# STATE OF THE ART REMOTE SENSING TECHNOLOGY FOR OIL PALM MANAGEMENT IN INDONESIA

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**ABSTRACT:** The oil palm industry is one of the most important sources of revenue for Indonesia but there are still many challenges that must be faced by the palm oil plantation management, one of which is to maintain production sustainability. The problem of palm oil plantations related to land resources requires effective and efficient technology inputs. Remote Sensing technology is one of the inputs that can be used as one of the decision support system (DSS) to decide the problem spatially quickly, accurately and dynamically. However, remote sensing technology has not been applied in Indonesian palm oil plantations. It is because of tropical climate conditions that tend to be covered with clouds that can inhibit the performance of remote sensing technology. Purpose this study is to review utilization of remote sensing technology in palm oil plantation in Indonesia. Based on the our review we found some journal paper in remote sensing application for oil palm from 1999 until now (2017). Remote sensing technology will produce a data in the form of description of palm oil conditions in the field which the data must be processed and re-analyzed using a customized method of management needs. The results revealed that remote sensing technology was able to provide output in the form of land mapping, tree volume estimation, palm fruit classification, palm oil growth, estimated age of plant, biomass estimates, palm oil productivity estimates, health detection and accurate mapping of palm oil diseases using the right method and opportunity the remote sensing application for oil palm management on the future in Indonesia

## 1. INTRODUCTION

The palm oil industry is experiencing rapid growth at this time. Palm oil demand has continued to increase in recent years, as at present many developed countries are shifting from the use of trans fat to a healthier alternative. Palm oil (Crude Palm Oil - CPO) has a very saturated, fat-shaped vegetable fat content at room temperature and has a relatively low price. CPO is a vegetable oil derived from palm oil fruits. Total world palm oil production is estimated at more than 45 million tons. World palm oil production is dominated by Indonesia and Malaysia, Both countries in total produce about 85 - 90% of total world palm oil production. In Indonesia, the development of CPO production increased by 5.39% to 8.42% per year. In fact Indonesia continues to experience an increase in the average proportion of CPO exports by 0.63% (BPS, 2017). If viewed from the side of world export performance, the increase of CPO export value has not been great. According to Ernawati & Saptia (2013) Indonesia's CPO export performance is lower than Malaysia and Thailand. In fact, Indonesia's performance is only in line with Columbia having the Revealed Comparative Advantage index (RCA) of about 0.98, while Malaysia has a RCA index of 1.04. According to the Director of the Palm oil Research Center (PPKS), although palm oil production continues to increase year-on-year, palm oil productivity is still relatively low, ie 15% - 35% or still below potential productivity, thus requiring research, innovation and implementation support best practices (Sri Mas Sari, 2017). It can be concluded that the competitiveness of CPO Indonesia products in the world market is lower than Malaysia.

The process of planning palm oil development can not be separated from the use of technology. Geographic information systems can be derived from the use of geospatial technology. Application of geospatial technology can produce topographical information in the form of maps that can be used to assist design of palm oil plantation design, irrigation design, land suitability, and infrastructure development. In addition, through the geospatial technology of palm oil plantation companies can perform Internal Quality Control , monitoring the

effectiveness and efficiency of palm oil cultivation, monitoring plant health, checking hydrological systems, checking conservation areas, calculating Stand Per Ha (SPH) and obtaining information on palm oil attributes such as tree height, canopy width and stem diameter.

Thus, the conclusion that entrepreneurs in the field of palm oil industry can find a variety of information that can support the company's operational activities through geospatial technology. However, geospatial technology has not been well utilized at this time by the palm oil industry, while palm oil plantation issues related to land resources require effective and efficient technology inputs in order to maintain production sustainability. Knowledge of the application of technology in the palm oil industry from various countries can be used as a comparison material and consideration in determining which technology can produce effective and efficient CPO production. Given the importance of the utilization of geospatial technology in the palm oil industry, the authors want to conduct research how far the remote sensing technology is applied in the management of palm oil in the world.

## 2. METHODOLOGY

Research methodology conducted are: 1) Study of literature. the study was conducted to better understand the information on palm oil plantations in different countries and remote sensing technologies used in the palm oil industry through journal reviews. 2) Analysis. The result of this research analysis is a remote sensing technology review used by the palm oil industry in Indonesia and Malaysia in the form of technology to analyze: Land cover classification, Tree mapping & counting, Age estimation, above ground biomass (AGB) estimation, Disease detection & yield estimation. And analyze what methods are used in processing the data obtained from remote sensing technology.

## 3. RESULT AND DISCUSSION

Remote sensing Satellite technology using optical and radar techniques has been successfully used in various applications related to earth resource studies and environmental monitoring. Some of the benefits of this technique are cost effectiveness, wide coverage, near real-time data acquisition and recurrent recording capabilities with regular time. Remote sensing has significant potential to assist palm oil monitoring and potential palm oil plantation prediction.

According to several studies already conducted in agriculture and plantations, remote sensing technology is able to provide accurate output estimates of the derivation of the relationship between the spekspectral character and vegetation index in the form of canopy cover by utilizing the reflection of visual waves red, green, blue and infrared wavelength

### 3.1 Land

Safira, et.al (2015) in his research proves that the dynamics of land use and development of palm oil plantations in West Kalimantan from 1990 to 2013 can be monitored through geospatial technology, the Landsat satellite imagery. Remote sensing data such as satellite imagery is particularly useful in observing changes in land use or closure. This research uses a combination of remote sensing technology and Geographic Information System (GIS) in identifying changes in land use or closure in West Kalimantan. Remote sensing technology can produce accurate maps to monitor land use change that can be used as a consideration in management for regional planning. Researchers combining other remote sensing imagery are Lissa Fajri and Ryota (2015). In their research the detection of palm oil plantations in Simpang Pematang, mesuji regency, Lampung province by using ALOS (Advanced Land Observing Satellite). The researchers managed to integrate radar data and optical sensors from ALOS satellites. Texture analysis is chosen as the most appropriate method for extracting this unique pattern because of its ability to measure the correlation between the tones of gray. The conclusion is the PALSAR (Phased Array type Synthetic Aperture Radar) type satellite device is capable of providing all-day earth observations in all weather, and offers the opportunity to identify and map the palm oil plantations in the cloudy areas. Harintaka, et.al (2007) detected the location, distribution, and extent of palm oil plantations in Bengkulu City from Landsat 7 ETM + satellite images. Artificial neural network classification algorithm (ANN) is used for the extraction of satellite imagery. The result of the research shows that the controlled ANN classification method is able to classify the land cover categories gradually up to the type of plant. Mapping of palm oil plantations can be done using SPOT technology. The results of H.A. Setyowati (2016) showed that the SPOT-6 image was able to identify and map land use in palm oil plantations with a high degree of accuracy of 96% with the best multispectral classification of ARVI transformations. Other researchers mapped palm trees using air hyperspectral imaging. Images generated from hyperspectral sensors contain a lot of data than images of multispectral sensors and have greater potential for detecting differences between land and water features. For example, multispectral imagery can be used to map plantation areas, while hyperspectral imagery can be used to map trees in palm oil plantations.

### 3.2 Volume of Trees

According to Priske's research, et.al (2012) and Anita Priyani (2013) Lidar can detect individual trees automatically and is able to estimate the volume of trees in an area equipped with high information and the width of the canopy diameter of each individual tree being detected. Level of accuracy of Lidar's technology use in this study is 93% with an estimated 7% error for an area of 20 Ha. Tsanaa Alifia, et.al (2017) that examines the volume of the tree using Lidar technology also indicates that Lidar technology is effectively used to calculate the number of trees in palm oil plantations. The accuracy of the calculation reached 95.53%. It means the presentation of the calculation is reached (> 80%). From these studies, we can conclude that Lidar technology can be utilized for estimating tree volumes.

### 3.3 Palm oil Growth

Ari Purno and Iwan Rijayana (2017) have shown that the process of monitoring and growth of palm oil in the air imagery using drones can be implemented and can save time and energy and able to supervise a wide area. Image acquisition features image processing or image segmentation, computer vision is able to explain a process or an explanation of an object and bias is used in real time. Classification of the growth of palm oil plantations in a plantation can be done using high resolution satellite imagery as well, such as FORMOSAT-2. Laju Gandhrum and Chen (2011) succeeded in utilizing texture information for the palm tree classification using the FORMOSAT-2 image. In their research, image classification using Maximum Likelihood guided classification technique. The results showed that the overall accuracy of the multispectral channel image classification was 66.4%, while the overall accuracy of the multispectral channel combination image classification with the texture information reached 76.8%. It can be concluded that the addition of texture information on the multispectral channel can increase the classification result of 10.4%.

### 3.4 Plant age

Jansen Sitorus (2004) states that the age of palm oil crops can be predicted with NDVI derived from Landsat data. In addition, the index spectral IRI (InfraRed Index) and MIRI (Midle Infrared Index) are significant in determining the age of palm oil, while RVI (Ratio Vegetation Index) is a parameter that can not be used in predicting the age of palm oil. The best model for calculating palm age by using Landsat data is in the form of multi linear regression with R2 0.69. Utilization of Landsat-TM technology is also done by Harsanugraha (1999). Based on his research, it can be concluded that palm oil in its growth will undergo physical changes so that it can be monitored by remote sensing data, which is to observe the influence of age on band spectral reflectance and spectral index that can be derived from Landsat-TM data. Based on his research, palm oil will experience physical changes in growth so that it can be monitored with remote sensing data, that is by observing the effect of age on spectral band reflectance and spectral indices that can be derived from Landsat-TM data. Jansen Sitorus, et.al (2013) evaluates methods that can monitor the expansion of palm oil plantation areas and demonstrate planting time by determining the age of palm oil plantations using SPOT6. Method used is classification based on texture analysis Combinations of texture parameters are evaluated in texture analysis. The results showed that the accuracy of classification using 8 kernel texture with 21 being the highest compared with the combination of texture parameters and smaller kernels. So, it can be concluded that SPOT 6 technology is very effective in detecting vegetation and age of palm oil. Ita Carolita, et.al (2015) analyzed the age of palm oil planting using SPOT 6 with the NDVI analysis method and regression analysis to derive a model from the palm oil growth profile. This formula can be used to predict palm oil life for an average of 4 to 11 years with an accuracy of 89%. So it can be concluded that SPOT 6 remote sensing technology can help palm oil processing management to obtain an accurate data.

### 3.5 Biomass

Haniefah Astriani, et.al (2017) analyzed the value of carbon stock by using modeling method by calculating the vegetation index of RVI, MSARVI and NDVI on Landsat 8 Oli image and sentinel 2A. The results showed that the correlation value between the MSAVI vegetation indeks on sentinel image with the biomass value in the field showed the strongest correlation when compared with the other correlation. Sentinel image is better in terms of object identification in the field because the error in sentinel image is relatively smaller than Landsat image. Sentinel 2A images produce better accuracy values due to differences in spatial resolution. The results showed that the best model was found in 2- A sentinel image with NDVI vegetation index with 37.40% accuracy.

### 3.6 Productivity and Estimation of Palm oil Production

Tsana'a Alifia, et.al (2017) result of calculation of palm tree identification calculation using Lidar technology able to achieve 95.53% accuracy level. High productivity of palm oil plantation is strongly influenced by plant age composition and land suitability. In this research, orthophoto is done by using template matching method for calculating automatic extraction on palm tree and calculation of manual tree digitization. Lidar data is done for the manufacture of DEM, SDM and CHM used to determine the height of each palm tree, because the age of the plant can be identified based on the identification of the height of the tree. Grefie Dwinita (2013) analyzed the ability of remote sensing data in identifying palm oil and estimates palm oil production from image analysis.

Spatial modeling analysis based on remote sensing image analysis using SPOT 5. The method used in this research calculation is index transformation. Whereas, the algorithms used in the vegetation transformation index are NDVI, GNDVI, and SAVI. The resulting modeling result produces an image of palm oil productivity in which each pixel states the amount of productivity in each pixel. So it can be concluded that, the amount of palm oil productivity can be known by multiplying the breadth and the production value of each pixel. Heratania (2011) examines the image capability of SPOT 6 to recognize and estimate the production of palm oil plants and to know the variation of the estimated production yields of each estimation model. Methods used in the study were NDVI, MSAVI2, PANNDVI and regression analysis with SPOT image 6. The research resulted in accurate estimation of production for NDVI of 83.33%, ARVI of 78.87%, MSAVI2 of 78.03% and PANNDVI of 80.74%. It can be concluded that the result of production estimation analysis using NDVI transform has the highest accuracy value. The final result of this research is the mapping of palm oil productivity estimation with various vegetation index transformations. The productivity estimation map shows the variation of palm oil productivity estimation so that it can be seen which area has high productivity until low productivity. Heratania, et.al (2017) conducted further research on the effectiveness of the vegetation index transformation emphasis on the effects of atmospheric spots based on the image of SPOT 6 for the estimate of palm oil production. The method used to process SPOT 6 image data is Ratio Vegetation Index (RVI), Atmospherically Resistant Vegetation Index (ARVI) and Visible Atmospherically Resistant Index (VARI) to estimate the production of palm oil using SPOT image 6. The results show that production estimate using RVI method has 77,99% accuracy level, ARVI transformation 78,87% and VARI transformation equal to 81,25%. Thus, it can be concluded that the best transformation to estimate palm oil production is the VARI transformation.

### 3.7 Detection of Health and Disease of Palm oil

Uktoro (2017) analyzed the drone image to monitor the health of palm oil plants. This study examines and analyzes the relationship between visible and infrared drone sensors with palm oil plants in order to easily monitor plant health levels at an efficient cost. The method used is to perform a photo shoot on palm oil blocks using a drone with visible and infrared sensors. The results of the photos were then used for the analysis of the canopy area on palm plants. Percentage of infrared reflection height indicate the amount of green substance or chlorophyll in the plant and assumed the healthier the plant. The analysis of the vegetation index can be calculated by NDVI. Assuming that healthy plants will exhibit an active process of photosynthesis and an increased NDVI value, and vice versa. Both analyzes will produce a palm oil health map.

Heri Santoso, et.al (2010 ) examined the potential of high resolution QuickBird satellite images, which have synoptic images, to detect palm oils infected by alopecia and to map disease. The results show that the image segmentation can be used effectively in describing areas infected by the disease with a mapping accuracy reaching 84%.

## 4. CONCLUSION

Utilization of remote sensing technology in palm oil industry in Indonesia has been done. Remote sensing technology is used in palm oil plantations located in South Sumatera, North Sumatera, West Sumatera, West Kalimantan and South Kalimantan. Remote sensing in Indonesia is already used for: land mapping, detect location, distribution and calculation of palm oil plantation area, calculate volume tree, detecting tree canopy, palm oil growth, palm oil productivity, above ground biomass and detecting plant age.

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