# DISCRIMINATION OF SAGO PALM FROM OTHER PALM SPECIES BASED ON IN-SITU SPECTRAL RESPONSE MEASUREMENTS

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**KEY WORDS:** Sago, Palm Trees, Spectral Response

**Abstract:** This paper presents the preliminary results of an on-going project which aims to distinguish sago palm from other palm trees through the conduct of in-situ spectral response measurements. The measurements were carried out in the sago palm-rich municipalities of Bunawan, Agusan del Sur; Tagbina, Surigao del Sur; Jabonga, Agusan del Norte, and Butuan City, Mindanao, Philippines. In-situ spectral response measurement was done using Ocean Optics USB4000 Field VIS-NIR spectrometer. There are four other types of palm trees considered to be compared with sago palms in this study, namely: coconut, buri, nipa, and oil palm. It is hypothesized that each palm tree has a distinct spectral response at a certain wavelength and that it is possible to discriminate and identify sago palm from remotely-sensed imagery. Also, the reflectance of the sago palm at four different phonological stages (rosette, bole formation, inflorescence, and fruit ripening) was measured in order to detect if harvestable sago (bole and inflorescence stage) can be discriminated from the other stages. Based on the results of the analysis of the different spectral responses of each palm tree in different wavelengths, the spectral curves for coconut and buri palm are distinct from those of nipa, oil palm and sago palm. It was observed that spectral response of sago palm is highly correlated with nipa and oil palm, but is highly separable at wavelengths ranging from 930-970 nanometers. Also, the sago palms at bole formation stage and at inflorescence stage are highly separable from sago palms at rosette and fruit ripening stage at wavelengths ranging from 720 to 920 nanometers which mean possible delineation of harvestable sago stands at these wavelengths.

## 1. INTRODUCTION

The potential of Sago palms as good source for food and biofuel has drawn increasing interest recently. Sago palm (*Metroxylon Sagu* or *M.Sagu*) is gaining much importance as a crop par excellence and a starch crop of the 21st century, due to its being an extremely sustainable plant with an ability to thrive in most soil conditions (Rekha S. Singhal et al., 2008).

*Metroxylon* species may be confused with other palms, although not with any that are found in the native range (Will McClatchey, Harley I. Manner, & Craig R. Elevitch, 2006). However, forest inventory, which is a tedious procedure, may even be more difficult to conduct in the sago palm areas because of the type of habitat they are thriving. The natural habitat of *Metroxylon* is tropical lowland forest and freshwater swamps. These palms are often found growing in the freshwater margin at the back of mangrove swamps, extending inland as far as slow moving freshwater flows (Will McClatchey et al., 2006).

As forests are a complex and widely distributed ecosystem, remote sensing provides a valuable means of monitoring them. Remote-sensing instruments allow for the collection of digital data through a range of scales in a synoptic and timely manner. Both multispectral and hyperspectral remote sensing techniques have been used to discriminate and map wetland species (Elhadi Adam & Onisimo Mutanga, 2009). Forest cover mapping are evidently accomplished with less hassle and in a non-destructive manner by employing remote sensing techniques (Cohen, Prenger, & DeBusk, 2005; Qingmin Meng, Chris Cieszewski, & Marguerite Madden, 2009; R. Casa et al., 2010; Rahul J. Shrivastava & Jennifer L. Gebelein, 2007; and Elhadi Adam & Onisimo Mutanga, 2009) but very limited to sago palms. However, distinguishing sago palms from other palm trees on satellite images could be challenging. When viewed on a satellite images, most of these species are almost of the same appearance. Coconut, nipa, and sago palms are almost similar during their young stages. While cococut, oil palm and sago palms at mature stage can draw uncertainty upon looking at them on a satellite image.

In anticipation of the emergence of sago industry in the country, more particularly in Mindanao, Philippines, there needs to be a reliable data that will aid in determining its total area coverage. To aid in mapping sago resource in Mindanao, this study therefore demonstrates the applicability of remote sensing techniques to discriminate sago palms from other palm species based on in-situ spectral response measurements. The study mainly aims to determine the spectral responses of sago palms and four (4) other palm species and be able to compare each derived spectral curves, in order to discriminate sago palms from other palm trees accurately. The study area is located in places where sago palms abound which are the municipalities of Bunawan, Agusan del Sur; Tagbina, Surigao del Sur; and Jabonga and Butuan City, Agusan del Norte in the islands of Mindanao, Philippines.

## 2. METHODOLOGY

Five different palm species (Figure 1) were subjected to in-situ spectral response measurements. Sago palms at four different phonological stages (Figure 2) were also subjected to in-situ spectral response measurements in order to delineate the harvestable sago palm from the non-harvestable.

Reflectance spectra were measured within each sampling sites above the palm canopy using Ocean Optics™ Spectrometer. The sensor detects and records data with spectral range from 345 nm to 1047 nm. In order to measure the spectra of sago palms and that of other palms, the set-up is composed of the sensor, mounted in an improvised pole, attached to fiber optics and is positioned just above the canopy. The spectrometer is connected to a laptop computer that performs the scanning procedure, displays the plot of the observed reflectance and stores the reflectance data. Measurements of target radiance were repeated three times at each sample and the average value was used for the calculation. For each sample, the spectrometer is calibrated using a "white reference panel" before and after measurements. All gathered data were converted to Microsoft Excel format and the reflectance was calculated using the equation:

$$R = \frac{L_{canopy}}{L_{panel}} \qquad (1)$$

where $R$ is the canopy reflectance, $L_{canopy}$ is the measured radiance above canopy (average), and $L_{panel}$ is the radiance measured for the calibration panel. All spectral data in Microsoft Excel format are compiled in one spreadsheet file to compute the average reflectance and graphically assess the spectral patterns of the each palm species. After computing the average reflectance of each palm tree, the file must be exported as ASCII files, which will be the input file for the spectral resampling.


**Figure 1:** The different Palm species subjected to analysis

A. Sago at bole formation stage
B. Sago at rosette stage
C. Coconut
D. Nipa
E. Sago at inflorescence stage
F. Buri
G. Oil palm


**Figure 2**: The four phenological stages of Sago palm

## 3. RESULTS AND DISCUSSION

In-situ spectral measurements were conducted within the periods of April 30, 2012 to August 11, 2012 in different sampling sites situated in the municipalities of Bunawan, Agusan del Sur; Tagbina, Surigao del Sur; and Jabonga and Butuan City, Agusan del Norte. A total of 60 sago palms at various growth stages (rosette, bole formation, inflorescence, and fruit ripening) were sampled and subjected to spectral measurements. While there were 11 coconut trees, 21 nipa palms, 5 oil palms, and only 1 buri palm were sampled during the field data collection. The figures below shows the average spectra of sago palms at four (4) different growth stages and that of four other types of palm trees.

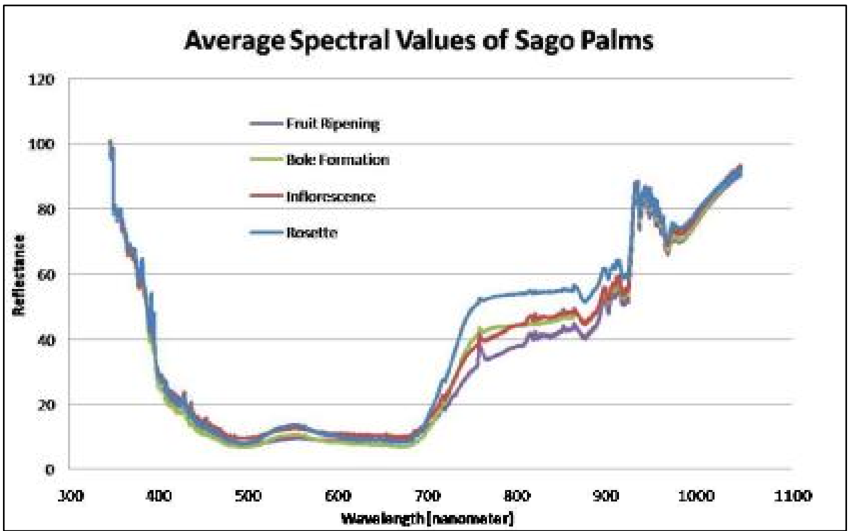


**Figure 3:** Average spectral curve of sago palms at different growth stages.

Figure 3 shows the average reflectance curves of sago palms at various growth stages. It can be observed that sago palms at all growth stages are highly correlated at the visible spectrum. But, it is remarkable to note that sago palms at bole formation stage and at inflorescence stage are highly separable from sago palms at rosette and fruit ripening stage at wavelengths ranging from 720 to 920 nanometers (shown in Figure 4). This means that delineation of harvestable sago stands (at bole formation and inflorescence stage) is possible at these wavelengths.

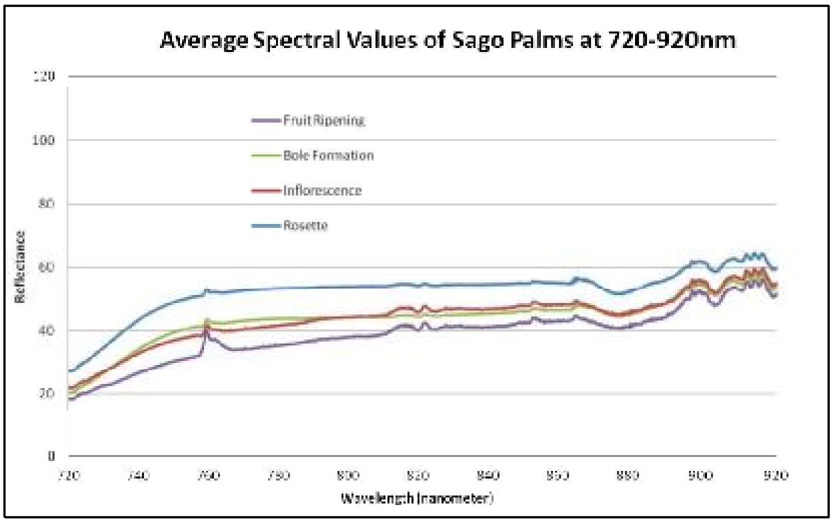


**Figure 4**: Average spectral response of sago palms showing separability of harvestable (bole formation and inflorescence stage) and non-harvestable (rosette and fruit ripening stage) at 720 to 920 nanometers.

Figure 5 shows the average spectral response of all palm species such as coconut, nipa palm, oil palm and buri palm including sago palm at bole formation and inflorescence stages. It was observed that buri and coconut palm is separable from the other palms from 720-900 nm. With the buri and coconut palm eliminated in the analysis, it was observed that starting in the 870nm onwards oil palm is separable from the nipa and sago palm (shown in Figure 5). However, significant result was observed at around 935- 1010 nm where the separability of spectral curve between nipa and sago palm is evident.

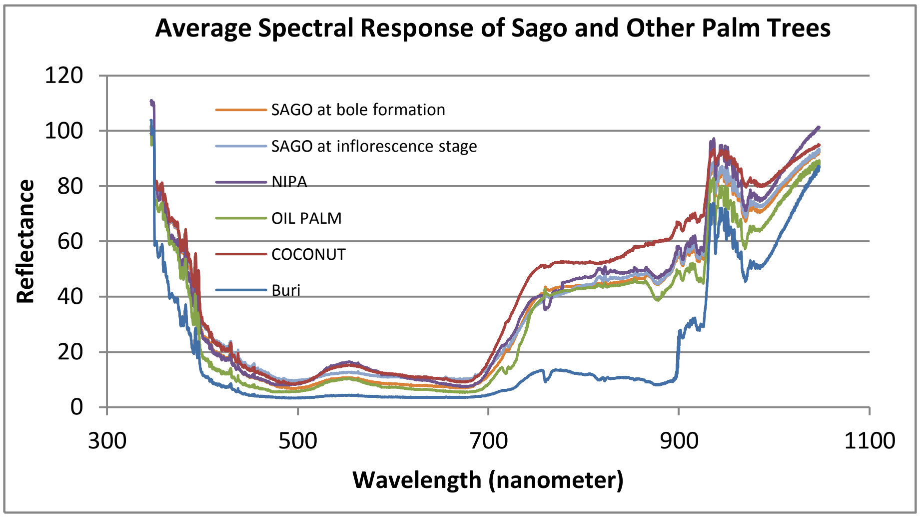


**Figure 5**: Average spectral curve of coconut, nipa palm, oil palm, buri palm and sago palm

## 4. CONCLUSION

This study therefore demonstrates a plausible and straight-forward technique in discriminating sago palms from other palm species based on in-site spectral measurements. Findings of this study proved that remote sensing techniques can lead to an accurate inventory and mapping of a forest resource by collecting and processing in-situ spectral data. Establishing the statistical relationship between sago palms spectral characteristic and other data related to sago palms like the structural data (diameter at breast height, tree height, age, etc.) and biophysical data (soil conditions like pH, moisture content, nutrient content, organic matter, etc.) should be done. The results can then be used for: (1) precise inventory of sago palms that can provide data on yield estimates, production rates and forest management practices; (2) realistic resource sustainability assessment; and (3) reliable suitability rules that can aid in identifying sites for expansion and commercialization.

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