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International Conference on Tropical and Coastal Region Eco-Development 2014(ICTCRED 2014)

EDITORIAL

All the papers published in this Environmental Science Procedia were being presented at the 2014 International Conference on Tropical Region Eco Development(ICTCRED2014) organized by Institute of Research and Community Service Diponegoro University, Semarang Indonesia, which held in Semarang, August 11-13,2014. The main objective of this conference was to promote exchange of knowledge and ideas through friendly and intimate interaction and communication of the research individuals and groups who were concerned about and take interest in the Coastal and Tropical Eco Developments. The ICTCRED 2014 was merely sponsored and organized by Diponegoro University.

I also would like to thank to our distinguished keynote speakers, Prof Ichaki Imada, from Tokyo University of Marine Science and Technology (TUMSAT) Japan, Prof, Katsuo Miyashita from Bio-functional Material Chemistry, Faculty of Fisheries Sciences, Hokkaido University, Japan, Dr. Soottawat Benjakul from Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, Thailand, Dr Maria Barbosa from Algaeparc Wageningen University, The Netherlands, Prof. Jamaludin Jompa, Director of Research Center for Marine, Coast & Small Island at Hasanuddin Universtiy, Prof. Taufiq-Yap Yun Hin, Founder and current Coordinator for the Centre of Excellence for Catalysis Science and Technology (Putra CAT), Universiti Putra Malaysia, Dr. Lily Eurwilaichitr, Deputy Executive Director of BIOTEC, Thailand, and Dr Hussein Gasem, Associate Professor at Faculty of Medicine, Diponegoro University who kindly spare their times amidst their tight schedules to deliver high valuable speeches. Indeed their speeches have given high quality impact of this conference.

The current issue contains 58 papers selected from 110 papers and covers papers from Thailand, Malaysia, Netherlands, Japan, and Germany , which mostly represented the latest research on coastal development ranging from life sciences and technology in that area.

I believe that the this issue will benefit not only the participants of the meeting but also all of colleagues engaging in the research and development of tropical and coastal eco developments. I wish to thank The Rector of Diponegoro University, The head of Institute of Research and Community Services Diponegoro University and all the speakers for their dedicated contributions in this symposium.

Dr Hadiyanto and Prof. Heru Susanto
Chairman/Guest Editor

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Carbon Biomass Algorithms Development for Mangrove Vegetation in Kemujan, Parang Island Karimunjawa National Park and Demak Coastal Area – Indonesia

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ABSTRACT

The increase and accumulation of greenhouse gases such as CO_2 was believed had caused global warming. Effort to decrease accumulation these gases is by increasing the role of mangrove forests with its ecological function as carbon sinks through good management system. To this date, very limited study on the mangrove carbon biomass using satellite data espescially in tropical region. Purpose of the research were to calculate the carbon biomass of mangrove vegetation above ground through allometric equations, and to build spatial model algorithms of each mangrove species in the region by remote sensing technology using Quickbird, Geo Eye and ALOS satellite data. The research use an exploratory field survey and purposive sampling method and was performed through the measurement of trunk diameter (DBH) of above ground mangrove biomass without damaging vegetation (non-destructive sampling). About 21 mangrove species in Kemujan Island with total mangrove biomass above ground consist of the trunk, branches, leaves : 182.4 ton or 91.2 tons of Carbon, with largest carbon storage in the trunk. The results of spatial algorithms mangrove carbon biomass for Kemujan island using Quickbird data are *Ceriops tagal* with $Y= - 0.003(B2/B3)^2 + 0.267(B2/B3) – 3.452$; *Rhizophora apiculata* with the algorithm $Y= 0.001(B2/B3)^2 - 0.116(B2/B3) + 3.415$; *Bruguiera cylindrical* with the algorithm $Y= - 0.003(B2/B3)^2 + 0.336(B2/B3) – 7.265$; *Xylocarpus granatum* with algorithm $Y= 0.000(B2/B3)^2 - 0.058(B2/B3) + 2.101$; *Rhizophora mucronata* with the algorithm $Y= 0.000(B2/B3)^2 - 0.022(B2/B3) + 1.941$. Mangrove carbon biomass algorithm using Geo Eye satellite data at Parang island for *Rhizophora mucronata* $Y = -0.0436(B2/B3)^2 + 0.526 (B2/B3) – 1.4642$; *Bruguiera gymnorrhiza* $Y = - 0.0027 (B2/B3)^2 + 0.0649 (B2/B3) – 0.2432$ and *Bruguiera cylindrical* $Y = - 0.0089 (B2/B3)^2 + 0.0632 (B2/B3) – 0.0683$. Total mangrove carbon biomass at Demak coastal area range from 2.9 – 44.74 ton. Algorithm of mangrove carbon biomass at Demak using ALOS-AVNIR satellite data for *Avicennia marina* was $Y = - 79.18 ((B1-B2)/(B1+B2))^2 + 31.35 ((B1-B2)/(B1+B2)) - 1.191$. The research concluded that band rationing of Band-2 with Band-3 for Quickbird and GeoEye data and Band-1 with Band-2 for ALOS data as the spectral signature of mangrove chlorophyll pigment with wave length of 0.5 - 0.6 μm as the best for mangrove carbon algorithms.

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Key words : mangrove, carbon biomass, Quickbird, GeoEye, ALOS

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Introduction

Climate change as the effect of global warming with the increase of atmospheric and seawater temperature was related with the increase of greenhouse gasses from industrial and human activities. That is caused by excessive accumulation of greenhouse gasses such as CO_2, CH_4, NO_X, CFC. One effective solution to prevent or reducing of global warming are adaptation and mitigation [1-4]. Mitigation with replantation and rehabilitation on mangrove ecosystem would be expected to reduce the concentration of CO_2 in the atmospher. Therefore need a quantification method to measure carbon mangrove trees (trunk, branch, leaf) as baseline in the mangrove rehabilitation and management. Rehabilitation of mangrove was one effective meassures to increase biomass and carbon and will decresase CO_2[5-8]. Ecologically, mangrove ecosystem role as buffer zone in coastal area and in specific role as spawning ground, nursery ground as well as for feeding ground for coastal organisms, which highly dependence to mangrove ecosystem. Mangrove role as primary productivity with large number of organic, detritus from mangrove leaf and nutrients [9-11]. Effective mangrove carbon measurements for a wide area need spatial algorithm based on the field allometric plots. The use and development of spatial algorithms to measure mangrove carbon will have some advantages such as wide area coverage, high spatial resolution as well as time series capability for monitoring in a digital spatial database system. To this date there is no mangrove carbon algorithms using high resolution satellite data with high accuracy had been developed for tropical area such as Indonesia. Aims of the research were to observe mangrove species composition, biomass and carbon and spatial algorithm develoment using Geo-Eye data for Parang island, Quickbird data for Kemujan island and ALOS_AVNIR data for Demak area. Field measurement was done on 7 - 12 November 2012 at Parang island, and on 2013 for Kemujan island, Karimunjawa islands and July 2010 for Demak coastal area. Spatial analysis and algorithms develpments was done at Marine Geomatic Laboratory – Diponegoro University, Semarang.

Materials and Methods

Field equipments were consist of GPS (*Global Positioning System*) for sampling coordinate, rope- roll 30 meter, mangrove identification, salinity refractometer, compas, digital camera. Software used for spatial analysis was ER Mapper ver-7. High resolution satellite data used in the study were GeoEye for Parang island, QuickBird data for Kemujan island and ALOS_AVNIR data for Demak coastal area. Field measurements are trunk diameter,tree height and mangrove species for community structure study. Field measurements in the field were designed with 1x1m, 5x5m and 10x10m plot size [12]. Plot of 3 station at Parang island (see Fig.1) are station I (Legon Batu Hitam) at the north part with wide of mangrove area 4.57 Ha, station II (Legon Batu Merah) at the east wide mangrove area 3.94 Ha, and station III (Legon Ipik) at the west wide of mangrove area 4.16 Ha. Ten stations at Kemujan island where St. 1 consist of 22 plots, St. 2 : 28 plots, St. 3 : 19 plots, St.4 : 19 plots, St. 5 : 32 plots, St.6 : 6 plots, St. 7 : 12 plots, St. 8 : 5 plots, St. 9 : 10 plots, St. 10 : 9 plots.

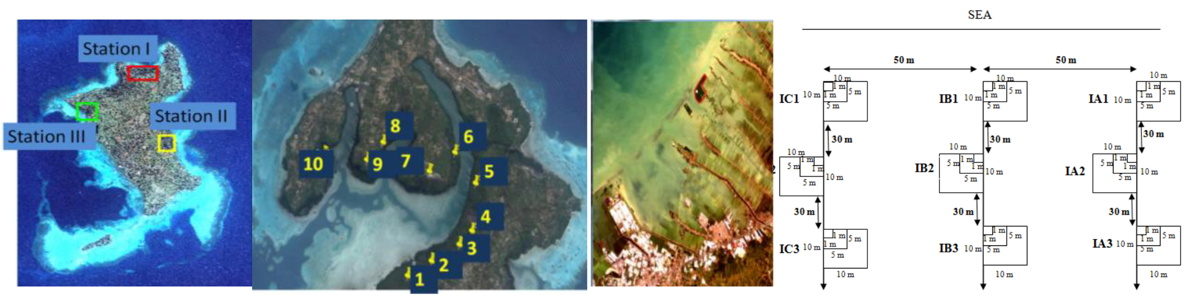

Figure 1. Position of the sampling station and transect line at Parang (above-left), Kemujan island (below-left) and Demak coast (below-right)

Field measurement used line transect and plot method [13-15]. There were transect-line with *purposive* plots and vertical against the coastal line landward, with distance between plots was 50 meter. Mangrove biomass and carbon analyisis was done for the above ground biomass measurement covering the trunk, branch and leaf. Mangrove biomass and carbon was done with *non destructive* method using the allometric equation. Procedure for the above ground measurements are [16] : a. Record of local and latin name, measure DBH = *diameter at breast height* = 1.3 m above ground both diameter bigger than 4 cm and less than 4 cm, b. Measure of trunk circle (2 π r); c. trunk diameter; c. height of tree; and d. Dry weight biomass and carbon based on the allometric equation ***Rhizophora mucronata, Bruguiera gymnorrhiza, Bruguiera cylindrica*** were using [17] and ***Avicennia marina*** using [18]. Mangrove carbon estimation based on *allometric equation* of [19-22] which explain that value of C = 0.5 W, where C = Carbon (ton C), W = Biomass (kg), 0.5 = convertion factor.
Satellite data processing. Mangrove carbon algorithms development were done based on band rationing using selected chlorophyll-band in considering the spectral character of each band. After a series of preliminary band composite exploration proceure the research had confirmed that the most suitable band composite method of satellite data was RGB 231. In order to increase the spatial and spectral accuracy of the result, then the selected area of mangrove for further analysis should be *cropped.* Mangrove carbon algorithm was developed based on the highest polinomial correlation coefficient (r) between satellite data DN (*digital number*) of Band-1, Band-2 for ALOS_AVNIR data Band-2, Band-3 rationing for GeoEye and Quickbird with the field measurement data. The use of Band-1 and Band-2 of ALOS data with wave length of 510 – 580 nm or 0.51 – 0.58 μm and Band-2 with Band-3 of GeoEye and Quickbird data with wave length of 655 – 690 nm or 0.66 – 0.69 μm were based on consideration that data recorded in these band had measured the chlorophyll pigment of mangrove [23].

Results and Discussion

Spesies found at all stations at Parang island for all growth category (*mangrove-tree*, *mangrove-sapling*, *mangrove-seedling*) were *Rhizophora mucronata*. At station I and II only 2 species of mangrove *Rhizophora mucronata* and *Bruguiera gymnorrhiza*. Station III more species mangrove were found *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Bruguiera cylindrica*, and *Avicennia marina*. Value of mangrove tree biomass at Parang island of Basal Area (BA), Density (A), Frequency (F), Domination (D), Relatif Density (RA), Relative Frequency (RF), Relative Domination (RD) and Important Value Index (IVI) by species at Parang island for mangrove-tree growth category was presented as in Table 1 and mangrove biomass and carbon at each stations were presented in Table 2.

Table.1. Value of Basal Area (BA), Density (A), Frequency (F), Domination (D), Relatif Density (RA), Relative Frequency (RF), Relative Domination (RD) and Important Value Index (IVI) for Mangrove-Tree category at Parang island

Station	Species	No of Tree	BA (cm^2)	A (ind/ha)	F	D (m^2/ha)	RA (%)	RF (%)	RD (%)	IVI (%)
I	*Rhizophora mucronata*	156	15820,56	1733	1,00	17,58	81,68	56,25	79,47	217,39
	Bruguiera gymnorrhiza	35	4087,62	389	0,78	4,54	18,32	43,75	20,53	82,61
	Sub Total	**191**	**19908,18**	**2122**	**1,78**	**22,12**	**100**	**100**	**100**	**300**
II	*Rhizophora mucronata*	149	9034,83	1656	1,00	10,04	63,95	50	50,76	164,70
	Bruguiera gymnorrhiza	84	8766,00	933	1,00	9,74	36,05	50	49,24	135,30
	Sub Total	**233**	**17800,83**	**2589**	**2,00**	**19,78**	**100**	**100**	**100**	**300**
III	*Rhizophora mucronata*	371	14327,59	4122	0,89	15,92	75,10	32	71,84	178,94
	Bruguiera gymnorrhiza	54	1759,91	600	1,00	1,96	10,93	36	8,82	55,75
	Bruguiera cylindrica	50	2230,81	556	0,67	2,48	10,12	24	11,19	45,31
	Avicennia marina	19	1627,23	211	0,22	1,81	3,85	8	8,16	20,00
	Sub Total	**494**	**19945,54**	**5489**	**2,78**	**22,16**	**100**	**100**	**100**	**300**

Table 2. Mangrove Biomass ad Carbon in Mangrove Tree, Branch and Leaf at each station at Parang island, Karimunjawa islands

Station	Species	No of Tree	Tree		Branch		Leaf		Tree, Branch, Leaf	
			Biomass (ton)	Carbon (ton C)	Biomass (ton)	Carbon (ton C)	Biomass (ton)	Carbon (ton C)	Biomass (ton)	Carbon (ton C)
I	RM	156	8,88	4,44	1,83	0,92	0,38	0,19	11,09	5,55
	BG	35	1,74	0,87	0,36	0,18	0,08	0,04	2,18	1,09
Sub Total		**191**	**10,62**	**5,31**	**2,19**	**1,10**	**0,46**	**0,23**	**13,27**	**6,64**
II	RM	149	4,49	2,25	0,90	0,45	0,21	0,11	5,62	2,81
	BG	84	3,84	1,92	0,82	0,41	0,18	0,09	4,84	2,42
Sub Total		**233**	**8,33**	**4,17**	**1,72**	**0,86**	**0,39**	**0,20**	**10,46**	**5,23**
III	RM	371	6,12	3,06	1,18	0,59	0,32	0,16	7,62	3,81
	BG	54	0,68	0,34	0,13	0,07	0,06	0,03	0,87	0,44
	BC	50	1,08	0,54	0,10	0,05	0,02	0,01	1,20	0,60
	AM	19	0,71	0,35	0,10	0,05	0,41	0,21	1,22	0,61
Sub Total		**494**	**8,59**	**4,29**	**1,51**	**0,76**	**0,81**	**0,41**	**10,91**	**5,46**

Note : RM : *Rhizophora mucronata*, BG : *Bruguiera gymnorrhiza*, BC : *Bruguiera cylindrica*, AM : *Avicennia marina*

Spatial algorithm developemnt. Band ratio of Band2/Band3 using GeoEye data was found with the highest correlation coefficient (r) between GeoEye DN (*Digital Number*) with field data, compared with Band-2, or Band-3 for mangrove carbon estimation (see Fig 1). Algorithm resulted for *Rhizophora mucronata* for station I was $Y = -0.0436\ (B2/B3)^2 + 0.526\ (B2/B3) - 1.4642$ with $r = 0.8093$ (Fig 2). Algorithm resulted for *Rhizophora mucronata* for station II was $Y = -0.0021\ (B2/B3)^2 - 0.0012\ (B2/B3) + 0.0914$ with $r = 0.7181$ with range of mangrove carbon value of *Rhizophora mucronata* between 0,001 – 0,12 ton C. Algorithm resulted for *Rhizophora mucronata* for station III was $Y = -0.0018\ (B2/B3)^2 + 0.0135\ (B2/B3) - 0.0075$ value of $r = 0.7765$ with range of mangrove carbon between 0.0007 – 0.0934 ton C as shown in Fig 2.

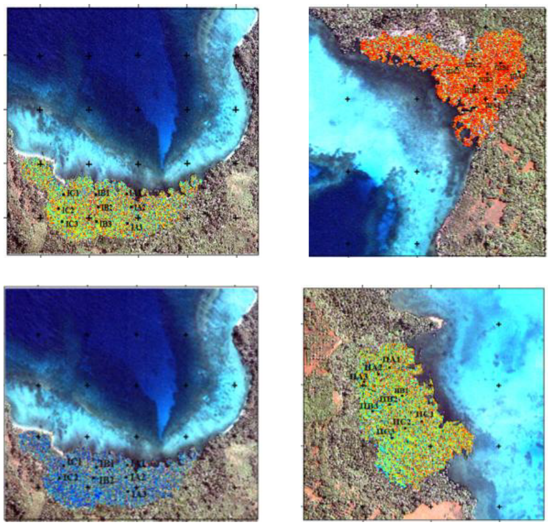

Figure 2. Algorithms of mangrove carbon for *Rhizophora mucronata* at station I and III and *Bruguiera gymnorrhiza* at station I and II

Algorithm resulted for *Bruguiera gymnorrhiza* station I, Y = - 0.0027 $(B2/B3)^2$ + 0.0649 (B2/B3) – 0.2432 with r = 0.8086 with range of mangrove carbon between 0.0001 – 0.081 ton C. Algorithm resulted for *Bruguiera gymnorrhiza* station II, Y = - 0.0163 $(B2/B3)^2$ + 0.1712 (B2/B3) – 0.4072 with r = 0.8733 with range of mangrove carbon between 0.0006 –0.0788 ton C. Algorithm resulted for *Bruguiera gymnorrhiza* station III, Y = - 0.0005 $(B2/B3)^2$ – 0.0028 (B2/B3) + 0.0511 with r = 0.7499 with range of mangrove carbon between 0.0005 – 0.0573 ton C at Fig 2. Mangrove carbon algorithm for *Bruguiera cylindrica* that only found at station III was Y = - 0.0089 $(B2/B3)^2$ + 0.0632 (B2/B3) – 0.0683 with r = 0.7290 with range of carbon between 0.0014 – 0.0619 ton C. *Bruguiera gymnorrhiza* will grow better at coastal susbtrate of clay and sometime at sand [24]. Station III at the west part of Parang species of *Bruguiera cylindrica* and *Avicennia marina* were also had been found and *Avicennia* spp usually found near to the sea. Mangrove at Parang island was dominated by *Rhizophora mucronata* value of density of the three stations between 1656 – 4122ind/ha. According to the Ministry of Environments classification No. 201 year 2004 that Parang island can be classified as high density of mangrove with more than 1500 ind/ha. *Rhizophora mucronata* had been found have mostly high IVI value at three stations with range 164.70 – 217.39. Convertion based on carbon per hectare with 0.09 hectare resulted with 147.44 ton/ha biomass (73.72 ton C/ha) for station I, 116.22 ton/ha biomass (58,11 ton C/ha) at station II and 121,22 ton/ha biomass (60,61 ton C/ha) at station III or average of the three stationis 128.29 ton/ha which relatively low compared mangrove at Merbok with 245 ton/ha and with more intensive management will reach to 300 ton/ha [25- 28]. There were 21 species of mangrove which belongs to 5 Family had been found at Kemujan island, Karimunjawa islands consist of *Acrosticum aureum* (Pteridaceae), *Acanthus ebracteatus, A. Ilicifolius* (Acanthaceae), *Aigiceras corniculatum* (Myrsinaceae), *Avicennia marine* (Avicenniaceae), *Bruguiera cylindrica, B. Gymnorhisa, B.sexangula, Ceriops tagal, Rhizophora apiculata, R.stylosa, R.mucronata* (Rhizophoraceae), *Excoecaia agallocha* (Euphorbiaceae), *Heritiera littoralis* (Sterculiaceae), *Lumnitzera racemoca, L.littorea* (Combretaceae), *Sonneratia alba, S.ovata* (Sonneratiaceae), *Scyphipora hidrophyllacea* (Rubiaceae), *Xylocarpus moluccensis, X.granatum* (Meliaceae). Dominant mangrove species were *Excoecaria agallocha,* and *Ceriops tagal*. Result of inventarization by Karimunjawa Conservation office [13] had found before there were about 25 true mangrove at the island. Species of *Excoecaria agallocha* and *Ceriops tagal* usually found at the edge of the island. *Excoecaria agallocha* and *Ceriops tagal* belongs to family of Euphorbiaceae and Rhizophoraceae will grows well at clay and sandy substrate [29]. Species of *Xylocarpus granatum* with number of tree of 142 having 21.36 ton C, *Bruguiera cylindrica* with number of tree of 279 with 19.51 ton C. *Rhizophora apiculata* have the highest trunk carbon of 27.25 ton C and total mangrove biomass in the area was 182.62 ton biomass (equal to 91.31 ton C) with total number of three 977. This value was lower if compared with mangrove at Merbok with 245 ton/Ha [25] or total carbon of Ciasem West-Java with 364.9 ton/Ha biomass or carbon 182.5 ton C/Ha [30, 31, 26, 27, 28, 32] which is also lower than Parang island with 192.44 ton C/Ha. Mangrove occupy only 0.5% of the global coastal area, but they contibute 10 – 15% (24 $TgC.y^{-1}$) with potential carbon losses to dforestation by 90-970 $TgC.y^{-1}$ [31]. While estimate of mangrove deforestation generates emmisions of 0.02 – 0.12 Pg carbon per year or about 10% of global deforestation or about 0.7% in ropical area [32-34] .

Mangrove carbon algorithm with Quickbird satellite data at Kemujan island and Demak Coast. [32,33,34, 4] stated that the peak vegetation chlorophyll absorption was at the wave length of 600 – 700 nm, and less absorbtion at the wave length of 500-600 nm. Use of Quickbird satellite data of Band-2 (green band) wave length 520 – 600 nm and Band-3 (red band) wave length 630 – 690 nm. Highest corelation coefficient of Digital Number of Band2/Band3 band ratio of Quickbird satellite data with the field mangrove data *Ceriops tagal* have resulted algorithm Y = -0.003$(B2/B3)^2$ + 0.267(B2/B3) – 3.452 with r = 0.806. Algorithm for *Rhizopora apiculata* Y= 0.001$(B2/B3)^2$ - 0.116(B2/B3) + 3.415 with value r = 0.655 as in Fig 3. Algorithm using digital number of Band-2/Band-3 of Quickbird satellite data with field mangrove carbon of *Bruguiera cylindrica* Y = -0.003$(B2/B3)^2$ + 0.336(B2/B3) – 7.265 with r = 0.813. While algorithm for *Xylocarpus granatum* Y = 0.000$(B2/B3)^2$ - 0.058(B2/B3) + 2.101 with r = 0.791 and algorithm for *Rhizophora mucronata* Y = 0.0001$(B2/B3)^2$ - 0.022(B2/B3) + 1.941 with r = 0.866. Algorithm of mangrove carbon biomass at Demak using B-1 and Band-2 of ALOS-AVNIR satellite data for *Avicennia marina* was Y = - 79.18 $((B1-B2)/(B1+B2))^2$ + 31.35 ((B1-B2)/(B1+B2)) - 1.191 as in Fig 4.

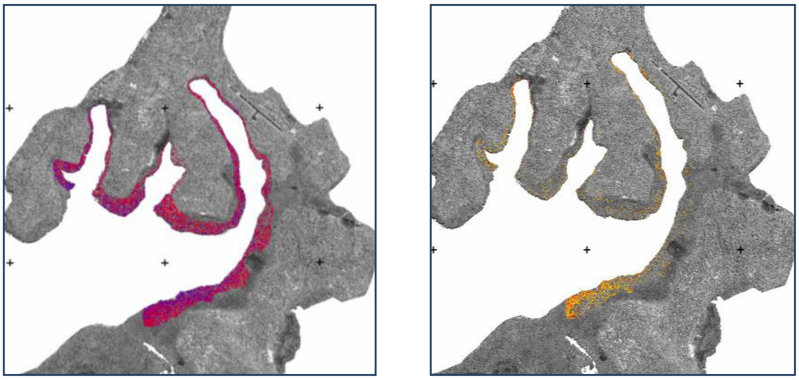

Figure 3. Spatial distribution of *Ceriops tagal* (left) and *Rhizopora apiculata* (right) at Kemujan island - Karimunjawa islands

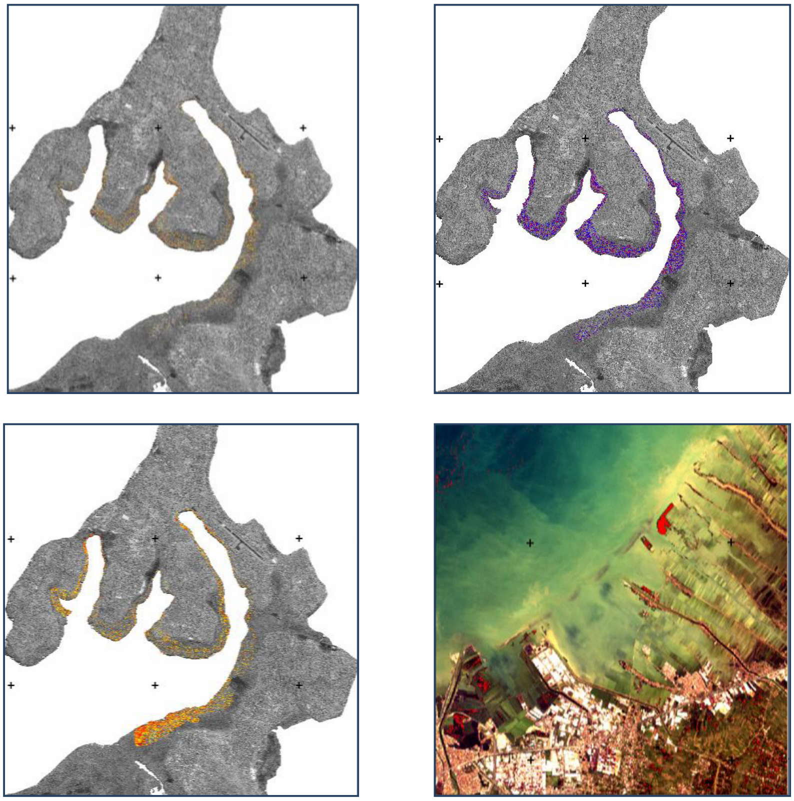

Figure 4. Spatial distribution of *Bruguiera cylindrica* (left), *Xylocarpus granatum* (right) and *Rhizopora mucronata* (below-left) at Kemujan island - Karimunjawa islands and *Avicnnia marina at* Demak coastal area (below – right).

Conclusion

The research concluded that band rationing of Band-2 with Band-3 for Quickbird and GeoEye data and Band-1 with Band-2 for ALOS data as the spectral signature of mangrove chlorophyll pigment with wave length of 0.5 - 0.6 µm as the best for mangrove carbon algorithms.

Acknowledgement

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