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# APPLICATION OF REGION GROWING SEGMENTATION METHOD FOR MANGROVE ZONATION ATPULAU KUKUP, JOHOR

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**Abstract:-**

The anticipated impact of Sea Level Rise (SLR) for the next century has been studied for the past long years. Prolonged submergence and changes in tidal inundation frequency changed the intertidal community landscape including the mangroves zonation pattern. This study aims to identify the mangrove species distribution at Pulau Kukup, Johor using a high resolution, Worldview-2 satellite data. Mangrove extent was extracted from multispectral and panchromatic images using region growing segmentation method. Several thresholds were used to identify the best-fit segmentation parameters. Eleven plots of 100m transects were established in the study area to sample the representative mangrove trees. The type of mangrove species, tree height, Diameter at the Breast Height (DBH), elevation, coordinate location and the sediment sample were collected during the field survey based on Point-Centre-Quadrate Method (PCQM). The general characteristics of mangrove tree were investigated and sampled from 186 mangrove trees. Rhizophoraapiculata and R.mucronata were found dominating the outer part of the mangrove island facing the seaward area. From the field analyses, the relative density of Rhizophoraapiculata and R.mucronataare 41.9% and 16.7% respectively. The mangrove characteristic and coordinate locations were then mapped out and used as a reference point for training processes. The image classification is determined based on Bhattacharyya method and the mangrove zonation pattern was mapped from the result.

Keywords:-*WorldView2 satellite images; object-based classification method; mangrove dominance; mangrove zonation map.*

## Introduction

Species zonation is a common feature of mangrove forest. It is largely influenced by the physical-chemical factors of the surrounding area (Bunt, 1996).The patterns are not always in a monospecific sequence or a clear cut zone. In tropical mangrove forest, zonation pattern is always hard to specify due to the complexity of the community structure (UNEP,2004).The species domination willformvisible assemblages in the complex mangrove structure which is finally defined as mangrove zones (Bunt, 1996).

Mangrove zones are define as a mangrove species distribution pattern that extend from shore to inland region (Davis, 1940).The mangrove zonation pattern provide a basic information for successional processes, geomorphological influences and dispersal (Ellison, 2000).

Mangroves live at intertidal zones and are largely exposed to any changes of seawater level. As aresult, mangrove communities will respond to the changes by migrating inlandor towards the sea. The migration will change thezonation pattern which can change the functionality of anatural forest structure. It shows the importance of zonation factor to the mangrove ecosystem. Therefore, the need to understand the basic information on mangrove zonation pattern is important as this can assist in strategically selecting the best sites and planting methods in any mangrove replanting programme.

This study focuses on the generation of mangrove zonation map using a remote sensing dataset and appropriate approaches for the complex and dense mangrove environment. This work is an exploratory study, implementing a multi-scale approach on World-View 2 dataset, field survey data and application of object based classification techniques from an open source software (SPRING 5.2). The result provide basic information onthe mangroves zonation pattern of the area which is important for future conservation planning as well as toshow the strategic approach for mangrove mapping at mangrove island environment.

## Methodology

*Study Area*

The study site is located at the Pulau Kukup mangrove forest in the state of Johor (Figure 1). The Pulau Kukup mangrove forest, covers about 647ha of extensive mangrove forest and 800ha mudflat at the north-west coast of the island. The island is a unique biodiversity on its own and holds a reputation as a RAMSAR site since 2003. According to Yaman et al., (2008), Pulau Kukup is the second largest mangrove island in the world and a home for *Brugueirahainesii* (Bakau Berus Mata Buaya) and *Mycteriacinerea*. Both species were listed in IUCN endangered species list. This study focuses on approximately 647 ha of wetland vegetation. This site was characterised by a high density of vegetation covers and known as a pristine mangrove forest. The dominant mangrove species were identified as *Rhizophoraapiculata*, *Rhizophoramucronata* and *Bruguieracylindrica*(Tan *et al*., 2012)

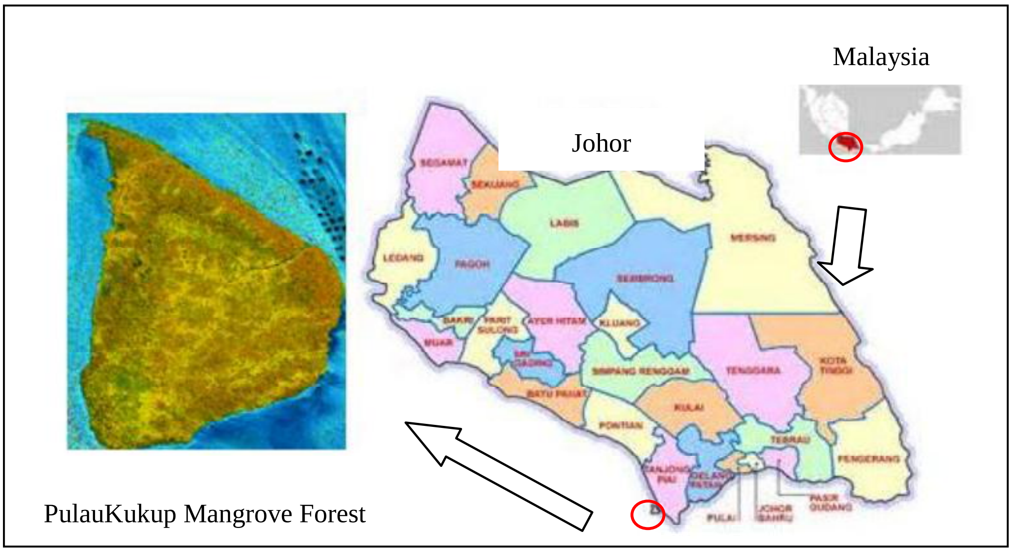


**Figure 1:Location of study site**

The field survey was carried out between 9 June and 16 June 2014. Point-Centre Quarter Method (PCQM) based on Cintron and Novelli (1984) studies was adopted as a sampling procedure. Six random blocks were established to generate eleven plots for theentire island. A 100-m transect line were established within each plot to determine the centre node at every 30m interval. Four quarterswere established at each centre node to determine the nearest mature mangrove tree to the centre node. The mangrove characteristic of individual tree was recordedfor each quarter (Q1, Q2, Q3 and Q4). Height, circumference, coordinate location, mangrove species and tree images (root, stem and leaves) were captured and recorded for further analysis. Identification was made according totheidentification reference card published by Ng and Sivatoshi (2009). The image of mangrove tree and surrounding area was taken for future reference and identification.

*Image Processing*

A 25-km$^2$WorldView-2(WV2) image was acquired on 11$^{th}$ May 2005and was already or thorectified and georeferenced to WGS-84 projection system. It is a high resolution multispectral satellite image, which is commercially available for land use mapping. The main features of WV2 are the 8-band multispectral imagery with 2m spectral resolution and0.5m spatial resolution for panchromatic image. Thespectral ranges of the eight bands are 400–450 nm (B1-coastal),450–510 nm (B2-blue), 510–581 nm (B3-green), 585–625 nm(B4-yellow), 630–690 nm (B5-red), 705–745 nm (B6-red edge),770–895 nm (B7-near infrared-1), and 860–1040 nm (B8-near infrared-2*)*. The WV2 system offers incredible accuracy and diverse spectral range, useful for vegetation mapping. First, the image was imported to ENVI 4.8 for image pre-processing procedure.

The Gram-Schmidttransformation tools inENVI 4.8 was use to improve the spatial resolution of multispectral bands. The transformation enhanced the imageresolution from 2m to 0.5m. The Gram-Schmidt (GS) pan sharpening technique is a pixel fusion method to increase the low spatial resolution multispectral image (MS) with high resolution panchromatic image (PAN) (Maurer, 2013). The pan-sharpen image was converted to (.tiff) file and imported to SPRING 5.2 for image segmentation and classification. SPRING 5.2 is a GIS and remote sensing image processing system with an object-oriented data model which provide for the integration of raster and vector data representations in a single environment. SPRING 5.2 is a product of Brazil's National Institute for Space Research (INPE/DPI (Image Processing Division) (Camara *et al*., 1996). Figure 2 shows theconceptual flowchart formultistage mangrove mappingtechnique.

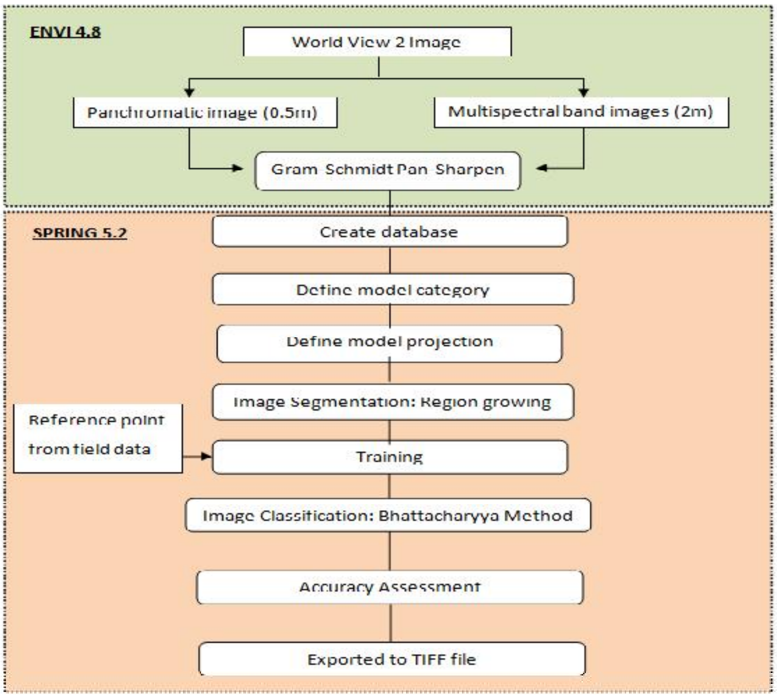


**Figure 2: Flowchart of multistage mangrove mapping technique using ENVI 4.8 and SPRING 5.2 software**

*Segmentation*

The segmentation is a grouping process of individual pixel that has certain homogeneity criteria into a group pixel (Espindola et al., 2006). In SPRING 5.2 the region based segment was developed using region growing method by statistically comparing the mean greylevelin the seed points with spatially adjacent region toform a definitive object (Espindola et al., 2006).The algorithm iteratively tries to merge the resulting region until it reached certain limitation defined by area threshold. Similarity is a threshold value that determines iftwo neighbouring pixels (objects) can be grouped together, while the area threshold is used to filter out the objects smaller than this value (Camara et al., 1996). In this study, three set of segmentation parameters was tested on hit and trial method to find the best combination. Theoptions for the sets of parameters are Set 1 (Similarity 5, Area 10), Set 2 (Similarity 10, Area 15) and Set 3 (Similarity 20, Area 30). Visual interpretations were used to select the best-fit segmentation output based on field survey information and satellite image observation.

*Object Based Classification*

The classification process was conducted onto the best-fit segmented region. Classification is an identification process of segmented region to match the field land cover. The first step of classification procedure is a trainingprocess to place the ground control point from the field survey onto the segmented region. Targeted elements were classified into eight categories namely WATER (water bodies), NM (non-mangrove), RM (*Rhizophoramucronata*), RA (*Rhizophoraapiculata*), SA (*Sonneratiaalba*), BP (*Brugueiraparviflora*), BC (*Bruguieracylindrica*) and XM (*Xylocarpusmoluccensis*).

The placement of ground control point within the segmented region was equally divided for classification and validation purpose. To fulfil the principles in object-oriented classification of image processing, Bhattacharyya distance algorithm was used to perform the classification. The fundamental idea in Bhattacharyya classifier is to measure the overlap between two statistical populations and determine the relative closeness from the two populations (Camara et al., 1996).

Bhattacharyya algorithm was applied to measure the separability of spectral classes in segmented region. The classification processes was tested on three possible band combinations which are visible band (5, 3, 2), modified false band (7, 3, 2) and vegetation band (7, 6, 5).The threshold level was set-up to 99.9% to run the Bhattacharya classifier. For accuracy assessment, a group of ground control point from field survey was use as a dataset for validation. It is to test thequality and reliability of theclassified map.Finally, the classified map was converted to (*.tiff) file and transferred to ArcGIS 9.3 for polygon construction. The polygon construction was developed based on the existence of the dominant species at the specific location at the study area to represent the mangrove zonation pattern

**Result and Discussion**

From the analyses, segmentation parameter of similarity 10, area 15was selected as the best-fit segmentation output. Figures3 and 4 shows the comparison between the segmentation outputs produced from three sets of segmentation parameters. Set 3 (similarity 20, area 30) parameters, shows signs of under segmentation, wheremost of the small object (i.e.: tree crown) was not segmented. Meanwhile, Set 1 (similarity 5, area 10) parameter shows an over segmentation for the large object such as rivers, jetties and fish cage (Figure 4). However, Set 2 parameters (similarity 10, area 15) produce the best-fit segmentation output, where the large and small objects wererelatively fittedinthe segmented region.

The suitability of segmentation parameters with land cover features is critical in order to produce a reliable classification map. According to Espindola et al., (2006) unsuitable segmentation parameters will decrease the accuracy of classified maps while the reliability of the output is questionable. Fardia et al., (2005) suggests that the human interpretation for segmentation output can be used to select the best segmentation parameter. Previous author had tested several combination of segmentation parameters in SPRING 5.2 software for forest such Joshi et al., (2012).

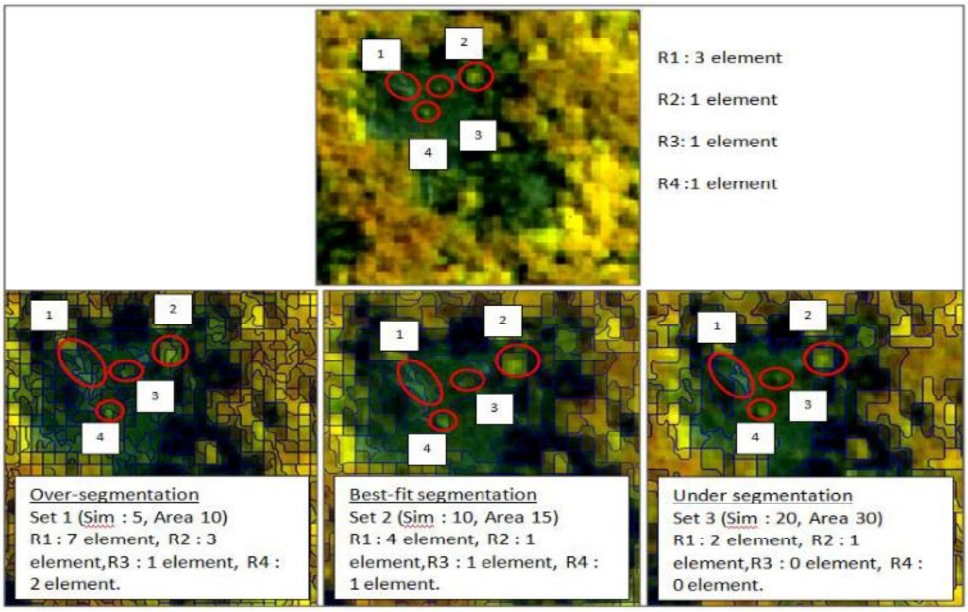


**Figure 3: The comparison of segmentation output from 3 set of segmentationparameters with original land cover image**

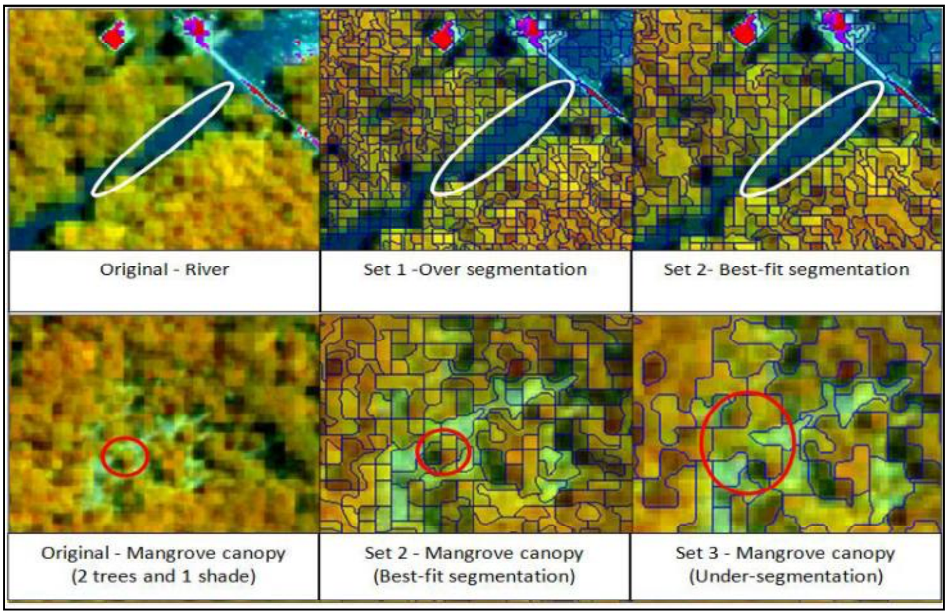


**Figure 4: Comparison of segmented output from segmentation parameters**

Apart from that, the segregation of spectrum range in WV-2 had become a major advantagefor forest classification. The red-edge band captured by WV2 was narrower than Quickbird dataset (Lane et al., 2014). According to the developer (Digital Globe), the new red-edge band in WV2 dataset was specialized for vegetation discrimination which capture the energy level between spectrum range 705-745nm. Several studies showed the application of red-edge band for vegetation analysis such as Muntanga et al., (2012), who described the significant correlation between Normalized Difference Vegetation Index (NDVI) with the red-edge band. In addition, several authors (Elsharkawy et al., 2012 and Lane et al., 2014) have proven that the application of red-edge band increases the accuracy level for vegetation mapping.

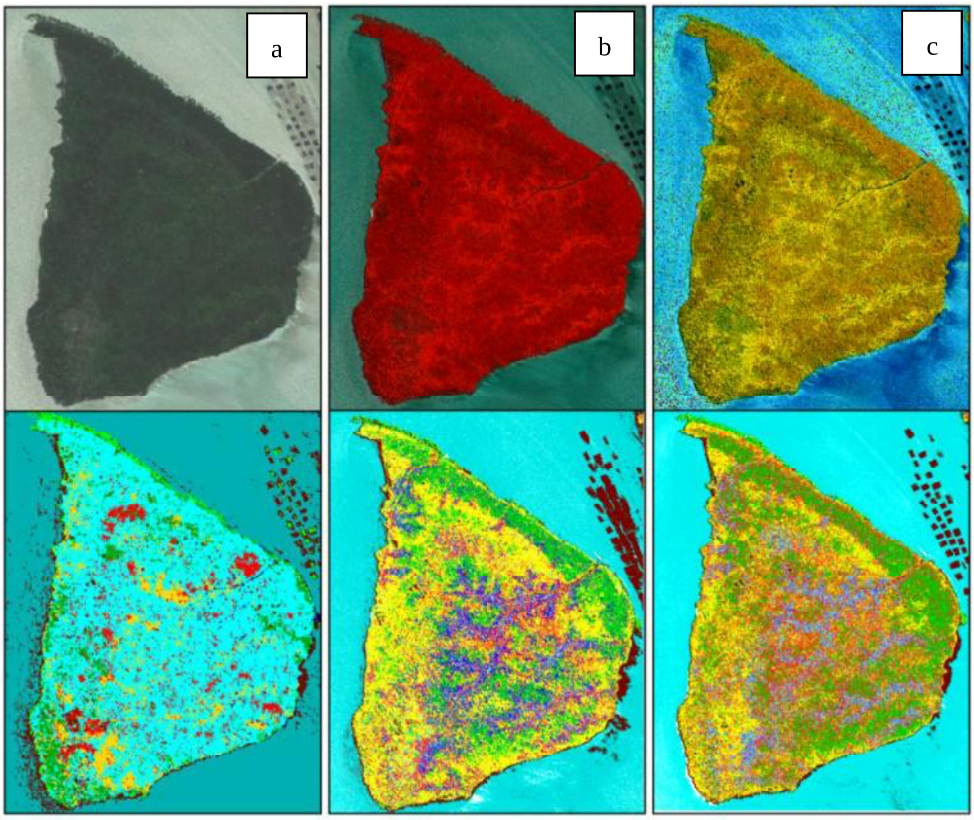


**Figure 5: The classification results from Bhattacharyya distance classifier using band combination of a) Visible color, b) Modified false color, c) Vegetation color**

From this study, the combination of red-edge band with Near Infrared-1 and red band had increased the reliability of mangrove mappingby approximately 20%. The studies conducted by Marchisio et al., (2010) concludethat the additional spectral band can improve the accuracy level by 5-20%. Figure 5 shows the result of classification using visible color band (red (5), green (3),blue (2)), modified false color band (Near infrared-1(7), green (3), blue (2)) and vegetation color band (Near Infrared-1(7), red-edge(6),red (5)). The vegetation color band shows the highest accuracy level

(91.28%) followed by modified false color band (64.49%). However, the visible color band had recorded the least accuracylevel (45.65%) among other band combination. The accuracy assessment was depicted from overall accuracy level served as an indicator for the output from classified map. It is a summary of total agreement and disagreement between the major diagonal of the results.

The complexity of species composition and dense vegetation intropical mangrove island contribute to the challenge for image processing (Adam et al.,2004). Although the use of fine spatial and spectral resolution from optical sensors had achieved certain degree of success rate for species composition mapping, some limitation and drawbacks was reported in a study by Lu (2006). Through the application of object based classification software such as SPRING 5.2, the vegetation mapping at the dense and complex environment is accessible. The object-based classification technique allow user to define and segregate the tree crown in the dense forest through image segmentation (Joshi et al., 2012). Later, the Bhattacharya distance algorithm focuses to classify the spectral separability between each segmented region from the information define in training processes. Studies reported by other authors such as Camara et al., (1996) and Joshi et al., (2012) shows the application of SPRING 5.2 in forest mapping field and derived a reliable classification output from the analysis especially for the complex ecosystem such as Pulau Kukup mangrove forest.

Figure 6 shows the illustration of mangroves zones at Pulau Kukup mangrove island using the band combination 7, 6 and 5. The construction of polygon was undertaken in ArcGIS 9.3 software to produce a distinctive zonation pattern. The ecology of amangrove island is well-known forits complexity and mixed species (Ellison et al., 2000). Certain consideration on diversity and complexity of mangrove environment should be practised, but only anextensive survey can be expected to reveal the full extent of zonal pattern in the associated vegetation (Bunt, 1996). Many studies on mangrove zonation pattern had focus on the existence of dominant species at the specific area to represent the formation of mangrove zone (Bunt,1996; Tomascik et al,1997; Ellison et al., 2000). The pattern was triggered by the responses of individual species variation in degree of tidal inundation, salinity or other measurable edaphic gradients that vary across the intertidal gradient (Snedaker, 1995).

In this study the field survey activities had revealed the domination of certain species which can contribute to the identification of mangrove zones (Figure 6(a). Six types of mangrove species namely *Rhizophoramucronata (RM)*, *R.apiculata (RA)*, and *Sonneratiaalba (SA)* (Zone 1), *Bruguieraparviflora(BP)* (Zone 2), *Brugueiracylindrica (BC)* (Zone 3) and *Xylocarpusmoluccensis* (XM) (Zone 4)

Figure 6(b) and 6(c) shows the zonal distribution pattern for Pulau Kukup based on the mangrove species classification studies by Watson (1928) and Tomascik et al., (1997).The domination of RA, RM and SA at the outer part of themangrove island (Zone 1) relates to the characteristics and species adaptation to livewithin all high tides condition.The mangrove of Zone 1 was normally found to have the stilt or prop roots system (Tomscik, 1997). This type of root system provides the stability andbreathing apparatus to the species (Ellison, 2000). The root configuration system increased the stability by anchoring to the substrate while trapping more sediment within the system. The breathing apparatus known as lenticels around the root surfaces provide more surface area for gaseous exchangeandefficiently enhanced the breathing activities (UNEP, 2004). This is an important feature for mangroves at Zone 1, which hasthe longest period submerged in water, compared to other species fromthe inner zone.

The Zone 2 mangrove species was represented by BP. According to Ng and Sivatoshi (1999), this type of species was commonly found at intermediate estuarine zones in the mid-intertidal region. The species was slow-growing tree and normally found as monospecific species. *Bruguieraparviflora* thrive on newly formed ground usually on the stiff clay behind pioneer species like Rhizophora sp. which are more salt tolerant.

*Bruguieracylindrica* was found dominating the inner part of the mangrove island which represents Zone 3. These types of species flourish at silt clay soil within the range of high and mid tidal zone normally near to the downstream. According to Watson (1928), Zone 3 species received less inundation frequency (around 20-45 times per month) and was adapted to shorter submergence period. Therefore the species was equipped with knee-root system which issmaller than Zone 1 roots system. The roots system was also unable to extend from branches to the ground like Rhizophora spp. *Xylocarpusmoluccensis* (Zone 4) lives slightly inland (higher elevation), and is closer to the riverbanks for freshwater supply (Tomascik et al., 1997). It is always found within the middle to the upper tidal limits of estuarine reaches. The species usually grows individually rather in assemblages. Therefore in our survey, the XM stands were found in the patches located near to the riverbank.

Figure 6(d) shows the distribution of mangrove species from the field survey data. The large numbers of RA and RMtrees were found at the outer area of the mangrove island concludes the clear domination of the species at Plot A, E, G, H and I. Meanwhile, Plot F showed more complex forest structure with the occurrence of RA, RM, BP, BC and XM. However, the high numbers of BC trees found at the area, shows the suitability of the habitat to the species which triggered the establishment at the area. Therefore, Plot F was represented by BC in mangrove zonation mapping.

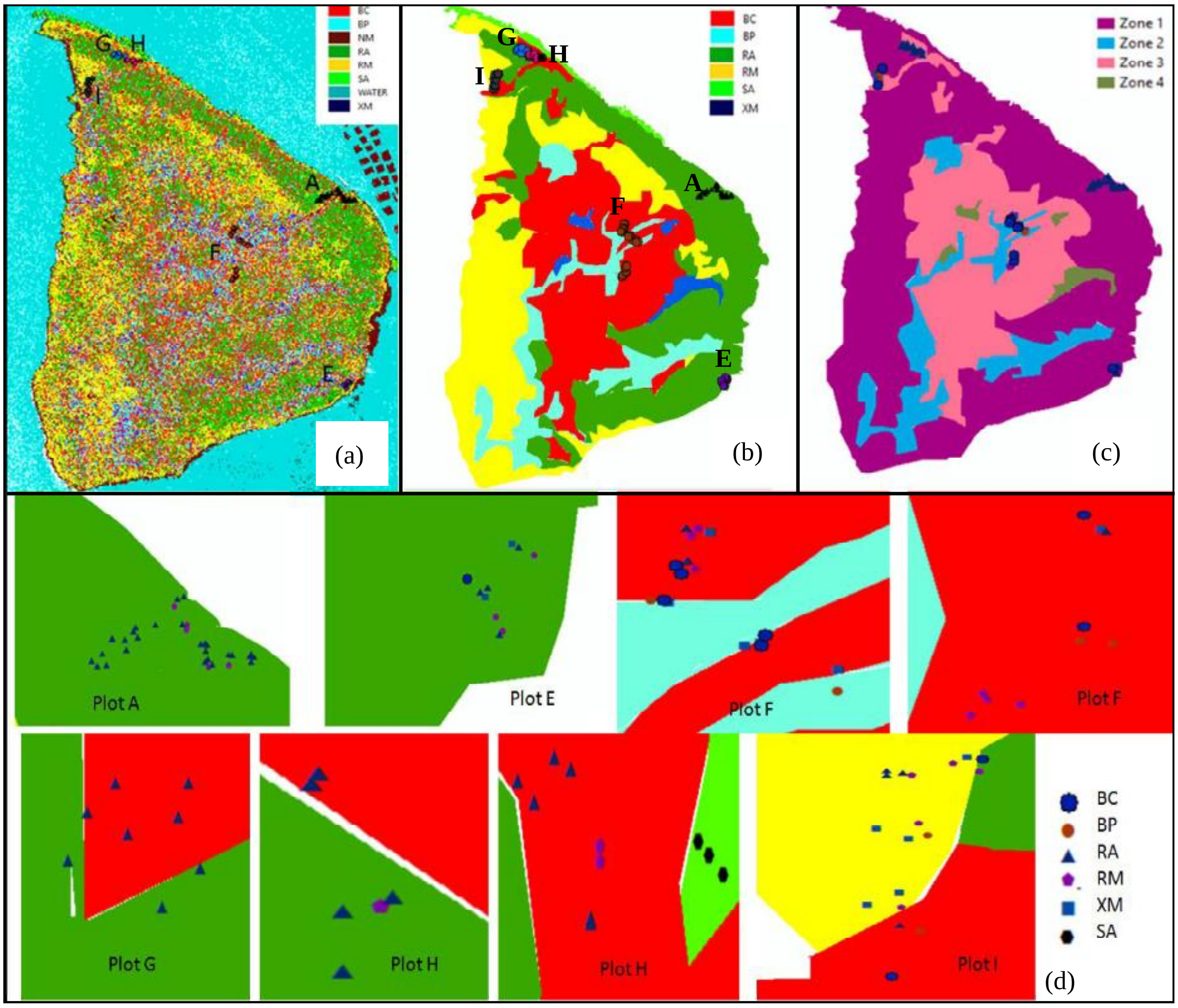


**Figure 6: Illustration of mangrove zones at PulauKukup mangrove forest. (a) Classification map for PulauKukup. (b) Zonation pattern according to dominant species distribution. (c) Zonation pattern according to Watson (1928) Mangrove Hydrological classification. (d) Mangrove species distribution from field survey data**

Overall, the mangrove zonation pattern generated from satellite images had shown the comparable results with field survey data (Table 2). The pioneer species such as RA, RM and SA were found in a large number near to the shorelines and facing the seaward area during the inventory activities (76-100% found in Zone 1). Meanwhile other species such as BP and BC was largely sampled from the inner part of Pulau Kukup (67-80% found in Zone 2 and 3 for respective species). The assemblages of XM were found in patches near to the riverbank, suggesting the requirements of this species to constant freshwater supply to grow. From the field observation, XM trees were normally found in the higher elevations which stiff and coarser sediment was available. Table (1) show the summary of individual mangrove species distribution from field survey dataaccording to thelocation of sampled plots

**Table 1:Summary of individual mangrove species distribution based on the field survey data**

| Plot | Location | RA | RM | SA | BP | BC | XM |
|---|---|---|---|---|---|---|---|
| A | Outer | 29 | 5 | 0 | 0 | 0 | 0 |
| E | Outer | 4 | 3 | 0 | 0 | 1 | 2 |
| F | Inner | 3 | 8 | 0 | 4 | 7 | 6 |
| G | Outer | 12 | 0 | 0 | 0 | 0 | 0 |
| H | Outer | 9 | 3 | 3 | 0 | 0 | 0 |
| I | Outer | 4 | 5 | 0 | 2 | 2 | 5 |
| **Total** | | 61 | 21 | 3 | 6 | 10 | 13 |

**Table 2: Summary of mangrove area (ha) from classification map analysis andpercentage of mangrove species distribution from the field survey data analysis**

| CLASSIFICATION MAP ANALYSIS | | | | FIELD SURVEY DATA ANALYSIS | |
|---|---|---|---|---|---|
| **Zone** | **Total Area (ha)** | **Species** | **Area (ha)** | **Field Survey Data (Outer Area) (%)** | **Field Survey Data (Inner Area) (%)** |
| 1 | 389.84 | *Rhizophoraapiculata* | 206.70 | 95 | 5 |
| | | *Rhizophoramucronata* | 176.50 | 76 | 24 |
| | | *Sonneratia alba* | 6.64 | 100 | 0 |
| 2 | 67.55 | *Bruguieraparviflora* | 68 | 33 | 67 |
| 3 | 180.66 | *Brugueiracylindrica* | 180.66 | 20 | 80 |
| 4 | 8.95 | *Xylocarpusmolucsensis* | 8.95 | 53 | 47 |

Providing information on the species composition and structural properties of mangroves is essential to support the conservation and management actions. Although mangrove forest was commonly found in a thick and dense community structure, the new technologies and approaches could be adopted for the basic classification at the remote and inaccessible area. The basic information on mangrove zonation patterns is equally important to ensure the success of the whole conservation strategies. By acknowledging the mangrove zonation pattern of the area, more complex studies could be plan out which hope to benefit the mangrove island sustainability in future.

## Conclusion

- The region growing method in SPRING 5.2 are capable to generate the best-fit segmentation region for Pulau Kukup mangrove forest using the similarity 10, area 15.
- The band combination (7,6,5) for red-edge, Near Infrared-1 and red band of WV2 generate the highest accuracy level for mangrove classification map at Pulau Kukup
- From the classification map, Pulau Kukup is dominated by RA, RM, and SA at the outer area of the mangrove island. WhileBP and BCdominate the inner area of the island. However,XMwas found in patches, suggesting its stand-alone behaviour

had contributed to the distribution pattern. The distribution pattern from classification map concurred with the field survey data which shows RA,RM and SA dominates outer area (76-100%), BP and BC (67-80%)

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