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STRATEGIES FOR SUSTAINABLE COASTAL FISHERY PORT DEVELOPMENT: A CASE OF PASONGSONGAN COASTAL FISHING PORT TECHNICAL SERVICES UNIT, SUMENEP REGENCY, INDONESIA

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Abstract

The operations of the Coastal Fishing Port Technical Services Unit (Port-TSU henceforth) in Pasongsongan face several challenges that obstruct port activities. First, the anchorage has become more shallow due to the sedimentation resulting from the Angsono River's erosion. Second, the limited area of the anchoring pool makes it difficult for fishing boats to anchor. Third, the shipping lanes, just like the anchorage, have become more shallow due to sedimentation from the mouth of the Angsono River. Fourth, the limited loading and unloading docks result in long queues, which not only delay ship activities in the queue but also reduce the quality of catches. Fifth, the damaged roads and drainage systems around the port pose a challenge to the loading and unloading activities. Considering these challenges, this research aims to evaluate Port-TSU facilities in Pasongsongan, understand the causes of Angsono River sedimentation, and formulate development strategies for the Port-TSU. The results show that the condition of Port-TSU facilities is generally adequate according to Minister of Maritime Affairs and Fisheries Regulation No. 08 of 2012. However, the rapid erosion of the Angsono watershed caused the shallowing of the anchor pool and shipping lanes. The underlying causes are monoculture farming practices, lack of agroforestry implementation, and the absence of agricultural terracing systems. The development strategy recommendation is to dredge the anchorage and shipping lanes and extend the pier. Other recommendations include implementing watershed management through agroforestry and terracing systems in the Angsono River watershed to minimize erosion and increase loading and unloading capacity by adding a conveyor belt to accelerate processes and reduce ship queues.

Keywords : Sedimentation, Angsono River Erosion, Coastal Fishing Port (Port-TSU), Watershed Management, Development Strategy

INTRODUCTION

A fishery port is designed for the berthing and mooring of fishing vessels to load and unload their catch or replenish supplies before heading seaward (Lubis, 2012). A fishery port serves as the center of fishermen's activities, so its function is central to the capture fisheries industry. Kamaluddin (2002) and Fauzi (2005) believe that a fishery port, as an economic development infrastructure, plays a significant role in the economic growth of a region.

The Coastal Fishery Port Technical Service Unit (Port-TSU henceforth) of Pasongsongan is located in Pasongsongan Village, Sumenep Regency, on the northern coast of Sumenep at coordinates of 06°53' and 113°39'. Based on Permen KP No.08/PERMEN-KP/2012 about the Fishery Port, a fishery port consists of land and waters around it with specific borders, functioning as places of government administration and fishery business system, utilized as mooring and berthing of fishing boats and loading and unloading of fish, complete with facilities for marine safety and activities to support fishery port. The facilities include primary, functional, and supporting facilities.

Developing the fishery ports is part of improving the capture fisheries system in terms of infrastructure. In addition to providing facilities for docking, processing, and distributing fish catches, a fishery port also ensures optimal services for fishermen as the primary users of the facilities. As one of the fishery ports, Pasongsongan Port-TSU must provide adequate services for fishing boats to unload their fish catches. The existing facilities must be functionally optimized and able to accommodate the berthing of fishing vessels at Pasongsongan. By understanding the facilities needed, the quantity, size, and type of facilities to be built or developed can be determined to meet the requirements of capture fisheries activities. This understanding of usability and estimation will help prioritize the development of facilities (Prasetyowati, 2017).

The development of fishery ports is expected to provide economic benefits to the community and positively affect the sustainable management of resources. Nonetheless, there are several issues at Pasongsongan Port-TSU that hinder the operationalization of the port. These issues include 1) the shallow anchorage due to sand sedimentation, (2) the limited space of the anchorage, which cannot accommodate the berthing of fishing boats, especially those from outside Pasongsongan, (3) the shallow shipping lanes as a consequence of the shallow anchorage, making it difficult for ships entering and exiting the port for mooring, (4) the limited loading and unloading docks, which cause long queues of ships, and (5) deteriorated the complex's road conditions and clogged drainage due to damaged cover materials, which disrupt fishing vessel loading and unloading activities. Based on these issues, this research aims to (1) assess the condition and utilization of port facilities, (2) examine the factors causing sedimentation in Angsono River, and (3) formulate strategies for the development of the Pasongsongan Port-TSU in Sumenep Regency.

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METHODS

This research was conducted from January to May 2022 at Pasongsongan Port-TSU in Sumenep Regency, East Java. This location was chosen due to its potential for abundant fishery resources and its being equipped with the most comprehensive port facilities in Madura. It is currently undergoing promotion for an upgrade. The data used in this study include primary and secondary data. Primary data were obtained from (1) field observations consisting of the Angsono River survey activities and the up-land area of the Angsono River watershed observations and (2) in-depth interviews with key informants, including the Head of the Capture Fisheries at Pasongsongan Port-TSU, the Head of Pasongsongan Port-TSU and the Consultant for the Development Project of Pasongsongan Port-TSU. Meanwhile, secondary data was obtained from relevant literature and documents related to the research topic.

Aligned with the research objectives mentioned, the first goal is to assess the condition and utilization of port facilities. To achieve this, the researcher uses a qualitative descriptive analysis of the existing conditions at Pasongsongan Port-TSU based on the standards outlined in the Minister of Marine Affairs and Fisheries Regulation Number 8 of 2012. Second, in examining the factors causing sedimentation in the Angsono River, we conducted a qualitative descriptive analysis based on the data obtained from observations and assessments of the Angsono Watershed. Lastly, in formulating strategies for developing the Pasongsongan Port-TSU in Sumenep, we utilized the Analytical Hierarchy Process (AHP) as an analytical tool. The stages of the AHP method include: first, the formulation of development program criteria covering the following variables: (1) port docks, (2) berthing basins, (3) navigation channels in and out of the port, and (4) internal road infrastructure and drainage system in the port area. Second, we determined the alternative development program variables, including (1) facility capacity, (2) facility completeness, and (3) facility layout. Then, the eigenvalues are calculated by creating a pairwise comparison matrix for criteria and alternative variables on a scale of 1 to 9. The scale is considered the best for expressing opinions (Saaty, 1993). Figure 1 presents the AHP.

1. The Preparation of Hierarchy

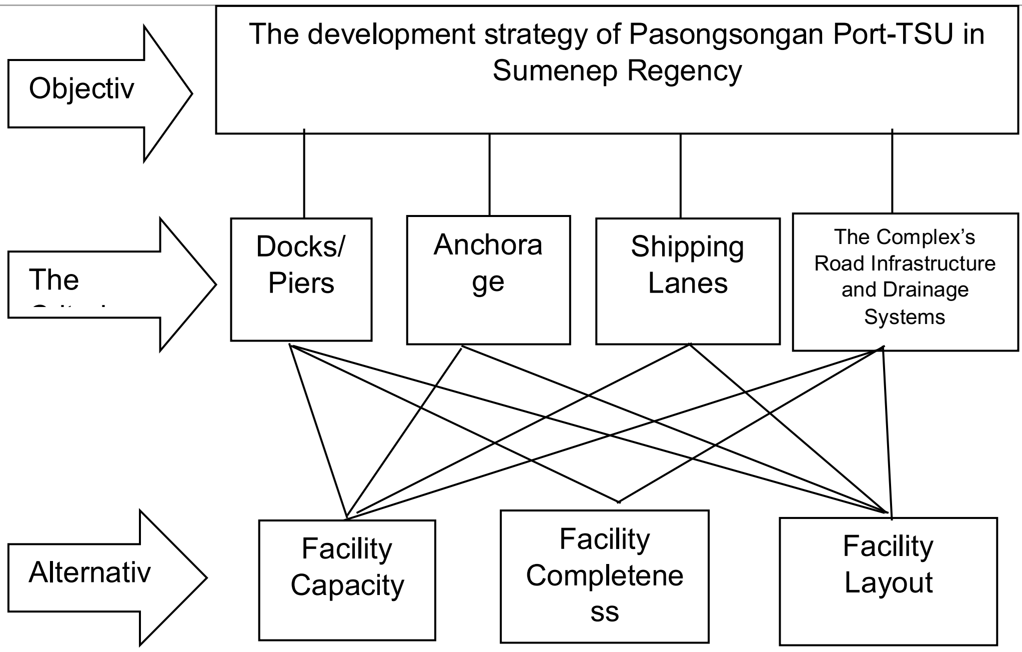

Figure 1: The Preparation of Hierarchy Structure

2. **The Assessment of Criteria and Alternatives:** The scale and the definition of qualitative opinions from the comparison matrix by Saaty are shown in Table 1.

Table 1: The Pairwise Comparison Values

Scale	The explanation
1	The criteria/ alternative A is equally important as criteria/ alternative B
3	A is slightly more important than B
5	A is more important than B
7	A is significantly more important than B
9	A is extremely more important than B
	In case of uncertainty between two close values

Source: Saaty, 1993

3. **Priority Determination**: For each criterion and alternative, pairwise comparisons are used. The relative comparison scales are then processed to determine the relative rankings of all alternatives. Both qualitative and quantitative criteria can be compared using predefined judgments to generate qualities and priorities. The

qualities or the priorities are calculated through matrix manipulation or by solving mathematical equations.

4. **Ratio Consistency**: is a parameter used to examine whether the pairwise comparisons between variables, calculated through matrix operations, have produced a consistent priority ranking.

RESULTS AND DISCUSSION

The Overview of the Pasongsongan Port-TSU, Sumenep Regency

The Pasongsongan Coastal Fishing Port Technical Services Unit (Port-TSU) is located in Pasongsongan Village, Pasongsongan District, Sumenep Regency, Madura Island, East Java, Indonesia. The Port-TSU was built on 24 March 1982 as a fish auction building and was inaugurated by the Director General of Fisheries, Abdu Rachman. The establishment was a response to the demand for adequate port facilities to support the rapidly growing fishing industry in the area. Pasongsongan Port-TSU started as a simple dock with limited loading and unloading facilities. Over time, the dock saw a significant development and became an important center of economic activities, with adequate facilities for loading and unloading, storing, and distributing fishery catches.

Table 2 shows the minimum facilities of Pasongsongan Port-TSU according to the standards of coastal fishing port status as per Ministerial Regulation No. 8 of 2021.

Table 2 The Primary Facilities of Pasongsongan Port-TSU

Facilities	Unit	Standard	Available	Compliance status
Berthing Facilities	GrossTon	For fishing vessels ≥ 10 GT	10-20 GT	Compliant
Dock Length	Meters	Dock length ≥ 100 m	210.3 m	Compliant
Berthing Basin Capacity	Vessel Units	Able to accommodate ≥ 30 vessels	40	Compliant
Depth	LWS	Depth ≥ (-2) LWS	-1 m	Not Compliant
Land Area	Ha	≥ 5 Ha	4 Ha	Not Compliant

Source: Processed from primary data, 2022

The minimum standard for ports with a coastal fishing status per Ministerial Regulation No. KP. 8 of 2012 equals or exceeds the standard for moorings for ships of 10 gross tonnage (GT). The current Pasongsongan Port-TSU has a maximum ship mooring of 20 GT, which has met the feasibility standard of being a coastal fishing port. However, the moorings at Pasongsongan Port-TSU are still insufficient to accommodate the number of ships. As such, most ships rest outside the anchorage, i.e., at the estuary and on the west side of the reclamation land. The current number of ships in Pasongsongan is 126, and only 30 (23.8%) can moor in the anchoring pool. This condition is exacerbated by the perpetual increase in sedimentation level, which narrows the anchorage area.

The number, size, and type of fishing gear at Pasongsongan Port-TSU, Sumenep Regency, are shown in Table 3:

Table 3 The number of ships at Pasongsongan Port-TSU with a size range of 0–20 GT

No	Type of Ship	Ship Size (GT)	Quantity	Percentage
1	Fishing/Trap	0 -5	46	36,5
2	-	5,1 – 10	0	0
3	Purse-seine	10,1 – 20	80	63,5
	TOTAL		**126**	**100,0**

Source: Processed from primary data, 2022

The number of ships measuring 0-5 GT is 46 or 36.5% of the total at the Pasongsongan Port-TCU, 39 of which are equipped with fishing gear and seven with fishing traps. Only ten ships are moored at the port, and the remaining 36 are moored at the estuary on the east side of the port. The Pasongsongan Port-TSU's anchorage is located adjacent to the estuary. Fishermen still moor their vessels at the estuary instead of the anchoring pool. In fact, some fishermen who live near riverbanks moor their vessels at the riverbanks close to their houses or fish storage warehouses.

There are 80 ships (63.5%) sized between 10.1 and 20 GT with purse-seine fishing gear. Thirty ships are moored at the anchorage, 35 at the estuary, and 15 on the west side of the harbor outside the anchor pool. The west side of the port is earmarked for the future development of Pasongsongan Port-TSU. Fishing boats are safely protected in this area during the east monsoon season. However, during the west monsoon season, fishermen have to move their boats to the anchorage and the estuary because the existing anchorage cannot accommodate all the fishing boats in Pasongsongan.

A pier is a marine establishment to dock and moor ships, load and unload catches, and fill supplies for fishing at sea. Based on KP Ministerial Regulation No. 8 of 2012, the minimum standard length of a pier is 100 meters. The current pier length at Pasongsongan Port-TSU is 210.3 meters, which has met the suitability standards for mooring, loading and unloading, and restocking supplies before sailing. However, not all parts of the 210.3-meter pier can be utilized. The existing building construction consists of four stairsteps on the south and two on the west sides. Each stairstep is five meters long, so the total length is 30 meters. Fishing boats use these stairs for loading and unloading activities. If more than six ships are loading and unloading fish, other ships must queue because the facility cannot accommodate all. In addition, fishing activities in Pasongsongan are regulated using a one-day fishing system. Most boats do not carry ice cubes for cool storage to maintain the quality of the fish catches. This long queueing time delays the handling of fish catches, which often deteriorates fish quality.

Anchorages are dock waters for docking operations and maneuvering. The feasible number of ships docked at the Pasongsongan Port-TSU pool is 40, which is in accordance with Ministerial Regulation No. KP. 8 of 2012 states that a standard port's pool should accommodate at least 30 ships. The anchorage at Pasongsongan Port-TSU covers an area of 2.4 hectares, which is sufficient for more than 30 ships. However, there are 86 other ships docked outside the anchorage. This means that the ships are at risk of drifting and sinking in case of extreme weather.

The main facilities at the Pasongsongan Port-TSU that do not meet the feasibility standards are (1) the depth of the anchorage, which is less than one meter from the minimum standard of two meters from the lowest tide, and (2) the land area, which is only four hectares from the five-hectare standard. The depth of the anchorage is less than one meter due to sedimentation from the estuary, which moves into the anchorage area due to the tidal and wind pressure during the east monsoon season. The high increase in sedimentation in the estuary is greatly influenced by the large amount of sand and clay material carried by the flow of the Angsono River during the rainy season. The color of the river water at this time is light brown to dark brown, indicating that the till layers in the upstream area of the Angsono River have been eroded. Deposits of sand and mud material accumulate at the estuary and are carried by sea currents during the east and west monsoon seasons, so the mud and sand immediately enter the anchorage. This event repeats itself continuously throughout the year, causing the depth of the anchorage to become increasingly shallow. Dredging by Pasongsongan Port-TSU cannot be relied on to overcome the silting problem because the budget is sourced from the central government budget (APBN), which is limited. In addition, the capacity of the sand pump machine to dredge the mud deposits is limited. If the machine breaks down, the maintenance costs can be costly. In this case, the capacity of Pasongsongan Port-TSU to effectively and efficiently budget dredging activities will be even lower. Therefore, other efforts are needed to slow the shallowing due to erosion material sedimentation from the Angsono River, which include implementing watershed management.

The Drivers of Sedimentation of the Angsono River

Sedimentation that fills the Pasongsongan Port-TSU area is spread over the Angsono River estuary, the anchorage, and the shipping lanes in and out of the port. The thickness of mud and sand deposits in the port area increases by an average of 30-100 cm per year, varying according to the distance from the river bank. The area around the edge of the estuary is the most affected by mud and sand deposits, which can reach 100 cm per year. The movement of sand and mud material around the estuary of the Angsono River is influenced by wind-induced tides, especially during the east and west monsoon seasons. When the sea water recedes, the wind pressure is high, pushing mud and sand deposits scattered outside the port to enter the shipping lanes where ships enter and exit the port and into the anchorage. As a result, shipping lanes are becoming shallow, making it difficult for ships with a tonnage of over 10 GT to pass. Meanwhile, the demand for anchorage services is high, especially with the arrival of large tonnage ships from other areas, such as Lamongan, Tuban, and Central Java. Shallowing in the anchorage reduces the carrying capacity. Of the 80 ships with a tonnage of more than 10 GT, only 30 (37%) can be moored in the anchorage. The rest are on the riverbank and the west side of the port, which is a reclamation area. The mooring capacity in this anchorage will continue to decrease as the area affected by sedimentation becomes wider.

Based on field observations using the river tracing method from the estuary to the upstream of the river, which reaches 8.84 km, the following information was obtained. First, the dominant crops around the river banks are coconut plants. Second, at the back of the coconut plantations, there is a community agricultural cultivation area with a monoculture farming pattern dominated by corn, peanuts, and tobacco. Third, the farmers' land plots do not have a terracing system, meaning that the land plots are mostly parallel to the contour of the land slope so that the speed of surface water flow is fast. Fourth, farmers are unfamiliar with the agroforestry farming system, with most farming areas left open without shade from perennial plants, especially on the land embankments. With an agroforestry system, more litter will be on the ground surface. This litter is rich in organic elements, which can improve soil structure and increase permeability and water-holding capacity (Rahman et al., 2016).

The erosion happens in three stages sequentially: detachment, transportation, and sedimentation (Chay Asdak, 2007). The erosion in the Angsono watershed is caused by rainwater. With the conditions of agricultural cultivation land as mentioned above, the types of surface erosion in the watershed are splash, sheet, rail, and gully erosions.

Splash erosion occurs when raindrops, with their kinetic energy, hit the surface of an open field, resulting in small splashes that release topsoil particles. These loose soil particles are then washed away by runoff and fill the Angsono River. Sheet erosion occurs when rainwater and runoff erode a thin layer of the soil surface in sloping areas as they flow to a lower area (Chay Asdak, 2007). Rainwater has more kinetic energy, so it has a greater erosion effect than runoff (Schwab et al., 1981). The hills 100-200 meters from the Angsono River have a slight slope of 8-15%. The runoff is relatively slow at around 5-10 meters per minute, so the effect on the soil layer is not severe. According to Yusuf et al. (2018), 48% of the erosion severity is determined by the slope level. The more extreme the slope levels are, the more severe the rail erosion will be. In any case, soil particles caused by runoff water are then concentrated in water channels.

The rainfall in the Pasongsongan sub-district is high, reaching 1800-2000 mm/yr. The high-intensity rains result in large runoff, which then forms small ditches in the area and cause gully erosion (Chay Asdak, 2007). This type of erosion often occurs in areas with slopes of 15-30% in areas less than 50 meters from rivers, especially on the surface that is not covered by grass and coconut trees. The ditches may become deeper along with the rainfalls from year to year.

The erosion in the Angsono watershed is attributable to the failure to implement an agroforestry system, which combines seasonal crops (such as corn and beans) with perennial crops. Aside from reducing the water runoff rate, the perennial plants' roots can filter rainwater in the soil layer. Therefore, Naharuddin (2018) states that agroforestry can help maintain the hydrological function of a watershed and influence water flow by adding land cover with cultivated trees and hedges. The land cover can 1) intercept rainwater before it falls to the ground so that much of it is retained in the canopy until it evaporates, 2) reduce the power of rainwater that hits the ground, and 3) allow the water to stay in the ground surface longer with the help of trees and vegetation.

From the economic point of view, losses from practicing agroforestry can be minimized by choosing perennial plants with high economic value but are resistant to drought, such as cashews and *siwalan* (lontar palm) trees. The loss due to allocating land for perennial plants can be compensated by the profit gained from the sales of the perennial plants' yields. In fact, the loss from land allocation, which reduces the yield of corn or beans, will not be as significant as the yield obtained from the cashew or *siwalan* harvests once or twice a year. *Siwalan* trees are tall and can be planted on embankments. The shadows cast by the trees do not have much influence on the productivity of corn and beans. In addition, *siwalan* trees will not compete with the *polowijo* plants cultivated as the main crop.

Another cause of massive water runoff is the failure to implement a terracing system by all existing farmers. Most farmers build embankments only based on the boundaries of their land area. In fact, in every plot of farmer's land, open slopes are not compartmentalized according to the terracing system.

Pasongsongan Port-TSU Development Strategies

The problem to be resolved is broken down into variables according to criteria and alternative levels and then arranged into an Analytical Hierarchy Process (AHP) structure. The goal of the AHP structure is the development of the Pasongsongan Port-TSU in Sumenep Regency. At the top level, the goal is the structure construction, and the lower level shows the criteria and alternatives. In-depth interviews were conducted with pre-selected key informants to compare the scale of interests and priorities for developing port facilities, including piers, anchorages, shipping lanes, and complex roads and drainage. The scale is extremely more important, significantly more important, more important, slightly more important, and equally important. Setting these priorities is crucial, considering the limited budget while the need for building facilities is pressing. In this way, the costs incurred will be more effective and efficient because the budget allocation can be directed according to the priority scale.

1. Criteria Level

At the criteria level, using AHP analysis, the factor eigenvalues for each variable are obtained, with the largest being the first priority and the smallest factor eigenvalues being the lowest priority.

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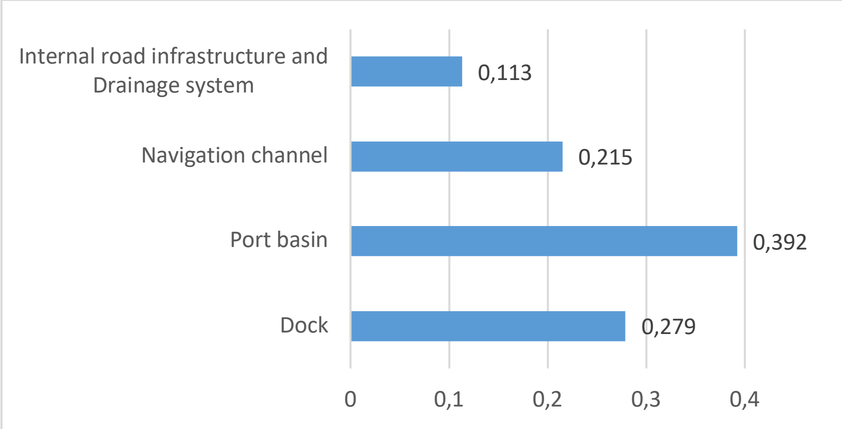

Figure 2 The Eigenvalue of Factor Variables for Criteria Level

From the perspective of basic port facilities, the development priority for the Pasongsongan Port-TSU in Sumenep Regency is an anchorage, with an eigenvalue of 0.392, followed by a pier, with an eigenvalue of 0.279, and a shipping lane with an eigenvalue of 0.215. The high demand for anchoring for fishing boats increases rapidly every year. Currently, the anchorage capacity can only accommodate 30 ships out of 126 existing ships. This means that the capacity is less than 24%. Numerous ships from areas outside Pasongsongan stop at this port, so the demand for anchorage is high. According to planning from the East Java Provincial Marine Fisheries Service, Pasongsongan Port-TSU is projected to become a fishing port with vessels with a tonnage of over 30 GT.

Although sedimentation remains a classic problem in this port, pier development is still the second priority. In line with the development of anchorage, the development of piers must follow so that anchoring activities and loading and unloading fish and supplies can be more effective. Then, the next priorities are shipping lanes, complex roads, and drainage systems.

2. Alternative Level

At the alternative level, the variables analyzed are 1) the existing facility capacity or the maximum ability to cater to various activities and services, 2) the range of facilities (completeness) or the features and equipment available at the port to support operational activities and services, 3) the facility layout or the spatial arrangement or placement of various facilities at the port.

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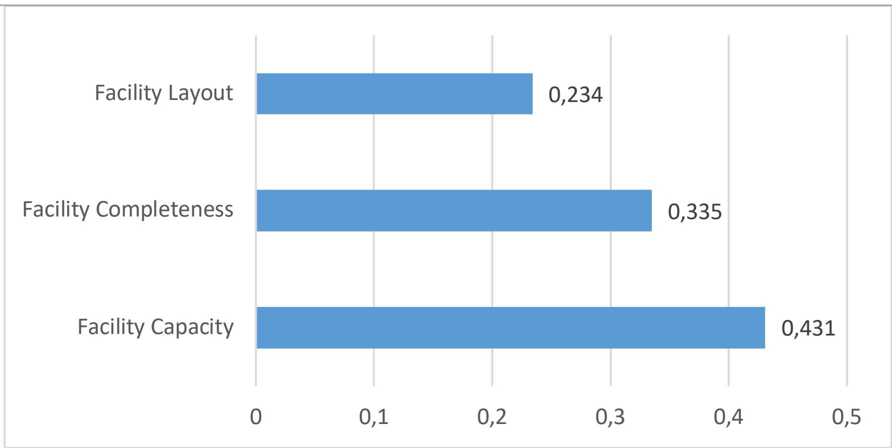

Figure 3 Eigenvalue of Factor Variables for Anchorage

Based on the AHP results for the anchorage development alternative, the first priority is the layout variable, with a factor eigenvalue of 0.435. The second priority is the capacity variable, with a factor eigenvalue of 0.318. The third priority is the completeness variable, with a value of 0.246. This shows that empirical observations on the condition of the anchorage match the feasibility standards according to Ministerial Decree No. KP. 08 of 2012. However, the depth of the port pool is currently around minus one (-1) meter, so ships have difficulty entering the anchorage for loading and unloading. Pasongsongan Port-TSU has to carry out annual sand dredging in the anchorage using a sand pump machine to reduce the impact of sedimentation. The strategy in developing anchorage is to avoid sand sedimentation, which hinders the flow of ships entering and exiting the port pool. This could be achieved by creating a new anchorage at a more protruding location toward the sea (to the north and to the west side), with a depth based on data on the sea map of minus two (-2) meters and beyond.

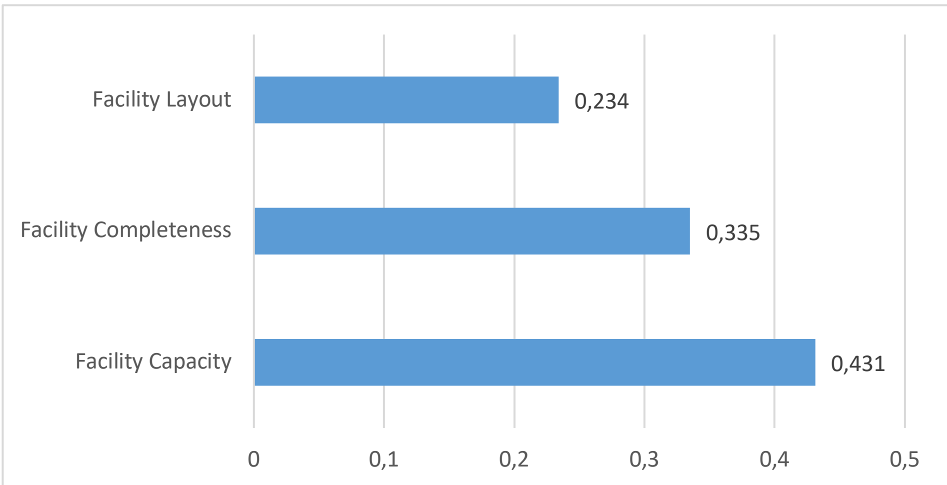

Figure 4 Eigenvalue of Factor Variables for the Dock

The priority scale for dock development is obtained from the results of AHP analysis according to the sequence of factor eigenvalues as follows: 1) the port capacity with a factor eigenvalue of 0.431, 2) the range of facilities (completeness) with a factor eigenvalue of 0.335, and 3) the facility layout with a factor eigenvalue of 0.246. These findings about the pier conditions show that the suitability standards of Ministerial Regulation No. KP. 08 of 2012 have been met. This suggests that the capacity needs to be increased in the development of the pier. Out of the 211.3 meters, only 30 meters (14%) are used. There are two stairsteps on the west side and four on the south side, which means that the loading and unloading service can only serve six ships at a time. Meanwhile, the total number of purse-seine ships at UPT PPP Pasongsongan is 80. This causes a long queue for ships to unload fish. As a result, fish may be damaged and only suitable for fishmeal raw material. The community has attempted to overcome this problem using conveyor belts, increasing the fish unloading capacity from six to 12 vessels in one unloading cycle.

CONCLUSION

The Pasongsongan Port-TSU in Sumenep has significant potential in the fisheries sector. Generally, the port facilities at Pasongsongan Port-TSU meet the standards as a Coastal Fishery Port (PPP) according to Ministerial Regulation of Marine Affairs and Fisheries No. 08 of 2012 (PER-KP No.08/PERMEN-KP/2012). The existing conditions of the basic facilities at Pasongsongan Port-TSU include an adequate anchorage for vessels ranging from 10 to 20 GT, a dock length of 210.3 meters, and an anchorage that is able to accommodate 40 vessels. However, the depth of the berthing basin does not meet the feasibility standard. It is only -1 meter deep compared to the required standard of -2 meters. Similarly, the available port land area of 4 hectares is still below the standard requirement of 5 hectares.

The factors causing sedimentation in the Angsono River are massive erosion, including splash, sheet, rail, and gully erosion. The high erosion rate in the Angsono River watershed is caused by environmentally detrimental farming practices, characterized by the absence of 1) terracing systems, 2) agroforestry practices, and 3) monoculture crop cultivation systems, such as corn, beans, and tobacco, without incorporating perennial crops that can conserve soil and water in the Angsono watershed.

The development strategy of Pasongsongan Port-TSU is prioritizing the reorganization of the anchorage. The reorganization should focus on the layout by relocating or shifting it towards the west side with a depth of -2 meters. Meanwhile, the development of the dock should focus on increasing capacity by adding stairstep capacity. The recommendations are 1) addressing farmers' concerns about a decrease in agricultural income by implementing an agroforestry system, such as planting high-value crops like cashews or *siwalan,* and 2) expediting ship loading and unloading by providing a conveyor belt facility.

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