Open Access, December 2021
p-ISSN : 2087-9423
e-ISSN : 2620-309X
J. Ilmu dan Teknologi Kelautan Tropis, 13(3): 379-394
https://journal.ipb.ac.id/index.php/jurnalikt
DOI: https://doi.org/10.29244/jitkt.v13i3.35311

SUSTAINABLE STRATEGY ON MARINE SPATIAL PLANNING OF TIWORO ARCHIPELAGIC

STRATEGI KEBERLANJUTAN PEMANFAATAN RUANG KEPULAUAN TIWORO

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ABSTRACT

Sustainable marine spatial planning in small islands requires a more comprehensive management strategy. Unsustainable use problems and issues in both land and seascape need a strategic formulation to manage Tiworo Small Island in the future. This study aimed to formulate the strategy for sustainable marine spatial planning of the Tiworo Small Islands. The rapid Appraisal for Land Use (Raplanduse) method was used to assess the sustainability and sensitivity of the attributes used in this study. The formulation of management strategies was carried out based on the levels of influence and dependence on sensitive attributes analyzed by the prospective analysis method. The results showed that the sustainable use of small islands in the Tiworo Islands varied, ranging from good, bad to less sustainable. Sensitive attributes observed in the ecological dimension were suspended solid materials and seawater surface temperature. In the social dimension, the sensitive attributes assessed were the conflict incidence among residents and human resources. Attributes observed in the economic dimension were income level, availability of business capital, and fisheries catch production. In the legal and institutional dimensions, the sensitive attributes observed were land ownership status and area zoning. Strategic management was developed based on these sensitive attributes, including increasing community adaptation capacity, controlling land-use in watershed areas in the mainland, developing business diversification, regulating spatial utilization, and improving the quality of human resources.

Keywords: attribute sensitivity, management strategy, sustainability

ABSTRAK

Kompleksitas persoalan lingkungan dan kesejahteraan masyarakat di Kepulauan Tiworo menuntut adanya strategi kebijakan pengelolaan ruang yang lebih komprehensif. Isu pemanfaatan secara tidak berkelanjutan adalah faktor utama yang membutuhkan penanganan berupa formulasi strategi pengelolaan pulau kecil di Kepulauan Tiworo. Penelitian ini bertujuan untuk merumuskan strategi kebijakan pengelolaan ruang pulau-pulau kecil yang berkelanjutan. Metode yang digunakan untuk menilai keberlanjutan dan sensitivitas atribut adalah metode Rapid Appraisal for Land Use (Raplanduse). Strategi kebijakan pengelolaan dilakukan berdasarkan tingkat pengaruh dan ketergantungan atribut-atribut sensitif yang dianalisis dengan analisis prospektif. Hasil penelitian menunjukkan bahwa tingkat keberlanjutan pemanfaatan ruang pulau-pulau kecil di Kepulauan Tiworo cukup bervariasi, mulai dari kategori baik, buruk, hingga kategori kurang berkelanjutan. Atribut sensitif dalam dimensi ekologi adalah material padatan tersuspensi, dan suhu permukaan laut. Dalam dimensi sosial atribut yang sensitif adalah kejadian konflik, dan sumber daya manusia. Dalam dimensi ekonomi adalah atribut tingkat pendapatan, ketersediaan modal usaha, dan produksi tangkapan. Dalam dimensi hukum dan kelembagaan atribut yang sensitif adalah atribut status kepemilikan lahan, dan zonasi kawasan. Kebijakan pengelolaan berdasarkan atribut-atribut sensitif tersebut meliputi peningkatan kapasitas adaptasi masyarakat, mengendalikan pemanfaatan lahan di wilayah DAS di daratan, mengembangkan diversifikasi usaha, menertibkan penggunaan ruang, dan meningkatkan kualitas sumber daya manusia.

***Kata kunci**: keberlanjutan, kebijakan pengelolaan, sensitivitas atribut*

I. INTRODUCTION

Marine spatial planning in small islands is meant to increase the value-added to the existing space. Various activities are carried out on small islands, such as conservation, mariculture, education and training, fisheries and marine activities, agriculture, settlements (Permen KP No. 20/2008), and marine tourism, such as in Gili Trawangan, Gili Meno, and Gili Air (Kurniawan *et al*., 2016). These activities prove that the existence of small islands has multi-use in supporting fisheries and marine development, including in Tiworo Small Island.

Tiworo Small Islands, located in the West Muna District of the Southeast Sulawesi Province, have inhabited local people for many years. Long-term inhabitation affects the sustainability of the surrounding ecosystems and environment. Land-use change and vegetation loss are among the negative impacts of inhabitation (Mekonnen *et al*., 2018; Rotinsulu *et al*., 2018). They also cause domestic waste to release significant ammonia concentration (Cao *et al*., 2017; Chen, 2018), although its concentration has still been below the standard regulated by the Ministry of Environment No. 51/2004 (Ketjulan *et al*., 2019). However, it needs to anticipate how to manage organic matter in the future.

The Tiworo watershed also causes significant pressures toward environmental and resource sustainability in Tiworo Islands. Six rivers have contributed total suspended solid (TSS) mattes into the Tiworo watershed and its influence coastal water of Tiworo Small Island. The six rivers are Soga, Remba, Wadahu, Umba, Guali, and Tiworo River. Analysis of satellite imagery in 2000 showed that TSS matter having a concentration of 0.95 mg/L was spread up to 1.5 km from the mainland. In 2018, the concentration of suspended solid matter had reached 8.5 km from the mainland (Ketjulan *et al*., 2019). The increase of spreading area will possibly increase with the increase of land-use activities in the mainland.

Aside from settlements and watershed issues, the area has also faced an over-fishing condition in the capture fisheries, which are the primary income for the local people. Fisheries data showed that fish production decreased in the period 2014-2017. The decrease became apparent in 2018, where the fish production from 49,602 tonnes in 2017 decreased to 33,504 tonnes in 2018 (DKP Provinsi Sulawesi Tenggara 2019). La Sara & Astuti (2015) confirmed the decrease of fish production followed by crab production, including in the fishing ground area of Tiworo Small Islands. The decrease in fish production has been affected the income and welfare of the fishermen in the West Muna, Bombana, and South Konawe Districts which use Tiworo Strait as their fishing ground. Other areas have also been affected by the decreasing fish production in the Tiworo Small Islands.

The government of West Muna District has declared that the Regional Medium Term Development Plan (*Rencana Pembangunan Jangka Menengah Daerah*) year 2017-2022 is the guideline for regional development, including fisheries and marine development. The Southeast Sulawesi Provincial government has also declared Provincial Regulation No. 9/2018 concerning Zoning Plan of Coastal and Small Islands. Unfortunately, these two regulations are not sufficient to overcome numerous complex issues and problems regarding land and seascape allocation and direction in Tiworo Islands, such as increasing number of people inhabiting the small islands, decreasing fish production and community welfare, high pressure on and degradation of coastal ecosystem, increasing run-off sedimentation from estuary and limited alternatives for livelihood development (e.g., mariculture and fish processing) in Tiworo Islands. To overcome these problems, it is necessary to provide spatial planning (zoning) as part of marine spatial planning based on sustainable

development and to formulate a sustainable management strategy. This study aimed is to formulate sustainable management strategy on marine spatial planning of Tiworo Islands.

II. RESEARCH METHODS

This study was conducted from January to April 2018 in Tiworo Islands, West Muna Regency, Southeast Sulawesi Province. Study locations were Balu, Tiga, Santigi, Mandike, Tasipi and Bero Small Islands (Figure 1). Ecological aspects were determined by measuring ecological parameters such as the state and condition of coral reef and mangrove ecosystem, land-use of small islands, seawater surface temperature (SST), and the total suspended solid (TSS) materials. Survey method was carried out by interviewing coastal communities as inhabitant of the Tiworo Islands to collect economic, social, legal and institutional aspects.

This study was carried out in several phases, started with identifying issues and problems in ecological, social, economic, legal and institutional dimensions by using direct observations in the study sites. The study subsequently determined the influential attributes in each dimension and prioritized the attributes for each dimension. The last phase of this study was formulation of sustainable management strategy for Tiworo Islands. The priority of management strategy was analyzed using the prospective analysis method (Godet, 1994; Godet *et al.*, 1999).

The primary data were collected using Rapid Appraisal for Land Use (Raplanduse) Method, derived from Rapid Appraisal for Fisheries (Rapfish) Method, with various dimensions to establish multi-dimensional scaling (MDS) approach (Pitcher & Preikshot, 2001; Susilo, 2003).

2.1. Defining Attributes

There were numerous attributes focused in this study. Ecological, economic, social as well as legal and institutional dimensions were focused in this study to assess the sustainable use of Tiworo Islands. Those demensions and attributes were defined based on literature studies which were developed by Pitcher & Preikshot (2001) and Susilo (2003).

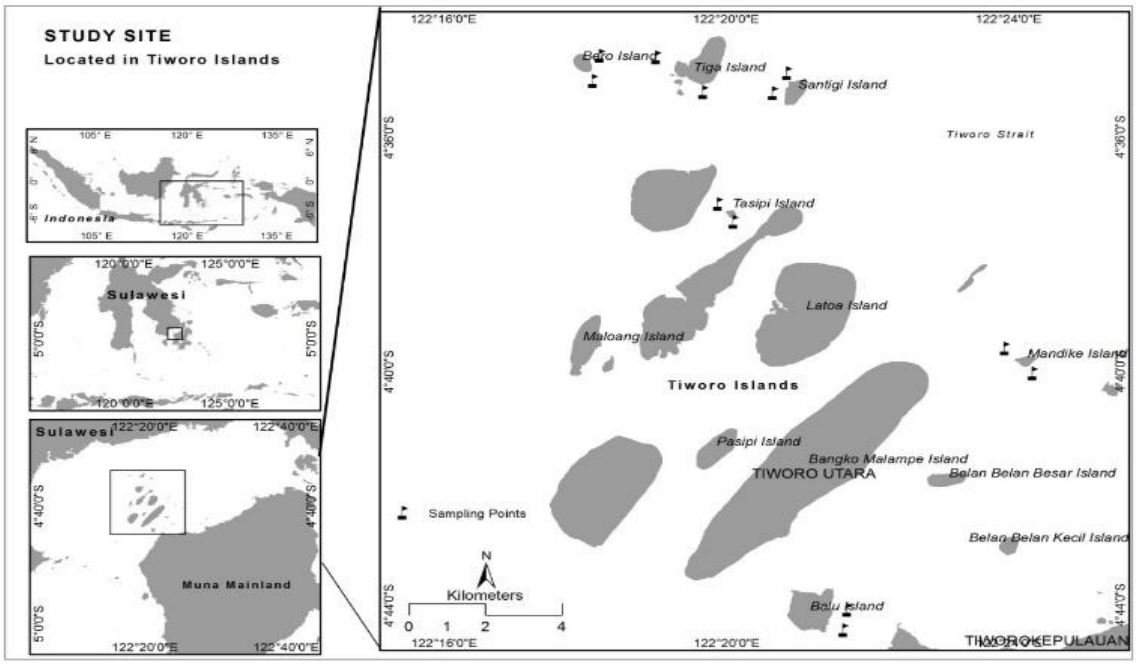


Figure 1. Research location in Tiworo Islands (Ketjulan *et al.*, 2019).

Table 1. Dimension and attribute assessment on sustainable spatial use in Tiworo Islands.

No.	Dimensions	Attributes	Remarks
1.	Ecological	Carrying capacity of land and seascape	The capacity of land and seascape should have tolerance in accepting activities
		Degree of land-use	A percentage of anthropogenic waste loads should consider the capacity of land-use
		State and condition of mangrove and coral reef ecosystems	The degradation rate of mangrove and coral reef ecosystem
		Seawater surface temperature and Total Suspended Solid (TSS)	The seawater surface temperature and TSS concentration in the seawater column
2.	Economic	Financial capital	Dealing with the existing capital source use for business availability
		Average income	Level of household per capita income
		Access to market	Easy access to market places
		Alternative livelihood for capture fisheries	Number and types of alternative livelihood developed by the community
		Capture fisheries production	Trends or developments of capture fisheries production
		Dependency on mainland	The level of necessary goods and services provision from mainland resources
3.	Social	Conflict incidence among residents	Types and intensity of conflicts occurrences
		Human resources	Level of education
		Perceptions of other existing residents	Community responses to the presence of other residents in the same community and collective access to natural resources
		Population density	Density level of population
		Population growth	Percentage of population growth
4.	Legal and institutional	Established local and customary laws	Number of customary law
		Regulations and trusts/beliefs	Number of existing regulations and beliefs in the community
		Availability of law enforcement	Number of personal law enforcement in Tiworo Islands
		Land-use regulations	Number of formal rules to be complied by the community
		Land ownership	Land ownership of communities in small islands
		Zoning area	Availability of zoning area in small island

Sources: modified from Pitcher & Preikshot (2001) and Susilo (2003)

Additionally, the dimensions were also developed and modified based on the findings from previous study by Ketjulan *et al*. (2019). The dimensions and attributes assessed are presented in Table 1.

2.2. Assessing Attributes in Each Dimension

Based on field observations and available secondary data, each identified attribute was scored following techniques developed by Pitcher & Preikshot (2001) and Susilo (2003). The scoring system consists of "bad" when the attributes found are in unsatisfying condition, and "good" when the attributes found are in satisfying condition. Between these two scores, there are several intermediary scores. Each assessed attribute is consistently scored based on the methods (Good *et al*., 1999; Hershman *et al*., 1999).

2.3. Preparing Sustainability Status Index

The sustainability status index ranged from 0 to 100. When activity in Tiworo Islands gets an index of >50, it means that spatial utilization for that activity has a good sustainability status. On the other hand, when an activity gets an index of <50, spatial utilization for that activity has a bad sustainability status. Susilo (2003) defined sustainability index into 4 categories, i.e., badly sustainable (index ≤25); less sustainable (index ranged from 25 to 49.9; sufficiently sustainable (index ranged from 50 to 75); and well sustainable (index >75).

2.4. Ordination Stages

Ordination stages using the multidimensional scaling approach (MDS) were applied to determine the positions of the well and badly sustainable categories. The Raplanduse version was modified from Rapfish used by Pitcher & Preikshot (2001). It was commonly used to evaluate the level of sustainability in multi- dimensional capture fisheries. Rapfish software was obtained through online http://www.rapfish.org/software. The ordination process is aimed at determining distances in the MDS approach based on Euclidian distance. In this study, the well and badly sustainable categories were depicted as horizontal lines, while different attributes scores were vertical. Rapfish application was used in the ordination process (Kavanagh, 2001).

2.5. Leverage Analysis

Leverage analysis was used to determine the most contributive attribute toward the sustainability index. The influence of each attribute was assessed using its root mean square (RMS). The Rapfish analysis is also helpful to analyze each attribute leverage by calculating the standard error of the difference between the score with attribute and score without the attribute. The larger the RMS, the more significant contribution from the attribute toward the sustainability index.

2.6. Prospective Strategy Analysis

Prospective strategy analysis was used to synthesize information to formulate strategy (Godet, 1994; Godet *et al*., 1999). This analysis was conducted in 3 stages, as follows: (1) determining objectives; the objectives should be specific and comprehended by all experts; (2) identifying sensitive attributes based on the MDS approach; and (3) assessing direct and indirect effects among attributes. Score 0 was given to attributes without effect; score 1 was given to attributes with small effect; score 2 was given to attributes with medium effect, and score 3 was given to attributes with significant effect.

III. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Ecological Dimension Sustainability

Within the ecological dimension, the sustainability index varied among islands. Tasipi Island had the smallest sustainability index of 30.91 and fell into the less sustainable category. Balu, Santigi, and Tiga Islands had the same sustainability index of 64.99 and fell into the sufficiently sustainable category. Bero and Mandike Islands had a sustainability index of 75.44 and 64.77, respectively, and fell into the sufficiently sustainable category.

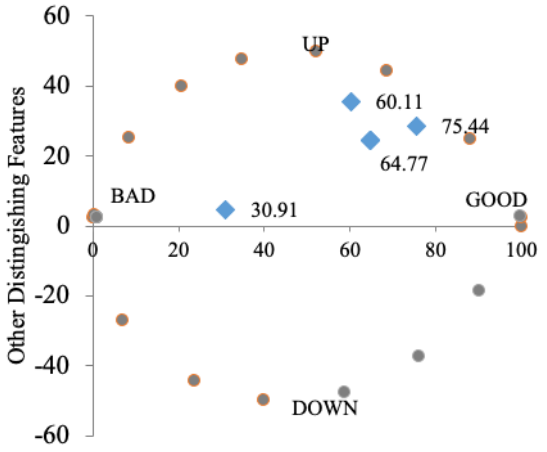
The leverage analysis showed that seawater surface temperature and suspended solid materials were sensitive ecological dimensions. The sustainability index of each island based on ecological dimension is presented in (Figure 2).

3.1.2. Social Dimension Sustainability

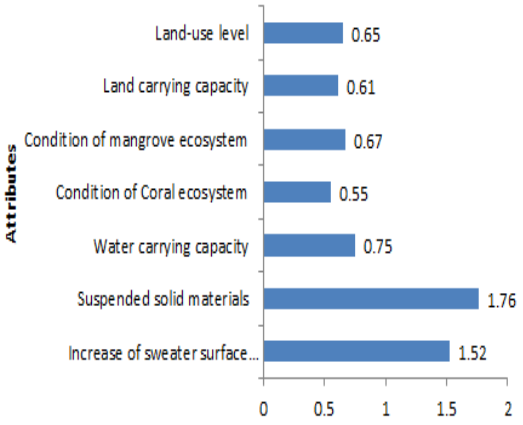
Five islands fell into the sufficiently sustainable categories within the social dimension with the same sustainability index of 76.60, i.e., Balu, Mandike, Bero, Tiga, and Santigi Islands. Tasipi Island fell into the healthy sustainable category with a sustainability index of 63.73. The conflict incidence among residents and human resources attributes were the most sensitive attributes. The sustainability index and sensitive attributes within the social dimension are presented in (Figure 3).

3.1.3. Economic Dimension Sustainability

Balu Island had the smallest sustainability index of 23.89 and fell into the badly sustainable category. Tiga, Bero, and Tasipi Islands had the same sustainability index of 37.51 and fell into the less sustainable category. Mandike and Santigi Islands had the same sustainability index of



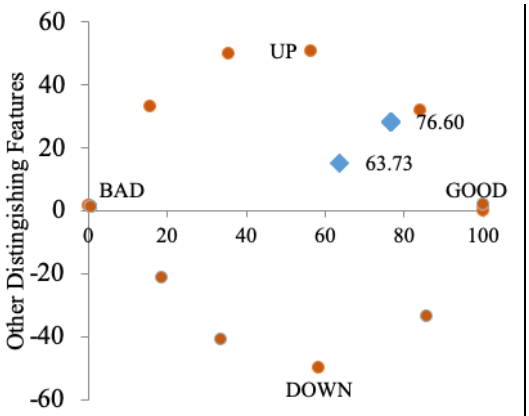
(a) Sustainability



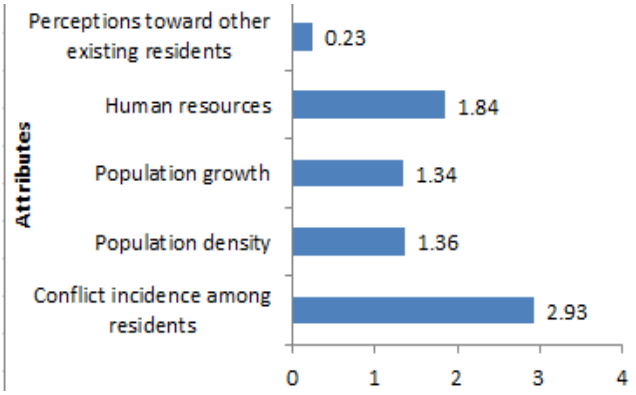
(b) Attributes leverage

30.91: Tasipi Island
64.99 : Tiga, Santigi and Balu Islands
75.44: Bero Island
60.11: Mandike Island

Figure 2. Sustainability index (a) and sensitive attributes (b) within an ecological dimension.



(a) Sustainability



(b) Attributes leverage

63.73: Tasipi Island
76.60 : Tiga Balu, Mandike, Bero, and Santigi Islands

Figure 3. Sustainability index (a) and sensitive attributes (b) within a social dimension.

32.76 and fell into the less sustainable category. Financial capital availability, fisheries catch a production of the last 5 years, and the average income was the sensitive attributes. (Figure 4) depicts the sustainability index and sensitive attributes within an economic dimension.

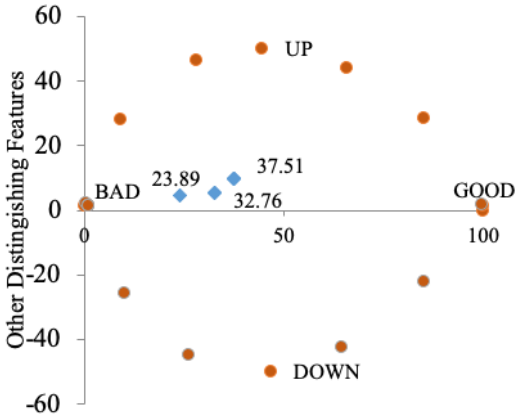
3.1.4. Legal and Institutional Dimension Sustainability

Within the legal and institutional dimension, small islands of Tiworo Islands fell into the less sustainable category with the same sustainability index of 15.14. The area zoning and land ownership status were the

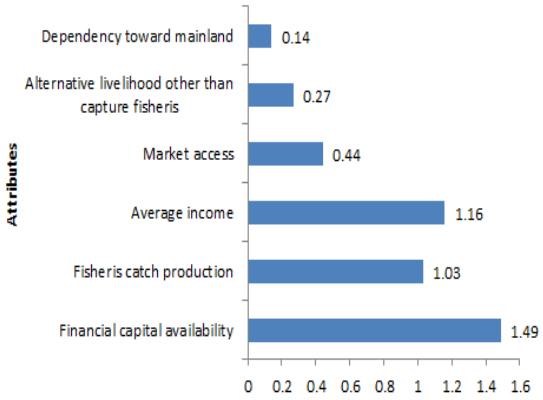
sensitive attributes. The sustainability index and sensitive attributes within legal and institutional dimensions are presented in (Figure 5).

Sustainability analysis in each dimension showed that sustainability of spatial utilization in Tiworo Islands varied from the well sustainable, less sustainable, and badly sustainable. The summary of sustainability analysis is presented in (Figure 6).

Figure 6 shows that economic, legal, and institutional dimensions were within the high level of vulnerability compared to the ecological and social dimensions. Therefore, the sustainability strategy was needed to



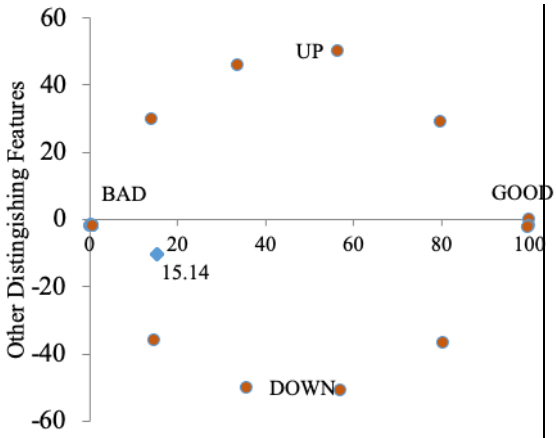
(a) Sustainability



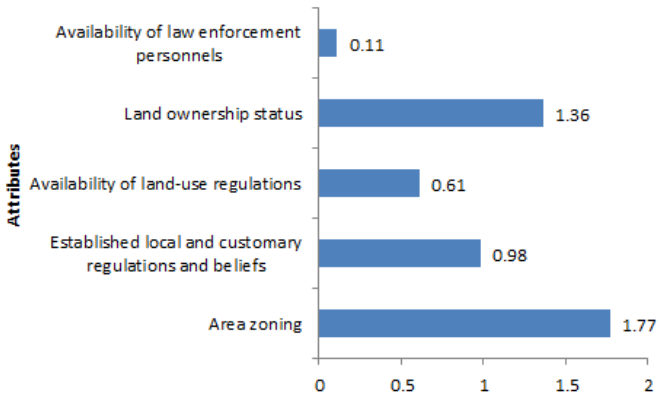
(b) Attributes leverage

23.89: Balu Island
37.51 : Tiga, Bero, Tasipi Islands
32.76 : Mandike and Santigi Islands

Figure 4. Sustainability index (a) and sensitive attributes (b) within an economic dimension.



(a) Sustainability



(b) Attributes leverage

15.14: Sustainability index of all small islands in the Tiworo Islands

Figure 5. Sustainability index (a) and sensitive attributes (b) within a legal and institutional dimension.

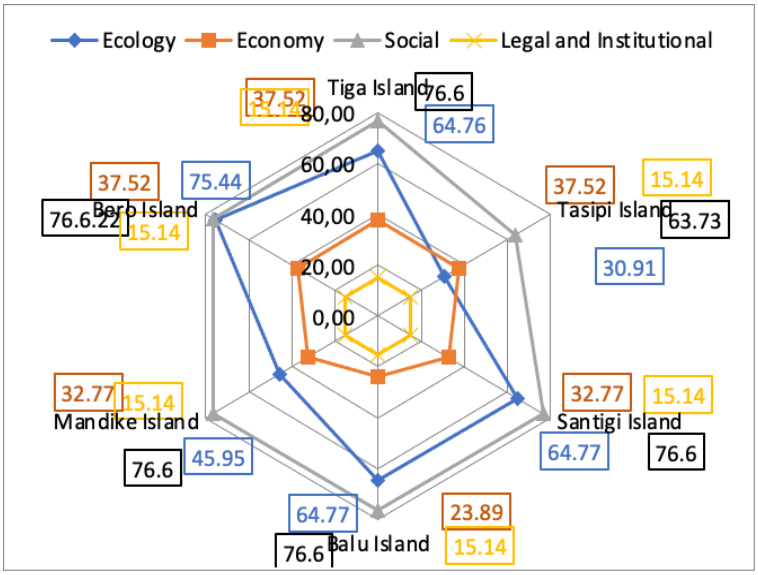


Figure 6. Kite diagram of sustainability indices in Tiworo Islands.

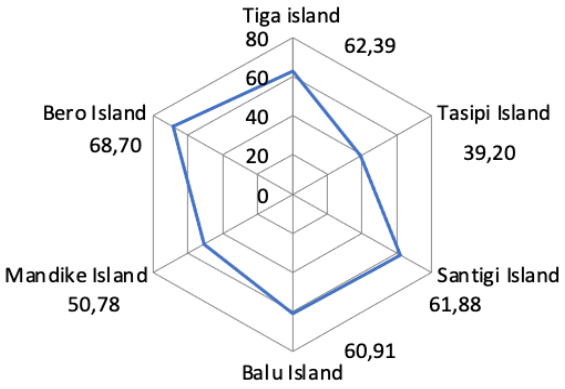


Figure 7. Sustainability index of six islands in Tiworo Islands.

improve spatial land and seascape use in Tiworo Islands. This strategy was aimed to control land-use in the watershed area, such as controlling business diversification development, regulating space use, and improving the quality of human resources. The sustainable strategy was not only selected based on the economic, legal and institutional dimensions but also based on ecological and social dimensions.

From the multidimensional perspective, small islands within the Tiworo Islands fell into the less sustainable and sufficiently sustainable categories. Tasipi and Mandike Islands fell into the less sustainable category, while the other four islands fell into the sufficiently sustainable category, i.e., Tiga, Bero, Santigi, and Balu Islands. Tasipi Island had the lowest sustainability index of 39.20, while Bero Island had the highest sustainability index of 68.70. (Figure 7) presents the sustainability index of each island in Tiworo Islands.

3.1.5. Impact and Attributes Dependency

This study indicated that within each dimension, there were several sensitive attributes. The seawater surface temperature and suspended solid materials were the most sensitive attributes in the ecological dimension. The sensitive attributes of the economic dimension were financial capital

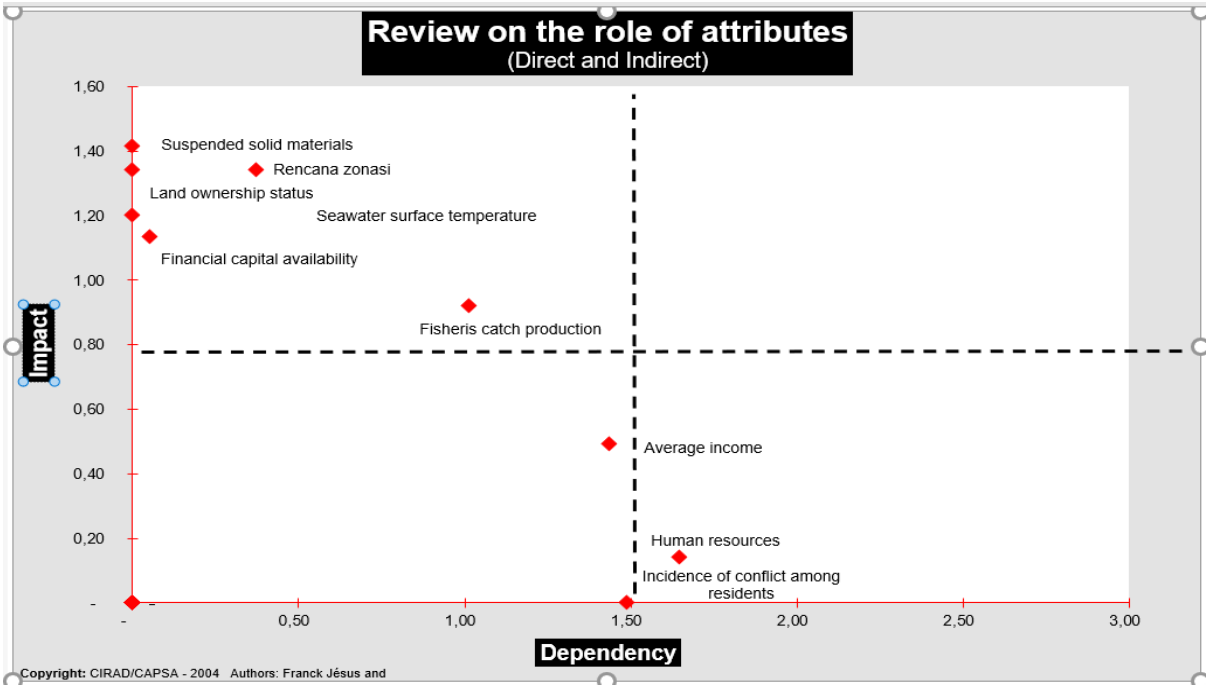


Figure 8. Level of impacts and dependencies toward sustainability attributes.

availability, fisheries catch production, and average income. The incidence of conflict among residents and human resources was the sensitive attribute in the social dimension. Area zoning and land ownership status were the sensitive attributes in the legal and institutional dimensions.

The prospective analysis indicated that five attributes strongly impacted the sustainability index, i.e., area zoning, the increase of seawater surface temperature, suspended solid materials, financial capital availability, and fisheries catch production, including ecological, social, economic, and legal institutional dimensions. The analysis also indicated that four attributes strongly depended on the sustainability index, i.e., average income, incidence of conflict among residents, and human resources. (Figure 8) presents the grouping of sensitive attributes based on prospective analysis.

3.2. Discussion

3.2.1. Sustainable Spatial Utilization in Tiworo Islands

The sustainability index of spatial utilization in small islands within the Tiworo Small Islands varied among islands. Balu, Bero, Mandike, Tiga, and Santigi Islands fell into the sufficiently sustainable category, while Tasipi Island was in the less sustainable category due to high spatial utilization in the island. Tasipi is the smallest island with the highest population density. The population density in Tasipi Islands is caused by useable land availability. Land-use activities will increase with the population growth, which eventually develops land-use competition (Nasution & Sunano, 2009).

The sustainability index varied among the ecological, social, economic and legal, and institutional dimensions. Legal and institutional dimensions fell into the badly sustainable category because four of the five attributes assessed within the dimension had low sustainability indices. Social and ecological dimensions fell into the well-sustainable category, while economic dimensions fell into the less sustainable category.

The increase of seawater surface temperature and suspended solid materials were the sensitive attributes within the ecological dimension. Based on satellite

imagery within the last 16 years (2003-2018) the Seawater Surface Temperature around Tiworo Islands increased about 0.4 ^{o}C per year. The rising sea surface possibly caused the temperature increase. Tiworo Islands is located at 1-3 m (Bappeda Kabupaten Muna, 2005), which is vulnerable to sea surface increase. The rise of sea surface caused by annual average temperature increase will escalate the potency of the submergence and inundation of small islands (Mimura, 1999). The increased global temperature also triggers the increase of monsoon rainfall in the Indonesia-Australia regions due to rising sea surface (Griffiths *et al*., 2009).

This study indicated that the amount of suspended solid materials from the rivers in the mainland increased and had spread to a wider area. Therefore, the suspended solid materials become a threat to sustainable spatial utilization in Tiworo Islands (Ketjulan, 2019) and negatively impact the aquatic ecosystem. The mangrove ecosystem in Tiworo Islands is resistant to suspended solid materials. The high density of mangrove forests can reduce the transport of suspended solid materials (Petra *et al*., 2012). On the other hand, the widespread suspended solid materials will harm the coral reef ecosystem in Tiworo Islands.

The human resources attribute of the social dimension is one of the sensitive attributes due to the low quality of human resources in the Tiworo Islands. This study showed that 52.55% of the residents graduated from elementary school, 20.32% did not graduate from elementary school, 21.55% studied in high school, and 6% were not formally educated (Ketjulan, 2019). A study conducted by Suryani *et al*. (2004) indicated that although the residents have a positive perception toward formal education, that does not mean that they will send their children to school. This phenomenon is identical to poverty and ignorance, which are the stigma of most fishermen (Satria, 2009; Kusnadi, 2012).

Within the social dimension, the potency of conflict among residents is also a sensitive attribute related to land ownership in Tiworo Islands. The long-term inhabitation in the islands has developed a system called "hak ulayat" (customary right) or common rights. However, not all parts of the common rights have been delivered to the residents. This issue is the potential to trigger vertical and horizontal conflicts. Parts of the common rights should be delivered to the residents based on the 1945 Constitution of the Republic of Indonesia article 18B (Hutagalung & Gunawan, 2009). Government law No. 5, the year 1960, also states that "hak ulayat" (customary right) is a form of land ownership by a community from generation to generation, whose existence is recognized by the government.

This study showed that the overall economic dimension fell into both the bad and less sustainable categories. The average income, fisheries catch production, and financial capital availability were the sensitive attributes. These three attributes are interrelated (Cai *et al*., 2004). A study conducted by La Sara & Astuti (2015) indicated that the crab catch production is over-exploited, shown by the decrease in size and the amount of the catch. The decreased fisheries catch production causes a decrease in the livelihood of the fishermen in the Tiworo Islands.

The average income from catch fisheries in Bero, Tasipi, and Tiga Islands ranged from Rp 3,465,000 to Rp 5,950,000, larger than the provincial minimum wages in the Southeast Sulawesi Province in 2018, i.e., Rp 2,177,052 (Disnakertrans Provinsi Sulawesi Tenggara, 2018). The average income in Santigi and Mandike Islands ranged from Rp 2,205,000 to Rp 2,590,000, similar to the provincial minimum wages in 2018, while the average income in Balu Island is Rp 2,073,600, which is smaller than the provincial minimum wage in 2018. Income earned by fishermen is related to the

fisheries catch production in the last five years.

The minimum income causes the decrease of financial capital available to conduct catch fisheries activities. Generally, in fulfilling financial capital necessities, the fishermen borrowed funds from personal capital lenders with various terms and conditions. The lack of accessible lending institutions causes the dependency from fishers to personal capital lenders. A study conducted by Widodo (2011) showed that regardless of the existence of lending institutions, fishers are reluctant to use the service provided by the lending institutions due to various requirements that the fishermen cannot always fulfill. Therefore, the fishermen depend on the personal capital lender, which is called the patron-client relationship. Sinaga *et al*. (2015) stated that the patron-client relationship is developed due to several factors, as follows: 1. Lack of marketing network owned by the fishermen who depend on the patron to sell the catch; 2. Catch fisheries depend on unpredictable climate causing unpredictable income for the fishermen. Therefore, in an economic crisis, the fishermen borrow funds to fulfill their daily needs.

3.2.2. Formulating Management Strategy

The phenomenon of ecosystem degradation was influenced by several factors. The anthropogenic factor, such as sedimentation and coastal ecosystem damage, were determined to be the cause of ecosystem degradation in Tiworo Islands. These two factors also resulted in the decrease of community income in capture fisheries. This problem might trigger a negative impact on land-use conversion and utilization to various activities in Tiworo Islands. This situation became worsened because certain areas of Tiworo Islands have been occupied by a small group of communities. According to Rotinsulu *et al.* (2018) and Mekonnen *et al.* (2018) the settlement was the main factor of changes in space-use patterns. Domestic waste (organic matter) might cause an increase in water quality hazard level (Mallin *et al.*, 2000; Liyanage & Yamada, 2017).

Raplanduse's analysis performed in this study recommended several strategies to improve spatial land and seascape use in Tiworo Islands in sustainable manner. These sustainable management strategies provide guidance on how to sustainably manage watershed land-use and allocation, business development and diversification, space use control, and human resources capacity building in Tiworo Islands. Integration of the prospective and Raplanduse's analyses categorized sensitive attributes into priority attributes and supporting attributes.

The prospective analysis showed that the management strategy of Tiworo Islands consisted of priorities and supporting strategies (Figure 8). Godet developed the theory (2006) mentioned that the role of attributes influenced a distribution pattern. The system of Tiworo Islands was indicated as a stable system concern on coastal and small island management (Figure 8). There was a clear distinction between the impacting attributes and the impacted attributes (Fauzi, 2019). Inter-relation patterns among attributes can directly happen or through intermediary attributes. Based on the performed prospective analysis the sustainable management strategy of Tiworo Islands is defined as follows:

3.2.2.1. Increasing Community Adaptation Capacity

This strategy aims to overcome the impact of climate change. Climate change is a variable triggering the increase of seawater surface temperature and causes many issues for fishers. The life of fishers is vulnerable to climate change because of: 1. the minimum supporting infrastructure for adapting to climate change, the low level of education, the lack of administration and social services; 2. the increase of sea surface can cause the loss of the already limited productive land,

the increase of storm risks, the decrease of clean water supply due to seawater intrusion.

A study carried out by Diposaptono *et al*. (2013) indicated that climate change can also cause: 1. the pattern change of fish migration due to the change of seawater temperature; 2. the change of upwelling condition due to seawater column stratification. Upwelling condition is positively correlated with fish schooling. Hence, the change of upwelling condition due to seawater column stratification causes difficulties for fishers in fish catching efforts; 3. the change of fishing ground; 4. the additional costs and time required for fish catching.

3.2.2.2. Controlling Land-Use in the Watershed Area in The Mainland

The flow of suspended solid materials in the Tiworo Islands is originated from several rivers, especially in the Tiworo Watershed. As the largest watershed in Muna Island, the Tiworo Watershed comprises six rivers, i.e., Soga, Remba, Wadahu, Umba, Guali, and Tiworo Rivers which are empty to the coastal area of Tiworo Strait. The water flow from the six rivers carries suspended solid materials to the coastal area of Tiworo Strait.

The Tiworo Watershed is threatened by land and water destruction caused by land-use change due to inhabitation and agricultural land use. Residential and agricultural activities are the main components of land-use change (Mekonnen *et al*., 2018; Rotinsulu *et al*., 2018). A study of land-cover change from 2013 to 2018 showed a forest area of 1,674.59 ha covering the Tiworo Watershed in West Muna District. One significant impact due to the land-use change is the flow increase of suspended solid materials in the coastal area of Tiworo Strait. The Citra MODIS analysis in 2016 showed a wider spread of suspended solid materials toward the sea (Ketjulan, 2019).

The flow of suspended solid materials into the waters is minimized by controlling the spatial utilization in the mainland, especially in the watershed areas. Normalization of the watershed area or designation of the watershed areas as protected forests is among efforts to control the spatial utilization in the watershed areas. The revitalization of the watershed areas is aimed to restore ecological functions in the watershed ecosystem as a filter for suspended solid materials from the river flow. The revitalization program or designation of protected watershed areas will indirectly limit the land opening for agricultural and residential activities in the watershed areas. The provincial government can implement these programs through coordination with the district and municipal governments, who have authority and responsibility for watershed management regulated in government regulation No. 37/2012.

3.2.2.3. Developing Business Diversification

The livelihood of people in the Tiworo Islands is primarily fishermen. This livelihood has been practiced for generations, with production depending on climate and environment. Sometimes, the fisheries catch production decreases due to the climate and the farther fishing ground, which affects the income and welfare of the people. Business diversification is an alternative to overcome these issues and adapt to unpredictable situations (Satria, 2009).

Aquaculture seems to be the most reasonable business alternative to elevate the economic condition of the people in the Tiworo Islands. The aquaculture activity is in line with the environmental characteristics and the Regional Medium Term Development Plan (Rencana Pembangunan Jangka Menengah Daerah) of the West Muna District, which designated the Tiworo Islands as the area for aquaculture development. The aquaculture in the area is quite promising and prospective. The land suitability analysis showed that an area of 17,461 ha in Tiworo

waters is suitable for culturing seaweed (Ketjulan, 2019). If one 50 x 100 m^2 is used to culture seaweed based on SNI 7579.2.2010, then within the area of 17,461 ha, there will be 20,784 units of seaweed culture. An area of 7,339 ha in Tiworo waters is also promising for fish farming in floating net cages. Those potentials have not yet been utilized for business diversification to elevate people's income in Tiworo Islands.

3.2.2.4. Regulating Spatial Utilization in Small Islands

Spatial utilization in small islands should be regulated to clarify the land status, including ownership rights, spatial or land management by individuals or communities. The regulation is urgent to be implemented to anticipate the conflict potential due to land ownership, both among communities and among residents. The residential activity in Tiworo Islands has been practiced for generations, and there are no clear boundaries among communities. The long-term inhabitation in Tiworo Islands is practiced as "hak ulayat" (customary rights) or common rights. A review conducted by (Hutagalung & Gunawan, 2009) stated that parts of the common rights should be delivered to the residents based on the 1945 Constitution of the Republic of Indonesia article 18B, which mentioned that the state recognizes and respects the indigenous people with their traditional rights following the society development.

Government law No. 5, the year 1960, also states that "hak ulayat" (customary right) is a form of land ownership by a community for generations, whose existence is recognized by the government. However, the rights given should refer to the prevailing laws and regulations. Government law ATR No. 17 the year 2016 regulates land management in small islands and states that rights granted to land in small islands are for a maximum of 70% of the island area or following spatial planning in small islands, or at least 30% of the island area is controlled by the state and used for a protected area, public area or for community interests.

3.2.2.5. Improving the Quality of Human Resources

In supporting spatial management in Tiworo Islands, it is important to improve the quality of human resources. The residents of Tiworo Islands as the spatial users or development actors should practice wise spatial utilization, including exploiting the available natural resources. The low quality of human resources is one cause of poverty in the fishermen community, in which poverty and ignorance are the stigmas of most fishermen (Imron, 2001; Kusnadi, 2002; Satria, 2009).

Residents of Tiworo Islands are mostly graduated from elementary schools. This study showed that 52.55% of the residents graduated from elementary school, 20.32% did not graduate from elementary school, 21.55% studied in high school, and 6% were not formally educated. The low education level is experienced by both the head and members of the family.

The quality of human resources in Tiworo Island is among sensitive attributes in the social dimension. The prospective analysis indicated that human resources quality is a highly dependent attribute and has a negligible impact on spatial utilization in Tiworo Islands. Therefore, the quality of human resources depends on other attributes, such as income level, fisheries catch production, financial capital availability, and the awareness of the importance of education. These four attributes affect the quality of human resources in the Tiworo Islands.

Improving the quality of human resources, especially fishermen, can be done by optimizing all efforts that have already been conducted by the government, such as implementing the nine-year basic education, free education for fishermen community up to a certain level of education, and scholarship provision for fishers to continue

their education to the university level. Those programs are available through the government but have not equally socialized to all fishermen communities. To alleviate poverty, aside from joining formal education, the fishermen can also join non-formal education, such as skills courses, extensions, education, and training, or technical guidance to overcome the underdeveloped socioeconomic status (Nikijuluw, 2001).

IV. CONCLUSION

Spatial utilization in Tiworo Islands is sufficiently sustainable. The ecological dimension fell into the well-sustainable category, except for Tasipi Island. The social dimension fell into the well-sustainable category, the economic dimension fell into the less sustainable category, and the legal and institutional dimension fell into the badly sustainable category. The most sensitive attributes in the ecological dimension were the increase of seawater surface temperature and suspended solid materials. The financial capital availability, fisheries catch production, and income level were the sensitive attributes within the economic dimension. The sensitive attributes within the social dimension were the incident of conflict among residents and human resources. The area zoning and land ownership status were the sensitive attributes within the legal and institutional dimensions. From a multidimensional perspective, the Tiga, Bero, Santigi, and Balu Islands were sufficiently sustainable, while Tasipi and Mandike Islands were less sustainable. The management strategy formulation comprises increasing community adaptation capacity, controlling land use in the mainland, developing business diversification, regulating spatial utilization in small islands, and improving the quality of human resources.

ACKNOWLEDGMENT

We would like to express our gratitude to Dr. Fredinan Yulianda, Head of Doctoral Program of Coastal and Marine Resource Management in 2018-2020, Department of Aquatic Resources Management, IPB University. We also thank the Director of SEAMEO BIOTROP for supporting this research.

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Submitted : 16 April 2021
Reviewed : 25 September 2021
Accepted : 04 November 2021