The Study of Discrimination of Remotely Sensed Data for Designing the Separation Technique between Cassava and Sugarcane Farmland

Anuphao Aobpaet[a] and Soravis Supavetch
Department of Civil Engineering, Kasetsart University, Bangkok, Thailand

Keywords: Cassava, Sugarcane, Remote Sensing for Agriculture.

Abstract: Cassava and sugarcane are the most important agricultural crops in Thailand. The cultivations of those are similarly in crop season, natural resources, and climate. For decades, the farmers usually switch their plant depending on unit price and government subsidy. The use of remote sensing data for monitoring change in farmland has encountered a problem on the similarity of vegetation index and the seasonal variation. In this work, we investigate the significant differences between cassava and sugarcane plantation by using satellite data from two sensors systems (Optical and SAR sensor) from Sentinel-1 and Sentinel-2 satellites. The result of the sampling fields of cassava shows the fluctuation of the growth and the mean of SAVI is slightly lower than sugarcane at the same age. SAVI values over the cassava farmland seem to approach the homogeneity of sugarcane when the age of more than 11 months. Thus, the difference between cassava and sugarcane farmland using this method should be investigated on the growth stage of the age between 4-9 months. For SAR polarization, the VV, VH of SAR backscatters have little difference in cassava and sugarcane. When compare the backscatters value of VV and VH from cassava and sugarcane, the sigma0 values in dB show that VV backscatters have a higher signal return. The variation of VH polarization of cassava and sugarcane seem difficult to identify due to the diversity of signal targets. Therefore, by using SAR data, the detection of the difference between cassava and sugarcane should be considered after working on time series techniques for crop seasoning to remove unwanted objects until only cassava and sugarcane remain. From the results, we also found that the parcel-based method is a better processing approach to separate cassava from sugarcane compared to pixel-based, and it requires descriptive statistics to distinguish between cassava and sugarcane at each age. This method requires the information of two agricultural plantations boundaries. The possible handling process when harvesting and preparation of the plantation are by observing time-related over an area to determine the boundary of the farmland. Therefore, the discrimination of remotely sensed data for designing the decomposition technique between cassava and sugarcane farmland is necessary because of the specificity of cultivation in Thailand.

1 INTRODUCTION

The Ministry of Agriculture and Cooperatives also announce the policy to reform Thailand's agricultural sector mainly focuses on seven areas. The first area is agricultural zoning to a suitable geographical and climatic condition. The second area is the establishment of learning centres for increasing the efficiency of the agricultural product. The third area is a grouping of farmers and farmland for better efficiency. The fourth area is seeking the encourage farmers producing in response to the market demand. The fifth area set up the banks for agricultural products through the grouping of farmers. The sixth area is seeking to promote working as a team through the "single command" system in order to translate the reform plan into action. The seventh area is the reduction of agricultural production costs. In the case of cassava and sugarcane, the factor of success policy is based on the monitoring of cultivation behaviour of the farmers. In recent years, Earth Observation Satellite (EOS) is a powerful tool for constantly assessing the status of agricultural production on a wide range of spatial and temporal scales. It provides time series data and can rapidly reveal where change has happened in a consistent and repeatable manner.

[a] https://orcid.org/0000-0001-7638-853X

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Information from Earth Observation is therefore very well suited to timely information on cropland distribution and status at various crop stages.

In a global scale, characteristics of satellite remote sensing data and processing implementations are available for the large areas applications such as forestry, agriculture, fishery, coastal and marine, environment, disaster mitigation, spatial planning, and so on. Nevertheless, in a small scale (high resolution), many factors are relevant due to many components of the ecological network which are involved i.e., small pond, farm dike, mixed cropping, species, soil types, moisture, etc.

In Thailand, the National Statistical Office (2013) reported that 87.8% of 5.9 million farmers owned land area lower than 6 ha. However, this small farm size alone is not only a limiting factor for determining the productivity (yield) and the homogeneity of the plant by using spectral reflectance determination. Moreover, Thai government pay attention to promote “Philosophy of Sufficiency Economy and New Theory” in agricultural sector following his Majesty King Rama 9 suggestion that the farmers are suggested to divided his land into four parts with a ratio of 30:30:30:10. The first 30% is designated for a pond to store rainwater during rainy season. The second 30% is set aside for rice cultivation during the rainy season for family’s daily consumption throughout the year. The third 30% is used for growing fruit and perennial trees, vegetables, field crops and herbs for daily consumption. The last 10% is set aside for accommodation, animal husbandry, roads, and other structures (The Chaipattana Foundation, 2017). Thus, these activities made more complexity on a small farm in term of remotely sensed data. For an agricultural country such as Thailand, the implementation of remote sensing technologies for monitoring and controlling the government’s policy in agriculture using a field-based approach is the importance for those smallholder farmers.

In this study, the cassava and sugarcane are selected as a feasible crop. The influence of the successive policy depends on the monitoring of the cultivation behaviour of the plants following farmers’ decision which sometimes varied and difficult to identify. The crop growing process of cassava and sugarcane are likewise in crop season, natural resources, and climate (Thai Meteorological Department, 2015), as already mentioned above. The farmers have their choice to select the plants base on the unit price and government subsidy made the difficulty of policy control. The potential on using remote sensing for farmland monitoring is the challenge technique due to the fact about the correspondence of vegetation index term, the seasonal effect on a reflectance make the signature of a phenotype cannot be determined. This study used permitted available data from Sentinel-1 and 2 for data processing and uses the parcel-based descriptive statistics in analysing and interpreting the results. In this stage of the study, we only focus on the technique for the separation of cassava and sugarcane which will make possible for crop forecasting in Thailand.

2 OBJECTIVE

As by the location of the country, there is a little difference in environments as well as the planting season, so we are unable to classify the agricultural farmland of both plants by means of single temporal classification. Therefore, the main objective of this study is to investigate the significant differences between cassava and sugarcane plantation by using satellite data from two sensors systems which are Optical and SAR sensor from Sentinel-1 and Sentinel-2 satellites. Both satellites that we applied are available at no cost and it is possible to develop the automatic system for future operation.

3 DATA PREPARATION

The sampling areas of cassava and sugarcane are selected in Nakhon Ratchasima province which is the largest cassava plantations in Thailand (Figure 1). This province economy has traditionally been heavily dependent on agriculture which is the production of rice, tapioca, and sugar.

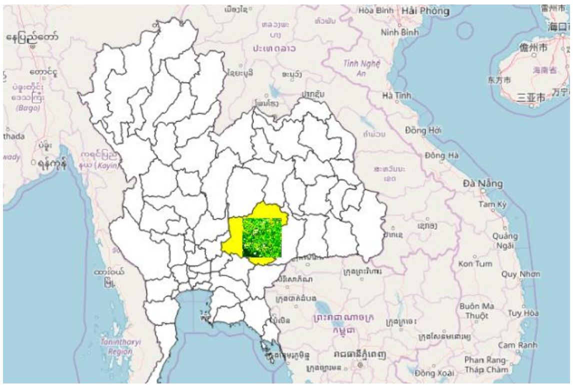


Figure 1: Nakhon Ratchasima province, the largest cassava plantations.

The Sentinel-1 and Sentinel-2 satellites data are able to access via Copernicus Open Access Hub (https://scihub.copernicus.eu/) for this investigation (European Space Agency). Satellite data processing from Sentinel-1 uses the Orfeo Toolbox software as a processing tool (Inglada et al., 2009) (Christophe et al., 2009) (Teodoro et al., 2016). The data downloaded from the Copernicus Open Access HUB is in Level-1 Ground Range Detected (GRD) and Level-1 Single Look Complex (SLC). The processing step started with the adjustment of the satellite's orbit value with the most accurate orbit data (precise orbit), and then apply radiometric correction by calibrating to adjust the pixel value to backscatter and convert them to decibel (dB). The data was then filtered using speckle filter for noise reduction with speckle filtering which offers many options for filtering as follows: Boxcar (mean), Median, Frost, Lee (Lee et al., 1999), Refined Lee, Gamma-MAP, Lee Sigma, and IDAN, etc.

Subsequently, geometric correction is performed using the Range Doppler Terrain Correction method because the terrain pattern along the plane of the scene and the inclination of the sensor on the satellite will cause distances in the radar image distorted. Since, the image data is not always in the middle position (nadir) of the image sensor; there will be distortion. Thus, the terrain is corrected to compensate for these distortions in order to show the geometric patterns of the image as close to the most accurate. However, we skip the step for applying SRTM DEM in height data correction because of the plane study areas. The image has been corrected (geocoded) and then subset to the study area and classify the area features using the statistical values. The polarization was used to distinguish and display by mixing polarized colors such as Dual pol multiple sigma0, Dual pol ratio sigma0, or Dual pol difference sigma0 depending on appropriateness. In our investigation, the program was developed to an automatic SAR data processing using Orfeo Toolbox together with the python language program for creating Dual Polarization data in VV and VH that will be used to study the characteristics of the backscatter signal from cassava and sugarcane plantation.

While, the reflectance obtained from the L1C product of the data from Sentinel-2 is a reflection that has been mixed with the diffusion effect in the atmosphere. This information is called Top of Atmosphere (TOA). Therefore, it is necessary to adjust and remove the reflection by atmosphere out of the data set before being used in order to be a reflection value at the canopy layer (Bottom of Atmosphere, BOA). The effect of modifying the atmosphere to bring the reflection in the atmosphere makes it possible to know the particles in the atmosphere which makes the additional data layer called Aerosol Optical Thickness (AOT). When comparing the reflection values to the results from adjustment, it is found that the values that have been removed, such as clouds, shadows of clouds, etc., are correlated in each band in the same proportion. The data of the Soil-adjusted vegetation index (SAVI) (Qi et al., 1994) is an index data that is closer to the crop and plant health than NDVI (Normalized Difference Vegetation Index) (Senay et al., 2000) because it has been modified to reflect the influence of the soil. Therefore, the SAVI data is an appropriate index to be applied to the crops such as cassava and sugarcane. When observed from satellite data, the effect of soil reflection will be mixed with the sensor's detection value. Reducing the impact of this soil will result in more information that reflects evidences about plants. The calculation of SAVI (Huete, 1988) is calculated as by equation below using L = 0.48 according to the recommended values from European Space Agency (ESA).

$$SAVI = (1+L)*(NIR-R) / (NIR+R+L) \quad (1)$$

When verified to the cassava plantation area and define the display with false color combinations, we will see the data as shown in Figure 2. These time series data shows the crop stage measurement and the growing season, respectively.

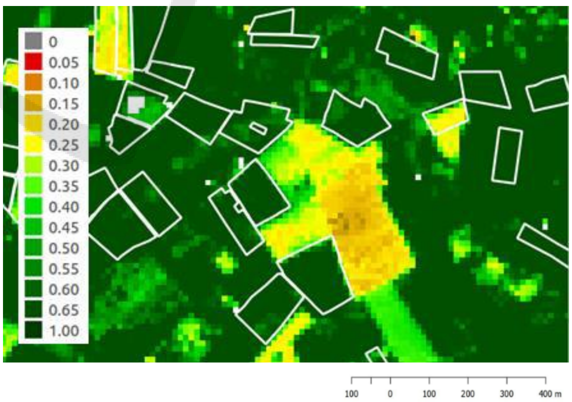


Figure 2: SAVI information displayed with false color combinations showing the amount of plant cover (green) and soil without plants covered (yellow to red colors shade).

4 HYPOTHESIS

From the inspection area, the growth of cassava and sugarcane taxonomy can be recognized as soil preparation, planting time, and yield period. In Thailand, there are many species of cassava crop cultivation. Each type has a leaf size, height varies, and some types are 2 meters high, some 4 meters tall, while the sugarcane has a height between 2-5 meters as well. When both plants are fully grown and yield 8-12 months, the top cover is similar, not significantly different.

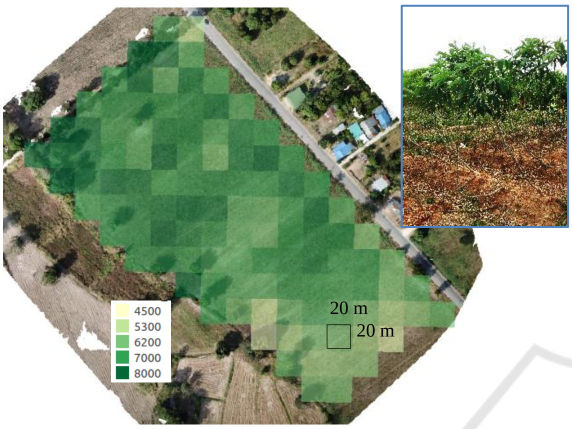


Figure 3: The cassava farmland.

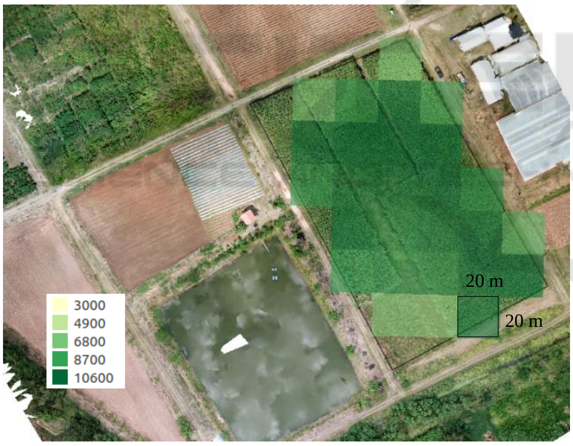


Figure 4: The sugarcane farmland which follows the “Philosophy of Sufficiency Economy and New Theory”.

In this study, we measured the inspection area using UAV (Unmanned Aerial Vehicle) to capture a vertical shot an overlaid with SAVI (Soil-adjusted vegetation index) and SAR (VV-VH) data. Some important features that can be hypothesized to find differences in satellite data between cassava and sugarcane plants are the growth of cassava (Grown at the same time in the farmland). It has a variable appearance according to the environment of the farmland, rather than the growth of sugarcane (Figure 3 and Figure 4 respectively).

For cassava aged 9-11 months in the sample farmland in Figure 3, the different heights can be seen with some little leaves, some plant looks good growth mixed together while the sugarcane has a relatively stable growth. Therefore, assuming that cassava at the same age as sugarcane as shown in figure 4 has a variation of the LAI (Leaf Area Index) and results in the plant index or the different altitude of the variable canopy layer are important to be able to distinguish between 2 types plantation.

5 METHODOLOGY

The method on building the phenotype from such time-series of Normalized Difference Vegetation Index as Savitzky-Golay, Gaussian, Logistic function and so on, are using the data in a term of pixel-based time-series for describing the plant's growth. Some factor such as unstable of a growth rate of the cassava over the farmland cannot be detected due to the pixel-based time-series does not demonstrate the spatial autocorrelation.

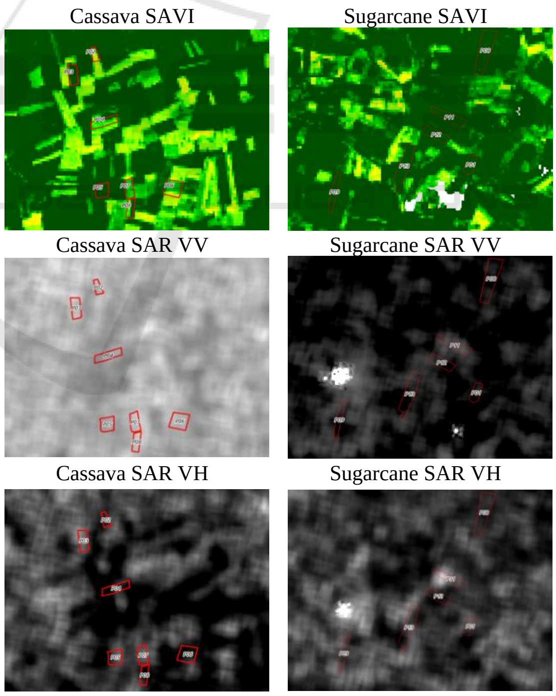


Figure 5: The 8 samples areas of cassava and sugarcane with background of SAVI and SAR VV/VH.

Thus, in this research, the parcel-based with the descriptive statistics is selected for use as the detector of the homogeneity different between the growth of cassava and sugarcane over the farm parcel. Soil

Adjusted Vegetation Index (SAVI), is used instead of NDVI for reducing a soil effect in the reflectance, especially for the field crop in which LAI is a low value over the growth period. The descriptive statistics such as min, max, mean, standard deviation, and percentile are used in the calculation for demonstrating the homogeneity of the plant's growth over the farmland. The different of 25 and 75 percentile of the cassava should be more than the sugarcane following the research hypothesis. The 8 samples of cassava and sugarcane are examined SAVI and SAR backscatter shown in figure 5.

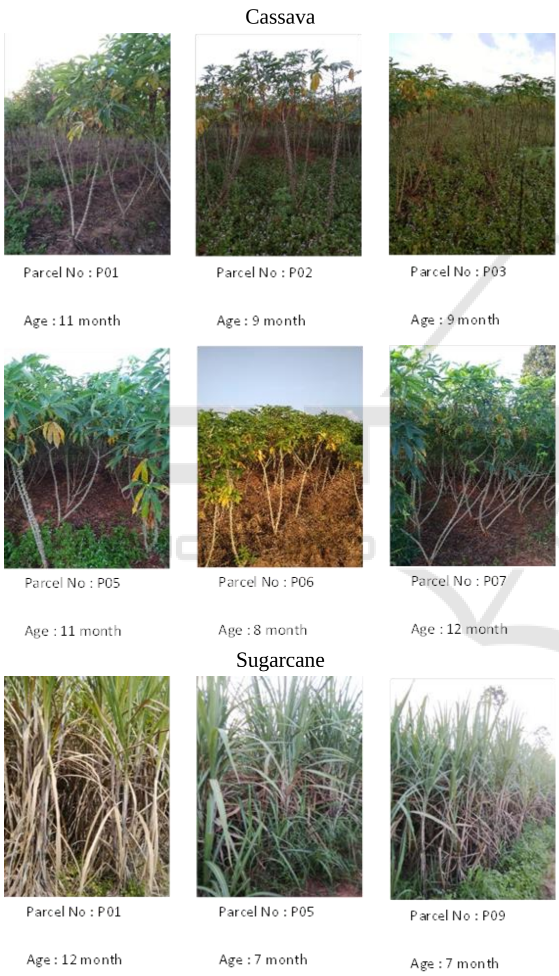


Figure 6: The images of cassava and sugarcane in difference growing stage.

Due to the field visit on the harvesting season, cassava and sugarcane are mostly in the maturity stage as shown in Figure 6. The density of leaves and stems of the sugarcane seem to be more than the cassava in every farmland. The height of cassava is varied and unequally growth except for the age more than 12 months due to cassava stop growing on root after 8 month then leaf and stem are growers at 8-12 months.

6 RESULT AND DISCUSSION

The boxplot of the sampling fields of the cassava in Figure 7 shows the fluctuation of the growth and the mean SAVI quite lower than the sugarcane in which the same age. SAVI values over the farmland seem to approach homogeneity the same as in sugarcane when the age of the cassava for more than 11 months. Thus the detection on the difference of the cassava and sugarcane farmland using this method should be investigated on the growth stage that age between 4-9 months. In our assumption, the physical characteristics of cassava and sugarcane from start planting on the farmland is supposed to show some difference of the backscatter signal when returning back after reflected the objects. In the investigation, SAR sensor in VV and VH polarization on board Sentinel-1 satellite were generated and analysed using Orfeo and then interpreted with parcel-based descriptive statistics for cassava and sugarcane crop separation.

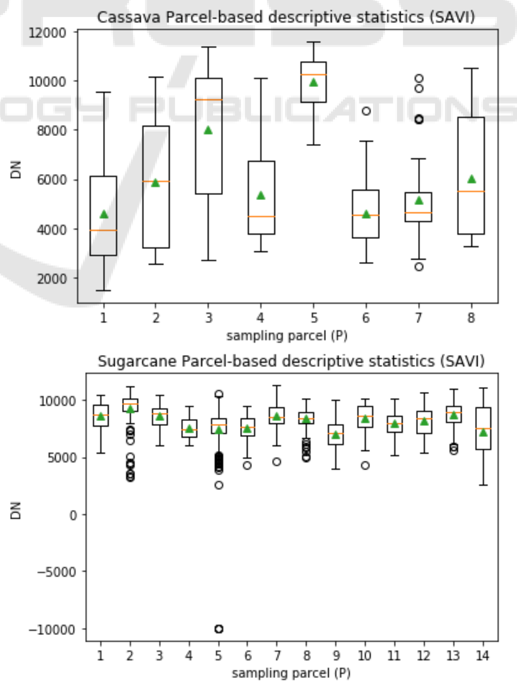
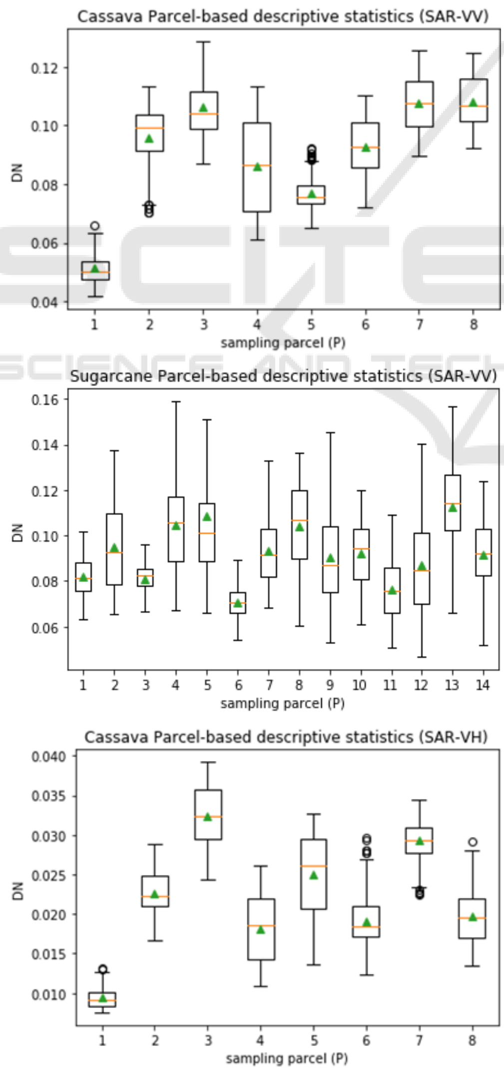


Figure 7: The boxplot of cassava and sugarcane parcel-based from SAVI.

For SAR polarization in Figure 8, the VV, VH of SAR backscatters have little difference in cassava and sugarcane. The VV backscatters of sugarcane seem to have more outlier value due to the better backscatter compare to VH polarization. When compare the backscatters of VV and VH from cassava and sugarcane, the sigma0 value in dB show that VV backscatters have a higher signal return. The variation of VH polarization of cassava and sugarcane appear difficult to identify due to the diversity of the signal target. Therefore, by using SAR data, the detection on the difference of the cassava and sugarcane should be considered after working on time series technique for the crop season to filter or remove unwanted objects until only cassava and sugarcane remain. In the next step of our study, it ought to focus on the Polarimetric SAR Classification. This technique can provide more information and a variety of method to calculate on the structure of farmland which is a function spatial variation in canopy structure and density.



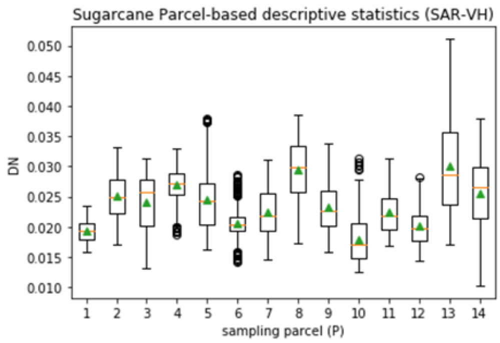


Figure 8: The boxplot of cassava and sugarcane parcel-based from SAR VV and VH polarization.

7 RECOMMENDATION

From the results, we found that the parcel-based method is a better processing tool to separate cassava from the sugarcane compared to pixel-based, and it requires descriptive statistics to distinguish between cassava and sugarcane at each age. This method requires information on the boundaries of the two agricultural plantations. The possible handling process is when the harvesting and preparation of the plantation by observing time-related over such area to allow the boundary of the farmland to be determined. With the assumption that each farmland belongs to a small farmer, usually harvesting in different periods of time due to the small amount of labor in the harvest season compared to the output quantity causing the need to be in the waiting list for harvesting queue. Therefore, determining the boundary of the farmland by using the time series of the cutting tracking data set will help determine the farmland boundary.

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