Journal of Tropical Resources and Sustainable Science

journal homepage: jtrss.org

Implementation of Open Source GIS to Palm Oil Tree Plantation Database: A Case Study in Bukit Kerayong and Bukit Rajah Estate

Shaparas Daliman[1,*], Nur Adilah Mohd Azmi[2], Alvin Lau Meng Shin[2]

[1]Faculty of Earth Science, Universiti Malaysia Kelantan, 17600 Jeli, Kelantan, Malaysia
[2]Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

Received 17 April 2017
Accepted 30 July 2017
Online 23 September 2017

Keywords:
Palm oil plantation industry, geographic information system, open source software.

⊠*Corresponding author:
Dr. Shaparas Daliman,
Faculty of Earth Science,
Universiti Malaysia Kelantan,
Jeli Campus, Kelantan, Malaysia.
Email: shaparas@umk.edu.my

Abstract

The palm oil plantation industry is on the rise and it is the biggest plantation industry in Malaysia. Due to its importance and the rise in demand of palm oil plantation, thorough care needs to be given in order to produce high quality products. Nevertheless, the increasing number in the plantation makes it difficult for the plants to be taken care manually. It requires an appropriate Geographic Information System (GIS) to manage the plantation. Database management system through GIS can help solve the problem as the data developed by the system can help ease the work of monitoring and analysing the growth of the plants. Companies usually used the expensive proprietary software due to its accountability. However, the development of Open Source Software nowadays should not be taken for granted as its ability is at the same par with the proprietary software and it could provide the same good services just as the proprietary software does. The aim for this study is to develop GIS database using open source GIS software which is Quantum GIS (QGIS) by determining the information of oil palm; numbers of oil palm tree, area covered by the estate and the vegetation index for oil palm using WorldView-2 images. This study shows that the respondents are positive and open about the usage of open source software although they do have their concern regarding the friendliness and performances of the software.

1. Introduction

Palm oil plantation is important in Malaysia. It is one of the main sources in Malaysia. The history of oil palm trees starts in early 1870's, which an ornamental plant was introduced to Malaysia, then Malaya, by the British. In 1917, the first commercial planting took place in Tennamaran Estate in Selangor, developing the foundations for the palm oil plantations and the palm oil industry in Malaysia (MPOC, 2012). It was the beginning for this industry to be well developed. The palm oil plantations in Malaysia are largely based on the estate management system and smallholder scheme. This could root out poverty for landless farmers and smallholders.

Since then, the developing of foundations for the palm oil plantations and the palm oil industry in Malaysia kept on rising. Despite threats of the Emergency during the 1960s, the oil palm expansion in Malaysia was rapid as its economic potential was recognised by the Malaysian Government as a complementary crop to rubber in the poverty eradication programme. Despite Indonesia having overtaken Malaysia as a leading producer of palm oil since 2007 due to its vast land bank expansion and labour opportunities, the industry is still thriving in Malaysia. Malaysia is still a leading exporter of palm oil to major consumers in China, EU and India. In fact, Sime Darby and FELDA, both Malaysian-based companies are today the world's largest plantation companies (based on planted area).

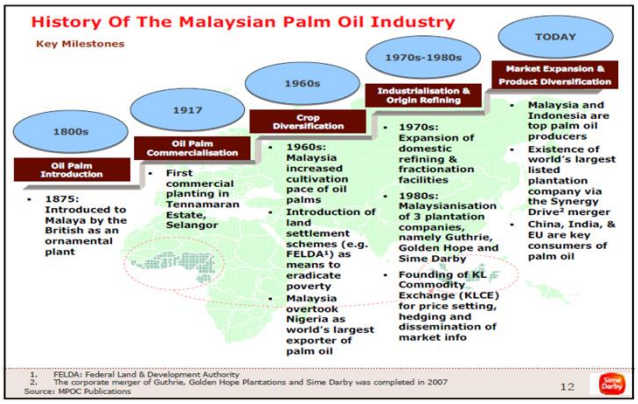

Figure 1: Flow of Malaysian palm oil industry

The statistics shows that 4.49 million hectares' land in Malaysia under cultivation of palm oil trees; producing 17.73 million tonne of palm oil and 2.13 oil palm kernel tons of oil and Malaysia is one of the largest producer and palm oil exporter in the world, considered successful producing 11% world oil and fat production and 27% oil export trade & fat (MPOC, 2012). This industry has increased the economy in Malaysia altogether become source of work for local community. The characteristics of oil palm tree contains both male and female flower in the

eISSN Number: 2462-2389

same tree. Each oil palm tree will produce compact bunches between 10 and 25 kilograms with 1,000 to 3,000 fruitlets per bunch. The physical shape of the fruitlet is mostly spherical or elongated. The fruitlet could easily be determined as dark purple which almost black in color and will turn to orange red when ripe (Breure, 2010). MPOC (2012) states that every fruitlet consists of a hard kernel (seed) enclosed in a shell (endocarp) which surrounded by fleshy mesocarp. The physical appearances of the oil palm tree have a lot of information that can be used to understand the trees itself.

According to Gerritsma et al. (1999), palm oil plantations are among the major production in Malaysia and followed by Indonesia. Together these two countries account for 84% of total world production and 88% of global exports. Typically, palm oil plantations include production areas requiring supporting infrastructure such as buildings, roads and services. The extracted palm oil is used in many food and household products as well as biodiesel production. Increases in global demand for food and fuel are driving forest clearance in the tropics, a significant portion of which is due to the rapid expansion of oil palm mono-cropping. The management of palm oil plantation is vital in order to keep and monitoring the plantation to be in a good condition. Thus, it is vital to have a strategic and consistent management which allow accessing all the information regarding palm oil plantation.

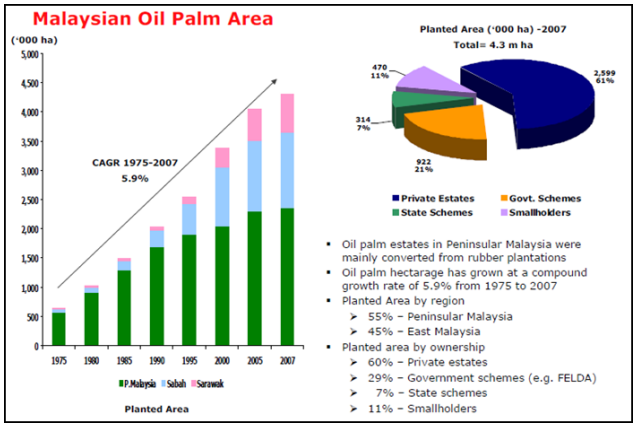

Figure 2: Malaysian oil palm area

It is essential to monitor the palm oil plantation and maintain all important information that relates with oil palm (Tan et al., 2013). The plantation of oil palm need to have a proper surveillance with a strict monitoring often. The surveillance of palm oil plantation would take a lot of time by having a manual monitoring. Thus, it is important to store all the information regarding oil palm tree in a proper database management for ensuring a high yield output and secure from disease. MPOC (2012) states that oil palm has an economic life of about 25 years and the harvesting of the palm could only begin 30 months after field planting. Oil palm trees in Malaysia should be monitored and managed in a more effective and efficient with low-cost maintenance to get the optimum yield rate. Vegetation index is vital in ensuring the health of palm oil plantation. There are agencies that are responsible in taking care of palm oil plantation such as the Malaysian Palm Oil Board (MPOB) and Sime Darby Plantation. Sime Darby Plantation is one of the private sectors that works on plantation business and owns a large area of palm oil plantation. By having a good management of palm oil plantation, it can help the betterment in the production of palm oil plantation itself. This can be done by using remote sensing techniques and GIS to help in managing a plantation.

Palm oil plantation usually covers large areas and need a good management to take care of the plantation (MPOC, 2012). With the availability of the latest technology such as digital techniques of data capture, data storage and processing, along with the application of GIS, it will be more flexible and convenient to produce such maps. GIS can help in developing a GIS database that is able to store all the data and information and monitoring the plantation simultaneously. The development of a GIS for several palm oil estates is with the aim of improving plantation and production management. For this project, GIS is needed in creating and developing a GIS database to store all the information of the data involves.

The process of developing the GIS database can be done by using Open Source Software (OSS) (Rasid et al., 2014). OSS is now a significant option in arranging the output by involving software program and processes accumulated with reputation. OSS is suggested in developing the GIS database is because of the reduction in price tag and not just licensing income however it is also for the particular progressively readily available skills regarding OSS techies in the employees. As mentioned by Rasid et.al (2014), OSS is basically similar to other database programs, it analyses and store data with unique characteristics of location based function where the information has a link with a unique point on the earth's surface.

One key feature to distinguish open source software from other types (such as proprietary software and shareware) is their "free software licenses", which explicitly define the legal rights to users with freedoms to run, study, change, redistribute, and access the source codes of the licensed software. OSS is free software that is available and accessible in the market. In Malaysia, a report by the OSCC mentioned that the overall cost of savings for open source software products was recorded to about RM 46.9 million in 2011. However, most of companies have been used ESRI ArcGIS and GeoEnviro as their main software to manage spatial database (Rasid et al., 2014). The examples of OSS software are Quantum GIS (QGIS), GRASS, Diva GIS, and MapWindow. The capability of OSS in providing varieties of modules is also in line with proprietary or commercial software. Although open source is capable in providing various advantages to

eISSN Number: 2462-2389

both consumers and businesses, many of the consumers have kept their distance from it. Reasons for that include fear of security vulnerabilities, the thought that open source software comes with no dependable technical support, concern relate to the reliability issues, and other concerns that had not been examined thoroughly before taking the decision of not implementing open source software.

Issues related with oil palm management usually come in term of difficulties in managing and monitoring their properties. A commercial palm oil plantation could cover many hectare areas of oil palm tree. There would be a variation of oil palm planting regarding years. It would be a problem to keep the information and data about the oil palm separately as it would lead to difficulties in monitoring the estate. It would be a near impossible task to monitor the oil palm manually. Monitoring single oil palm trees would take a lot of time and without having a proper management of oil palm, it would affect the palm oil plantation development.

There would also be problems in querying for the oil palm data as there are many variables of data that is used in palm oil plantation. All aspects involved in palm oil plantation should be related to one another. Although proprietary software is good, it is high in cost and would need license to support the maintenance of the software since it is only used for the staff. Hence, the usage of Open Source Software (OSS) is more profitable as it is free and it allows for different kind of data formats to be used. OSS is now at the same par with proprietary software. Thus, this research is to propose the used of OSS in the organization by developing the database.

2. Materials and Methods

2.1. Study Area

The oil palm areas that would be focused on are Bukit Kerayong Estate and Bukit Rajah Estate that are located in Selangor. This study focused on these estates as they were established and cover a lot of hectares lot that owned by Sime Darby Properties. In addition, Sime Darby have also purchased remote sensing imagery of WorldView-2 covering Bukit Kerayong and Bukit Rajah estates for research and development (R&D) purposes. The coordinates for Bukit Kerayong Estate is 3 10’ 6.6” N, 101 23’ 3.5” E with a total area of 2311.964ha. While the coordinate for Bukit Rajah Estate are 3 7’ 26’’N, 101 24’ 3’’E and the total area is 1134.22ha. The total area of both estates is huge which will cause some difficulties if it is to be handled manually. These estates are full with the palm oil plantation that is managed by Sime Darby properties.

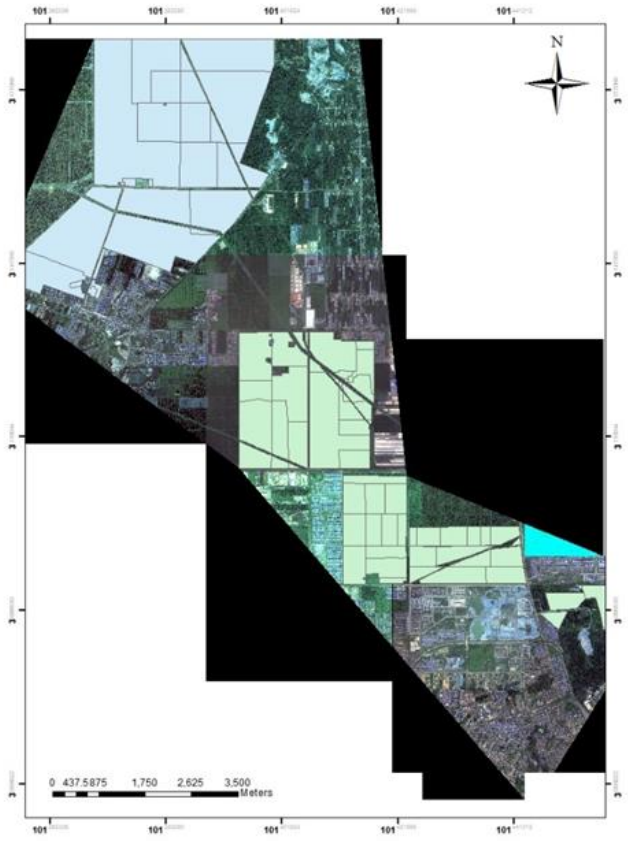

Figure 3: Research area of Bukit Kerayong Estate and Bukit Rajah Estate

2.2. Dataset

Remote sensing is one of the most reliable measurement tools for accurate monitoring over large areas by using appropriate vegetation indices that able to enhance the contribution of vegetation properties and allow reliable spatial inter-comparisons of canopy structural variations (Rakwatin et al., 2014). The remote sensing imagery used in this project is WorldView-2 imagery. There are 4 bands used which are red, green, blue (RGB) and near infrared (NIR). This remote sensing imagery is very high in resolution and the most spectral diversity commercially available. It is available with high resolution and 8 – bands multispectral. It has spatial resolution of 0.46cm and 0.52cm out to 20° off nadir.

eISSN Number: 2462-2389

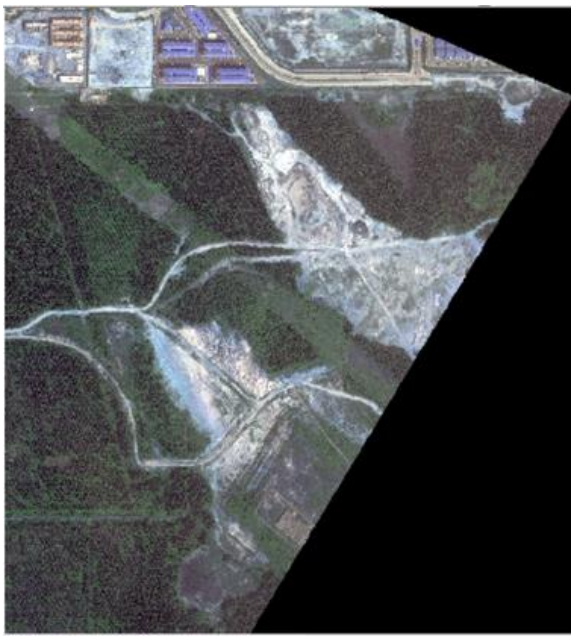

Figure 4: Example of WorldView – 2 images

2.3. Normal Difference Vegetation Index (NDVI) for Oil Palm

NDVI is an indicator that used to describes the greenness of vegetation. Although there are several vegetation indices, but NDVI is widely been used. Raun et al. (2001) reported estimates of in-season yield using NDVI that was well correlated in wheat. Likewise, Inman et al. (2007) found that NDVI has potential to estimate grain yield in corn. Previous studies have also shown that crop yields can be successfully estimated using NDVI (Hayes & Decker, 1996; Rasmussen, 1998) and the relationship between yield and spectral reflectance could be integrated into process-based crop models for better predictive power (Moulin et al., 1998). According to de Wit and Boorgaad (2001), NDVI is the most widely used and well understood vegetation index. This may be driven by the fact that NDVI computation is simple, and possesses the best dynamic range and sensitivity to changes in vegetation cover (Gielen & de Wit, 2001).

2.4. Statistical Analysis

GIS technology is a system computer that have the ability to handle the geographical data that categorized into several types of data such as data input and data output. The information that relate with the management have 70% - 80% that relate with the spatial data. GIS is one of the suitable ways and can produce a good system that can fulfil the needs of the oil palm management. Plantation and production can be more efficiently managed and well monitoring. GIS differs from traditional methods to provide alternative tools which can monitor and analyse data. By having a GIS, plantation and production can be more efficiently and effectively managed to increase profitability.

Information that been handled by using information system will involve a combination of operation that include planning, observation, collecting, storing, management and importantly analyses data that will be used in the decision making. GIS can be used in decision making. A good design of database is needed in storing all the information that can lead to a better management of data. Database design would include conceptual design, logical design and physical design that these design would be the base in developed the database itself. Database can be described as a repository for data in every types of management.

2.5. Database using Quantum GIS

Quantum GIS (QGIS) is a user friendly open source Geographic Information System (GIS) that is licensed under GNU General Public License. QGIS is under Open Source Geospatial Foundation (OSGeo). It can support numerous vector, raster, and database formats and functionalities. QGIS can be used in creating a database that will integrates with other open source GIS packages such as PostGIS and GRASS. There are also plugins able for QGIS in order to extend its capabilities. Usually in creating database, QGIS will integrate with the interface of PostgreSQL/PostGIS and MySQL databases. All the manuals and procedures are available in their website. According to Rosca et al. (2001), QGIS contains all the tools needed for collecting and process the data, for creating complex spatial databases and for designing and publish professional looking maps. It can work really well with PostGIS + PostgreSQL in term of data storage.

2.6. Survey of Needs Assessment

Survey of needs assessment was conducted through questionnaire that distributed to Sime Darby Plantation and Tabung Haji Plantation. A total number of 25 respondents are selected in the GIS department for each company. Two companies were chosen to see the level of awareness of open source GIS software among them. Questions are divided into several sections to get an analysis of the data. Section A is demographic questions of respondent's background such as gender, range of ages and the position of the respondents in their company. While for Section B is on the current database management used by the company and the software used to support the database management system. In this section, the question is specifically about knowing their own database system that been used and the satisfaction of using the software. It also to see which company used open source GIS software in developing their database. Part C was basically about explored the knowledge of the respondent in open source GIS software. This section used to see the level of awareness and acceptance of the respondents toward open source GIS software.

eISSN Number: 2462-2389

2.7. Data Collection

For data collection, the main data that was used is from remote sensing imagery that was gained from the usage of WorldView – 2 data that covers the study area. The data that has been given had provided 4 spectral band of red, green, blue (RGB) and near-infrared (NIR). The extraction of information based on the remote sensing imagery was done in order to store all the information required for the database. The information needed for the database are number of oil palm, the total area of the palm oil plantations and the vegetation index of oil palm by using NDVI method. The process of NDVI was done using Quantum GIS. Tool of Raster Calculator in Quantum GIS was used to calculate NDVI and the result produced has also been stored. The NDVI ratio was calculated by dividing the differences in the near-infrared (NIR) and red colour bands by the sum of the NIR and red colour bands for each pixel in the image as Equation 1.

$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{RED})}{(\mathrm{NIR} + \mathrm{RED})} \quad (1)$$

2.8. Development of GIS Database

The results acquired from the data collection were stored in the GIS database that had been designed. The development of GIS database is the most crucial part of the research. The GIS database design involved in developing the GIS database. All the user requirements had been finalized and used in designing the GIS database. The stages involved in designing a GIS database are creating the conceptual model, logical model and physical model. Conceptual model is a model the spatial and non-spatial used needed. While logical design is a logical scheme that functions in helping to describe the structure of database and lastly, physical design is a more important process as it designs the data model according to the logical design. These models are important in making sure the database that had been created is correct and can be used. All this processes were finalized by developing the data using GIS software, Quantum GIS. Quantum GIS was used to propose the usage and credibility of open source software in developing and managing the database.

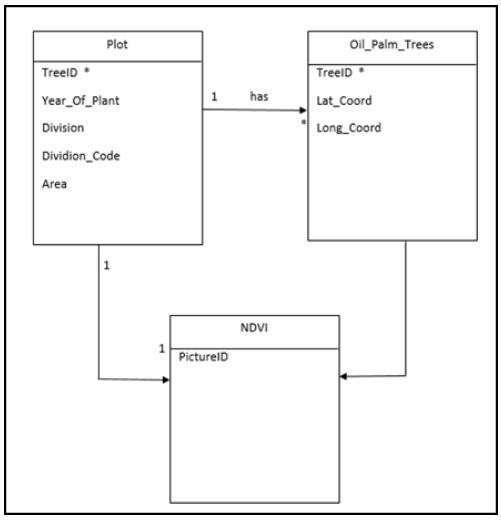

Figure 5: Conceptual model for database design

3. Results and Discussion

3.1. Results of Survey of Needs Assessment

A total of 25 volunteers from Sime Darby Plantation and Tabung Haji Plantation became the respondents for this study. The questionnaires were distributed to GIS department for each organization. There were varieties of experienced worker from different department and position in dealing with GIS participated in this survey.

3.1.1. Awareness of Open Source Concepts Based on Survey Questionnaires

Study regarding the level of awareness of open source GIS platform among the organizations was made. The results from given questions pointed out whether the volunteers know about any open source GIS software and the level of acceptance in using it in their work or research in future time.

Based on the results, 17 volunteers have experiences in handling GIS in open source platform and all of them are willing to use it in their work. The other eight volunteers have not encountered with open source GIS yet but all of them are willing to try. The result shows that most of the respondents are aware of open source GIS software and their acceptance level towards the usage of open source GIS software is high. The occurrence among the volunteers that have experiences in dealing with open source GIS software might be due to regular training and campaign provided by the Open Source Competency Center (OSCC) agency under MAMPU which had been applied within the organizations.

eISSN Number: 2462-2389

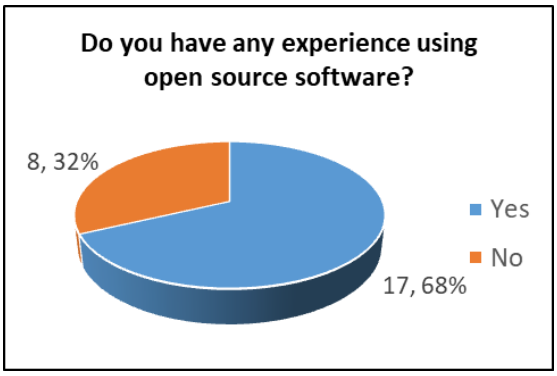

Figure 6: Experience in using open source GIS software

3.1.2. Comparative Analysis between Open Sources GIS and commercial GIS

Five questions were asked to the volunteers about the implementation of open source GIS in their organization particularly. These questions were mainly asked to get an overlook about the respondents' perspectives about open source GIS software in term of security issues, user-friendly, high functionality, performances and fulfil requirements.

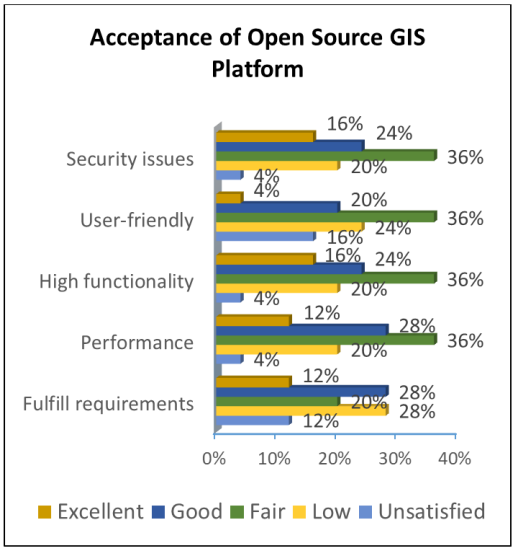

Figure 7: Acceptance of open source GIS platform

Based on the results shown in Figure 6, there is a wide range of understanding of Open Source GIS amongst the users in Malaysia. Mostly, all the users are well aware that there is no licensing limitation in the usage of open source software. The usage of open source software is lower in cost compared to the usage of commercial GIS, which required the user to have subscription and licensing fees.

For the time being, respondents' main concerns are due to the problems caused from the installation with other extensions of the software that has not been bundled together as compared with most mainstream GIS. This is supported with the results on open source GIS as not being user friendly especially for beginners, and the respondents agree that most open source GIS may require user to have additional technical knowledge especially in computer language and programming. These results can be viewed in such that users are open to accept the usage of open source software although they do have their concerns regarding the usage. In addition, these findings are expected and will be used as guidance for future development of advanced palm oil tree plantation database.

3.2. Oil Palm Data from WorldView-2 Images

The main dataset used for this research is images from WorldView-2 imagery that cover the whole study area. The data that been extracted from the dataset were number of oil palm trees that been extract by using method Wavelet transform that specifically used Haar wavelet. The geographical location of the trees been processed to have the latitude and longitude of the trees to display it in Quantum GIS. The result can be seen in Figure 8 below. The point of trees represents each trees that been identified in the images. Basically, there were a lot number of trees that cover for small area.

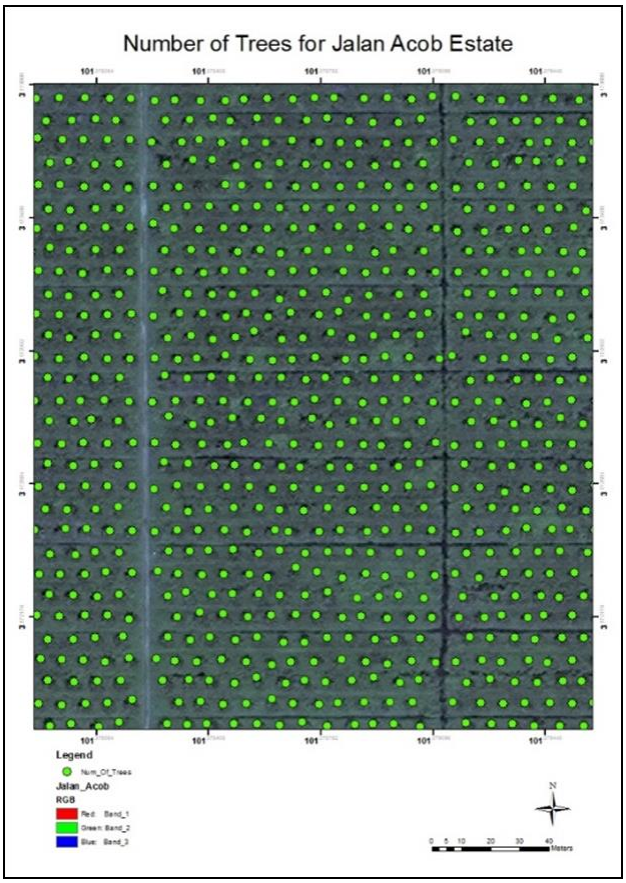

Figure 8: Trees located on the WorldView-2 image

Another data that been extracted from the World-View 2 images is the NDVI for the whole study area. Figure 9 shows the example of NDVI processed for the area of Jalan Acob estate that is under Felda Bukit Kerayong. The processed been done by using Quantum GIS (QGIS) which support the remote sensing processing. The range of NDVI value for Figure 9 start with 0.08 – 0.90. This information regarding NDVI values could be

eISSN Number: 2462-2389

used in determining the fertilizer application that contributes to the yield of oil palm plantations.

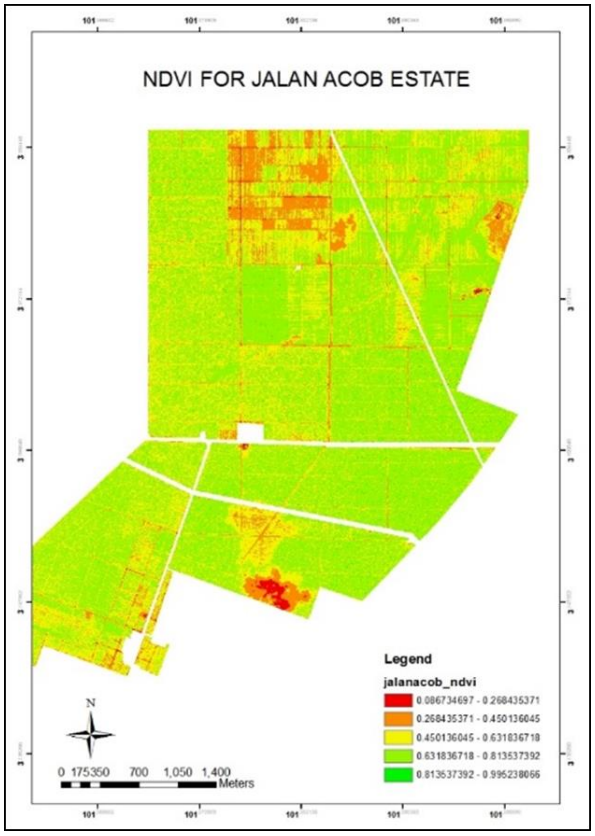

Figure 9: NDVI for Jalan Acob Estate on the WorldView-2 image

4. Conclusion

In conclusion, this study initially sees the usage of Open Source Software as something that is as good as the proprietary software. However, based on the results shown, there are reasons behind the lack of usage of Open Source Software in the respondents' companies.

This study is aware that the usage of Open Source Software is applicable in monitoring and analysing the oil palm data and most of the respondents are well aware of the benefits in using it. The usage of Open Source Software is becoming more prevalent among the workers in Oil Palm Industry.

This study also shown that as much as the respondents are positive and open about the future usage of Open Source Software, there are still concerns regarding the performance of the software, the user friendly, the issues caused by the usage, its functionality and the fulfil requirements of the software.

This study is expected to give attention to the usage of Open Source Software in managing the oil palm industry data. It is hoped to open the eyes and heart of those who are in the industry to consider the usage of Open Source Software in managing their data. It will help lower the budget, as it is cheaper in comparison to the proprietary software.

Other than that, this study is expected to bring forward the reasons behind the companies' lack of usage of open source software so that the developers could help in enhancing the software in terms of its usage and performances.

Acknowledgement

The authors would like to thank Sime Darby for providing the WorldView-2 imagery data which operated by DigitalGlobe. Authors would also like to express appreciation to Sime Darby Plantation and Tabung Haji Plantation for providing useful information and data throughout the survey. Authors also acknowledge the Ministry of Higher Education Malaysia and Universiti Teknologi Malaysia (through research grant Q.J130000.2527.11H22) for providing financial support in completing this study.

References

Breure, C.J., (2010). Rate of expansion: a criterion for identifying oil palm (Elaeisguineensis Jacq.) types suitable for planting at high densities. NJAS-Wageningen J. Life Sci. 57, 141–147.

de Wit AJW & Boogaard HL., (2001). Monitoring of crop development and crop model optimization using NOAA-AVHRR: Towards an integrated satellite and model-based crop monitoring system in the European context. Beleidscommissies Remote Sensing (BCRS), Delft (Netherlands).

Gerritsma et al., (1999). An analysis of the growth of the leaf area of oil palms in Indonesia. Exp. Agric. 35, 293–308.

Gielen H, de Wit A., (2001). Crop yield forecasting simulation study. Harare, Zimbabwe. Final report. Beleidscommissie Remote Sensing, Delft (The Netherlands).

Hayes M J, Decker WL, (1996). Using NOAA AVHRR data to estimate maize production in the United States corn belt. International Journal of Remote Sensing; 17: 3189-3200.

Inman et al., (2007). Active remote sensing and grain yield in irrigated maize. Precision Agriculture 2007; 8: 241-252.)

Moulin et al., (1998). Combining agricultural crop models and satellite observations: From field to regional scales. International Journal of Remote Sensing; 19: 1021-1036.

MPOC (2012), "The Oil Palm Tree", Malaysian Palm Oil Council, www.mpoc.org.my (Access date on 17th October 2015).

Rakwatin, P., Prakobya, A., Sritarapipat, T., Khobkhun, B., Pannangpetch, K., Sobue, S. & Tomiyama, N. (2014). Rice crop monitoring in Thailand using field server and satellite remote sensing. Crop monitoring for improved food security.

Rasid, M. Z. A., Kamis, N., & Halim, M. K. A. (2014). Comparative Analysis Study of Open Source GIS in Malaysia. In IOP Conference Series: Earth and Environmental Science (Vol. 20, No. 1, p. 012042). IOP Publishing.

Rasmussen MS. Developing simple, operational, consistent NDVI-vegetation models by applying environmental and climatic information: Part I. Assessment of net primary production. International Journal of Remote Sensing 1998; 19: 97-117.

Raun et al., (2001). In-season prediction of potential grain yield in winter wheat using canopy reflectance. Agronomy Journal; 93: 131-138.

Rosca B. et al (2013). Soil Survey and Mapping Using QGIS in the Specific Methodological Context of Romania, Department of Geography, Faculty of Geography and Geology Al.I. Cuza University of Iasi.

Tan et al., (2013). Use of UK-DMC 2 and ALOS PALSAR for studying the age of oil palm trees in southern peninsular Malaysia. Int. J. Remote Sens. 34, 2013, 7424–7446.

eISSN Number: 2462-2389