

Strategi Pengelolaan Ekosistem Mangrove Berbasis Multy Criteria Decision Making Analysis (Kasus Pada Pulau Bunaken Manado, Indonesia)

Management Strategy Mangrove Ecosystem Base On Multy Criteria Decision Making Analysis (Case In Bunaken Island, Manado, Indonesia)

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ABSTRACT

This research purpose is to analyze the effectiveness of mangrove ecosystem management strategy in Bunaken Island of Bunaken National Park in Manado City, North Sulawesi Province. The research used the research methods of field surveys, sampling, and literature studies for several components that require the periodic data. The data analysis used in this research is the Criteria Decision Making Analysis (MCDMA) with the Rapid Appraisal of Mangrove Ecosystem Sustainability (RAPMECS) tools modified from the Rapid Appraisal for Fisheries (RAPFISH). The obtained data will analyze the effectiveness of the ecological, socio-economic, and institutional dimensions that directly affect the mangrove ecosystems. It is indicated that the mangrove ecosystem management sustainability dimension in Bunaken Island is poor, and the socio-economic and institutional dimensions are not good. The main point that makes the management sustainability dimension unfavorable is the island slope and total extent of the mangrove ecosystem area. As buffer zone the mangrove ecosystem is low effective, this island is vulnerable to sea currents and waves. The strategies to minimize the vulnerability of this island from sea currents and waves include the increase of the mangrove ecosystem area, community awareness and participation in managing the mangrove ecosystems, and the supporting infrastructure in the mangrove ecosystem management activities.

Keywords: *Strategy; Management; Mangrove; Bunaken*

ABSTRAK

Kajian ini bertujuan untuk menganalisa efektivitas strategi pengelolaan ekosistem mangrove Pulau Bunaken, yang masuk dalam kawasan Taman Nasional Bunaken di Kota Manado Provinsi Sulawesi Utara. Kajian ini menggunakan metode penelitian antara lain survei lapangan, sampling, dan studi literatur pada beberapa komponen yang membutuhkan data berkala. Analisis data bersifat *Multy Criteria Decision Making Analysis* (MCDMA) dengan tools *Rapid Appraisal of mangrove ecosystem sustainability* (RAPMECS) yang dimodifikasi dari the *Rapid Appraisal for Fisheries* (RAPFISH). Data yang didapatkan untuk menganalisa efektivitas dimensi ekologi, sosial-ekonomi, dan kelembagaan yang mempengaruhi ekosistem mangrove. Pada dimensi ekologi terindikasi keberlanjutan pengelolaan ekosistem mangrove di Pulau Bunaken kurang baik, sedangkan pada dimensi sosial ekonomi dan kelembagaan kurang baik. Hal utama yang membuat keberlanjutan pengelolaan pada dimensi ekologi kurang baik adalah kemiringan lereng pulau dan luasan dari ekosistem mangrove. Akibat dari rendahnya efektivitas mangrove sebagai buffer zone membuat pulau ini rentan terhadap aksi laut yaitu arus dan gelombang. Strategi yang dapat dilakukan meminimalkan kerentanan pulau ini antara lain adalah penambahan luasan ekosistem mangrove, peningkatan kesadaran dan partisipatif masyarakat dalam pengelolaan ekosistem mangrove, dan peningkatan infrastruktur pendukung dalam kegiatan pengelolaan ekosistem mangrove.

Kata Kunci: *Strategi; Pengelolaan; Mangrove; Bunaken*

INTRODUCTION

A conservation area with small islands in Indonesia is located in Bunaken National Park. The total area of Bunaken National Park amounts to 89,065 hectares. There are two parts of Bunaken National Park, i.e. North Bunaken National Park and South Bunaken National Park. North Bunaken National Park covers five islands, i.e. Bunaken Island, Manado Tua Island, Mantehage Island, Siladen Island and Nain Island as well as the islands around Tanjung Pisok (*Pisok Cape*) located between Molas Village and Tiwoho Village. Moreover, South Bunaken National Park covers the territorial waters from Poopoh Village to Popareng Village. Bunaken National Park has a wealth of natural resources. These are three coastal ecosystems, i.e. the mangrove ecosystem, seagrass bed, and coral reef. A small island mangrove ecosystem has ecological and economic functions. It can be developed as a basis of mitigation in the degraded small island environment.

Mangroves are plants that live in tidal areas dominated by several species of trees that are capable of growing and developing in areas that have muddy substrates and can withstand the significant change of salinity. Mangrove forests are typical types of tropical forests growing along beaches or river mouths affected by tides. Mangrove forests can grow well in areas that have large river mouths and deltas containing muddy waters. From the function of aquatic ecosystems, mangrove ecosystems provide a place for spawning and raising various types of fish, crustaceans, and other aquatic species (Nagelkerken & Van Der Velde 2004).

The area of the mangrove ecosystem in Bunaken National Park is definitely wide (1,528.29 hectares) particularly in the southern part. The widest mangrove ecosystem in North Bunaken National Park is located in Mantehage Island. Total mangrove forest area in the small islands of Bunaken National Park is 977.63 hectares. Moreover, The total mangrove forest area in Bunaken National Park is around 10% of the total area of mangrove ecosystems in North

Sulawesi. Bunaken National Park is old mangrove communities in Southeast Asia. There are large mangrove trees above 1.5 m diameter that are rarely found elsewhere. The total area of mangrove ecosystem in Bunaken Island is 71.576 ha, the second largest in Bunaken National Park after Mantehage Island.

The existence of the mangrove ecosystem in Bunaken Island as part of the unity of the small island ecosystem is very important to study. It is because in the ecosystem there is very close connectivity. One indicator in the success of the mangrove ecosystem management is the status of sustainability. It can facilitate the managers in planning strategies to overcome problems in each management dimension. The research purpose is to analyze the effectiveness of the mangrove ecosystem management in Bunaken Island from the ecological, socioeconomic and institutional dimensions. Finally, the research benefits are to provide input to policy makers concerning appropriate strategy formulation in the integrated and sustainable ecosystem development and management.

RESEARCH METHODS

Research Location

This research was conducted in the Bunaken Island mangrove ecosystem in North Sulawesi Province. The mangrove ecosystem and the community in Bunaken National Park were the research object. The selection of the research object was define in accordance with the needs of the data and the method to analyze it.

This research was carried out in three stages. The initial stage of the research was a kind of the preliminary survey. At this stage the activities covered the collection of secondary data for the research location of Bunaken National Park from several existing sources as part of the literature study. This stage was carried out to obtain information from Bunaken National Park, i.e. village profiles and the mangrove ecosystem areas. The second stage of the research was the primary data collection at the research location. The primary data

collected here covered the data of mangrove vegetation with its biophysical conditions, questionnaires, and community

village profiles. The last stage of the research aimed to processing the data and writing the research results.

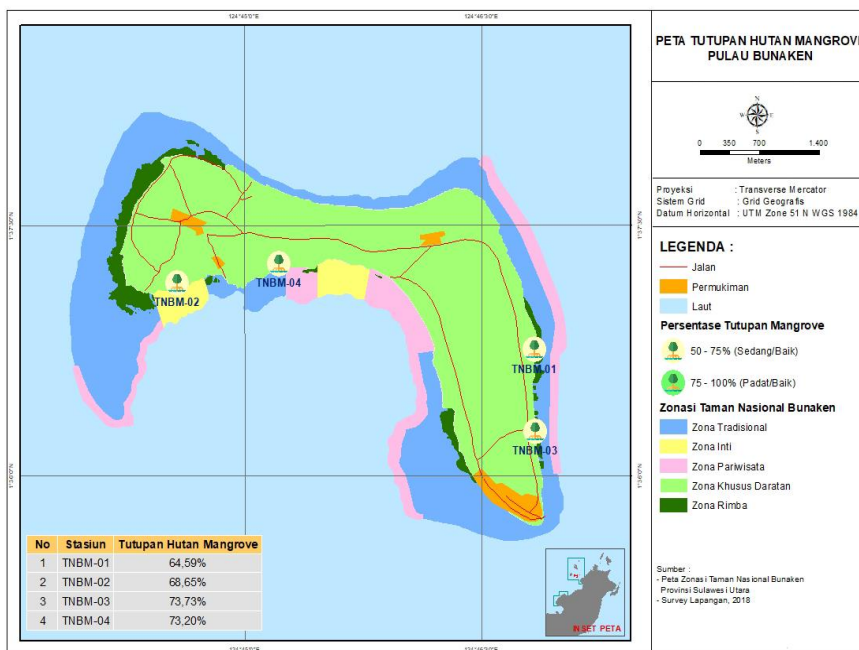


Figure 1. Map of Research Location

The primary data collection used the field observation and sampling methods (stratified, cluster, random, purposive, systematic sampling). The observation methods are very basic methods in conducting the inventory of potential resources in the mangrove ecosystem (Kusumastanto 2002; Kusmana *et al.* 2005). The social and economic data of the respondents related to the research activities would be collected at the research location. The respondents would selectively use the purposive sampling and accidental sampling. The data collection from the respondents would used the deep interview approach and the questionnaire.

There are a series of the parameters for the ecological dimension. These include the Beach Index (IEP), the Island Isolation Index (IEKP), the Core Zone Area Index (IELZI), the Utilization Zone Area Index (IELP), the Coral Reef Area Index (IELTK), the Mangrove Area Index (IELM), the Mangrove Degradation Index (IEDM), the Coral Reef Degradation Index (IEDTK), the Tidal Riding Index (IETP), the Slope Index (IEKM), the Wave Height Index (IETG), the Flow Velocity Index (IEKCA), the Water

Quality Index (IEKA), the Abrasion Index (IEAB), the Seawater Flood Index (IERO), and the Erosion Index (IEER) (Schaduw, 2018).

The social and economic data would be used for several indexes to determine the value of each island in Bunaken conservation area. Some indexes used in this research cover: the Population Growth Index (ISPP), the Population Density Index (ISKP), the Community Participation Index (ISPM), the Community Intelligence Index (ISPHM), the Education Level Index (ISTP), the Community Income Index (ISPD), the Economic Remoteness Index (ISKE), the Bunaken National Park Impact Index (ISDT), and the Building Density Index (ISLT) (Schaduw, 2015).

Moreover, the indexes of the institutional dimension include the Planning Quality Index (IKKP), the Coordination Quality Index (IKKK), the Implementation Quality Index (IKKI), the Monitoring Quality Index (IKKM), the Evaluation Quality Index (IKKE), the Regulatory Compliance Index (IKKA), the Infrastructure Readiness Index (IKKIN), the Higher Education Role Index

(IKPT), the Community Assistance Index (IKPM) (Schaduw, 2018).

The social economic data were directly collected in the questionnaire based interviews. Moreover, the data on population, livelihoods and education level were obtained from the village offices, sub-district offices, and the Regional Central Bureau of Statistics.

As the research units, the respondents were selected on the basis of the deliberate random sampling methods. The selected respondents were those who frequently associated with mangroves and lived on the coast of the islands. They were the respondents who directly interacted with the mangrove ecosystem.

Data obtained from the interviews are:

1. The individual characteristics of the communities are in the form of the respondent's identity (age, income, length of live, occupation, and level of education). The level of formal education in question is elementary, junior high, high school or other.
2. Work is the type of activities carried out daily to meet the needs of life, while income is the amount of money per month received from various sources of livelihood.
3. The community apprehension level of mangrove ecosystem resources relates to the opinions or viewpoints of the respondents regarding the use of mangrove ecosystems and their participation in managing the mangrove ecosystems.
4. Utilization which is frequently carried out in the mangrove ecosystems is in a kind of biological potential such as the utilization of animals and fauna in the mangrove ecosystems or the physical potential of the mangrove ecosystems and their economic value.
5. The role of the government in the preservation of mangrove ecosystems is through the intensity and frequency of activities in a kind of counseling, infrastructure development, mangrove planting, and supervision.
6. The community participation in efforts to preserve coastal resources particularly the mangrove ecosystems is part of the

government program. This form of community participation is the community involvement in a series of activities ranging from the socialization, planning and training stage, the implementation stage to the evaluation and supervision stage, and the community participation level.

Analysis

The next step is to normalize all the main variables and sub-units that make up the variables to equalize the units used in the measurement. Therefore, the index constituent variables measured here have different units, and the units must be normalized. The simple normalization formula used in this research is as follows:

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$$NV_{ij} = \frac{X_{ij} - \text{Min}X_j}{\text{Max}X_{ij} - \text{Min}X_j}, 0 \leq NV_{ij} \leq 1$$

NV = Normalization index of the j-th attribute in the i-th island

j = Index

i = Names of Small Islands

The analysis of the mangrove ecosystem management sustainability (KPEM) would use the RAPMECS method. The method used indexes having been analyzed previously as the management attributes. This sustainability index would explain the quality of the mangrove ecosystem management sustainability in small islands to mitigate any damage to the ecosystems for human or natural activities and to optimize their functions. The mangrove ecosystem management sustainability (KPEM) has a range of values from 0 - 100. The categories are very good if it is very good ($80 < KPEM \leq 100$), good ($60 < KPEM \leq 80$), moderate ($40 < KPEM \leq 60$), bad ($20 < KPEM \leq 40$), and very bad ($0 < KPEM \leq 20$). This sustainability index was analyzed in each dimension of each island. Furthermore, the sustainability status was analyzed in a

kind of multiplying the weighted results of the structured and in-depth interviews to the key stakeholders in each island to determine the priorities of the studied dimensions. This status would show the comprehensive sustainability status on each island. These indexes will be displayed in the kite charts and representative graphs (Schaduw, 2018).

RESULTS AND DISCUSSION

The Ecosystem Dimension of Mangrove Ecosystem Management Sustainability Index

The mangrove ecosystem management sustainability index for the ecological dimension on Bunaken Island

shows the number 35.80. This condition indicates that the management sustainability in the ecological dimension is not good. Some attributes that influence this value are island slope, tidal mount, the extent of mangrove area and the utilization zone area. The attributes of the island slope and tidal ridge are positive, while the extent of mangrove area and the utilization zone are negative. The related manager and the community must anticipate it to increase the sustainability index. The mangrove planting in an integrated and sustainable manner and the optimization of the use zone are wise steps to anticipate damage to the coastal ecosystems.

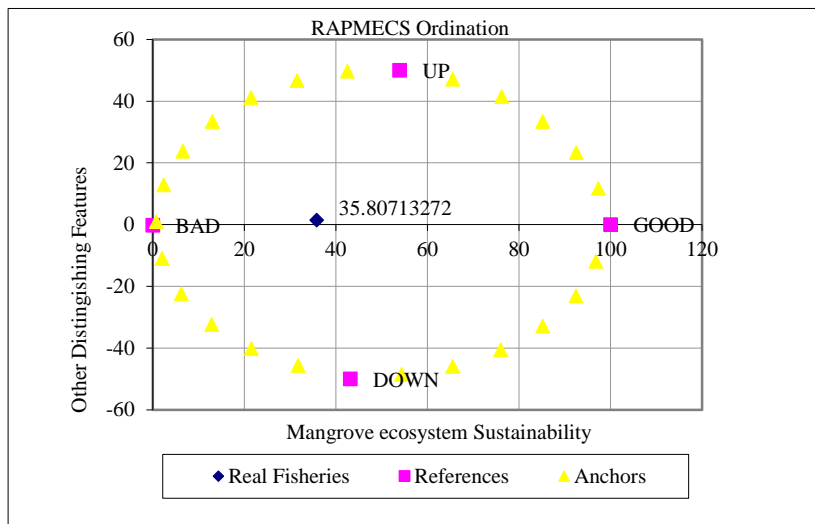


Figure 2 . Ecological Dimension of Mangrove Ecosystem Management Sustainability Index

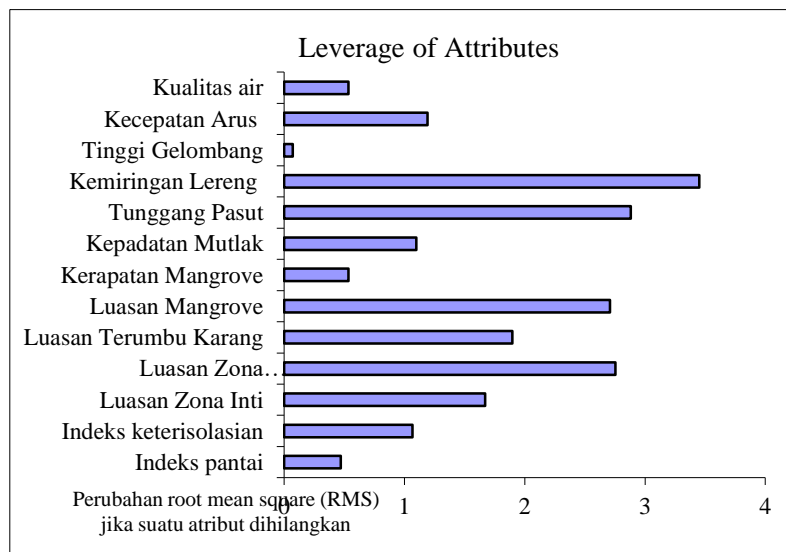


Figure 3. Ecological Dimension of Mangrove Management Attribute Role

The biological function of the mangrove forests is a source of water fertility, a breeding ground and a range of marine biota, a nesting place for birds (particularly water birds), habitat for various wild animals and a source of biodiversity (Khazali 2001). The next two figures will show the sustainability index and the related attributes that play a role in this matter.

Socio-Economic Dimensions of Mangrove Ecosystem Management Sustainability Index

The Bunaken Island mangrove ecosystem management sustainability index for the social economic dimension shows the number 64.91. This figure is well positioned for the management sustainability of the social economic dimension. Some attributes that influence this index toward a positive direction are the level of education and economic remoteness in the good category if compared to other islands, while the attributes with the negative influence are low community participation in the mangrove conservation activities and high population growth. To increase and maintain the index, it is necessary to socialize and increase public awareness on the importance of the environmental conservation, particularly mangroves and to increase public awareness on the importance of the family planning in

improving the community welfare in Bunaken island. The community activities conducted in the mangrove forest area of the research location resulted in destruction in the use or utilization of the resources. The activities can be divided into illegal logging, and the conversion of mangrove area into aquaculture farms, therefore it results in any changes in the land use from the existing conditions (Alimuna et al, 2009). The damage to the mangrove ecosystem in Tobati Village began with the clearing and stockpiling of the mangrove forest. Moreover, the mangrove land was converted into a central terminal, markets, shopping centers, offices and settlements. Individuals, the government apparatus and private parties carried out these activities.

The impact to the mangrove land conversion continuously has increased along the coast of Tobati, and it indirectly has resulted in erosion along Hamadi and Tobati beach. The faster sedimentation rate has produced many piles of garbage and these do not decompose and cause pollution to the mangrove ecosystem.

The communities living around the mangroves also experience difficulties in finding fishes, shrimps, shellfish and crabs (Arizona & Sunarto, 2009). The basic components of food chain in mangrove ecosystem are litter derived from mangrove plants (leaves, twigs, fruit, stems and others).

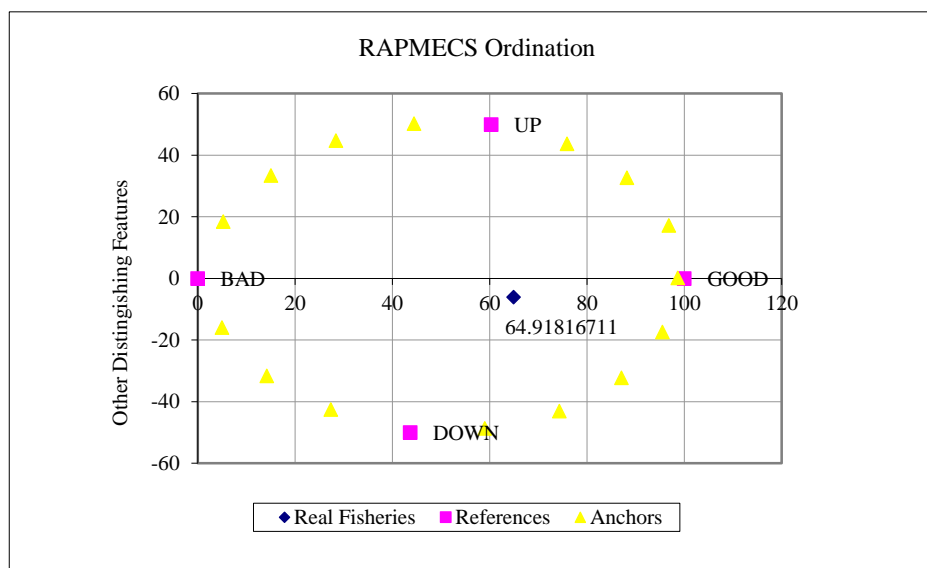


Figure 4. Mangrove Ecosystem Management Sustainability Index of Social Economic Dimension

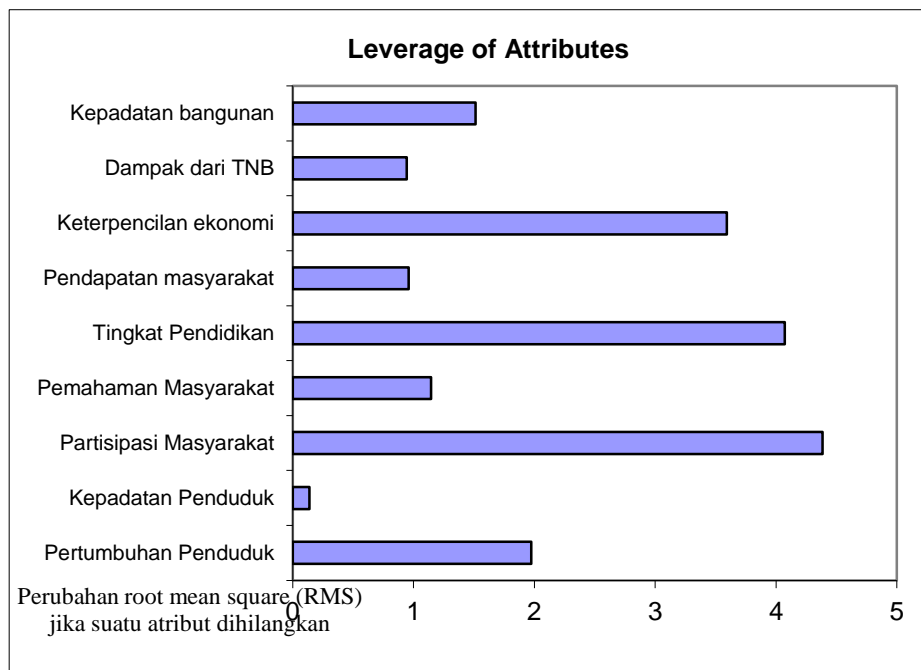


Figure 5 . Role of Mangrove Management Sustainability Attributes for Social Economic Dimension

Microorganisms will decompose mangrove litter that falls into the waters into detritus particles as a food source for aquatic biota with the feeding behavior of filtering seawater. It is estimated that leaf litter makes an important contribution to the mangrove ecosystem, the high productivity produced by leaf litter is as much as 7-8 tons per year per hectares. (Alongi et al 2002; Holmer & Olsen 2002). Fauna that live in the mangrove ecosystems covers a variety of groups, i.e. : birds, mammals, molluscs, crustaceans, and fish. The research of Gopal & Chauchan (2006) has proven that in the mangrove area in Sundarbans India there are 8 species of mammals, 10 species of reptiles and 3 species of birds that live and are associated with mangroves.

The Institutional Dimension of Mangrove Ecosystem Management Sustainability Index

The Bunaken Island mangrove ecosystem management sustainability index of the dimension shows a good number of 66.02. It indicates that the sustainability in the dimensions runs well. However, some important attributes that

push this index towards the negative such as infrastructure readiness and compliance with regulations. It must be upgraded, and so the value will increase. For the quality of evaluation and the role of tertiary institutions, the recent condition is good, and it should be improved in the management. Based on the analysis shown in the following two figures, the position of the mangrove ecosystem management sustainability point has a great opportunity to be improved, therefore it can minimize the ecosystem damage and increase the living standard of the community on this island. According to Soekanto (1999) in Dianawati et al (2014) the institutional function is as a guideline for society to behave; maintain community integrity; as a social control system where it means the community supervision system to the behavior of its members. The three institutional pillars are society, the government and market; all of them have paradigms, ideologies, values, norms, shapes and the rules of game (Mutaali et al, 2007). The social and institutional aspects in the environmental management are the ecological economic harmonization. It means that the realization of an integrated

and environmentally oriented environmental management system, as an effort to maintain the stability and

preservation of the resources, environment, and to increase the community welfare (Dianawati et al, 2014).

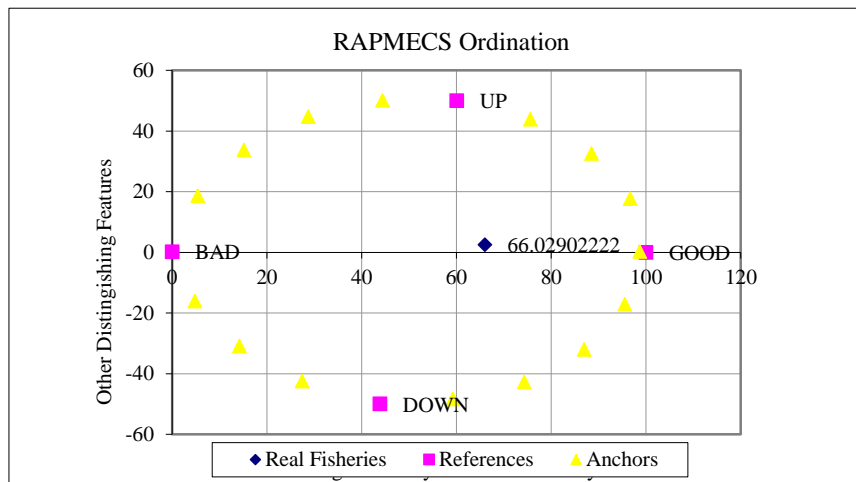


Figure 6. Mangrove Ecosystem Management Sustainability Index of Institutional Dimension

Mangrove Ecosystem Management Sustainability Status in Bunaken Island

After adding all the the multiplication results between the index and the weighted weight of each dimension, the mangrove ecosystem management sustainability status shows that the mangrove ecosystem management sustainability condition in Bunaken Island is good with total value of 52.49 (Figure 8). However, looking at the numbers, it means that ful of attention is needed to maintain or increase the index. It considers that this number is only an

excess of two numbers before it changes to a poor sustainability value. Increasing the community capacity as resource users and management coordination will be able to improve the quality of the mangrove ecosystem management in Bunaken Island. The important attributes that have a negative influence are very important to be minimized. The attributes are the most influential in determining the quality of the Bunaken island mangrove ecosystem sustainable management.

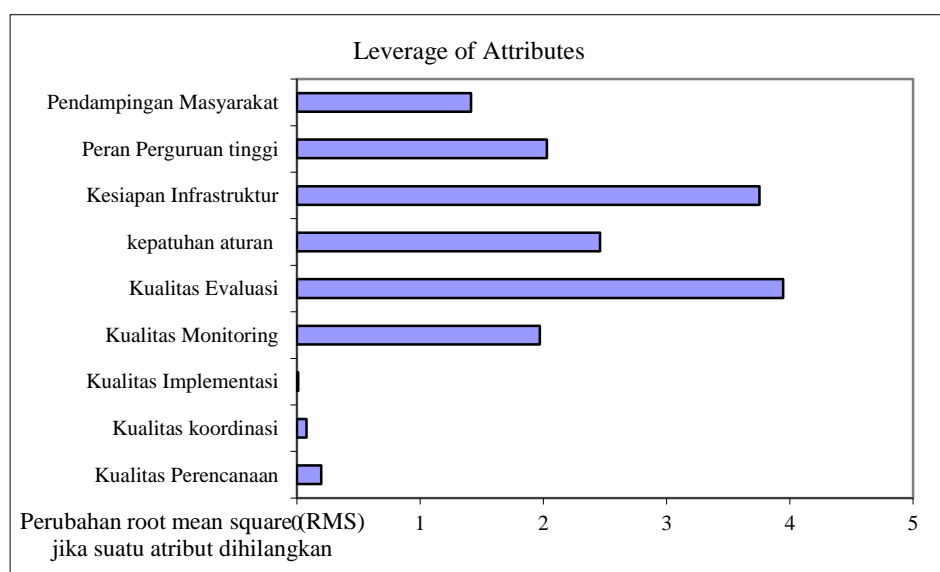


Figure 7. Role of Mangrove Management Sustainability Attributes for Institutional Dimension

According to Kenneth (1979), the goal of the mangrove ecosystem management is to achieve the maximum benefits from the forest in a versatile and sustainable way. Definitely the mangrove forest management is the application of forest management and exploitation methods as well as forestry techniques to the utilization of the forest natural resources.

The mangrove forest management must pay attention to the relationship with the surrounding ecosystem, therefore it should not have narrow orientation (Barkey 1990). If there is an over-exploitation of mangrove resources, this will cause an imbalance in the ecosystem. The mangrove ecosystems management sustainability is expected to maintain the productivity of mangrove ecosystems and the surrounding area, therefore the preservation of mangrove ecosystems can be obtained.

The increasing exploitation of the mangrove ecosystem can be seen in the cases in Muncar District, Pangpang Bay Banyuwangi. The mangrove ecosystems in this area are oriented to increase the economic development. However, the uncontrolled logging activities were shown over the last few years (Nazili 2004). According to Aksornkoe (1993), the mangrove zoning is one of the first steps for sustainable mangrove ecosystem monitoring and management. According to the international agreements on mangrove zoning, there are three main zones, i.e.: maintenance zones, protection zones, and development zones.

Rehabilitation is activities / efforts where the recovery and creation of habitats are carried out in a way of changing the damaged system to be more stable system. Recovery is activities to create an ecosystem or renew it and return to its natural function. The preservation of mangrove forests is very complex efforts because these activities really need accommodative nature from all parties around the mangrove forest area. However, the accommodative nature will be beneficial if the alignments to communities that are very vulnerable to mangrove resources have a larger portion (Khazali 2002). In implementing the rehabilitation activities or

reforestation of mangrove forests in the current regional autonomy era, the government should involve more elements of the community. The bottom-up approach has to be promoted and not otherwise considering that the community is the spearhead of development activities in the village. Moreover, communities should not be considered as the objects of development but the subjects of development. Particularly in this reform and democratization era, communities have been aware, smart and dare to assert their rights. It is because the communities know to be the subjects of development implementation which will enjoy the development results particularly in the field of seawater abrasion protection and fisheries (Sudarmadji, 2001).

The community participation in managing the community-based coastal area resources is a management program considered capable to motivate communities to participate in preserving and protecting mangrove ecosystems. The community participation can be divided into three groups, i.e. voluntary participation, induced participation, and forced participation (In Young Wang 1981).

The strategy of community involvement in the preservation of mangrove forests is in a kind of implementing an intensive system expected to stimulate and trigger efforts to the mangrove ecosystem management. The intensive system is among others carried out through increasing the quality of human resources and community participation (Bengen 2002). The community-based coastal area resource management (PSWP-BM) aims to involve more active community participation in planning and implementing the resource management. The PSWP-BM starts from an understanding that communities have the capacity to increase their own quality of life and are capable to manage their resources. All needed are the support of organizing and educating the public in utilizing the existing resources in a sustainable manner in order to meet their needs. The main advantages of the PSWP-

BM are the fairness and effectiveness of the sustainability.

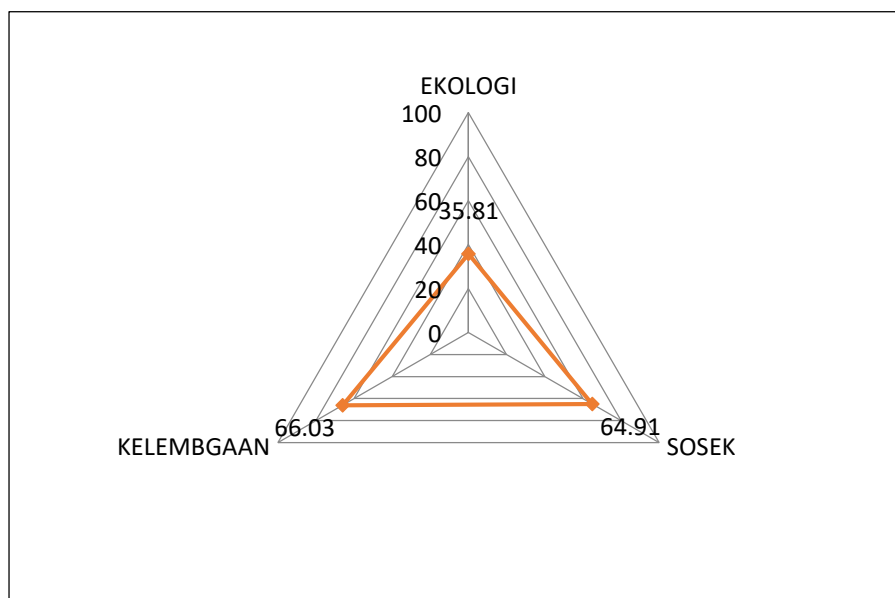


Figure 8. Bunaken Island Mangrove Ecosystem Management Sustainability Index

CONCLUSION

The effectiveness of the mangrove ecosystem management in Bunaken Island enters the good category after it takes into account the parameters as key to the success of the mangrove ecosystem management. The value shown in this analysis does not place the position of the Bunaken Island's mangrove ecosystem management sustainability status in the safe position, therefore the regular monitoring and evaluation is required to monitor the existing situation of the mangrove ecosystem.

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