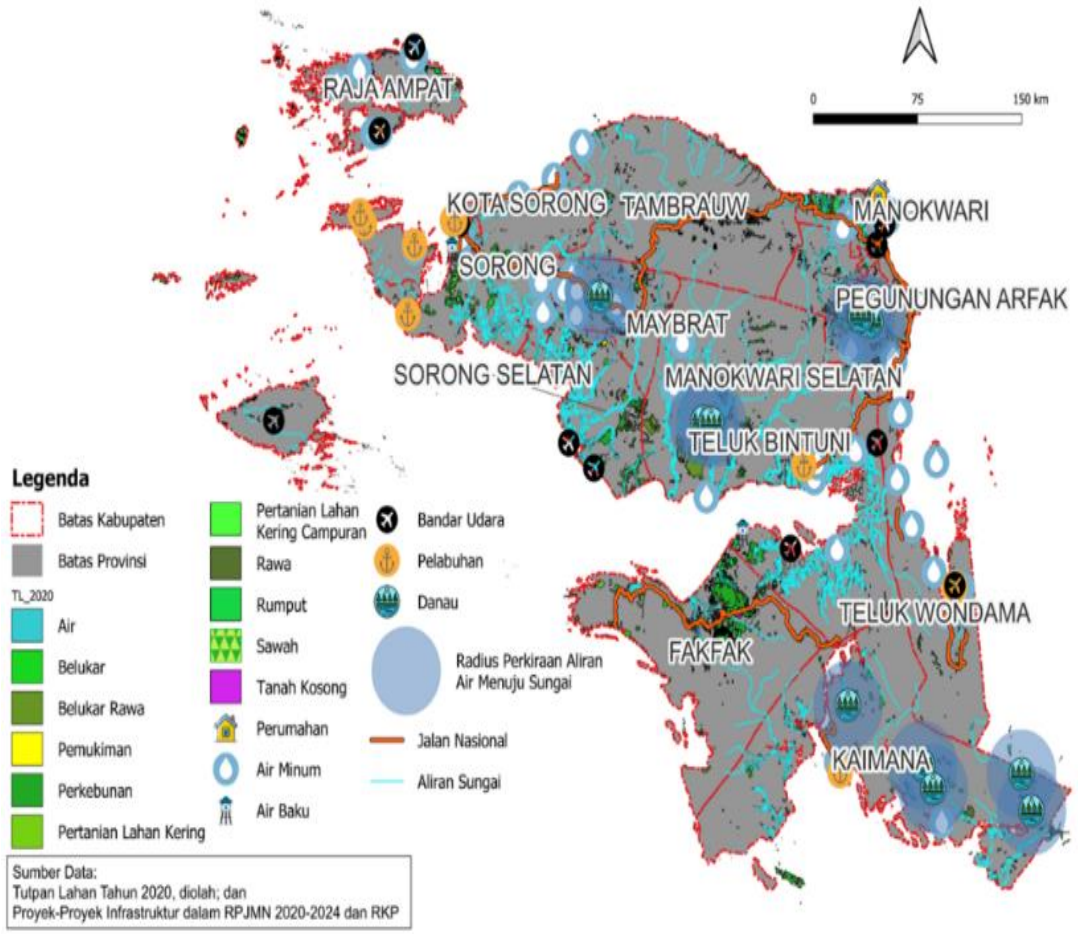

Figure 5. *Infrastructure and Agricultural Production Value Chain in West Papua (Processed Data, 2023)*

This finding supports previous research from (Indahyani et al., 2023; Lasaiba, 2023), which stated that the agricultural sector is the basic sector in all provinces of Papua and Maluku. There are three sub-sectors, which are the basic sub-sectors, from the five agrarian sub-sectors. Farm non-food crops are North Maluku's leading sector, while forestry and fishery are basic sub-sectors in Maluku and Papua. Farm food crops are a potential sub-sector that can develop in all Papua and Maluku Provinces. Increasing agricultural productivity contributes to a country's economic development by providing more food, increasing market competitiveness, and improving the distribution of agricultural products (Liu et al., 2020). The availability of agricultural products has the potential to positively impact Indonesia's food security because people's food needs can be met without the government requiring them to import foodstuffs from another country. Agriculture, food, and nutrition security interventions positively impact health and can impact inclusive economic development and environmental sustainability (Haby et al., 2016). Furthermore, increasing agricultural productivity can also increase Indonesia's economic security.

Water infrastructure in Eastern Indonesia, particularly in the Maluku and Papua regions, plays a crucial role in strengthening the local economy by supporting superior commodities such as fisheries, agriculture, and mining. In these areas, the development of adequate water infrastructure, including reservoirs, irrigation systems, and potable water supply networks, is essential for enhancing the productivity and quality of local commodities. For instance, effective irrigation systems can significantly boost agricultural yields, allowing for the cultivation of high-quality crops such as spices in Maluku and sago in Papua. Additionally, improved water supply and sanitation facilities contribute to better health outcomes, reducing illness-related productivity losses and creating a healthier workforce capable of driving economic activities.

Moreover, the strategic development of water infrastructure can foster the growth of the fisheries sector, which is a key economic driver in both regions. By ensuring a reliable supply of clean water, the aquaculture industry can thrive, producing high-value fish and seafood products for both domestic and

international markets. Enhanced water infrastructure also supports mining operations in Papua, where water is essential for processing minerals and maintaining environmental standards. Overall, investing in water infrastructure in Maluku and Papua not only improves the livelihoods of local communities but also strengthens the economic foundation by enabling the efficient and sustainable exploitation of their superior commodities.

Based on this study's findings, it is necessary to develop water infrastructure to support leading commodities. For water supply to meet water demand, investment is needed to support water infrastructure development in Maluku and Papua provinces. Investment in water infrastructure is essential for achieving the Sustainable Development Goals, including dams, hydropower, water supply, sanitation, irrigation, and stormwater management (Grigg, 2019). Investment in water infrastructure is needed to meet the United Nations' Sustainable Development Goals from US$120–330 billion/year until 2030, compared with current investment of US$40–50 billion/year in Asia countries. However, addressing the financing gap requires spending with greater quality and efficiency, considering competing national policy goals and the distinctive characteristics of water infrastructure that make its financing more challenging (Borgomeo et al., 2023). Investments in basic infrastructure may not have an immediate positive impact on economic growth in the short term. However, the positive impact will be gradual and continuous, with various aspects creating sustainable economic growth.

To achieve high and sustainable prosperity through water infrastructure development in Maluku and Papua provinces, a strategic approach is required, segmented into short, medium, and long-term stages. Short-term strategies are immediate actions that should focus on assessing and prioritizing critical water infrastructure needs. This includes conducting comprehensive water resource assessments to identify gaps and urgent requirements for dams, irrigation systems, and water supply networks. Short-term investments should target quick-win projects that can demonstrate immediate benefits, such as upgrading existing infrastructure to improve efficiency and reduce water loss. Additionally, efforts should be made to secure funding from international donors and public-private partnerships to kickstart necessary projects. Initial capacity-building initiatives and stakeholder engagement will also be crucial to ensure the effective implementation of these projects.

For medium-term strategies over the next 5 to 10 years, the focus should shift towards expanding and modernizing water infrastructure based on the findings from the short-term assessments. This includes constructing new dams and hydropower facilities, developing comprehensive irrigation systems, and enhancing stormwater management practices. Medium-term strategies should also involve improving water sanitation and wastewater treatment facilities to ensure sustainable water quality. Strategic investments in technology and innovation can be leveraged to increase the efficiency of water infrastructure. Collaboration with regional and national policymakers will be essential to align these investments with broader development goals and ensure coordinated efforts. Long-term strategies for sustainable economic development beyond 10 years, and a focus on maintaining and upgrading infrastructure will be essential. Long-term strategies should emphasize the development of resilient infrastructure capable of adapting to climate change impacts and population growth. Investments should support advanced technologies and integrated water resource management practices to optimize water use across sectors. Additionally, fostering a culture of innovation and continuous improvement in water infrastructure management will be crucial. Long-term planning should also include strengthening institutional frameworks and securing sustainable financing mechanisms to ensure the continuous and effective development of water infrastructure in alignment with the United Nations' Sustainable Development Goals. By following these staged strategies, Maluku and Papua provinces can effectively address their water infrastructure needs, contributing to sustainable economic growth and high levels of prosperity in the future.

Conclusion

Discussions regarding the influence of water infrastructure to support leading commodities have been studied and analyzed in several countries. This research intends to analyze water infrastructure to support leading commodities in Maluku and Papua. The analysis uses the Location Quotient (LQ) technique and a spatial approach to provide an overview of water infrastructure and its relationship with leading commodities in eastern Indonesia. The research results show that water resources infrastructure is related to the housing settlement sector and agricultural commodities in North Maluku, Maluku, Papua, and West Papua. Based on an analysis that considers water needs for rice commodities and clean water needs for households, West Papua Province is experiencing a water supply capacity deficit. So, it is necessary to develop water infrastructure sustainably to meet community water needs. Increasing agricultural productivity can also increase Indonesia's food and economic security. The government must encourage investment, both domestic and foreign, to support the development of water infrastructure. This research has limited data obtained so future research is expected to be equipped with field data and the use of machine learning.

Limitation

The research into water infrastructure's role in supporting leading commodities in Maluku and Papua reveals several important findings. However, it also has notable limitations that impact the applicability and depth of its conclusions. One significant limitation is the reliance on secondary data sources. The absence of comprehensive field data restricts the accuracy and granularity of the analysis, potentially overlooking local variations and specific infrastructural challenges. Future research would benefit greatly from direct field observations and more detailed data collection to provide a clearer picture of the current water infrastructure status and its direct impact on commodity production.

Another limitation of the study is the method used for analysis. The Location Quotient (LQ) technique and spatial approach, while useful, may not capture all the nuances of how water infrastructure affects different commodities. These methods can provide a broad overview but might miss intricate relationships and causations. Incorporating advanced analytical techniques, such as machine learning algorithms, could enhance the analysis by uncovering complex patterns and relationships that are not evident through traditional methods.

The research highlights a critical deficit in water supply capacity in West Papua, emphasizing the need for sustainable development of water infrastructure. Implementing this conclusion requires a multi-faceted approach. Governments and stakeholders need to prioritize investment in water infrastructure, ensuring that developments align with the actual needs of agricultural sectors and residential areas. This could involve upgrading existing facilities, constructing new ones, and adopting innovative technologies to optimize water distribution and use. To address the identified water supply deficit effectively, both domestic and foreign investments should be encouraged. Government policies and incentives can play a crucial role in attracting these investments and facilitating partnerships between public and private sectors. Additionally, community engagement and local stakeholder involvement are essential to ensure that the infrastructure developed meets the specific needs of the population and agricultural sectors. Future research should aim to overcome the limitations of the current study by integrating field data and advanced analytical methods. This would provide a more robust and actionable understanding of the water infrastructure needs and its impact on commodity production. Such research could guide more effective policy-making and infrastructure development, ultimately supporting increased agricultural productivity and contributing to Indonesia's food and economic security.

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