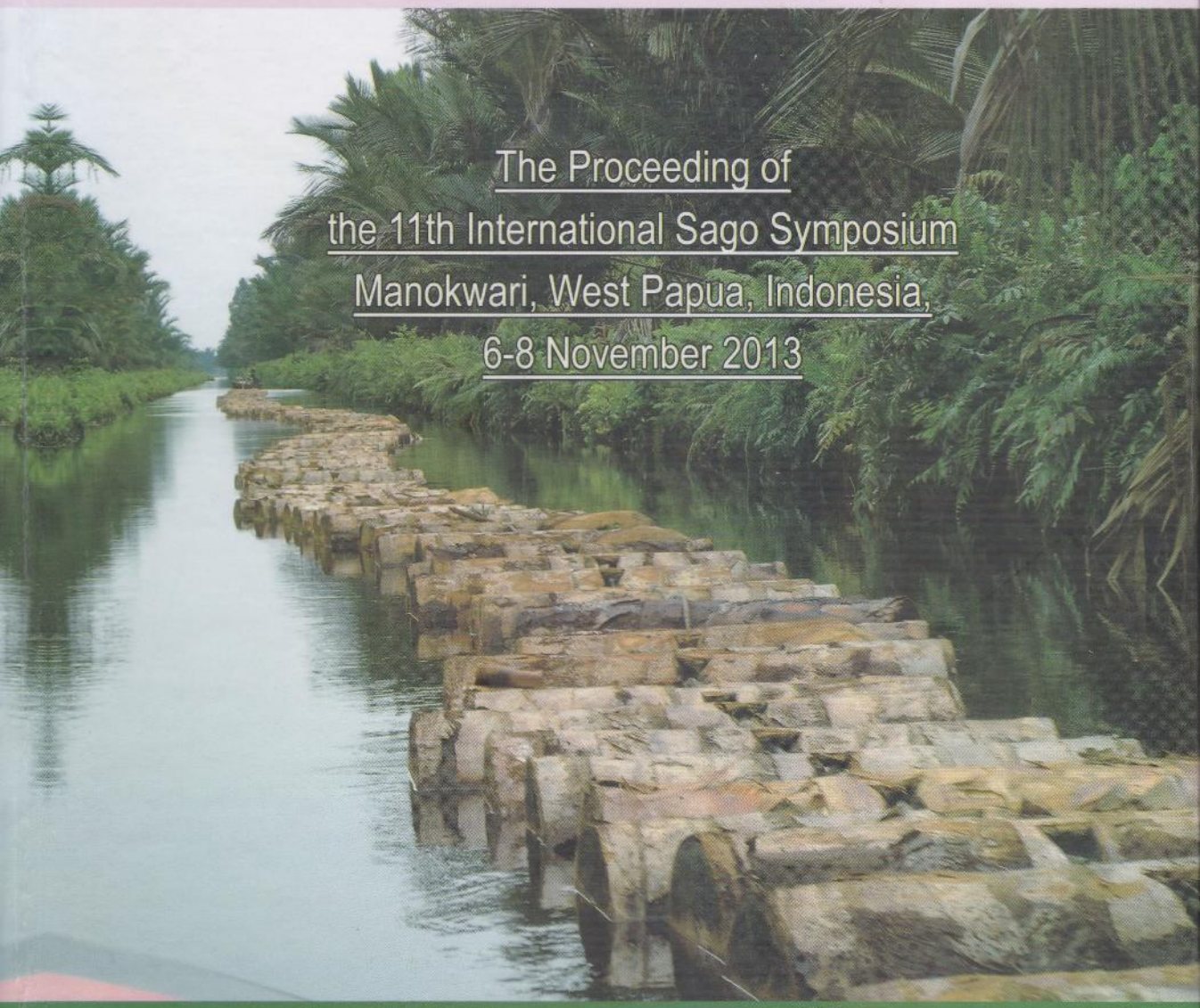
Unleashing Sago

Hidden Treasure of the World



The Proceeding of
the 11th International Sago Symposium
Manokwari, West Papua, Indonesia,
6-8 November 2013

Edited by

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Indonesia Society of Sago Palm
Development and Utilization

PT AUSTINDO NUSANTARA JAYA Tbk.

ANJ Agri
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Estimation of the Harvested Ripe Stage of Sago Palm Tree in Sentani District, Jayapura, Using Quickbird Imagery Band

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ABSTRACT

Sago (*Metroxylon sp*) as a domestic commodity could be used as source for food industry because high carbohydrate content and substitute ability as food resource. To determine ripe harvest sago tree, local knowledge can be implemented by indentifying morphological characteristics of sago. However, it seems not efficient to be applied for whole area of sago. Remote sensing is the proper method to analyze potential production of harvestable trees in sago forest. Therefore, objectives of the research were to know how Quickbird imagery was used to identify ripe harvest sago trees based on characteristics of reflectance and transformation index of vegetation. Besides that, transformation method of band rationing was used to estimate of sago production. Survey was the method to obtain data from remote sensing based on band ratio and field measurement. Band rationing of B2/B3 was analyzed in this research. Result showed that there are strong correlation between sago production and band rationing value. Correlation coefficient (r) was 0.823 and coefficient determination (r^2) was 0.678. In Sentani, area of sago forest is 917.40 ha and production of sago is 5729 $t.ha^{-1}$. Based on imagery analysis, estimation of sago production is 31,009.201 t for two times of harvest in a year within 917.432 ha.

Keywords: Band rationing, quickbird imagery, ripe harvest sago tree.

INTRODUCTION

Sago (*Metroxylon sp.*) is a staple food in the diet of Papuan communities. It has the potency as a source of basic food beside rice because it contains adequate carbohydrate and has the ability to substitute sago starch in the food industry. Until now, the sago community still rely on the local knowledge to determine "harvesting stage" or "ripe of trunk" (optimum condition to cut of trunk) sago based on its morphology characteristics. However, extensive sago forest and abundant sago population in nature has resulted in low sago production due to the late harvesting or over harvesting of sago trunk. This condition was caused by the steps of vegetative plant in converting nutrition into starch and store it in the stem occurred before flowering (Azis 2002; Singhal *et al.*, 2008). The condition includes factors causing sago forest in West Papua has not been utilized optimally. Meanwhile, according to Presidential Regulation Number 38 of 2008 on the government's work plan in 2009 stated that sago includes one of potential commodities that should be developed. Therefore, sago has the opportunity to be a national food commodities (Numberi, 2008).

Sago exploitation activities should consider the data of ripe or mature of trunk phase in order to achieve optimal production for long time period. The development of remote sensing technology has provided a wide variety of high-resolution imagery. "Quickbird imagery", in addition to have a high spatial resolution, also has good temporal resolution. The advantages of this study using high resolution Quickbird imagery is that the sharpness of the spatial resolution reaches 0.6 m, so that sago forest inventory can be done well and detail, especially to distinguish the sago forest area and non sago forest area. Another advantage of the spatial resolution of this imagery is also expected to clearly recognize the "harvesting stage" sago based on the physical characteristics in a certain time. Besides, Quickbird imagery has temporal resolution which achieve 1 – 3.5 days, thus the monitoring on the sago forest area can be done immediately. Regarding the determination of potential "ripe harvest" sago, this short period facilitates the accuracy in determining of sago production and the wide of harvesting area. In the study of sago potential particular for determining harvesting stage of sago and for estimating sago production, using of Quickbird imagery is necessary to obtain more accurate data and information.

The aim of this study is to identify harvesting stage of sago tree based on the characteristics of the reflection of spectra from the data of digital multi spectral band ratio in Quickbird imagery.

METHODS

- **Materials**
    1. Image Quickbird multi spectral with resolution 2,4 m, level 1B from Sentani District, Jayapura Regency (Kabupaten Jayapura), Papua Province, recording on 25 Juli 2010
    2. Map of Indonesia geography, Rupa Bumi Indonesia (RBI), page 3413, scale 1 : 50.000
    3. Map of Land Use in Jayapura Regency, scale 1 : 250.000
    4. Map of Land Jayapura Regency, scale 1 : 250.000 (Source: BPKH Wilayah X Papua).

- **Tools and soft wares**

Tools used in this study are GPS, digital camera and phy-band (measuring band), while soft wares are RSI ENVI4.5, ArcGIS9.3 for mapping, Microsoft Excel and SPSS19 for statistical analysis.

- **Variables**

Variables for determining potential production of ripe harvest sago at the habitat of sago forest and characteristics of harvesting stage of sago and sago production. The classification of multispectral applied in this study is supervised classification with maximum likelihood algorithm. This classification is more accurate methods compared to the others (Lillesand and Kiefer et al., 2004). The object of this study is Sago tree, thus the multispectral classification, the interpretation and the analysis will be carried out to divide the covered land into two classes: sago forest area and non sago forest area.

Vegetation transformation index used in this study:

BAND RATIONING

Color composite image is the combination of several images of different channels. The arrangement of color composite image involves several channels at once which is intended to obtain a better visual, specifically in recognizing the object of "ready to harvest" sago palm tree and and collecting sample. The ratio of channels is generally used to produce specific effect in relation to the protrusion of the spectral aspects of vegetation, reduction of shadow effects, as well as protrusion lithology (Danoedoro, 2012).

- **Identification of sago forest**

Theoretically, the reflection characteristics between objects water, soil and vegetation can be clearly distinguished based on the reflection response of each channel spectral of Quickbird imagery.

DETERMINATION OF SAGO TREE AT RIPE HARVEST STAGE

The characteristics "harvest stage" of sago palm tree are generally 8-12 years old or when the rod tip begins to swell followed by the release of flower sheath. The level of betel fruit is one of important indicators, in which sago flower buds have opened up and branched resembling to deer antlers and the fruits have begun to form.

For each type of Sago forest, if harvested area is represented with A_{pi} and the average value of sago production per hectare (t/ha) is expressed by the PPI, then the formula used in calculating the production of sago Tpp expressed by:

$$T_{pp} = \sum_{i=1}^{n} A_{pi}\, X\, P_{pi} \quad \text{(1)}$$

From Quick-bird image data, the production of sago in a year can be calculated.

- **Statistical Analysis**

Statistical analysis used in this study includes correlation and regression. The equation used is Pearson Correlation as follows:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}} \quad \text{(2)}$$

In which:
r = correlation coefficient
n = number of sample population
x = independent variable, which is the value of Sago productivity
y = dependent variable, which is the value of brightness, the output of NDVI/SAVI transformation, band rationing.

Regression equation used as follows:

$$Y = a + bx \quad \text{(3)}$$

Source : Burhan (2002)

- **Estimation of sago production**

The estimation of sago production in this study is the production of ripe harvest sago per hectare in a year. The estimation for a harvest period is calculated

from the data of digital multispectral band ratio in Quick-bird imagery. The total of harvested area will be used as basic data to determine the potency of ripe stage of sago palm tree for cutting.

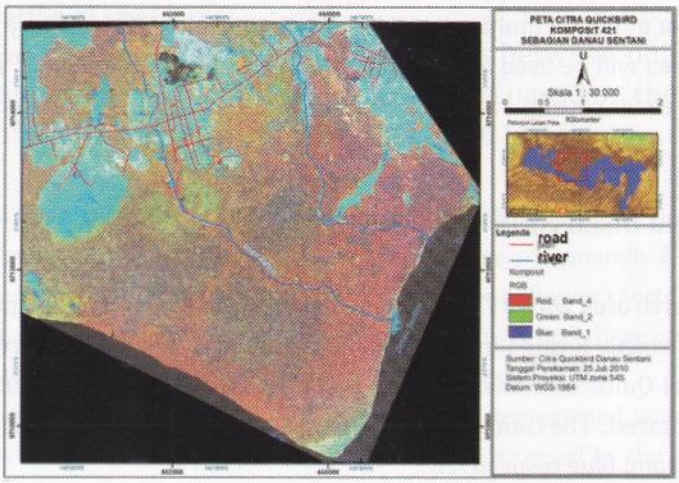
RESULTS AND DISCUSSION

Research area with 917,432 Ha is a part of Sen tani District, Jayapura Regency. This area is exactly located in Yobe, Yahim and Kehiran Villages. This research used multispectral Quick-bird image having 4 spectral channels mainly blue, green, red and short infrared. The combination of channels used is channels of 4, 2, 1 with color of red, green and blue respectively.

Sago at the harvesting phase will have a hue that is relatively low in the green. This is due to the aging of sago leaves, dried and loss of photosynthesis function as a result of less amount chlorophyll. Unlike the green band, the spectral response of sago plants at harvesting stage in the red band will be quite high because of the sago has lost chlorophyll. Composite image 421 is excellent in presenting the appearance of sago vegetation, in which sago plants at harvest ripe will have a bluish green color while those at unharvest ripe and other healthy plant will be red in color.

The difference between Sago tree and other plants, such are coconut tree (*Cocos nucifera*) and areca nut tree (*Areca cathecu* L.) in the investigated area is that Sago trees have not fully become cultivated plants, whereas coconut and areca nut trees are cultivated plants, so they look different each other according to their growing pattern. Sago trees generally have irregular growth patterns, clustered and a bit away from the settlements, while coconut and areca nut trees have regular patterns of growth in a narrow area, not clustered and located close to the settlement In Sago trees have different physical appearance from coconut and areca nut trees. These trees are physically smaller than sago trees. Also, the color of coconut leaf is lighter than the Sago leaves.

Matanubun et al. (2008), that there are four types of cultivated sago forests, such are hamlet sago, natural sago forest, swamp sago and mixed sago trees. This classification is based on site and human activity. Sago at the investigated area is found growing in permanently flooded areas, temporarily flooded areas and dry areas. The visualization of sago spectral on both a single channel and the composite image looks clearly different from non-sago vegetation by multispectral analysis. The sago trees are spatially concentrated at the bottom of the study area with an area of 917.432 hectares. The identification of sago forests produced from multispectral classification of Quickbird imagery is presented in Figure 1.



Figures 1. Quick-bird composite image 421

Band rationing is a ratio between a channel and other channel. It is used to highlight objects of vegetation, water, as well as boundary between the land and the sea. The transformation of band rationing uses 2 channels, mainly band 2 (green) and band 3 (red). Band rationing b2/b3 is used to demonstrate the value reflected by chlorophyll. Sago at ripe harvest would reduce the number of leaf in the tree, so the reflection in red and green channels would be greater and have a dark. The image generated by band rationing b2/b3 is displayed in Figure 2.

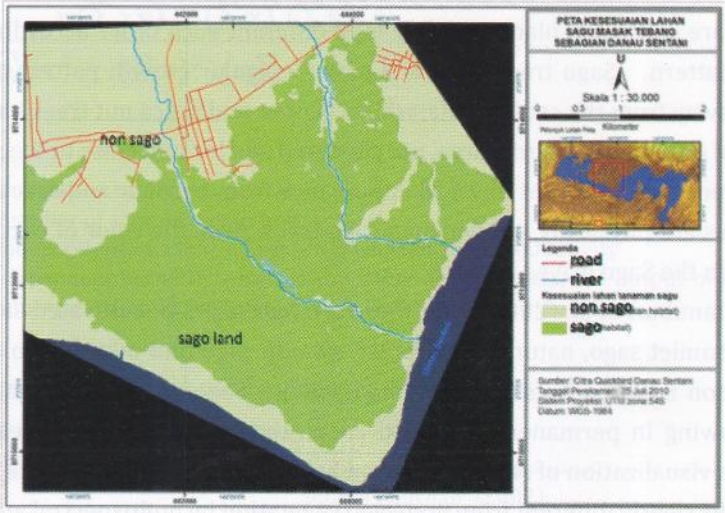


Figure 2. Map of land suitability of sago forest at some parts of Sentani Lake

Determination of the brightness values in Rationing Band was performed on samples obtained from field work. Field data collection was conducted from October to November 2011 with 23 samples for land use of sago forest. The value of brightness of each band and the transformation of vegetation index are presented in Table 1

Sago trees grow in cluster and have specific size and canopy type in comparison to other plants. The distribution of Sago plants in the investigated area are predominantly natural stands in a homogeny and wider area. All the vegetation phases in Sago stands, such as seedlings, poles, trees and Sago trees that are ready to harvest were found in all types of Sago forest, excepting swamp Sago.

Table 1. Brightness value of Band Rationing Transformation

Sample	Coordinate UTM, 54S WGS 84		B1	B2	B3	B4	Band Ratioing
	X	Y					
1	140°30'19,99"	2°35'54,40"	0.1375333	0.1154111	0.0674778	0.4284444	1.7102556
2	140°30'21,28"	2°35'58,48"	0.1352778	0.1070111	0.0606111	0.4028444	1.7672222
3	140°29'59,38"	2°36'37,88"	0.1364889	0.1137889	0.0638111	0.4892778	1.7846333
4	140°30'0,81"	2°36'34,96"	0.1356556	0.1140222	0.0639222	0.5051889	1.7864333
5	140°29'12,,21"	2°35'32,76"	0.1348556	0.1147444	0.0635778	0.4167778	1.808611111
6	140°29'12,21"	2°35'30,36"	0.1344556	0.1121667	0.0616778	0.3747667	1.8305556
7	140°29'41,63"	2°35'49,99"	0.1406333	0.1229778	0.0720889	0.4898111	1.7246
8	140°30'2,17"	2°35'18,95"	0.1371444	0.1192333	0.0647444	0.4565222	1.8419222
9	140°30'19,21"	2°35'32,11"	0.1361778	0.1115444	0.0639889	0.3603556	1.7488889
10	140°29'50,37"	2°34'49,53"	0.1365556	0.1168667	0.0677222	0.4083444	1.7334222
11	140°30'4,50"	2°37'5,35"	0.1400667	0.11850	0.0731889	0.3317444	1.6223556
12	140°30'3,01"	2°37'7,75"	0.1398111	0.1205556	0.0705667	0.4375889	1.7180556
13	140°30'8,00"	2°36'47,99"	0.1329778	0.1042111	0.0601556	0.3502444	1.7387
14	140°30'6,38"	2°36'29,78"	0.1359111	0.1135778	0.0673667	0.4662889	1.6973333
15	140°29'12,21"	2°35'30,36"	0.1359111	0.1186556	0.06480	0.4599222	1.8312444
16	140°28'41,88"	2°35'44,55"	0.1445333	0.1228111	0.0830111	0.3871556	1.4942111
17	140°49'15,14"	2°60'06,89"	0.1465110	0.1253330	0.0858333	0.3829000	1.491
18	140°47'74,00"	2°59'95,19"	0.1444780	0.1240000	0.0785000	0.3154560	1.59069
19	140°47'41,03"	2°60'43,24"	0.1458440	0.1252220	0.0891000	0.3716670	1.42019
20	140°47'51,88"	2°60'57,44"	0.1422560	0.1153000	0.0733111	0.3592000	1.6151
21	140°48'69,51"	2°60'80,69"	0.1470670	0.1190670	0.0858778	0.2999440	1.41032
22	140°49'11,41"	2°61'62,98"	0.1494330	0.1217000	0.0863444	0.3394780	1.44024
23	140°49'47,26"	2°61'33,41"	0.1438890	0.1204560	0.0885111	0.3541440	1.38118

Sourse: - Quick-bird image analysis

BAND RATIOING

At the study site, the most dense of Sago cluster was found in the Sago forest compared to other Sago types. This is due to this type has greater regeneration and trees at ripe harvest compared to the others. The least dense of sago cluster was found in the area types of mixed hamlet Sago and mixed Sago forest because those area types do not get well nursing and are planted with other commodities. As a result, Sago plants are shaded from the sun lights. The value of vegetation index generated from the transformation of band rationing and productivity value of each sample is displayed in Table 2. The result of correlation test of band rationing data on Sago productivity is presented in Tables 5.10; 5.11; and 5.12, respectively.

Table 2. Vegetation indeks values of samples and their productivities.

Sample No	Coordinate UTM, 54S WGS 84		Band Rationig	Productivity (ton/ha)
	X	Y		
1	140°30'19,99"	2°35'54,40"	1.710256	21.484375
2	140°30'21,28"	2°35'58,48"	1.767222	22.71701389
3	140°29'59,38"	2°36'37,88"	1.784333	24.75694444
4	140°30'0,81"	2°36'34,96"	1.786433	21.94444444
5	140°29'12,,21"	2°35'32,76"	1.808611	23.14236111
6	140°29'12,21"	2°35'30,36"	1.830556	20.25173611
7	140°29'41,63"	2°35'49,99"	1.7246	20.06076389
8	140°30'2,17"	2°35'18,95"	1.841922	20.80729167
9	140°30'19,21"	2°35'32,11"	1.748889	19.15798611
10	140°29'50,37"	2°34'49,53"	1.733422	16.90972222
11	140°30'4,50"	2°37'5,35"	1.622356	11.97916667
12	140°30'3,01"	2°37'7,75"	1.718056	16.88368056
13	140°30'8,00"	2°36'47,99"	1.7387	17.01388889
14	140°30'6,38"	2°36'29,78"	1.697333	*
15	140°29'12,21"	2°35'30,36"	1.831244	*15.82465278
16	140°28'41,88"	2°35'44,55"	1.494211	*
17	140°49'15,14"	2°60'06,89"	1.491	7.595486111
18	140°47'74,00"	2°59'95,19"	1.59069	*9.288194444
19	140°47'41,03"	2°60'43,24"	1.42019	*11.05902778
20	140°47'51,88"	2°60'57,44"	1.6151	14.94791667
21	140°48'69,51"	2°60'80,69"	1.41032	18.61111111
22	140°49'11,41"	2°61'62,98"	1.44024	*13.75868056
23	140°49'47,26"	2°61'33,41"	1.38118	11.98784722

Source : - Quickbird image analysis
- Band Ratioing transformation
* not using correlation and regression analysis

Table 3. Description of band Ratioing data and Productivity

	Mean	Std. Deviation	N
Band Rationig	1.690775041	.1366494198	17
Productivity	17.96466494	4.689943920	17

Table 4. Correlation analysis of Band Rationing Data with Productivity

		Band Ratioing	Productivity
Pearson Correlation	Band Ratioing	1.000	.823
	Productivity	.823	1.000
Sig. (1-tailed)	Band Ratioing	.	.000
	Productivity	.000	.
N	Band Ratioing	17	17
	Productivity	17	17

Table 5. Summary Model of Band Ratioing

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.823[a]	.678	.657	.0800859424

Predicators : (Contant), Productivity
Dependent Variable : Band Ratioing
Source : output of statistical analysis of product moment pearson

Statistical analysis was conducted to determine the relationship between Sago productivity and band rationing. For the whole samples, the analysis resulted correlation coefficient (r) = 0,823 and determination coefficient value (r^2) = 0,678. This result showed a positive correlation between Sago productivity and band rationing, meaning that the increase value in the variable in band rationing affects the increase of variable value of Sago productivity. This result suggested that the transformation of vegetation index can be used as initial basis to estimate the productivity of Sago trees through remote-sensing image.

One of the factors affecting the level of Sago productivity is the physical characteristics of the land. Each unit of land form is composed by different physical characteristics of the land. Thus certain land forms will have different levels of productivity. Sago production in each land form in the study area is presented in Table 6.

Tabel 6. Accuracy Data Test of Sago Production

No	Year	The average of Sago Production				accuracy (%)
		Research-based data of Sago Production		Department of Agriculture and Food *		
		Harvest Wide (ha)	Production (ton/ha)	Harvest Wide (ha)	Production (ton/ha)	
1	2011	917,40	5.729	38.670	6.540	87,60

Source : - Quickbird image analysis
*Department of Agriculture and Food Jayapura Regency, 2010

The productivity of Sago plants in each land form varies depending on the site quality, the natural state of the forest that has both irregular number of cluster

and distribution of sago tree. Sago at harvest ripe found in the land form of swamp in the back exhibited the highest productivity at 12229.009 tons, followed by sago production in the alluvial land form of 1681.905 tons. The land form of point bar has the lowest productivity at 122.677 tons. The suitable land for sago and productivity sago in Sentani District is presented in Figure 3 and 4.

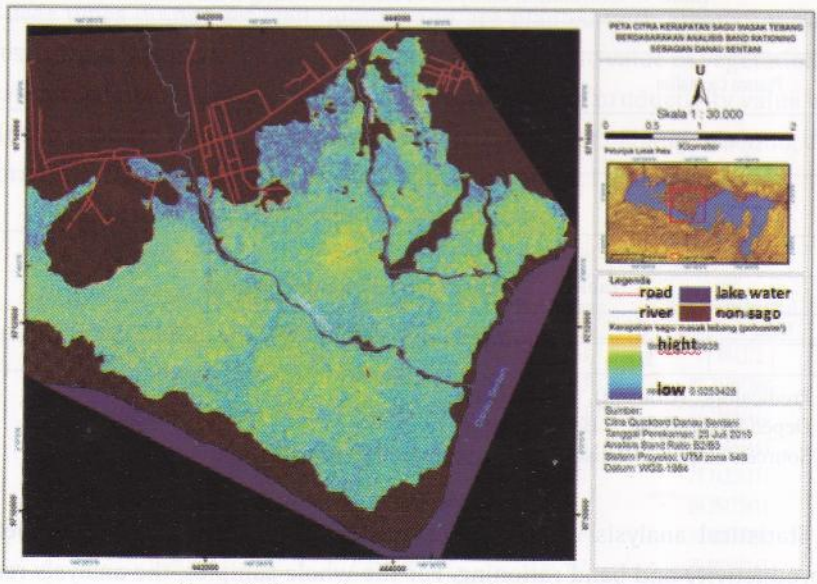


Figure 3. Output image of Band Ratioing B2/B3

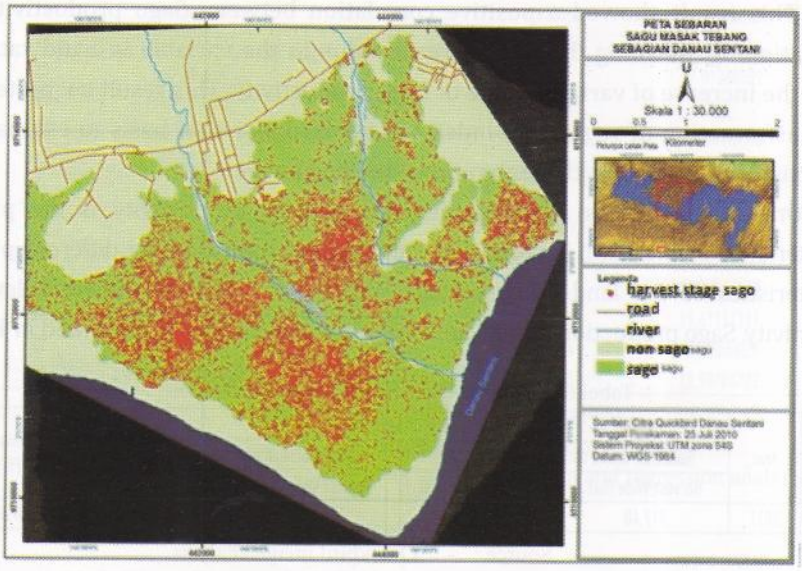


Figure 4. Map of Sago Productivity in Sentani District Jayapura Regency

Natural Sago stands is generally found in land areas and coastal swamps and watersheds at an altitude of 0-300 meters (Deinum, 1948; Heyne, 1950; Flach, 1977;

Schuiling and Flach, 1985 *in* Louhenapesy *et al.*, 2010). At the macro relief, sago plants can grow well on all land forms, from the lowlands to the mountenous area. At the micro relief, however, the plant can grow on the basin area, flat, and ramps that allow the availability of ground water.

The data of sago production recorded at the Department of Agriculture and Food is only the data of production per year, while the data produced from this research is the data of production in two times harvests in a year. Therefore, the estimation of the sago production for a year is obtained from the multiplication between the number of Sago production in 2-time harvests and the number of the plants harvested in a year. The image used in the study is the image recording in 2010, thus the accuracy test of the production is obtained from the comparison between the estimation of Sago production based on the result of image analysis and the production of sago in Jayapura Regency. The estimation result of Sago production is presented in Table 6.

According to the comparison between the production estimation generated from the image and the sago production data from the Department of Agriculture and Food, the accuracy test confirmed that the estimation has higher level of accuracy at 87,60%. It is suggested that Quick-bird imagery can be used to estimate sago production with higher accuracy level. Utilization of the Quick-bird imagery is multispectral and multi-temporary images with wide area coverage. It is efficient to reduce time of field work, number of worker and cost of field work, with higher level of accuracy.

CONCLUSIONS

In composite imagery 421, higher dense of sago vegetations had a lighter hue with fine texture, while those with moderate dense exhibited reddish yellow with light hue as a result of the combination between blue color of the land and red color of the crown of Sago plants. Sago vegetation with lower dense seemed yellow in color due to the reflection from the land that is more dominant compared to the reflection of the crown plants. Non Sago vegetation presented by greenish yellow with a light hue. Furthermore, the brightness value as the result of band rationing transformation is able to evident to display well the Sago plants at harvest ripe. According to analysis result of Quickbird imagery, the estimation result of Sago production is around 31.009,201 ton for 2-time harvest periods in a year in an area of 917,432 ha.

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