FISHPOND AQUACULTURE INVENTORY IN MAROS REGENCY OF SOUTH SULAWESI PROVINCE

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Abstract. Currently, fishpond aquaculture becomes an interesting business for investors because of its profit, and a source of livelihood for coastal communities. Inventory and monitoring of fishpond aquaculture provide important baseline data to determine the policy of expansion and revitalization of the fishpond. The aim of this research was to conduct an inventory and monitoring of fishpond area in Maros regency of South Sulawesi province using Satellite Pour l'Observation de la Terre (SPOT-4) and Advanced Land Observing Satellite (ALOS) Phased Array type L-band Synthetic Apeture Radar (PALSAR). SPOT image classification process was performed using maximum likelihood supervised classification method and the density slice method for ALOS PALSAR. Fishpond area from SPOT data was 9693.58 hectares (ha), this results have been through the process of validation and verification by the ground truth data. The fishponds area from PALSAR was 7080.5 Ha, less than the result from SPOT data. This was due to the classification result of PALSAR data showing some objects around fishponds (dike, mangrove, and scrub) separately and were not combined in fishponds area calculation. Meanwhile, the result of SPOT-4 image classification combined object around fishponds area.

Keywords: *Fishpond aquaculture, Optic remote sensing, Satellite imaging radar, SPOT-4, PALSAR*

1 INTRODUCTION

The coastal area of South Sulawesi Province has large potential for development of fishponds aquaculture. For example, in 2008 Maros Regency reached 20,197.93 tons of fish production in which 68.3% of capture fisheries, 26.4% of fishponds aquaculture, and the remaining 5.3% of other fisheries production. Therefore, fishponds aquaculture had a significant role in determining the fisheries production in Maros (Central Bureau of Statistics Maros Regency, 2009).

Inventory and monitoring of natural resources have normally conducted on conventional system that require time, effort and significant costs. Remote sensing technology can be used for inventory and monitoring of natural resources more efficiently, the solution to the problems of the conventional observation. Remote sensing techniques offer an alternative, giving an almost instantaneous overview over large areas at relatively low costs, and able to obtained data periodically and real time in areas that are difficult to achieve by conventional means.

Remote sensing in various aspects of aquacultures was demonstrated by Loubersac (1985) who used simulated high-resolution SPOT data (10-20 m) for aquaculture site selection. Kapolsky *et al*. (1987) has also made some GIS approach for aquaculture site selection. Travaglia *et al*. (2004) applied ERS SAR and RADARSAT data for maping coastal aquaculture and fisheries structure in Lingayen Gulf, Philippines.

The aim of this research was to apply remote sensing technique to inventory the fishponds aquaculture by using optical (SPOT-4) and radar data (ALOS PALSAR) in Maros Regency, South Sulawesi Province. The method used in optic data was supervised maximum likelihood while for radar data using the density slice method. In an effort to get a more accurate classification results, it was necessary to verify using field data obtained through field surveys. The use of optical remote sensing satellite data for fishpond aquaculture limited to cloud-free conditions, which are often difficult to be found in some parts of Indonesia. The use of radar remote sensing data can overcome the problems in optical remote sensing.

2 MATERIALS AND METHOD

Inventory and monitoring of fishpond area in Maros regency of South Sulawesi province used SPOT-4 and ALOS PALSAR. The study area was located in coastal areas of Maros regency, South Sulawesi province with boundary coordinate 4º 42 '56 "- 5 º 13' 57" South Latitude; 119 º 27 '47 "- 119 º 58' 29" East Longitude (Figure 1). In this research, we used two SPOT-4 images acquired on 25 April 2010 and 15 June 2011(Figure 2).

The research also used a radar satellite imagery ALOS PALSAR Level 1.5 Dual Polarization (Fine Beam Dual Polarization/ FBD namely HH and HV) acquired on 2 July 2010. ALOS PALSAR image had a spatial resolution of 12.5 x 12.5 m^2 with a projection of UTM WGS 84 Zone 50 South (Figure 1). Supporting data that used in this research were digital topographic elevation data (Digital Elevation Model/DEM) from SRTM; the administrative boundary map of Indonesia and Terrain map Indonesia (scale 1:50.000).

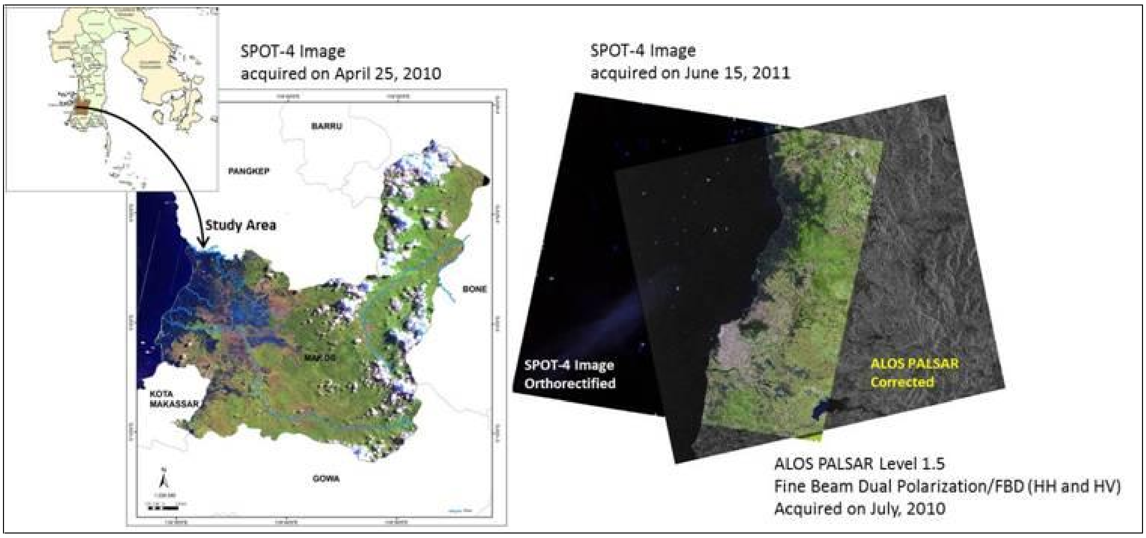
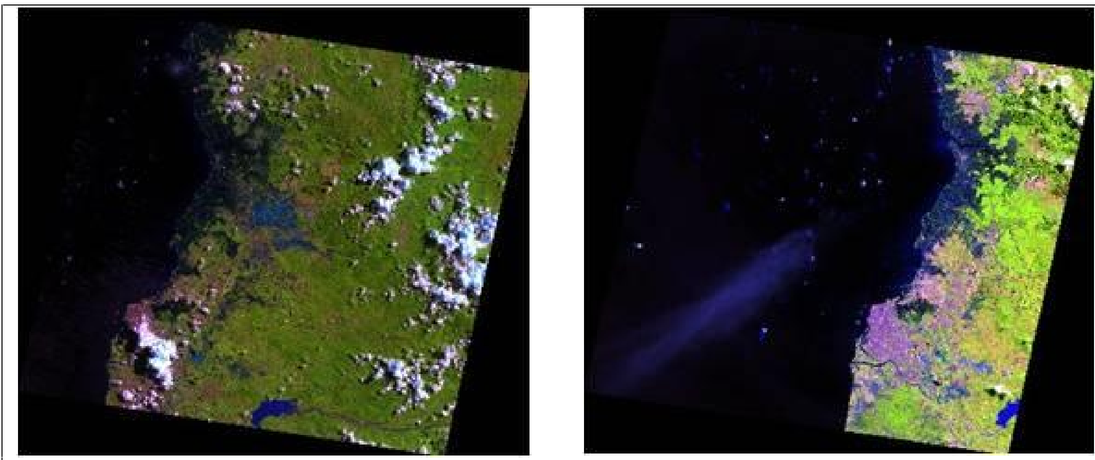


Figure 1. Research Location in Maros Regency, South Sulawesi Province



20100425SP4310360S0G2AXI (a)	20110615SP4310360S0G2AXI (b)

Figure 2. SPOT-4 image satellite 25 April 2010 (a) and 15 June 2011 (b)

The methods in this research used optical (SPOT-4) and radar (ALOS PALSAR) remote sensing technique. SPOT image classification process was performed using maximum likelihood supervised classification method and the density slice method for ALOS PALSAR. In general, method performed in this research are presented in the flowchart on Figure 3.

Technical classification of remote sensing imagery generally divided into two types; visual classification and digital classification. Visual classification was done by interpretation on delineation images directly, while the digital classification methods was done by supervised/ unsupervised (based on the digital image) using specific software. One of the digital classification method used in this study was supervised maximum likelihood classification method.

SAR image processing consisted of a geometric correction (orthorectification), radiometric calibration (absolute), noise reduction image disturbance due to the influence of atmosphere (speckle Noise Reduction), identification of fishponds using adaptive filter (Frost, Gamma and Lee) with the smallest window size which was 3 x 3, object identification using density slicing method and the classification of fishponds.

Data PALSAR level 1.5 already contained geometric information based on GRS80 ellipsoid. However, the same georeferenced was not used with SPOT-4 in this research. Therefore geometric correction was performed using the image reference of SPOT-4 15 June 2011 image orthorectified.

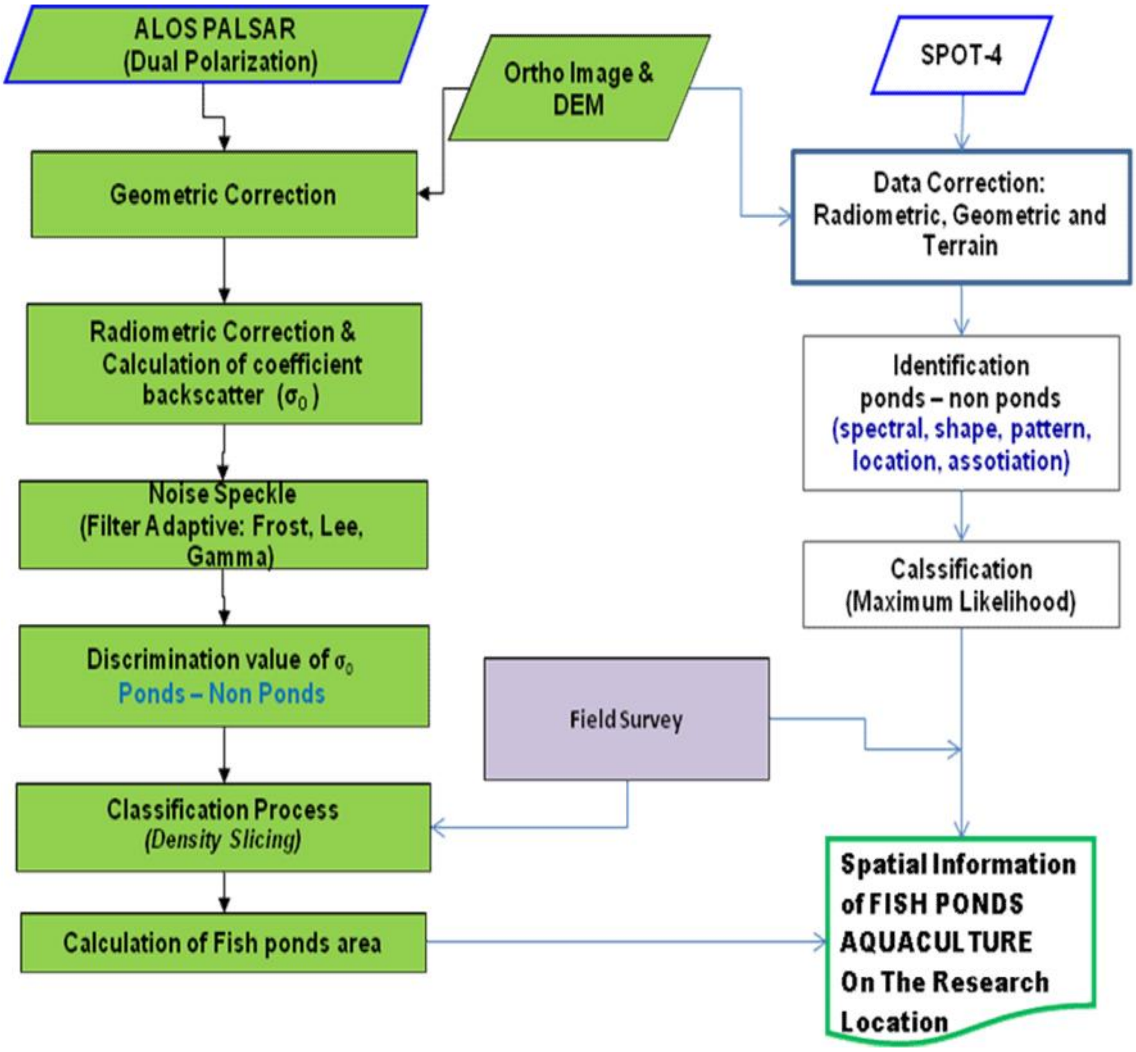


Figure 3. The flowchart of SPOT-4 and PALSAR data processing

3 RESULTS AND DISCUSSION

3.1 Optical data classification result

The classification result of fishponds area from SPOT-4 data in Maros regency was 9,462.527 hectares (Figure 4). This area calculation was taken before the field survey. Field survey is an effort to get a more accurate classification result. Deriving the correct information from the analysis of remotely sensed data requires some ground verification data. Once revised and verified by the ground truth data, the fishponds area became 9,693.58 hectares (Figure 5) or 2.44% larger. This was due to the different interpretation of the data processing with the actual situation, for examples fishponds area in Bontoa, before ground check the area are interpreted as non fishponds area. However, after ground check, it turned out that the location was fishponds area mixed with other vegetation (red circles in Figure 4a and 4b).

The difference in observation/ interpretation is shown in Figure 6, the area indicated by the color of cyan, while the area in accordance with the ground truth is colored by purple. These changes are mostly found in Bontoa, Maros Baru, Marusu and a small percentage located in Lau district. Classification results were also verified by geotagging of the observation points with IKONOS data on Google earth and Google Map website (Figure 7).

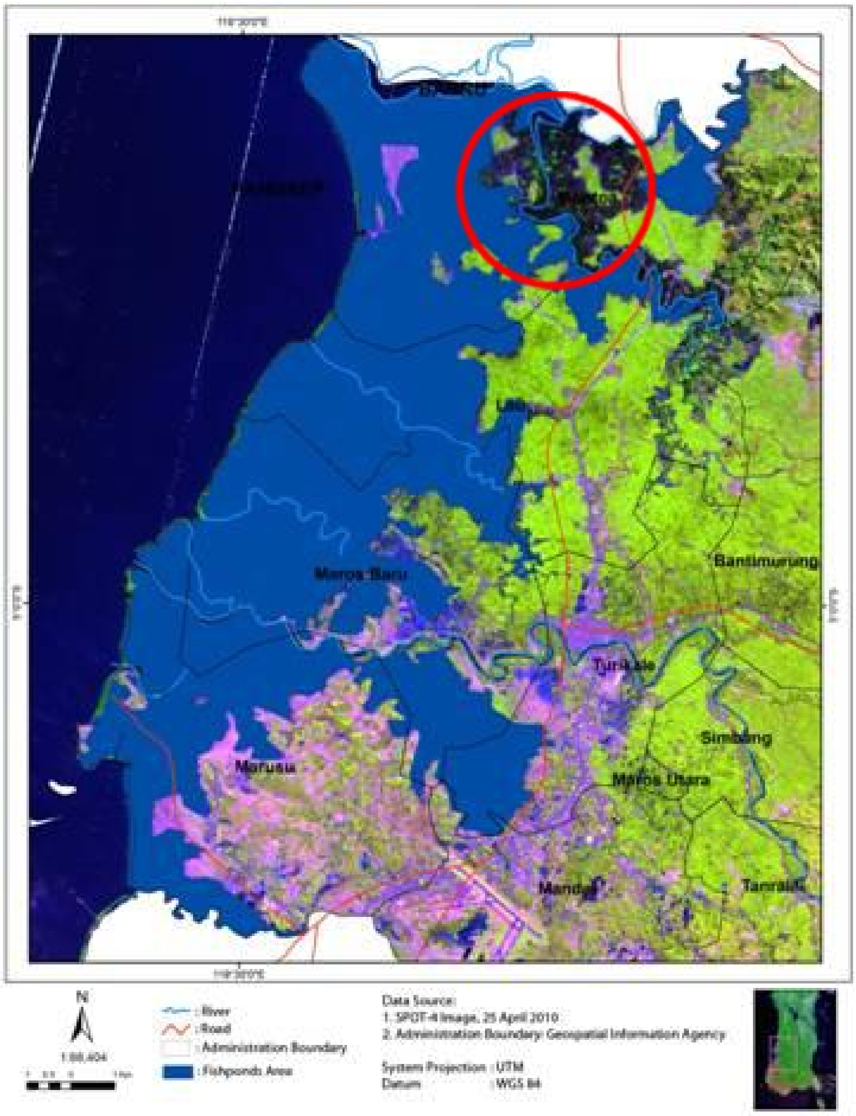


Figure 4. Classification result of fishponds area before verified by ground truth data

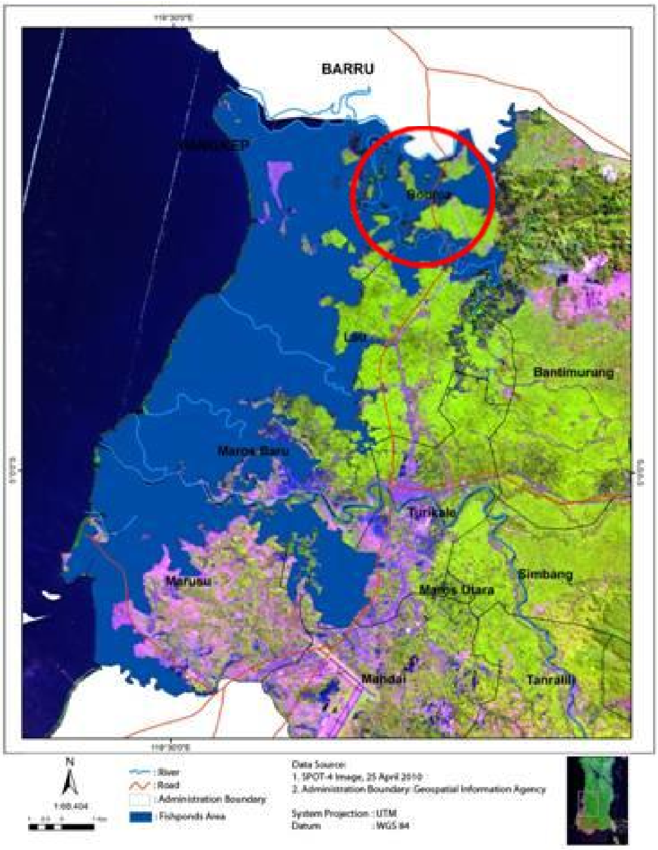


Figure 5. Classification result of fishponds area verified by ground truth data

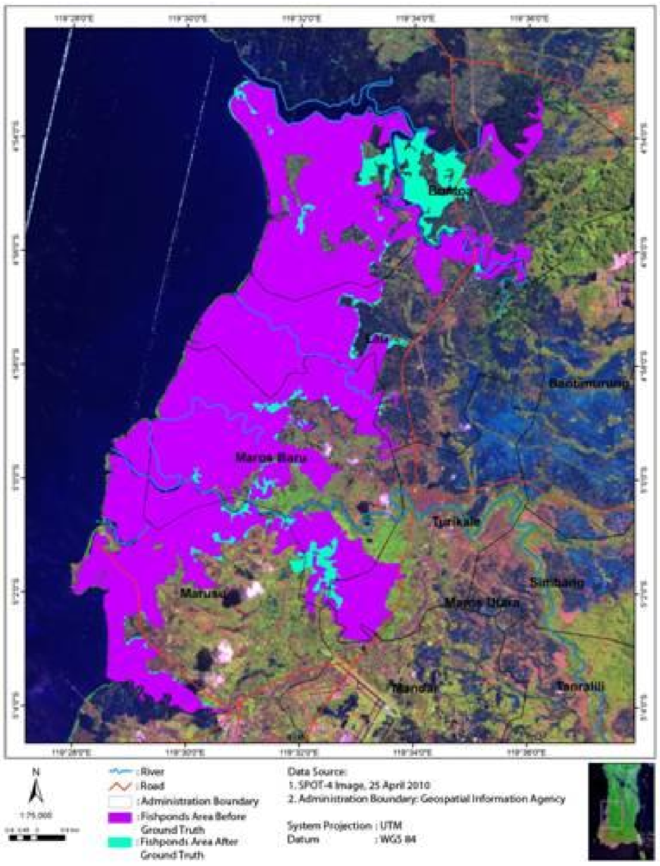


Figure 6. Fishpond area changes in Maros Regency before and after verified by ground truth data.

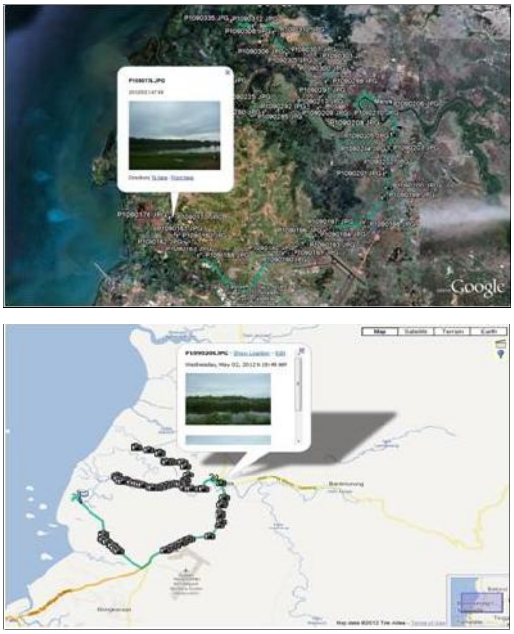


Figure 7. Geotagging of the observation points with IKONOS data on Google Earth Website and Google Map.

3.2 Radar data classification result

Visual object identification was done by creating a color composite of the two polarization PALSAR data and artificial band from two existing polarization. From both polarization, we produced 6 ALOS PALSAR image i.e., HH-HV, HH + HV, HH/ HV, HV / HH, (HH / HV) * (HH + HV) and (HH/HV) * (HH-HV). Based on these two polarization PALSAR data, the DN (digital value) pixels at HH polarization image had a higher value than the HV. This was because the energy of the signal transmitted and received back by the sensor had the same relative scale in HH polarization. While at HV polarization, emitted and received energy had decreased in the atmosphere.

From the two polarizations acquired in different objects appearance, HH polarization image had the advantages of object identification with reflection angle type. Object with respond of reflection angle had a high backscattering value (Wang, 2007). Urban areas with a high level of building development affect on a high value of backscattering. High backscattering was visualized with a bright hue in images ALOS PALSAR HH polarization. HV polarization had a high backscattering value on volumetric reflection type. Volumetric reflection generally occurred on vegetation object. This resulted in bright hue to the image of vegetation (Isti and Nur, 2012)

Six other artificial bands were made to show the appearance of the object based on addition and subtraction of two major bands (HH and HV) i.e., the ratio of the main band and the multiplication of the ratio of the addition and subtraction band. Based on the creation of six bands, visually there was no a specific object appearance, except for 1 band by multiplying the ratio of the addition and subtraction of the band (HH/HV) * (HH-HV). This artificial band showed single scattering from a flat surface with sparse vegetation and a variety of low density (for example rice vegetative phase. Therefore, to facilitate the visual identification of objects, we made a combination band or RGB color composite image of band polarizations HH, HV, (HH / HV) * (HH-HV). Visually from the appearance of the composite image, the objects with a flat surface (the surface water of the pond, dried pond), rough (forest and urban areas) as well as of the two appearances (the ground or water with sparse vegetation) can be clearly distinguished. Composite image as well as a composer of the combination band color and appearance of the object can be seen in Figure 8.

Composite color image of ALOS PALSAR can be used to complement the visual identification as well as the results in digital SAR image processing in identifying the fishponds. In fishpond identification, time series data were used to see the difference between the fishponds and in particular rice paddy field (in the water and dried phase) because the pattern and shape provided similar appearance. Some images can be distinguished the appearance of fishponds and paddy fields by the spectral response and the value of backscattering radar imagery. The difference between fishponds, paddy fields and appearance of other objects can be clearly seen in Figure 9.

The image of SPOT-4 of 25 April 2010 and the image of ALOS PALSAR showed that the pattern and appearance were almost the same because it was in relatively short period of time compared with SPOT-4 image of 5 June 2011. In April 2010, paddy fields in water phase were visible in the east of fishponds area in Maros regency. This condition was also observed from ALOS PALSAR image, particularly in the northeast Hasanuddin Airport. At this site in June 2011, land cover changed into green (rice generative phase). Appearance of fishponds area was more obvious from SAR imagery compared with optical images (at least two images necessary to distinguish rice fields and ponds).

Identification of fishponds from ALOS PALSAR image was done by applying an adaptive filter Frost, Gamma, and Lee. Based on the results obtained by applying the three filters, filter Gamma 3 x 3 showed the appearance of the pond clearer than the results of Frost and Lee filters, in particular to distinguish the ponds dyke and water bodies (Figure 10). Other land surface in the form of soil and vegetation around the pond can also be separated clearly. Frost filter exhibited less clear of ponds dyke, while Lee filter produced pixels roughness casuing blurring appearance of ponds. The results showed that Gamma filter was the best to identify and separate object from other object ponds. Separation was done by searching the pond backscattering value range of PALSAR image using density slicing.

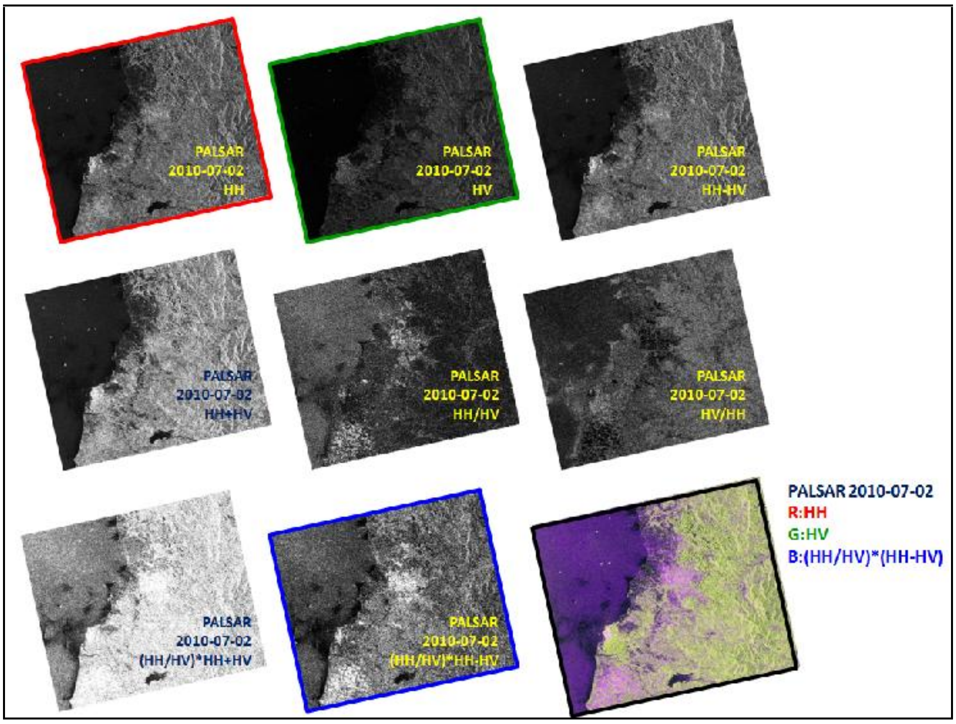


Figure 8. Dual polarization images (HH dan HV) and 6 artificial images of ALOS PALSAR data and composite image (R=HH, G=HV, B=(HH/HV)*(HH-HV))

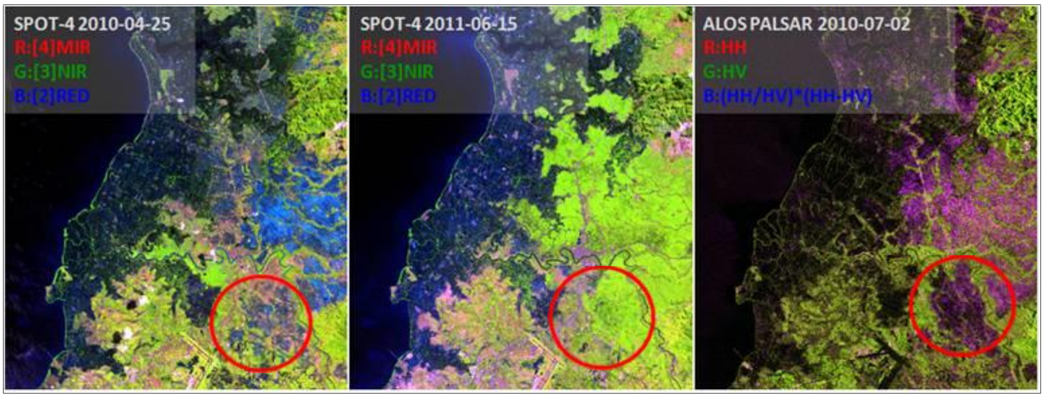


Figure 9. Land Cover and Fishponds Appeareances on SPOT-4 and ALOS PALSAR Images with Different Aqcusition Date

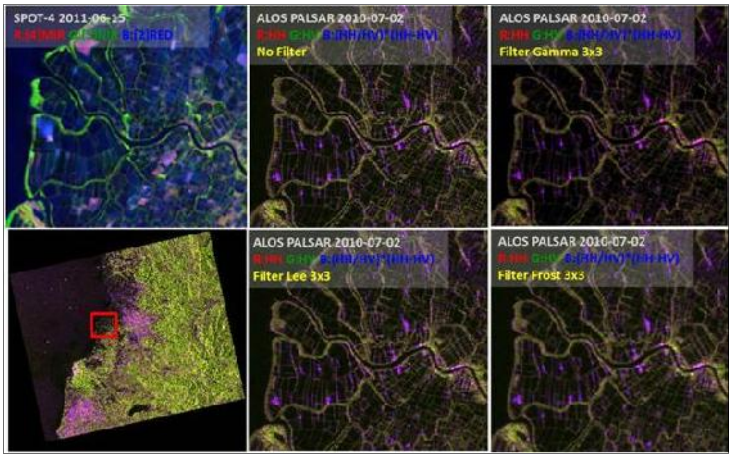


Figure 10. Fishponds visibility from optic sensor data (SPOT-4) and Frost, Gamma, and Lee filter result with 3x3window size on ALOS PALSAR image.

Density slicing is the process of converting the grey levels of an image into a series of discrete classes, each of which is equivalent to a data-range value. It provides a means of visually assigning classes to differences in radar backscatter or backscatter texture according to image brightness. Generally, a density slice is applied to a single variable by selecting data ranges and highlighting thematic classes or areas of interest by color coding (Cambell, 2002).

In the case of mapping fishponds and non-fishponds, density slicing assumes a threshold for identification of fishponds, since it is based on levels of brightness (or radar backscatter differences) where fishponds are small enclaves of calm water surrounded by dykes on all sides. A dyke is an earthen wall whose thickness ranges approximately from half meter to several meters, and elevation from the water surface is at the most one meter. Relatively smooth surfaces such as calm water appear in the radar image as dark tones. The approach assumes that water bodies appear in SAR imagery as areas of low backscatter, but low returns may also include pixels of smooth non-water regions. Nevertheless, the density slice technique was used in this study to evaluate the performance of the products of SAR sensor for fishponds identification.

Data-range values when applying the density slice for the fishponds class to PALSAR image was -22.01 up to -15.95 for HH polarization and for HV polarization was -32.33 up to -24.72. Figures 11 shows the density slice ranges for fishponds class in the PALSAR image in HH and HV polarization along graphic profile of the value of objects extracted and the classification of fishponds area from PALSAR data shown in Figure 12.

The result from density slice technique on PALSAR data 2010 showed that the spatial size estimation of the fishponds illustrated in Figure 13 was around 7080.5 ha compared with 9693, 6 Ha estimated from SPOT-4 2010 image that has been verified with the ground truth data. The difference was due to different classification results. The classification results of PALSAR data showed some objects around fishponds (dike, mangrove and scrub) separately and were not combined in fishponds area. Meanwhile the results of SPOT-4 image classification combined object around fishponds area.

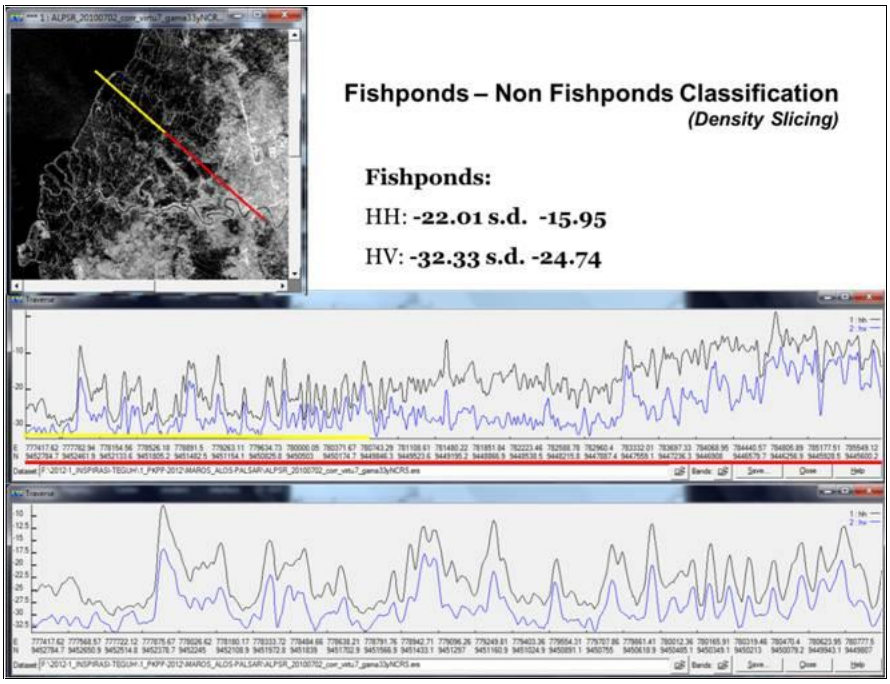


Figure 11. Graphic value profile of the objects extracted by the density sliced method.

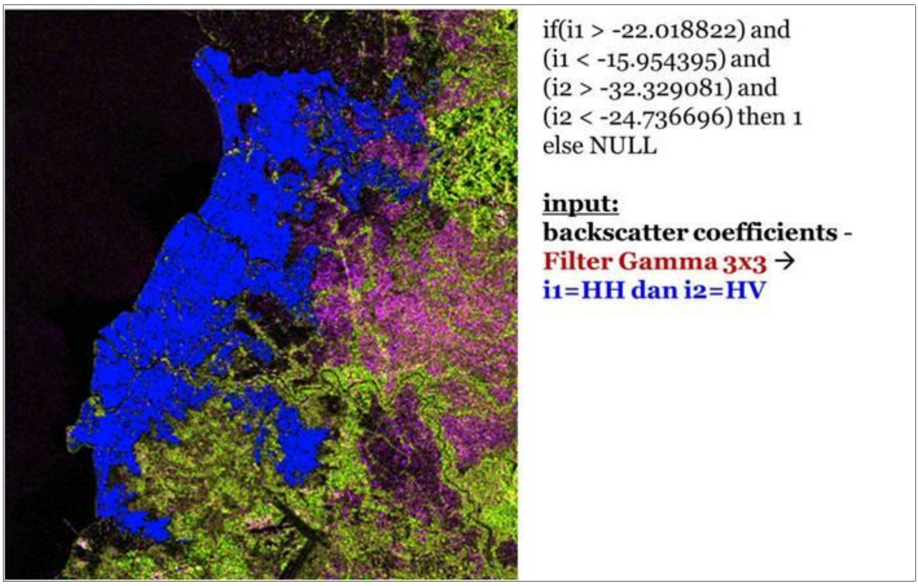


Figure 12. Fishponds area (blue color) of PALSAR imagery using density slicing method.

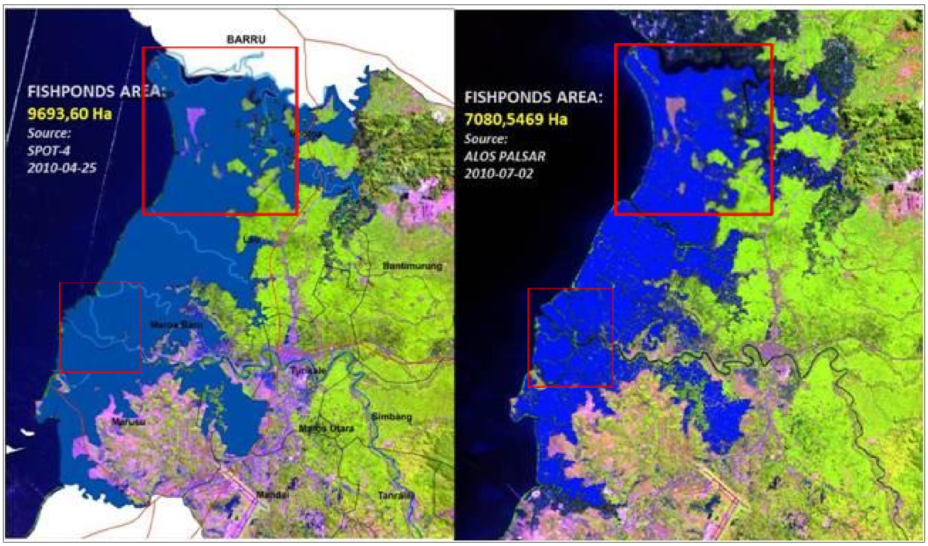


Figure 13. Classification result of fishponds area in Maros regency using SPOT-4 and ALOS PALSAR data.

Fishponds identification using ALOS PALSAR imagery provided information that unconstrained by cloud cover and backscatter from the fishponds components allowed for their easy identification and separation from other natural features.

4 CONCLUSION

The determination of fishpond area in Maros regency using SPOT-4 and PALSAR data showed different result. SPOT-4 data exhibited the fishponds area in Maros regency of 9,693.58 ha, while PALSAR data showed of 7,080.5 ha. The SPOT-4 estimation was validated with grouns truth data.

The PALSAR estimation was less about 27% than SPOT-4 estimation due the classification results of PALSAR data indicated some objects around fishponds (dike, mangrove and scrub) separately and not combined in fishponds area, meanwhile the results of SPOT-4 image classification combines object around fishponds area.

The PALSAR data are unique not only for their inherent all-weather capabilities in which very important for aquaculture activities in tropical areas, but also essential because the backscatter from the structure components allows for their identification and separation from other features.

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