THE INFLUENCE OF DIFFERENCE SPATIAL RESOLUTION OF SATELLITE IMAGES IN MARXAN ANALYSIS FOR MARINE PROTECTED AREA DESIGN IN SHALLOW WATER HABITAT OF KEMUJAN ISLAND, KARIMUN JAWA ISLANDS

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Abstract. Marxan is one of the many methods of analysis used in determining the priority areas for the protection of both terrestrial and marine ecosystems of shallow waters. In the process, Marxan is very dependent on the data input on which to base its analysis. Worldview 2 imagery and Landsat 5 imagery was used as input in Marxan analysis. This image has a different spatial resolution and also gives different classification. Worldview 2 imagery that included imagery with high spatial resolution produces 4 shallow water habitat classifications. While, Landsat 5 images, which includes medium spatial resolution produces 3 classification. These data are then inserted into Marxan analysis to obtain the priority areas for conservation. From the results it can be concluded that high value in BLM which set for compact and clustered area showed insignificant best selected area from both satellite imagery. Contrast, lower value in BLM produce significant difference of best selected area and become more varied. It can be concluded that designing a new area for Marine Protected Area (MPA), the difference in image resolution will not have a considerable effect. Determine for small priority areas such as zoning, Worldview II image with high resolution will be more accurate.

Keywords: Marxan; Landsat; Worldview 2; shallow water habitat; spatial resolution.

1. Introduction

Shallow waters habitat is an important component of coastal ecosystems. Various species dependent on this habitat shallow waters. Mangroves, seagrass and coral reefs are most important habitat incoastal ecosystem. These habitat plays vital function as a breeding, feeding, and nursery ground for many fish and key species in marine area. But some threats from development of human population and economic growth contribute to decline of shallow waters habitat existence. Therefore, the existence of protection areas or conservation areas is very important. This is done as a step to protect and ensure the presence of shallow waters habitat can be maintained and always provide benefits both ecologically as well as economically for the surrounding area.

Determination of the protection area have a lot of approaches and methods. One of the latest methods that are widely used is the systematic conservation planning. Systematic conservation planning is one of many methods used to define the areas of high biodiversity that potentially to be protected. This method is more commonly used by various sectors, i.e academics, practitioners, policy makers, legislation and conservationist. Systematic conservation planning is a process to identify a configurations of complementary areas that achieve explicit, and generally quantitative, objectives (Pressey et al.2007). This method emphasizes the complementarity where the analysis depends on the input that will suit every purpose of the analysis. The principle is representativeness and persistence that will accommodate the objectives and targets of the features that will be conserved.

Representativeness is an important factor which is the key the analysis of a systematic conservation planning. Representativeness is an extraction of features of biodiversity on the earth's surface shown in a data which is used as an input in the analysis. Biodiversity features that occupy a location would have to be plotted so that similarities or differences. Among areas can be estimated (Margules and Pressey 2000). Systematic conservation planning includes several stages, listing important habitat and types of species, and set targets for each types of data protection. Analysis of determining the area of protection then involves the calculation of cost and features that are conserved in each planning unit (Moilanen et al. 2009). Marxan as a systematic conservation planning software can be used to answer the needs of the determination of the protection area in accordance with the objectives and targets of systematic conservation planning.

Marxan is a conservation systematic software, which is software to find the location, design and manage a comprehensive protected area includes biodiversity in each area (Mace et al. 1006). Marxan is used as a decision support that is used to try to find potential targets protected area and the most cost efficient (Possingham et al. 2006). Marxan works by performing algorithm analysis on the features of biodiversity, bringing with social features and economy and provide the best solution in the form of an area at a low cost. This work phase is very applicable and systematic so it is best used in the planning, management and evaluation of a protection area. Applications Marxan has been widely used for conservation purposes in various countries such as the Great Barrier Reef Marine Park Authority (GBRMPA), and the planning of Protected Areas in the Channel Islands National Marine Sanctuary, California. Marxan analysis process is very dependent on the input data. Marxan will produce a various result rely on different scenarios and the data that we use. Therefore, it is important to perform data management and data quality before using it in Marxan analysis. Good input data will perform better result of Marxan analysis and give a better recommendation of area priority for design Marine Protected Area (MPA).

One source of data is the most frequently used, especially for shallow water habitat classification, is satellite imagery. There are several products from satellite imagery that is widely used as a data source of important habitat with a variety of accuracy and level of detail. Some of the satellite imagery used to analyze important habitat in the waters are divided into several classifications that are tailored to the resulting spatial resolution. Landsat 5 series, SPOT series and ASTER included in the medium spatial resolution (Wicaksono 2014), and High Spatial resolution like Quickbird-2, IKONOS and WorldView-2 (Phinn et al. 2012). The difference in image resolution used will certainly produce a different data classification. This study aims to determine effect of spatial resolution which delivered from different satellite image as an input to the data analysis in Marxan. By knowing the result of differences spatial resolution of satellite imagery in Marxan data inputs, references of the best data source to design effective MPA can be delivered. Moreover this study can give some suggestion and recommendation for better analysis in MPA design, includes processing data, scenario analysis, and interpretation of result.

2. Methods

Imagery from Landsat 5 and Worldview 2 are used as a source of data to generate classification data of shallow water habitat. The results of this classification will then be included as input data into Marxan analysis. Area study located in Kemujan Island as a part of Karimun Jawa National Park. This study area covers just an area of shallow marine waters that limited from Kemujan Island shoreline to the reef slope (see figure 1). Deep water are not included in the study area due to the limited light penetration. Satellite imagery can only record area of marine waters with a depth of less than 30 meters.
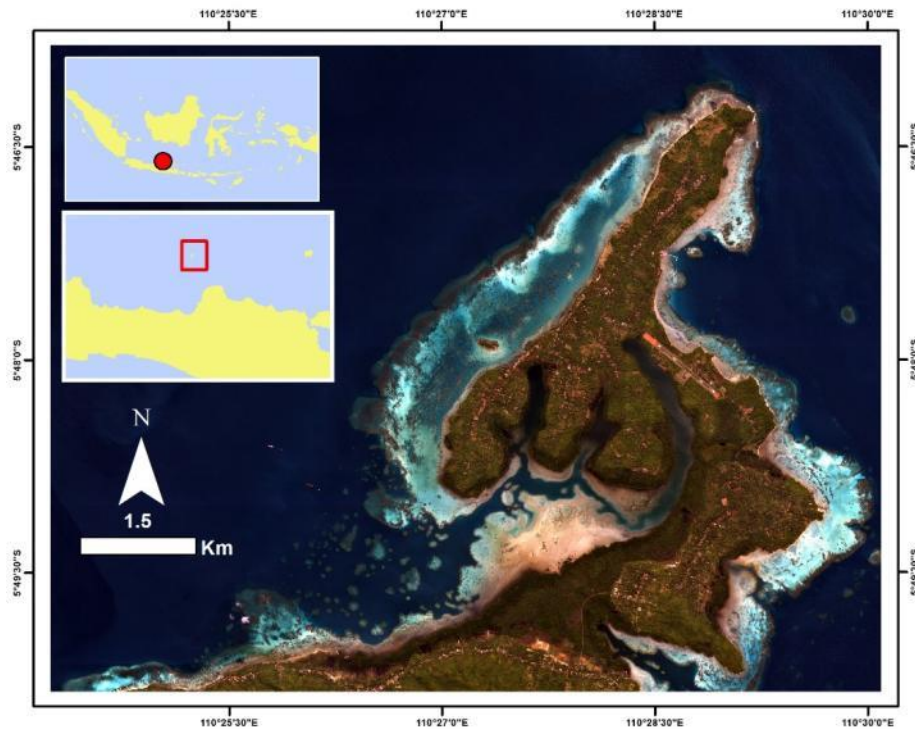
Figure 1. Worldview 2 satellite image of Kemujan Island as study area. This image in true colour composite (R:Band 5, G:Band 3, B:Band 2)

2.1. Digital Image Processing

Digital image processing carried out on imagery of Landsat 5 and WorldView 2. Preprocessing image no longer carried out because of the satellite imagery had been processed through of geometry, atmospheric, and radiometric correction. Image Worldview 2 has gone through several stages of processing before classification. Land masking is done to take the area of interest of shallow water habitat. Sunglint correction process using algorithm described in Hochberg et al. (2003) performed to reduce the effects caused by the reflection sunglint that occur on the surface of the waters. While the water column correction made to reduce bias due to the light that enters the water column that are different from free air. Correction of the water column using Lyzenga transformation (1981). The band used to do the classification process is Band 5; 3; 2. Classification of shallow water habitat to image Worldview 2 carried out using several ways, namely visual analysis, pixel-based and both (hybrid) analysis. The processing of image from Landsat 5 also has a similar process to the processing by Worldview 2. However sunglint correction is not used on Landsat 5. In the process of correction also uses a water depth correction from Lyzenga transformation. Image classification of Landsat 5 using analysis method that also uses visual analysis, digital / pixel based and a combination of both (hybrid). Satellite image processing stages can be seen in figure 2. Test accuracy is also carried out on the second image based on multiple samples with the existing field data. We set that accuracy of the classification is less than 50%. We did repetition in the analysis step if the accuracy of result is less than 50%.

2.2. Marxan Analysis

Preparation of Marxan analysis carried out through several stages of designing planning unit and preparing protection scenario. Marxan analysis works very dynamic and the scenario can run several times, until the result meet the targets has been designed. Stage of designing planning unit carried out with taking consideration into the maximum habitat protection aspect, namely one planning unit are

considered capable of providing effective protection of habitat impacts. The extent of planning area of this unit and then based on the Green et al. (2014) where the size of the effective protection of coral reef fisheries have a certain minimum limit. Therefore, the extensive of planning unit was set 1000 Ha. It is also taking into consideration the effectiveness of time when the analysis was performed. Develop scenario for protection considering several conservation targets to be achieved by the protection area. Aichi biodiversity targets set minimum conservation target is 10%. And on the other hand, the IUCN (2003) recommends that habitat needing conservation should cover 20-30% of the total area of available habitat. Therefore, the analysis of Marxan run for a protection scheme 30% and 10%. Marxan analyses were also carried out for each target conservation of coral reefs and seagrass. As for setting compactness, which in this case is the setting in BLM (Boundary Length Modifier), run in the third scenario, which decreased regularly. This was done to see the effect on the result of the determination of priority areas for conservation. Marxan scenario analysis can be seen in table 1.
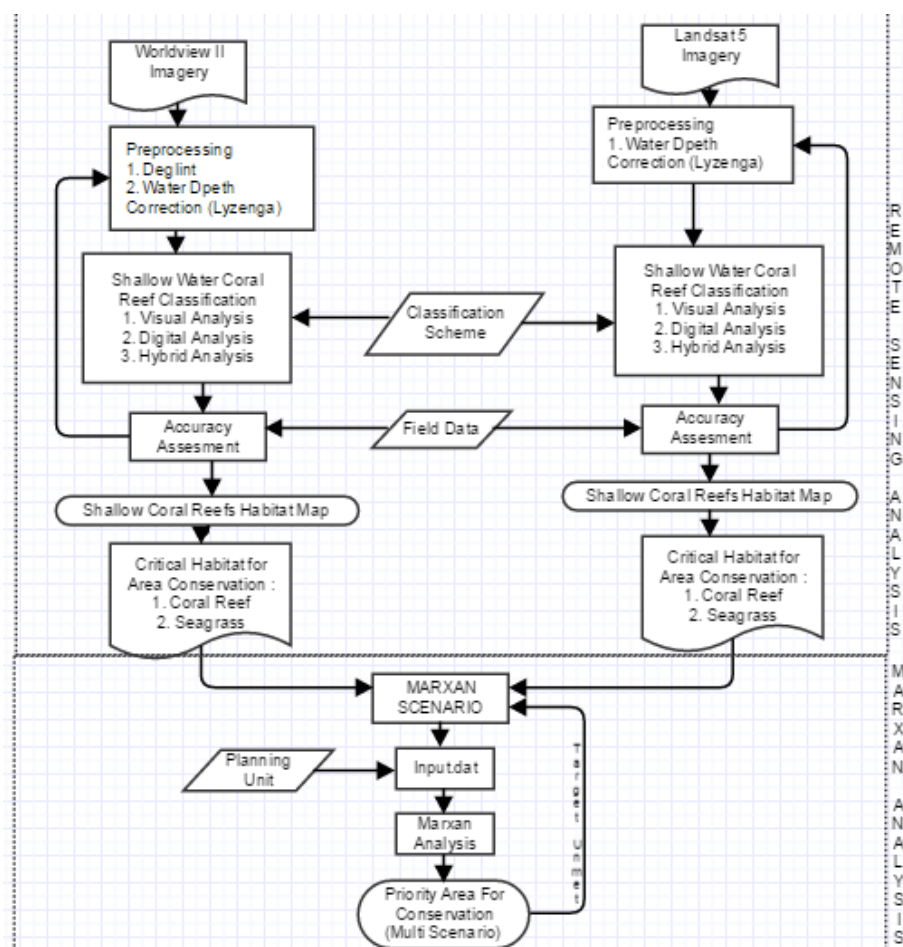

Figure 2. Flowchart of benthic habitat mapping process and Marxan analysis for Priority Area Conservation.

Table 1. Marxan scenario for different classification of remote sensing analysis.

| Scenario	Conservation Features	Marxan Variables	
		Proportion Target (Prop)	Boundary Length Modifier (BLM)
Landsat 5 A1	Coral Reef and Seagrass	30%	0.005
Landsat 5 A2	Coral Reef and Seagrass	30%	0.1
Landsat 5 A3	Coral Reef and Seagrass	10%	0.1
Landsat 5 B1	Coral Reef	10%	0.005
Landsat 5 B1	Coral Reef	10%	0.1
Landsat 5 C1	Seagrass	10%	0.005
Landsat 5 C2	Seagrass	10%	0.1
Worldview 2 A1	Coral Reef and Seagrass	30%	0.005
Worldview 2 A2	Coral Reef and Seagrass	30%	0.1
Worldview 2 A3	Coral Reef and Seagrass	10%	0.1
Worldview 2 B1	Coral Reef	10%	0.005
Worldview 2 B1	Coral Reef	10%	0.1
Worldview 2 C1	Seagrass	10%	0.005
Worldview 2 C2	Seagrass	10%	0.1

3. Result and Discussion

3.1. Image Classification Results

Analysis result of Landsat 5 imagery yielding three classes of classification of shallow water habitat, namely coral reef with a total area of 757.26 hectares, seagrass and macroalgae with a total area of 157.08 hectares and bare substrate with the smallest area 353.16 hectares. Class separation between seagrass to macroalgae is very difficult to carry out so these classes are combined into one class. Classification of Wolrdview 2 produced 5 classes of shallow water habitat. This class classification is composed of hard corals, and bare substrate, seagrass and macroalgae. The composition of the area for each of classification are coral reef with a total area of 751.26 hectares, Seagrass with a total area of 242.43 hectares, macroalgae with a total area of 181.213 hectares and bare substrate with a total area of 638 783 hectares. From the total area, when compared with the results of classification Landsat 5 it can be seen that the area of coral reef is not much different between the two. But the most significant difference is the total area of seagrass. On the results of image classification Worldview 2 appeared that seagrass decreased as much as 32% of the total area of seagrass classification results from Landsat 5. The extensive seagrass decline is due to the largely seagrass total area in classification of Landsat 5 image still include macroalga and bare substrate. While the higher spatial resolution of WorldView 2 can separate this two classes habitat. So with the class of macroalga habitat, extensive of seagrass will be reduced. In addition, these results show that the WorldView 2 is better to identify the bare substrate and seagrass, while in the Landsat 5 still occur high pixel mixing between the two. Therefore, the results of image classification Worldview 2, an area of bare substrate is higher than the total area of bare substrate on Landsat 5. Comparison of the total results of the classification of the image can be seen in figure 4.

Based on the distribution, the processing of both images for the classification of shallow water habitat, shows that analaysis in result of Worldview 2 imagery produced area with more patchy, was separated and fragmented especially for coral reef habitats. While on Landsat 5, the habitat class looks more clump and within the scope of the fused area. It is very important to consider the ecological

function of habitat is very dependent on home range of certain species. For species that live in the habitat has home range without knowing the boundaries area. If in one object known as coral reef separated by bare substrate, then the bare substrate actually may also be categorized as a unity of coral reef habitat. This is due to the bare substrate was included into the area home range in certain species. Therefore, it is important to know how the results of image analysis data is used. In the Marxan, and later modification of the connection between one planning unit and another planning unit is very important.
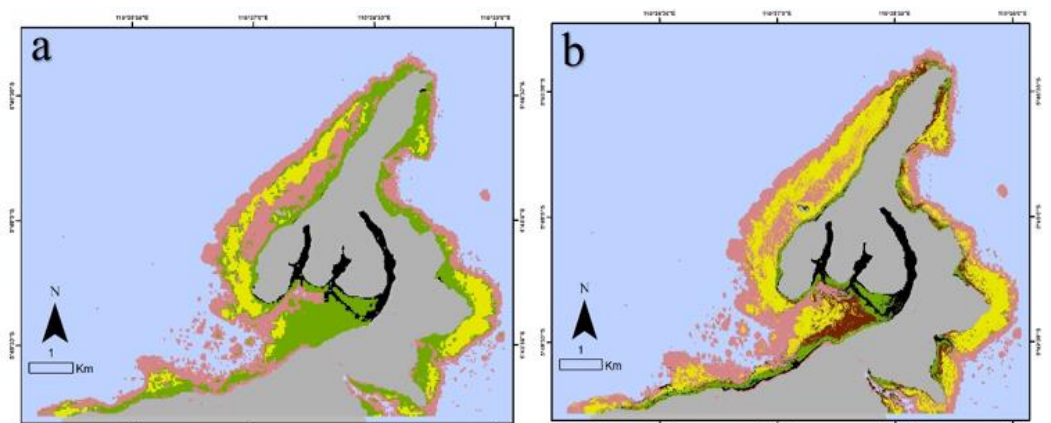
(Notes: ■ coral reef; ■ seagrass; ■ bare substrate; ■ macroalgae; ■ excluded from analysis

Figure 3. Shallow water habitat classification for Landsat 5 (A) and Worldview 2 (B).
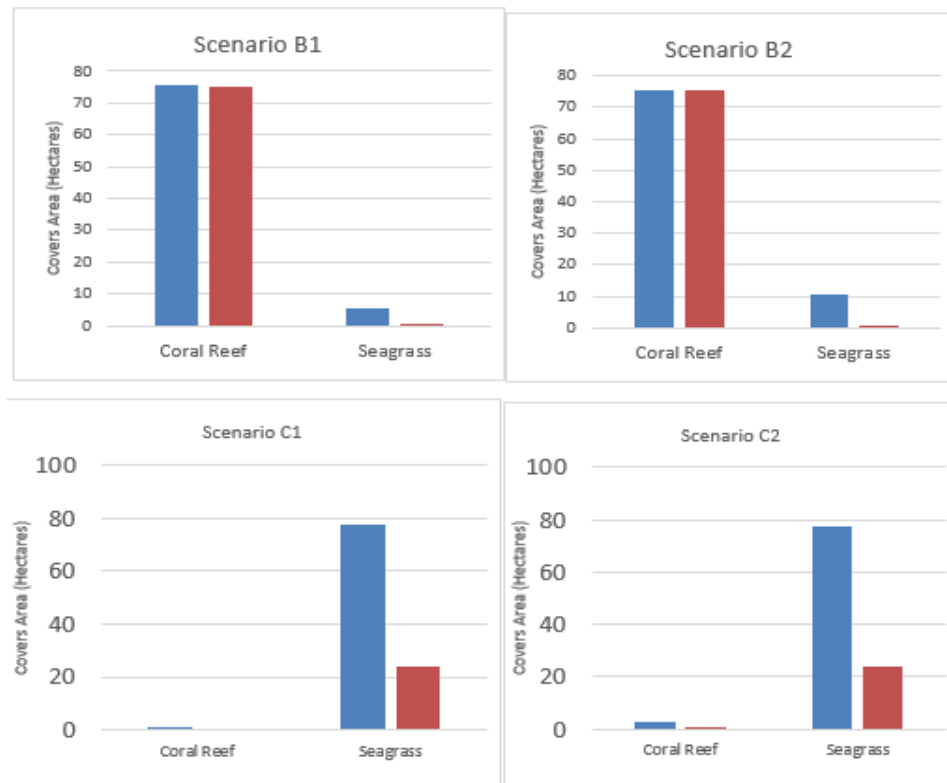
3.2. *Marxan Analysis*.

Marxan analysis is the process which are then run to analyze the data and obtain the best protection area selection of the study area. At this stage, Marxan analysis only process coral reef and seagrass habitat classification results from each image. The selection for both habitat based on their ecological functions in the shallow waters. Macroalgae are not included in the analysis because of the less important ecological functions. Besides, we exclude the macroalgae because this habitat is not exist in Landsat 5 result, so we did it as to reduce the bias determination of the priority areas. Based on the scenario that has been prepared prior to running Marxan, the total of all the results obtained are the 14 best solution for priority conservation area. Scenario A is a scenario that analyzes the important habitats are coral reef and seagrass with each conservation target of 30%. This scenario is intended to seek the highest priority area of the distribution area of coral reef and seagrass habitat throughout the study area in Kemujan Island. In scenario A, modification of BLM is a determinant factor for the variation of the results of any scenario in Marxan analysis, because it is based on target in conservation and SPF, a variation on the selected area does not vary much. In the scenario A1 and A2 there is an increase of BLM for each scenario. The results obtained showed that the best selected area does not have a far different variations of value (figure 4). But for scenario A3 where there is a decline in conservation target into 20%, then the best selected area is smaller. This is because Marxan was set to select and hold just 10% of the priority areas for coral reef and seagrass.
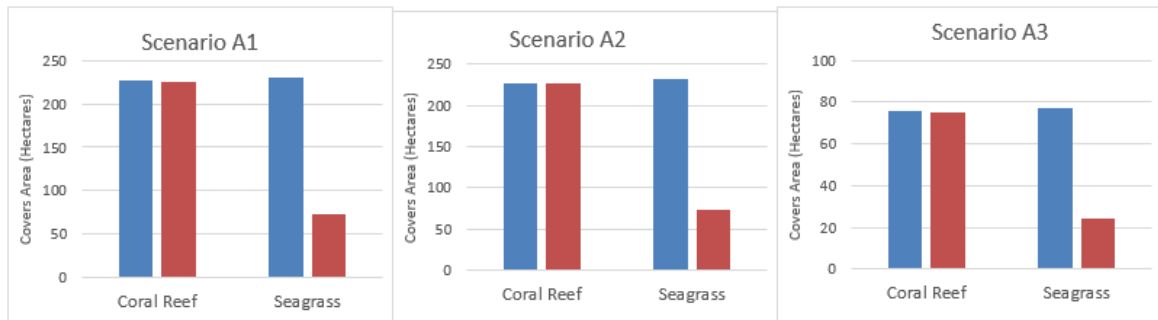
Figure 4. Comparison of total best selected area of coral reef and seagrass for Landsat 5 and Worldview 2.

Figure 5. Comparison of total best selected area of coral reef and seagrass for Landsat 5 and Worldview 3 in Scenario B and C.

Comparing the result of Landsat 5 and Worldview 2 to the A scenario, we get the result that in coral reef, the best selected area covered in Landsat 5 almost the same with Worldview 2. But differently with seagrass that Worldview 2 result is smaller than Landsat 5. This result is not very interesting because this difference was occurred because the data was input to Marxan before the seagrass from Worldview 2 is smaller than Landsat 5. The result from spatial perspective is more

interesting because this result is very important where the priority area for conservation would be located. Scenario A1 where the Landsat 5 and Worldview 2 was set for 30% conservation target and BLM was set for most compactness show the result that best selected area is not very different each other. We can see that the best selected area from Landsat 5 located in west, spread from west of Kemujan Island to the bay, almost same with the result of Worldview 2. In Scenario A2 where the BLM was set to 0.005, the selected area would split and more patchy. In this scenario, we can see there is a big different area which selected by Marxan compare from Landsat 5 and Worldview 2. In Landsat 5, the best selected area was covered along the west area of the Kemujan Island. In addition, there are area in the east and northwest were selected. Worldview result showed the best selected area located just in the west area and not far from the best selected area result from scenario A1. There are some area which selected in Landsat 5 but incredibly be avoided by Marxan in Worldview 2. This area was identified as bare substrate and macroalgae according to the classification result in Worldview but in Landsat 5 included as a seagrass. Trying to find the core area located, we decreased the proportion target of coral reef and seagrass and set BLM to 0.1 consider for compactness of area. The result for scenario A3 showed that best selected area almost located in the same area from Landsat 5 and Worldview 2. From three scenario A, can be concluded that BLM value influence the selected area for conservation target. More compact we set the scenario, the result would select almost the same area from different source of satellite image. But if we set the BLM lower and the area will be spread and patchy and best selected area will located very different. See figure 6 and figure 7 for to compare the result of scenario A.
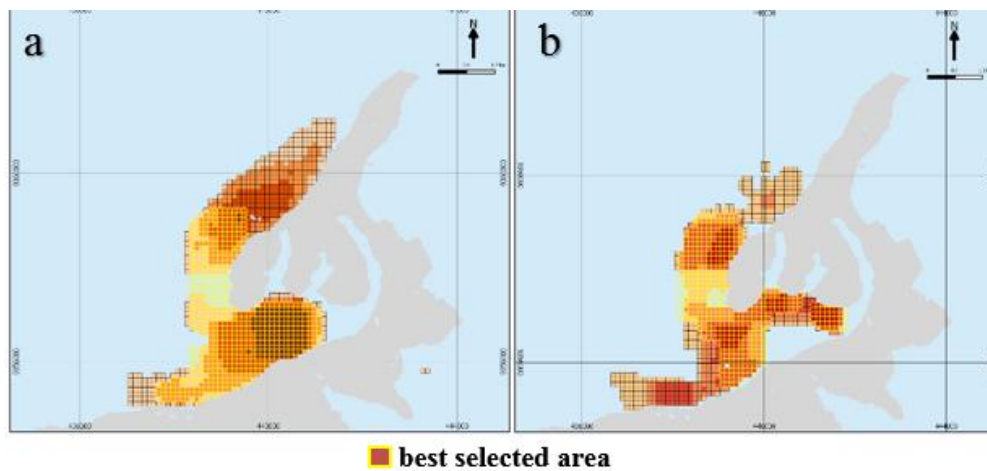

Figure 6. Best selected area from Landsat 5 (a) compare to best selected area from Worldview 2 (b) in scenario A1.
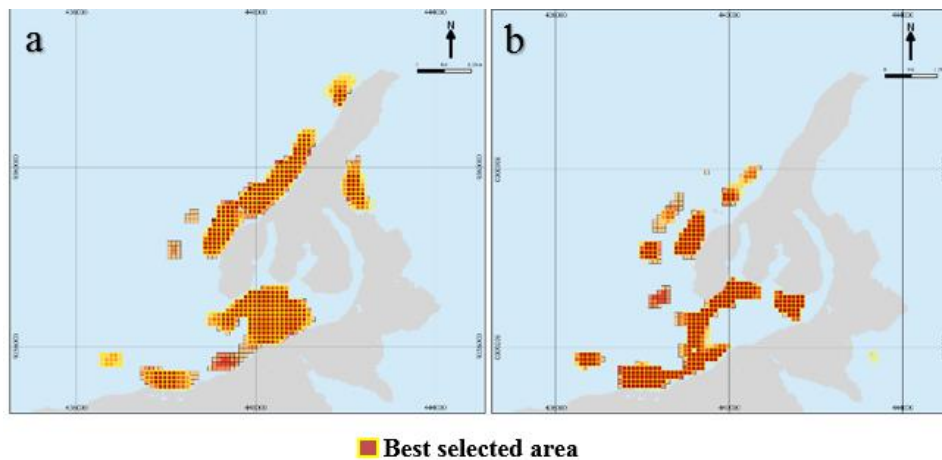
Figure 7. Best selected area from Landsat 5 (a) compare to best selected area from Worldview 2 (b) in scenario A2.
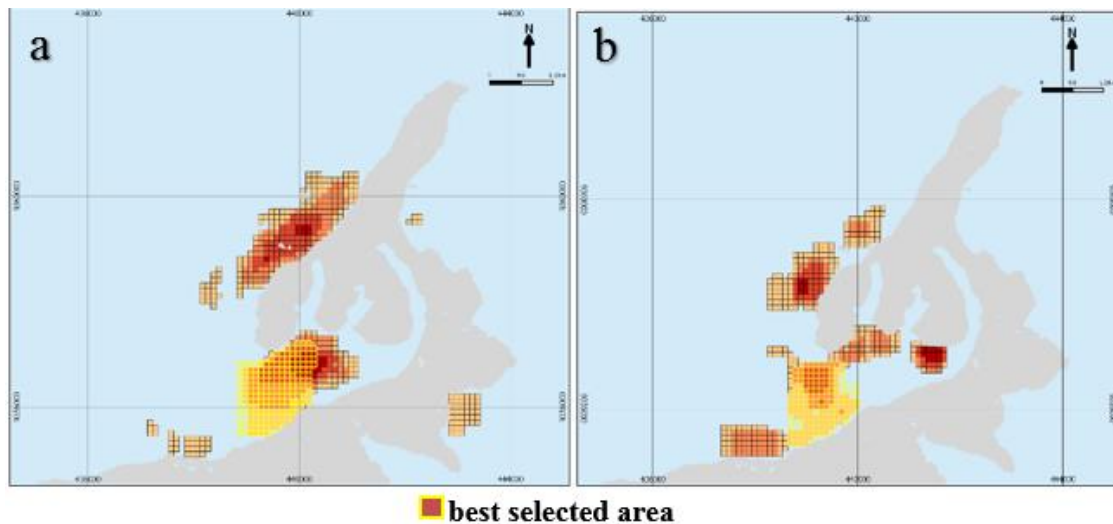

Figure 8. Best selected area from Landsat 5 (a) compare to best selected area from Worldview 2 (b) in scenario A3.

Analysis for each class of habitat was run in different scenario. Identification the prioritization of coral reef area was conducted in scenario B which separated by two sub scenario B1 and B2. Scenario B1 was set for compactness area with coral reef reserves. The result showed that Landsat 5 and Worldview 2 select the best location area in the same location which located in west of Kemujan Island. The best selected area covered 75 hectare from all of the coral reef in study area. In this scenario, Landsat 5 can hold about 5 hectares of seagrass while set to meet the coral reef target but Worldvie 2 just covered about 0.2 hectare of seagrass (see Figure 9) . Scenario B2 set the BLM in 0.005 and show more patchy selected area than B1. The result show that the best selected area in Landsat 5 has a different location from Worldview 2 even the best selected area located in west area. There is a same area was selected in Landsat 5 and Worlview too. But in Landsat 5, there are 3 best selected area spread in west. This result was support the result from scenario A that decreasing the BLM value influence the best selected area and get the area more different from Landsat 5 and Woldview 2.

Scenario C was ran to identified the prioritize area for seagrass habitat. This scenario has the same setting for proportion target and BLM for two subscenario. Scenario C1 ran with BLM 0.1 which

indicated for compactness area. The result showed that Worldview 2 located the best selected area differently with Landsat 5 best selected area. In Worldview 2 result, the best selected area is located near from coastline while the Landsat 5 result showed the best selected area more far from coastline and located down of Landsat 5 best selected area (see figure 10 to compare the result). In parallel with other scenario (scenario A and B). We identified that Worldview 2 identified the area was selected in Landsat 5 as a macroalgae habitat and bare substrate thereby Marxan avoid this area and select the area near a coastline which identified as a seagrass. Otherwise the Landsat classification result this area as a seagrass and consider it as a prioritize area to select. Increase the BLM value will not give the different selected area because Marxan will not select an area that does not contain seagrass.

All of scenario showed that different source of data which come from different resolution of satellite imagery would influence the Marxan analysis. Especially if the BLM is set to patchier, the best selected area located more different one to each other. But if the BLM is set for compactness area, the best selected area will give not slightly different location to select. Scenario C give more information that the classification result of remote sensing analysis will affect the Marxan selected area. Ensuring the classification result from remote sensing analysis is the necessity because Marxan running based from the input data.
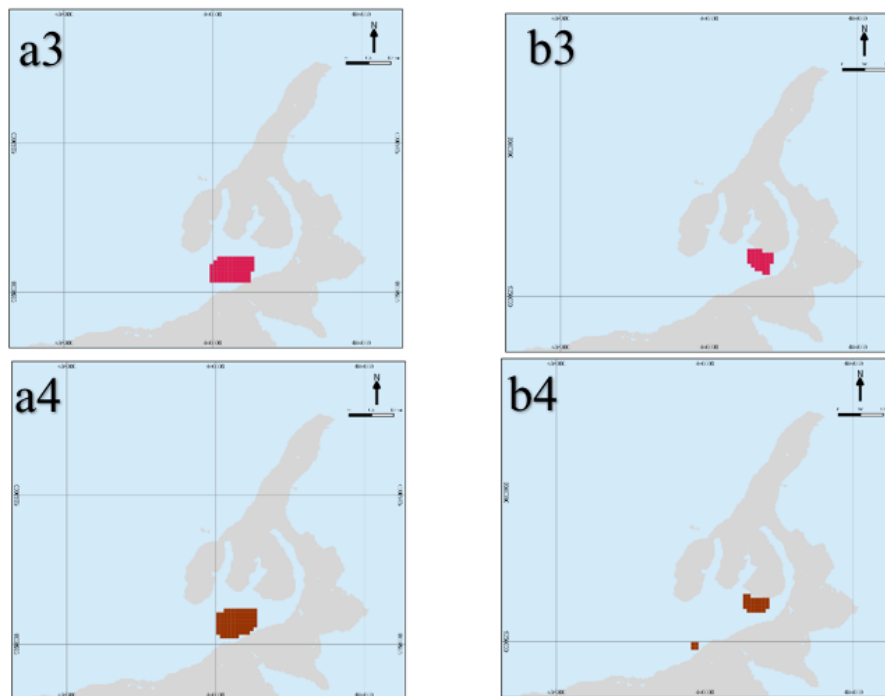

Figure 9. Best selected area from different scenario coral reef (a= Landsat 5 Imagery; b= Worldview 2 Imagery; 1= 0.1 BLM; 2= 0.005 BLM).
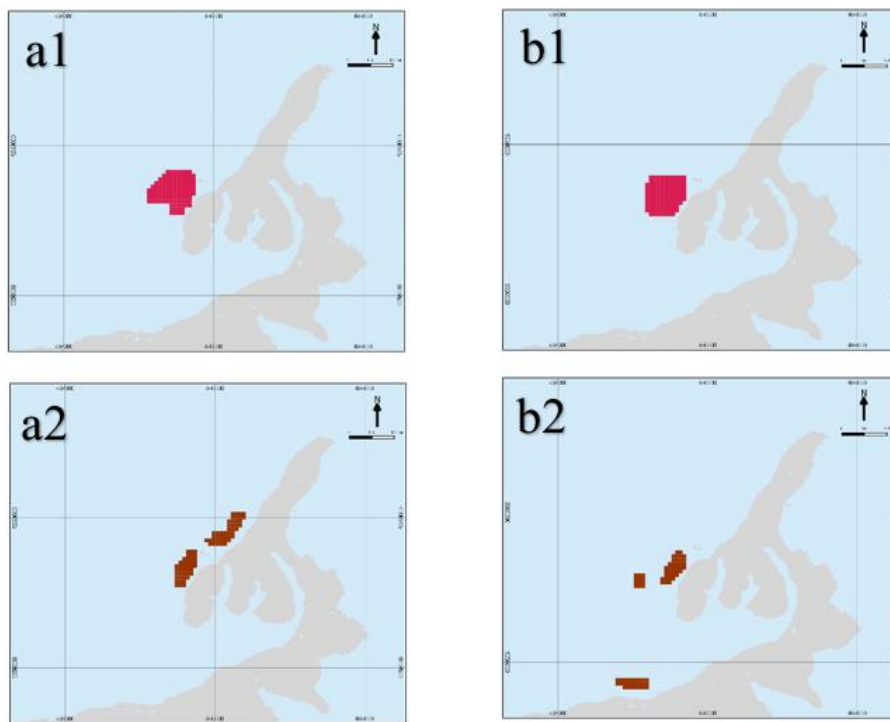
Figure 10. Best selected area from different scenario of seagrass (a= Landsat 5 Imagery; b= Worldview 2 Imagery; 3= 0.1 BLM; 4= 0.005 BLM).

3.3. *Discussion*

The different spatial resolution of satellite imagery (Landsat 5 and Worldview 2) result differences classification of shallow water habitat. This consequences influence Marxan analysis to determine best selected area for conservation. But several result from scenarios shows that in high value of BLM (in purpose to produce more compact area), the best selected area are similar. Based on this result, we can recommended for designing a new MPAs or initiate best prioritize area for conservation can be delivered from medium scale resolution of satellite imagery. Result from Landsat 5 clearly showed that in compact area, the best selected area are not vary with the result from Worldview 2.

However some scenario results also need to be of particular concern to determine the priority areas for the design of marine protected areas that is precise in the study area. Setting a low value of compactness was also necessary to find the pristine area without considering the boundary value of of each planning unit. This scenario is typically used to determine the zone and determine the core zone in a water conservation area. These results indicate that the use of high-resolution imagery will be very useful and give better results if you want to design a system of zoning within marine protected areas. When using the medium resolution imagery such as Landsat 5, it shows a very large bias. This can be seen in scenario C3 where the area identified as seagrass at medium resolution imagery such as Landsat 5, was in fact a mixture of bare substrate and macroalgae. Of course with a low level of accuracy, the effectiveness of the protection of the habitat becomes low as well.

Based on analysis of Marxan in the whole scenario, it can provide recommendations for the initiation of the conservation areas design that it is preferably using a medium-resolution image, which is already quite representative and can protect important habitat area in shallow water. The use of medium resolution imagery can also collaborate with more of ground sampling data and a more precise image analysis process which can give better results in Marxan analysis. However, the use of

high-resolution imagery is more advisable when planning the design of conservation areas with patchier area, especially for the purpose of zonation.

Acknowledgments

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