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OPPORTUNITIES AND CHALLENGES OF SEAPLANE TRANSPORTATION MODES AS SUPPORT FOR CONNECTIVITY IN FRONTIER, REMOTE, DISADVANTAGED, BORDER (3TP) REGIONS OF INDONESIA

Ibnu Fauzi[1]✉, Ade Ratih Ispandiari[2]✉, Alan Putranto[3]✉

[1] ORCID: 0000-0002-0396-8928
[2] ORCID: 0000-0002-8274-5828
[3] ORCID: 0000-0003-4732-868X
[1] Research Center for Hydrodynamics Technology, National Research and Innovation Agency
Jl. Hidro Dinamika, Keputih, Kec. Sukolilo, Kota Surabaya, Jawa Timur 60112, **Indonesia**
[2] Research Center for Transportation Technology, National Research and Innovation Agency
Gedung Teknologi 2 Lantai 3 Kawasan Puspiptek, Serpong, Tangerang Selatan 15314, **Indonesia**
[3] Department of Civil Engineering, National Central University
No. 300, Chung-da Rd. Chung-Li city, Tao-Yuan 32011, **Taiwan, Republic of China**

ABSTRACT

Motives: Indonesia, as the largest archipelagic nation, faces significant connectivity challenges in 3TP regions. The term 3TP in Indonesia refers to regions categorized as *Terdepan* (Frontier), *Terpencil* (Remote), *Tertinggal* (Underdeveloped), and *Perbatasan* (Border). These areas are characterized by geographical remoteness, limited infrastructure, and economic disparities, necessitating innovative transportation solutions. The development of seaplane transportation presents a promising opportunity to address these issues, providing faster access to remote areas without extensive infrastructure requirements. Seaplanes align with national development goals, supporting equitable regional growth, enhanced mobility, and the achievement of Sustainable Development Goals (SDGs), particularly SDG 9 (Industry, Innovation, and Infrastructure), SDG 10 (Reduced Inequalities), and SDG 11 (Sustainable Cities and Communities). However, seaplane implementation in 3TP regions remains underexplored, with critical challenges including regulatory gaps, high operational costs, and technical limitations. This study investigates the feasibility of seaplanes as a solution to 3TP connectivity issues, emphasizing their potential to transform regional accessibility while identifying strategies to overcome existing barriers.

Aim: This research aims to identify the opportunities and challenges associated with seaplane transportation in Indonesia's 3TP regions, employing a qualitative case study approach. Data collection involved literature reviews and structured interviews with policymakers from the Regional Development Planning Agency (Bappeda) in selected districts. Utilizing SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, this study evaluates seaplanes' operational viability in diverse geographical contexts, highlighting strengths such as speed, minimal infrastructure needs, and domestic production capabilities. Concurrently, the research addresses weaknesses, including high

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

costs, limited skilled personnel, and operational constraints due to environmental factors. External opportunities like growing tourism and intermodal synergies are juxtaposed with threats such as regulatory inadequacies and energy accessibility issues. The study proposes a comprehensive strategy combining internal improvements with external support to maximize benefits and mitigate risks.
Results: The SWOT analysis reveals that seaplanes possess unique advantages for 3TP regions, offering expedited travel, reduced infrastructure dependency, and compatibility with Indonesia's vast water resources. However, implementation is hindered by operational limitations in adverse weather conditions, human resource shortages, and the high costs associated with procurement and maintenance. Key opportunities include expanding tourism sectors, enhancing intermodal transport systems, and leveraging geographical advantages to improve regional connectivity. Meanwhile, external challenges such as regulatory gaps, competition with lower-cost sea transport, and unequal energy distribution threaten to impede widespread adoption.
Stakeholder insights underscore the need for targeted strategies to overcome these challenges. Suggested interventions include identifying optimal waterbase locations, fostering industry collaboration to strengthen domestic production, and enhancing pilot and technical training programs. Additionally, government-backed financing and subsidies are recommended to address cost barriers, while regulatory reforms and energy infrastructure investments are vital for sustained operations. By implementing these measures, seaplanes can effectively address connectivity gaps, promote economic equity, and align with Indonesia's national development priorities and SDG commitments.

Keywords: policy, SWOT, territory, Indonesia's 3TP, strategy, SDGs

INTRODUCTION

Indonesia is the fourth most populous and largest archipelagic country in the world, with more than 17,500 islands (Martina et al., 2023). These geographical conditions make Indonesia rich in natural resources and on the other hand there is inequality in remote areas and islands (Akhyary et al., 2019; Hajad et al., 2023; Himawan, 2019). Obstacles faced in implementing equitable development on small and outermost islands are limited infrastructure conditions, transportation services are not yet fully accessible and independent, exacerbated by poor sea and land transportation systems and vulnerability to the impact of natural disasters (Firdatin & Gifary, 2021; Kerr, 2005; Prasetyo et al., 2019). Connectivity is an important aspect in efforts to address inequality between regions in Indonesia (Indriastiwi et al., 2023; Putra et al., 2019). This is in line with President Joko Widodo's agenda in Indonesia's development commitment which focuses on peripheral and underdeveloped areas, both in the outer islands and on the mainland, by strengthening economic, social and human resource development (Hartojo et al., 2022; Situmorang & Ayustia, 2019). Indonesia must start creating connectivity that can connect the islands of Indonesia (Andréfouët et al., 2022; Lembaga Ketahanan Nasional RI, 2017; Spencer et al., 2023). Connectivity that connects remote areas to major economic growth centers will have an impact on national economic growth, improving access to social services, health, education and economic opportunities that improve people's living standards (Nawir et al., 2023; Sandee, 2013; Wahyuni et al., 2022; Wardana, 2020).

The term 3TP in Indonesia refers to regions categorized as *Terdepan* (Frontier), *Terpencil* (Remote), *Tertinggal* (Underdeveloped), and *Perbatasan* (Border). These areas are characterized by their geographical, economic, and social challenges, making them a priority in national development policies (Ayunia et al., 2020; Fauzi et al., 2024; Krisdiyanti et al., 2023). Connectivity and accessibility problems in 3TP are closely related to several Sustainable Development Goals (SGDs), especially SDGs 9 (Industry, Innovation and Infrastructure), SDGs 10 (Reducing Inequality), and SDGs 11 (Inclusive, Safe, Disaster-Resistant and Sustainable Cities and Settlements). Efforts to increase

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

connectivity and accessibility in the area will support the achievement of sustainable development goals, especially those related to infrastructure development, reducing inequality, and inclusive and sustainable development of cities and settlements. Air transportation has been proven to be able to serve remote, geographically isolated areas more quickly than land and sea transportation (Bråthen & Halpern, 2012; Tusmar & Mora, 2015). Remote areas can be islands, outermost areas and areas with political requirements (Fageda et al., 2018). In this area it is very difficult to develop land infrastructure such as trains and roads, but there is potential to develop a seaplane/seaplane network to meet transportation connectivity needs (Ayuni et al., 2022; Hidayat et al., 2016; Hobbis, 2019; Iliopoulou et al., 2015). The development of aerospace technology is increasingly advancing rapidly, one of which is the emergence of many amphibious aircraft. A seaplane or seaplane is an aircraft that has a float on the bottom of its body which is useful for carrying out operations in water. Apart from that, it also has a landing gear system, so that at certain times it can still carry out operations to and from land (Ghifari & Ahyudanari, 2021).

Research on the use of seaplane transportation has been conducted by several academics, both in Indonesia and internationally, but the number of studies remains limited. Among them, Ghifari and Ahyudanari (2021) analyzed seaplanes on connectivity in South Halmahera Regency, with research results that seaplane transportation can save travel time significantly compared to using boat transportation. Another research conducted by Arif and Qiram (2021) discussed the opportunities and challenges of seaplanes as an alternative transportation in Indonesia. In their conclusion, it was stated that the existence of seaplanes could have a significant impact on economic growth, especially in Indonesia's coastal and marine areas, which has not been done much. Andrade et al. (2022) conducted research entitled Exploratory analysis of seaplane operations in Greece: insights from a survey and SWOT analysis, the results of the analysis concluded that the potential of seaplanes as a mode of transportation lies in increasing sustainable transportation, connectivity to remote areas and economic growth. However, there is still no comprehensive picture of the opportunities and challenges of the seaplane transportation mode as supporting connectivity in 3TP areas in Indonesia.

The aim of this research is to identify (based on SWOT (Strength, Weakness, Opportunity, and Threat) analysis) the most extraordinary opportunities and challenges based on the existing conditions of 3TP areas in terms of connectivity issues and the application of seaplane transportation modes in these areas and propose a "strategy formulation" regarding future actions and guidelines that need to be considered in order to maximize strengths and opportunities and answer the challenges of the seaplane transportation mode in 3TP areas in Indonesia. The contribution made by this research is that this research proposes an approach to building SWOT factors from a literature review related to seaplane transportation modes and connectivity in Indonesia's 3TP areas. Apart from that, it uses an expectation approach from policy makers or regional governments in 3TP Indonesia. Strategies originating from a policy maker-centred approach will be very relevant for seaplan modal development strategies. This also reduces the subjectivity of the research. To the best of our knowledge, there has been no research related to strategies for developing seaplane transportation modes in 3TP areas in Indonesia.

RESEARCH METHODOLOGY

This research methodology is qualitative research using a case study approach. Qualitative research is research that is descriptive in nature, tends to use analysis and makes the meaning process more visible. The qualitative data analysis method is a method of in-depth data processing using data from observations, interviews and literature (Meiryani, 2021). This method will help to understand the phenomenon in a specific context, namely the use of seaplanes as a mode of transportation to support connectivity in the Frontier, Remote, Disadvantaged, Border (3TP) areas of Indonesia. The following (Fig. 1) are the stages that can be followed for this research.

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

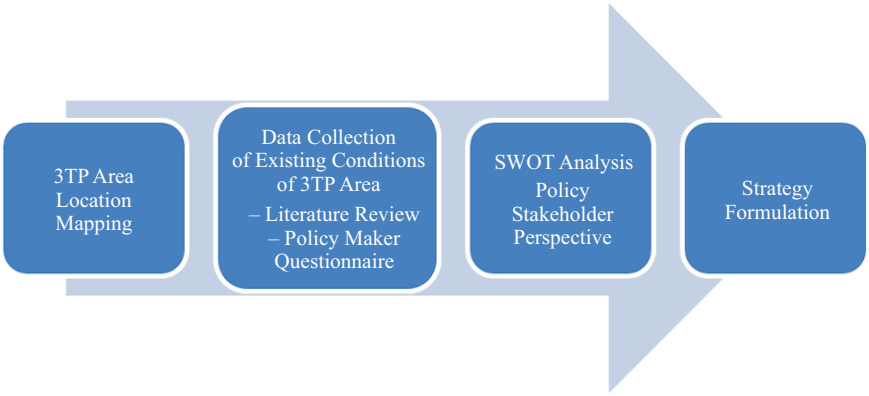

Fig. 1. Research Flow
Source: own elaboration.

Research Location

The locations for this study are frontier, remote, underdeveloped and border areas (3TP) referring to Presidential Regulation (Perpres) no. 63 of 2020 concerning Determination of Disadvantaged Regions for 2020–2024 and Presidential Regulation no. 118 of 2022 concerning the Master Plan for Management of National Borders and Border Areas for 2020–2024, there are 103 districts included in the 3TP area, with the majority being in the Papua Islands and Sumatra Islands. For more details regarding the distribution of the 3TP areas, see Fig. 2.

Data Collection

Data collection was carried out using center reviews and interviews via questionnaires. The literature review will be carried out by searching and collecting various literature references related to seaplane transportation modes and connectivity in Indonesia's 3TP areas. Data collection through a literature review is a process that involves identifying, collecting, and analyzing relevant information from written sources such as journals, scientific articles, and books related to the research topic being studied (Daniel, 2016; Snyder, 2019).

Data collection in the study was carried out using a standard questionnaire containing mostly closed questions (Aiyede & Muganda, 2023). When using a questionnaire, careful planning needs to be carried out, including designing questions, selecting respondents and analyzing the data appropriately (Marshall, 2005). Methods for collecting data through questionnaires can vary, such as filling it out yourself by the respondent or filling it out by a professional, filling it out individually or in groups. The questionnaire also includes a series of items that reflect the research objectives, including demographic questions and valid and reliable research instruments (Ponto, 2015). In this study, the questionnaire respondents were the Regional Development Planning Agency (*Bappeda*) in the 3TP area, the number of willing respondents was 12 respondents with a distribution according to Fig. 3. Which is quite representative of each region.

Bappeda was chosen because the governmental body has important tasks and functions in regional development planning, including preparing regional development plans, coordinating tasks, monitoring and evaluating the implementation of regional development plans, and providing guidance to relevant agencies in the region (Alhasanah et al., 2020; Lewerissa, 2016; Rosmayani, 2021; Saputra et al., 2022). The purpose of the questionnaire is to determine the perspective of policy makers regarding the existing conditions of the 3TP area regarding the opportunities for implementing seaplanes as a support for regional connectivity.

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

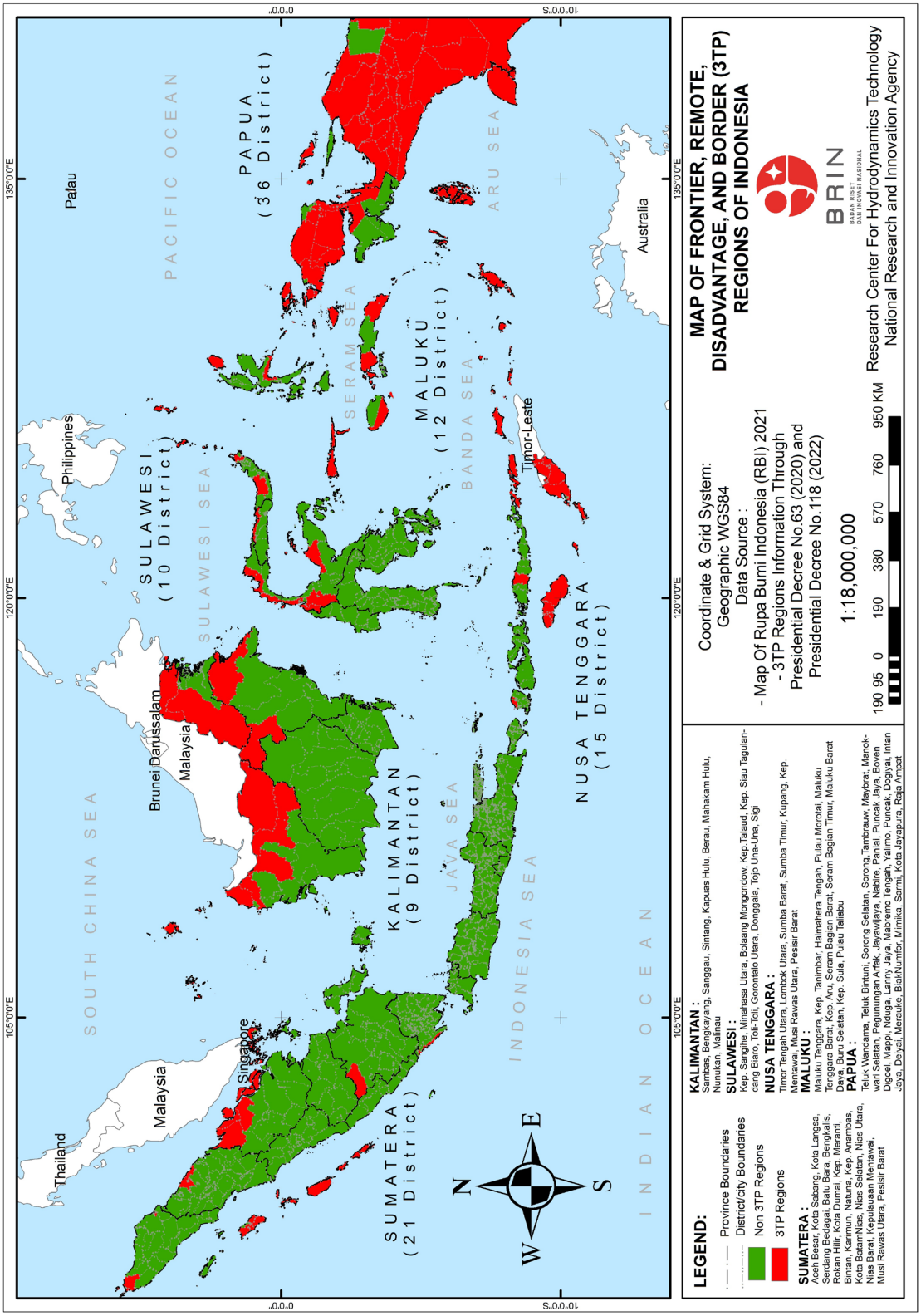

Fig. 2. Map of Frontier, Remote, Disadvantaged and Border Areas (3TP)
Source: own elaboration.

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

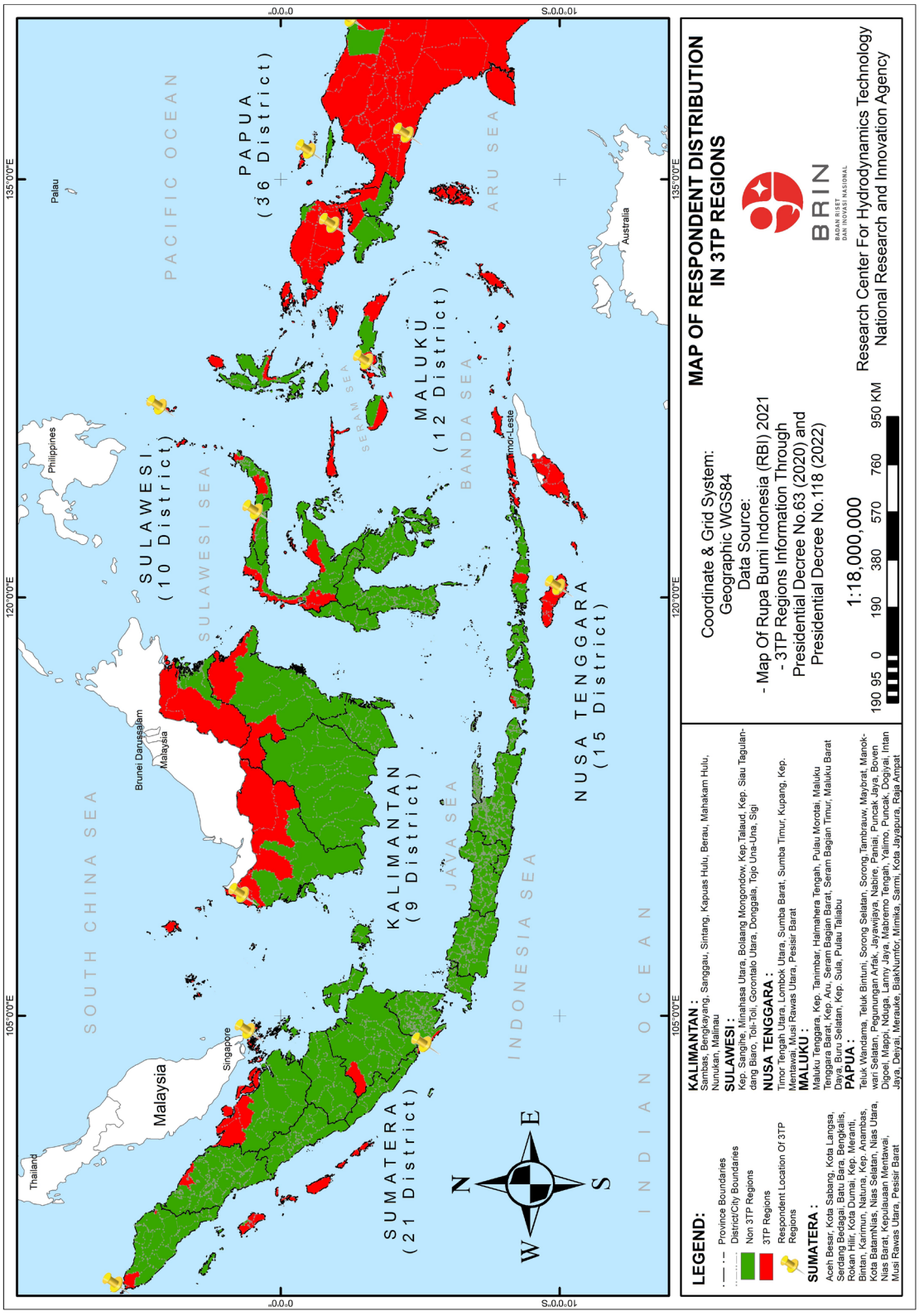

Fig. 3. Map of Respondent Distribution in 3TP Areas
Source: own elaboration.

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

Data Analysis

The data that has been collected is then analyzed to understand the opportunities and challenges of using seaplanes as a mode of transportation to support connectivity in the 3TP area. Data analysis can be done by creating a SWOT (Strength, Weakness, Opportunity and Threat) matrix to see the strengths, weaknesses, opportunities and threats of using seaplanes as a mode of transportation to support connectivity in the 3TP area. SWOT analysis was first carried out in strategic management research in the 1960s and 1970s (Sevkli et al., 2012). Most research related to strategic planning uses SWOT analysis, this applies to research in the transportation sector (Ispandiari et al., 2025). SWOT has 4 (four) components, including strengths, weaknesses, opportunities and threats. SWOT analysis or SWOT matrix is a strategy that helps identify the strengths and weaknesses of a strategic plan to achieve goals (Benzaken et al., 2022; Gao & Peng, 2011; Nassaji, 2015). In this study, SWOT is an analysis tool to assess the potential and challenges of seaplanes in the 3TP area. The use of SWOT analysis in this study aims to assess the potential and challenges of utilizing seaplanes in the 3TP regions. This tool provides a structured framework to identify and evaluate internal factors, namely strengths and weaknesses, as well as external factors, namely opportunities and threats, that influence the success of implementing this mode of transportation. SWOT analysis not only facilitates an understanding of the dynamics of potential and challenges but also plays a crucial role in the planning stage by offering insights into how strengths and opportunities can be leveraged, while weaknesses and threats can be mitigated. Through this approach, planners can design more effective and adaptive strategies to support connectivity in 3TP areas, which often face limitations in infrastructure and accessibility (Daniel, 2016; Phadermrod et al., 2019; Sahu et al., 2023). Furthermore, SWOT enables researchers to explore the potential of seaplanes, such as their flexibility in water-based transportation, while simultaneously identifying challenges such as high operational costs and limited supporting facilities. As a tool that has proven effective in various studies in the transportation sector, SWOT provides a scientific basis for recommending data-driven strategic steps. Therefore, this analysis becomes a critical component in formulating more efficient implementation strategies to optimize the role of seaplanes as a mode of transportation in enhancing connectivity in the 3TP regions.

Interpretation of Results

The results of the analysis are then interpreted to see a picture of the strengths, weaknesses, opportunities and threats of using seaplanes as a mode of transportation to support connectivity in the 3TP area.

DISCUSSION ANALYSIS

Existing Conditions of 3TP

The geographical conditions of the 3TP area are remote areas and small islands that are difficult to access. Connectivity that links remote areas to major economic growth centers has been proven to positively impact national economic growth (Sandee, 2013), as demonstrated by the Sea Toll Program initiated in 2015. This program successfully reduced price disparities and promoted economic equity, as seen in Morotai Island in 2020, where the price of steel bars decreased from Rp90,000 to Rp75,000 per unit, sugar from Rp14,000 to Rp12,000 per kilogram, and rice from Rp12,000 to Rp11,500 per liter. Additionally, local products such as fisheries could be directly shipped to economic hubs like Surabaya, enhancing economic opportunities for local communities. The development of strategic ports, such as Patimban, Kijing, and Gilimas in 2020, strengthened inter-island connectivity and supported goods distribution across 636 active ports. This infrastructure not only lowered logistics costs but also expanded access to social services, education, and healthcare in remote areas. Thus, improved connectivity through the Sea Toll Program and port infrastructure has enhanced living standards in remote regions and contributed

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

significantly to national economic growth (Wardana, 2020). The following (Fig. 4) is the percentage of poor people in the 3TP area.

The poverty rate in 3TP areas demonstrates a significant disparity compared to the national (Indonesia) average, highlighting complex development challenges in these regions. During the 2021–2023 period, the national (Indonesia) poverty rate gradually declined from 9.71% in 2021 to 9.4% in 2023. However, in 3TP areas, the poverty rate remained substantially higher, decreasing from 25.50% in 2021 to 24.29% in 2023. This stark disparity indicates that poverty levels in 3TP areas are nearly three times higher than the national (Indonesia) average. This phenomenon underscores the urgent need for more inclusive and locally tailored development strategies to accelerate poverty reduction in 3TP regions while promoting equitable development across Indonesia.

The issues currently facing the 3TP region are divided into 6 aspects, namely: education, health, community economy, facilities and infrastructure as well as accessibility, regional finances and regional characteristics. Connectivity almost affects all of these aspects, especially in aspects of education, health, community economy, facilities and infrastructure as well as accessibility, problematic issues (Gede & Mangku, 2018; Harruma, 2022; Iman et al., 2023). The development of the outermost areas of the archipelago in Indonesia is experiencing a gap compared to the development of other regions of Indonesia and neighboring countries (Notohamijoyo et al., 2021; Vinata et al., 2023; Wahid et al., 2023; Yarlina & Lindasari, 2015). Limited facilities and services in border areas make border communities become neglected communities. In this context, stranded refers to a condition where border communities are not looked after carefully by Indonesian government officials, both regarding the distribution of food needs and other life support facilities (Aji & Khudi, 2021; Rahman, 2019). Food distribution from the center (Indonesia) is still limited in quantity, considering the long distances combined with unsuitable road terrain (Ningtias et al., 2018; Pawlak & Kołodziejczak, 2020; Safitri, 2017).

There are several challenges in transportation connectivity in the outermost areas of the Indonesian archipelago. The outermost areas of the Indonesian archipelago have shallow waters that are difficult for large ships to reach (Cribb & Ford, 2009; Lampe, 2021; Schwerdtner Máñez et al., 2012; Yuniastuti et al., 2018). Wave conditions in the outermost areas of the Indonesian archipelago are quite high, reaching 1.5 meters to 2 meters as in Fig. 5. Apart from that, the condition of regional infrastructure is also inadequate.

The review of the above library becomes a reference for validating existing conditions through a questionnaire. The results of the questionnaire submitted to 3TP Regional planning policy makers revealed several obstacles faced in the area. As many as

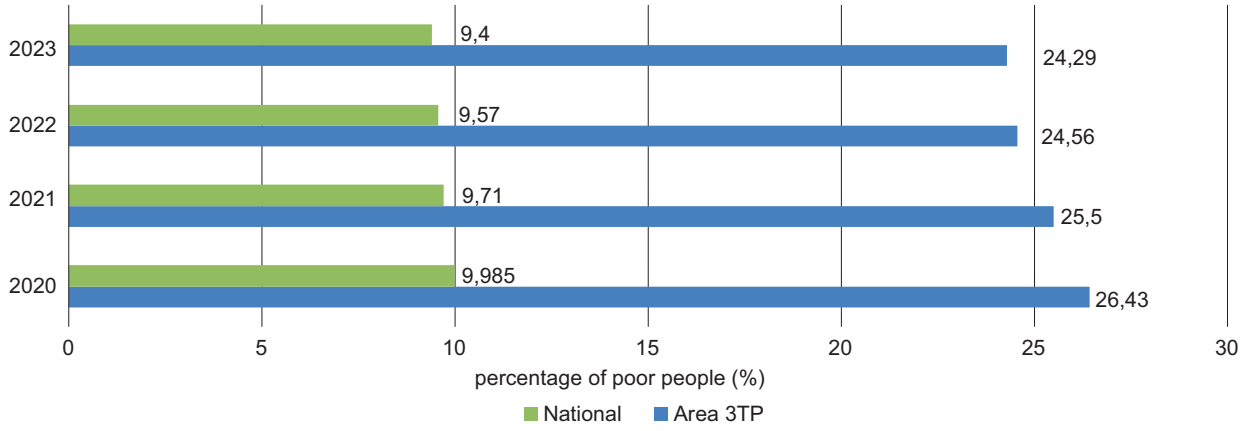

Fig. 4. Diagram of Percentage of Poor Population
Source: own elaboration based on (Prasetyo et al., 2022).

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

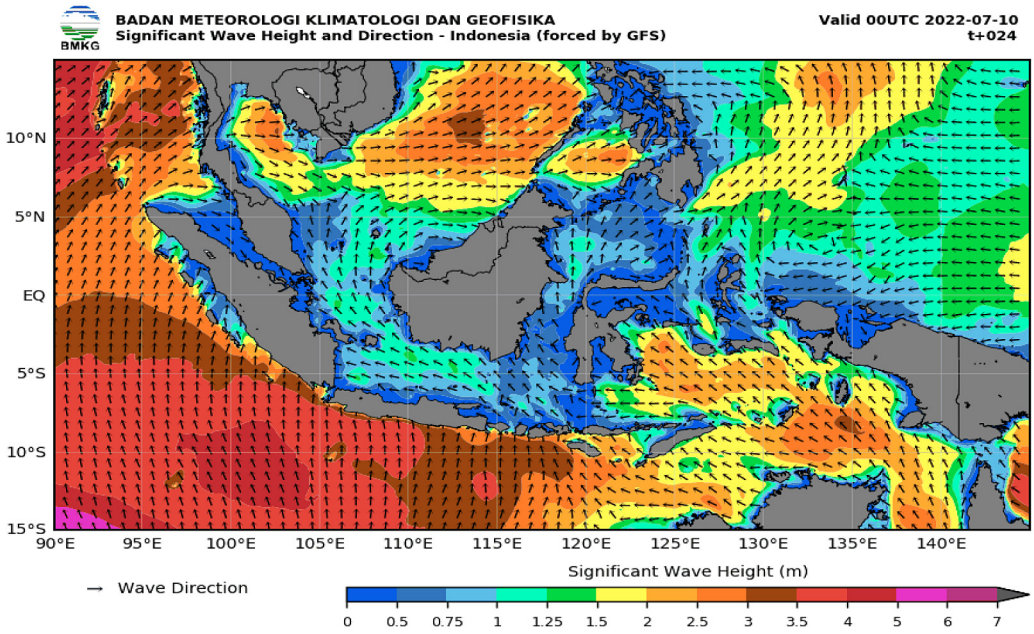

Fig. 5. Wave height in Indonesian waters
Source: own elaboration based on (Meteorology, Climatology and Geophysics Agency, 2022).

41.7% of respondents said that the lack of accessibility of underdeveloped areas to regional growth centers and weak logistics systems were the main obstacles. In addition, 25% of respondents revealed that there were socio-economic disparities in society in border areas which could give rise to jealousy, as well as several land and sea boundaries with neighboring countries that had not been resolved. In North Kalimantan, there are three major Outstanding Boundary Problems (OBP): the Pulau Sebatik Segment, the Sinapad River – Sesai River Segment, and the B2700 – B3100 Segment, as well as a Non-OBP area known as the New West Pillar AAA2. Additionally, four OBPs in West Kalimantan bordering Malaysia and two unresolved segments, along with two unsurveyed segments in East Nusa Tenggara (NTT) bordering Timor Leste, also remain unresolved. Low access to health and lack of market access are also obstacles with a percentage of 16.7%. Apart from that, the condition of minimal infrastructure and inadequate posts in border areas means that supervision of border areas is still weak and cases of cross-border violations occur (16.7%). In overcoming these obstacles, policy makers need to make comprehensive efforts to increase accessibility, reduce socio-economic disparities, improve infrastructure, and strengthen monitoring of border areas in 3TP areas.

SWOT Analysis

The factors that influence the competitiveness and seaplane transportation mode as a supporter of 3TP regional transportation connectivity are presented in the following SWOT (Strength, Weakness, Opportunity, and Threat) matrix.

Strengths Analysis

1. Faster than other modes of transportation
   Amphibious aircraft, such as seaplanes, offer higher travel efficiency and can be faster than other water-based modes of transportation, such as ferries and motorboats, particularly for short distances and remote destinations (Gobbi et al., 2011; Iliopoulou et al., 2015). For example, the Twin Otter amphibious aircraft can reach a speed of 337 km/h

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

Table 1. SWOT analysis

SWOT	Beneficial (Beneficial)		Harmful (Dangerous)
Internal	Strengths		Weaknesses
	S1	Faster than other modes of transportation	W1	Limited operations are influenced by the height of water waves
	S2	No major infrastructure is required for construction	W2	Uncertainty in domestic production of seaplanes
	S3	There is a domestic aircraft industry (PT. Dirgantara Indonesia)	W3	Human resources (HR) are still low
	S4	There is a special pilot school for seaplanes at the Indonesian Pilot Academy (API) Banyuwangi	W4	Investment and maintenance costs are quite high
External	Opportunities		Threats	
	O1	The geographical conditions of 3TP are in accordance with seaplane mode	T1	Lack of/incomplete regulations to permit massive seaplane operations
	O2	The tourism sector continues to grow	T2	Cheaper mode of sea transportation
	O3	Low accessibility to airports/ports	T3	Obstacle animals (bird migration)
	O4	Synergy with other modes of transportation (as a complement)	T4	Unequal access to energy/fuel.

Source: own elaboration.

with a distance of up to 231 km. The seaplane boarding process is also shorter because there is no need to arrive early like at the airport (Gobbi et al., 2011). Apart from that, the N219 Amphibious aircraft, currently being developed by PT Dirgantara Indonesia (PTDI), has a maximum speed of 296 km/h at an altitude of 10,000 feet. This aircraft is designed for water landings and has a passenger capacity of 19 people (Sutrisno, 2021). Compared to ferry boats, seaplanes offer shorter travel times, such as the trip from Ambon City to Banda Naira which only takes 45 minutes with the N219 Amphibi (Kartakusuma, 2020). Seaplanes are also superior to helicopters in terms of speed, comfort, and flexibility (Castelluccio et al., 2016). Overall, Seaplanes can be relied on as a fast and comfortable mode of transportation, as they provide efficient access to remote areas, enhance connectivity in archipelagic regions, and support tourism and logistics, particularly in environments where traditional transportation modes are less effective.

2. No major infrastructure is required for construction
A waterbase, or water airport, is a combination of an airport and a seaport, which allows the use of equipment and equipment from both (Iliopoulou et al., 2015; Malik et al., 2021). Waterbase construction is more economical and efficient in land use compared to other infrastructure (Ghifari, 2021). Seaplane does not require a rigid runway, airport or permanent port like planes and ships in general, because it can take off and land on land and water (Adhi Nugroho et al., 2020; Xiao et al., 2020). The N219 Amphibious seaplane has good flexibility, can operate on land, lakes, large rivers, bays and sea. The construction of amphiports (airports for amphibious aircraft) is also easier and cheaper than conventional airports (Sutrisno, 2021).
3. There is a domestic aircraft industry (PT. Dirgantara Indonesia)
PT Dirgantara Indonesia (PT. DI) is the first and only aviation industry company in Indonesia and Southeast Asia, founded in 1976 and owned by the Indonesian government (Wicaksono et al., 2018). The company not only produces planes and helicopters, but also weapons, and provides training and maintenance services for aircraft engines (Yosua & Tjakraatmadja, 2015). PT. DI is collaborating with the National Institute of Aeronautics and Space (LAPAN) in developing

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

the N219 Amphibious aircraft variant which can function as a seaplane, with the ability to take off and land on the water surface (Kartakusuma, 2020). This collaboration aligns closely with Indonesia's characteristics as an archipelagic country, where such an aircraft can provide practical solutions to enhance connectivity across its vast network of islands (Adhi Nugroho et al., 2020).

4. There is a pilot school specifically for seaplane mode at the Indonesian Pilot Academy (API) Banyuwangi Strengthening and preparing Indonesia's human resources by establishing a special Seaplane pilot school at the Indonesian Pilot Academy (API) Banyuwangi which will open in 2022. The Ministry of Transportation has inaugurated the Seaplane Amphibian Land To Sea Cessna 172 SP which will support the opening of the Seaplane Class Rating and training program being the only one in Southeast Asia (API Banyuwangi, 2021; Prasojo et al., 2020).

Analysis of Weaknesses

1. Limited operations influenced by water wave heights
   Seplane can operate up to category 2 conditions on the Beaufort wind scale, also called Light breeze with average wind speed conditions at a height of 10 meters above ground level 6–11 km/hour, wave height 0–0.914 meters. This includes strict restrictions in offshore areas and operating in high wind conditions (Gobbi et al., 2011). For the N219 Amphibious seaplane type, the permitted wave height for take-off is 0.907 meters and the permitted wave height for landing is 0.902 meters. Seaplanes can generally operate through level 3 sea conditions, with limited operations in higher seas for waves 550 feet or longer (Odedra et al., 2004; Xu et al., 2023). In assessing seaplane operating factors, water conditions such as current speed, wind speed, wave height, and tides have a significant influence (Chen et al., 2022; Shabrina et al., 2023).
2. Uncertainty in domestic seaplane production
   The main problem faced in the development of the N219 Amphibious aircraft, especially in terms of budgeting, lies in securing sufficient funding to support research, development, testing, and production while balancing operational costs and meeting industry certification requirements. In development planning until 2024, the budget was allocated through LAPAN and BPPT, but with organizational changes, LAPAN and BPPT merged and incorporated into the BRIN organization, affecting the development planning that had been determined until 2024 (Dirgantara, 2021). There are three stages of research into the N219A aircraft which still require large funding. First, research related to improving aircraft performance. Second, the development of composites in aircraft floaters. Lastly, development of N219A integration. BRIN is no longer able to fully finance all N219A research and development activities as it was when the project was still held by LAPAN (Wahidin, 2022).
3. Human resources (HR) are still low
   Indonesia faces significant challenges in the development of new technologies, including amphibious aviation, due to limited human resources (HR) and inadequate technical infrastructure. This condition is one of the primary reasons for the slow progress in this sector (Devi et al., 2020). A major obstacle in the development of amphibious aircraft in developing countries such as Indonesia is the lack of skilled human resources, despite the country's vast potential in this field. The primary challenge lies in insufficient training and qualifications of the workforce. The number of pilots for General Aviation aircraft, including amphibious planes, in the Asia-Pacific region – particularly Indonesia – is significantly lower compared to regions like the United States, reflecting a substantial gap in training and the availability of competent personnel (Liem, 2018). In Indonesia, the majority of amphibious aircraft pilots are foreign nationals, with only 12 Captains and 7 First Officers (Arif & Qiram, 2021). This disparity is particularly concerning, considering Indonesia's archipelagic nature, which necessitates the development of amphibious aviation to support inter-island connectivity.

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

4. Investment and maintenance costs are quite high
   Seaplanes are a suitable solution for the 3T regions, although their implementation requires significant initial investment and relatively high maintenance costs. The infrastructure needed for operating seaplanes is not extensive, but the rental cost of seaplanes remains high, and their maintenance is more expensive compared to land-based aircraft due to additional components such as floats and specialized landing systems that require more intensive care (Denz et al., 2007; Helmi, 2020; Pagonakis et al., 2018). The procurement cost of a seaplane is estimated to be around $81 million per unit in 2007, significantly higher compared to ferries, which range from $10 million to $50 million for large vessels. In terms of operational costs, seaplanes are also more expensive, with an operational cost of approximately $3,739 per flight hour, whereas ferries have lower operational costs, ranging from $500 to $1,500 per hour depending on the type of vessel (Gobbi et al., 2011; Leyva & Leonel, 2012; Prayitno et al., 2022). Therefore, the private sector can play a role in developing seaplane-based transportation; however, government intervention is crucial, especially for 3T areas. Government support through subsidies and policies that can boost other sectors, such as sustainable tourism, is necessary to achieve economic sustainability in this transportation system (Su & Rogers, 2012; Woo et al., 2021).

Opportunity Analysis (Opportunities)

1. The geographical conditions of 3TP are in accordance with seaplane mode
   Seaplane is very suitable for accessing and monitoring remote and hard-to-reach areas (Khoirunnisa et al., 2021; Schwoerer et al., 2022; Shabrina et al., 2023). Seaplanes can improve connectivity in areas close to water (Andrade et al., 2022). Development of the N219 Amphibious aircraft to fulfill pioneering flight routes or routes to reach underdeveloped, remote, outermost and border islands (3TP) (Hakim, 2022). Easy usability among places with many islands and areas with (lots of) water resources (Gobbi et al., 2011). Some types of seaplanes, such as the N219 Amphibi, are equipped with landing gear that allows them to land not only on water but also on land (Odedra et al., 2004).
2. The tourism sector continues to grow
   Seaplane can make a positive contribution to the growth of the tourism sector (Camilleri, 2020; Chen et al., 2022; Gao, 2014; Hafizah et al., 2023; Shabrina et al., 2023). He development of the N219A aircraft is very relevant to support equal access to transportation in Indonesia which does not yet have airport infrastructure and also for tourism development (Kementerian PPN/Bappennas, 2022). Indonesia's excellent coastal and marine potential provides opportunities for the community in the tourism industry, with 75% of marine resource potential providing a significant contribution to national development (Safitri et al., 2024). The coast is considered strategic in tourism development, with a coastline length of around 81,000 km which has the potential to be developed as a marine tourism area (Bhudiharty, 2019; Ratnasari & Bhudiharty, 2020). Tourism's contribution to National GDP continues to increase, with average growth of 11% from 2016–2019 (Ayuni et al., 2022). The number of domestic tourist trips and foreign tourist visits also experienced a significant increase during this period (BPS-Statistics Indonesia, 2021). This is the market share and demand for seaplane development, especially in 3TP areas, the majority of which are islands (Maulana & Benita, 2017; Mukrimin & Acciaioli, 2023; Suriadi et al., 2022).
3. Low accessibility to airports/ports
   Uneven infrastructure conditions are an obstacle for the 3TP area (Kalalo & Samingun, 2021; Sunarti, 2018). Not having many transportation nodes such as airports and ports is a problem, and road access is very poor (Gede & Mangku, 2018; Kementerian Desa, 2020). The development of N219A is very relevant to support equal access to transportation in Indonesia, which does not yet have airport infrastructure, as well as tourism development (Kementerian PPN/Bappennas, 2022).

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

4. Synergy with other modes of transportation (as a complement)
   Seaplane operations cover a wide range of uses, namely its ability to serve intermodal. The Seaplane is uniquely capable of operating between population centers and to remote areas (Arif & Qiram, 2021). Seaplanes can be synergized with various modes of public transportation, both direct competitors such as ferries and planes and land transportation such as trains and buses (Castelluccio et al., 2016; Iliopoulou et al., 2015; Pagonakis et al., 2018).

Threat Analysis (Threats)

1. Lack of/incomplete regulations to permit massive seaplane operations
   Until now there are no regulations or technical documents related to planning and determining the location of water aerodrome in Indonesia. The operation of seaplanes is often opposed, many people say that the development of seaplanes in Indonesia has obstacles, one of which is licensing (Arif & Qiram, 2021). Licensing is an important aspect in implementing the seaplane transportation mode in Indonesia because it involves safety, security and aviation regulations (Gao, 2014; Xiao et al., 2020).
2. Cheaper mode of sea transportation
   Air traffic is considered expensive in general by people. Seaplane ticket prices can be too expensive for general travel (as operating costs include high investment costs for the aircraft and landing location) (Cockcroft & Lameijer, 2012; Gobbi et al., 2011; Singh et al., 2023). Seaplane travel is on average 6–10 times more expensive than other options such as ferries and high-speed trains (Andrade et al., 2022).
3. Obstacle animal
   Bird strikesis the occurrence of bird collisions, either in groups or individually, on airplanes during the flight process. A bird strike incident can cause minor to serious accidents, such as breaking the airplane cockpit glass and burning the airplane engine, the consequences of which are very detrimental economically (International Civil Aviation Organization, 2011; Sodhi, 2002). Mostly, bird disturbances occur near airports at low altitudes (Mora et al., 2021), seaplane is a category of low-cruise aircraft. Indonesia is included in two world shorebird migration routes, namely the East Asian-Australian Flyway and the West Pacific Flyway (Alikodra, 2018). Migratory birds travel a long way to their resting places in tropical areas (Septian, 2017). Indonesia has at least 15 important locations for coastal migratory birds, namely on Sumatra Island (mangrove forests and mud fields of Tanjung Bakung, Tanjung Datuk, Musi River Delta), Java Island (Muara Angke, Muara Gembong, Indramayu-Cirebon coast, Bengawan Solo Delta and Brantas), Bali Island (Suwung), NTT (Sumba, Kupang Beach), Kalimantan Island (Berau Island, Layangan Island, Tanjung Sembilang), Sulawesi Island (Lampuko-Mampi, Lanteboeng, Salowatu River Estuary, North Coast of Bone Bay), Papua (Kimaan Island, Rawa Biru, Wasur National Park (Alikodra, 2018). Most of these areas are 3T areas, these birds really like swamp, mangrove and rice field environments.
4. Unequal access to energy/fuel
   Seaplanes still have to run on fossil fuels (Uddin et al., 2020), so it still depends on the costs of this type of fuel, which is known to be volatile. At least for the next few years (Favro et al., 2016). The government still has unfinished homework regarding energy. One of them is equal distribution of energy (pontas.id, 2019). Even though Indonesia has the potential for renewable energy in Indonesia (Nasrudin et al., 2022; Setyowati, 2021).

Policy Stakeholder Perspective

Faced with the question of obstacles or hindrances to the implementation of seaplanes in the 3TP region, planning policy makers in the 3TP region obtained results as shown in the following picture (Fig. 6).

The implementation of seaplanes in the 3TP regions faces several significant challenges as identified by policymakers. The primary obstacle is the high cost

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

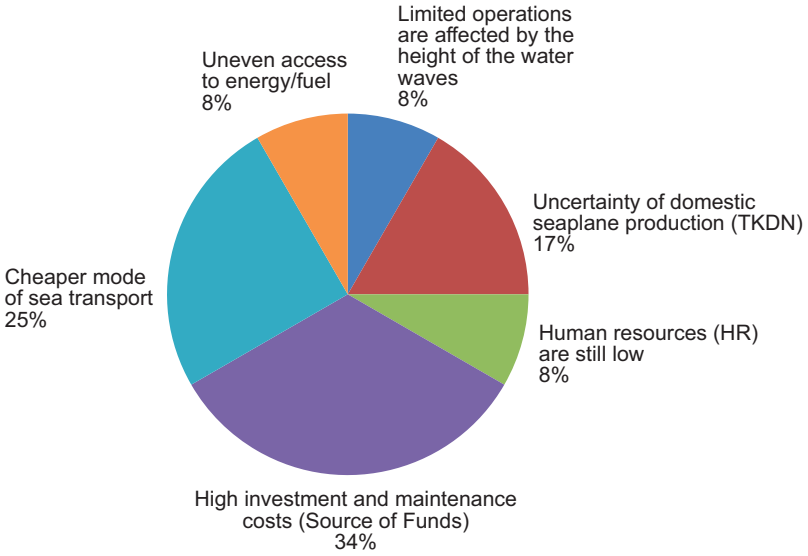

Fig. 6. Seaplane Implementation Obstacles
Source: own elaboration.

Table 2. Coping Strategy

	Harmful (Dangerous)		Strategy
Internal		Weaknesses	
	W1	Limited operations are influenced by the height of water waves	1. Selection of seaplane waterbase locations in calm/protected waters, with the option of using coastal protection structures (breakwater)
	W2	Uncertainty when domestic seaplanes will be produced	2. Trengthening synergy and collaboration between institutions and industry in building the domestic seaplane industry
	W3	Human resources (HR) are still low	3. Opening opportunities to increase the competency of pilots, cabin crew and technicians involved.
	W4	Investment and maintenance costs are quite high	4. Opening more competitive financing opportunities with government guarantees
External		Threats	
	T1	Lack of/incomplete regulations for permitting massive seaplane operations	1. A study will immediately be carried out regarding regulatory needs and problems in the field, both technical and non-technical
	T2	Cheaper mode of sea transportation	2. Using subsidy options and implementing Public Service Obligations (PSO)
	T3	Obstacle animals (bird migration)	3. Choose a location that is safe enough. Equipping waterbase operational facilities and providing human resources in accordance with Air Transportation Director General Regulation No. SKEP/277/XII/2010 concerning Instructions and Procedures for Civil Aviation Safety Regulations Part 139-09 (Advisory Circular CASR Part 139-09)
	T4	Unequal access to energy/fuel.	4. Opening opportunities for establishing energy shelters in 3TP areas

Source: own elaboration.

✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

of investment and maintenance (34%), encompassing funding needs for procurement, operations, and supporting infrastructure. Additionally, the availability of cheaper sea transportation alternatives (25%) serves as a more economically viable option for local communities, thus hindering the adoption of seaplanes. The uncertainty surrounding domestic seaplane production, particularly the low level of local content (17%), further raises doubts about the sustainability of this industry. Other impediments include the limited availability of skilled human resources (8%), unequal access to energy or fuel supplies (8%), and geographic conditions such as high water waves, which restrict operational feasibility (8%). These interrelated factors underscore the complexity of addressing the barriers to deploying seaplane technology in the region.

Coping Strategy

Examining the results of the SWOT matrix (Strength, Weakness, Opportunity, and Threat) and the Policy Stakeholder Perspective above, the strategy formulation offered in this research is a combination strategy of internal issues and external issues on Weakness and Threat which is depicted in table 2.

By overcoming internal weaknesses and facing external threats, the development of seaplanes as a mode of transportation in the 3TP area can be carried out more effectively and efficiently.

CONCLUSION

The geographical challenges faced by the 3TP (remote, disadvantaged, and outermost) areas significantly hinder economic development, access to social services, health, and education, aligning these challenges with several Sustainable Development Goals (SDGs), notably SDG 9, SDG 10, and SDG 11. These regions exhibit poverty rates exceeding national averages, underscoring the critical need for intervention. SWOT analysis reveals that seaplanes hold potential as a viable transportation mode, offering strengths such as speed, minimal infrastructure requirements, and domestic production capabilities. Nonetheless, they are constrained by operational limits due to environmental factors, high costs, and gaps in human resource competency. Opportunities like tourism growth and synergy with other transport modes present promising avenues, but external threats – ranging from regulatory gaps to cheaper sea transport alternatives – must be addressed. Strategic implementation, leveraging the strengths and opportunities while mitigating weaknesses and threats, is crucial for the sustainable integration of seaplanes in 3TP areas.

To address the identified challenges, policymakers propose a combination of strategies that synergize internal and external factors. Internally, selecting waterbase locations with calmer conditions, enhancing collaboration between industries and institutions, and fostering human resource development through targeted training programs are prioritized. Moreover, government-supported competitive financing options could mitigate the high investment and maintenance costs associated with seaplanes. Externally, addressing regulatory deficiencies and operational challenges through comprehensive studies, subsidies, and Public Service Obligations (PSOs) is imperative. Establishing energy hubs and selecting operational sites free from animal interference, such as bird migration zones, further bolster the viability of this transport solution. These integrated strategies not only strengthen the feasibility of seaplane implementation but also contribute to equitable regional development and the achievement of SDGs, paving the way for a transformative approach to transportation in 3TP areas.

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw

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✉ibnu.fauzi@brin.go.id, ✉ader006@brin.go.id, ✉alanputranto@g.ncu.edu.tw