Geospatial application for the identification and monitoring of rubber smallholders in the Malaysian state of Negeri Sembilan

Mohd Hafiz Mohd Hazir\textsuperscript{1} and Tuan Mohamad Tuan Muda\textsuperscript{2}
\textsuperscript{1,2}Extension and Development Division, Malaysian Rubber Board, 14\textsuperscript{th} Floor, Bangunan Getah Asli (Tower), Jalan Ampang, 50450, Kuala Lumpur, Malaysia

E-mail: mohdhafiz@lgm.gov.my

Abstract. The Malaysian rubber industry, especially in the upstream sector, is much dependent on smallholders to produce latex or cup lumps. Identification and monitoring of rubber smallholders are essential tasks when it comes to the Malaysian rubber industry’s sustainability. The authorised agencies who support the rubber smallholders can do better planning, arranging, and managing. This paper introduces a method of calculating the total number of smallholders as well as identifying the location of their planted rubber area. The scope of this study only focused on land owners as rubber smallholders in the selected study area of Negeri Sembilan. The land use map provided by the Department of Agriculture Malaysia gave information on distribution of rubber area in Malaysia, while the cadastral map from the Department of Survey and Mapping Malaysia was specifically used for identifying land owners of each rubber parcel or rubber lot. Both data were analyzed and processed with ArcGIS software to extract the information, and the results were then compared to the Malaysian Rubber Board smallholders database.

1. Introduction
Malaysia is a well-known producer of raw material commodities. Today, the largest commodity sector in Malaysia is oil palm, followed by rubber. Malaysia’s rubber industry was established in 1876, when the British introduced the rubber tree in Malaya [1]. A great deal of research has been conducted by various institutions and organizations to ensure the sustainability of the rubber industry — this involved upstream and downstream study [2]. The Rubber Research Institute of Malaysia (RRIM) is already known as the leading rubber research institution in Malaysia. In 1998, the organization was rebranded by combining with other rubber agencies, and it was eventually recognized as the Malaysian Rubber Board (MRB). The board became a pioneer — and custodian organization — in the Malaysian rubber industry activities operated under the Ministry of Plantation Industry and Commodity (MPIC).

The rubber industry in Malaysia, especially the upstream sector, is highly dependent on smallholders [3]. Rubber smallholders covered about 93% of total cup lumps and latex production in 2014. As reported by MRB in 2015, the total Malaysian rubber area in 2014 was 1,065,630 hectares; smallholders owned 985,510 hectares (Figure 1). Rubber smallholders can be divided into two categories: rubber land owners and rubber tapper workers [4]. However, throughout this paper, the term “rubber smallholders” will specifically refer to rubber land owners. The term smallholder refers
to the owner of land less than 40 hectares; on average, each rubber smallholder owns about 2 to 4 hectares of rubber area [5]. The monitoring of rubber area is crucial for estimations of national rubber productivity. Rubber area in Malaysia has been decreasing recently because rubber landowners and plantation companies have been moving to other types of commodities. The real estate industry and the development of rural areas have also affected the total land area planted with rubber [6].

![Total Rubber Area in Malaysia](image)

**Figure 1.** Total rubber area in Malaysia.

Therefore, methods are needed to determine the total number of smallholders, calculate smallholders’ rubber areas, and identify the location of smallholders’ rubber areas. The MRB has already taken proactive action by collecting smallholders’ information through the Permit Autoriti Transaksi Getah (PAT-G) database. The purpose of PAT-G is to ensure that all transactions to buy and sell cup-lumps and latex are conducted legally. Smallholders also need to have a PAT-G card to make use of the Insentif Pengeluaran Getah (IPG) program. This program was initiated by the Malaysian government to help rubber smallholders during times when the cup-lump and latex prices are low by giving them an interest in the rubber commodity.

MRB also published the nationwide Independent Rubber Smallholder’s Survey in 2012. The objective of this survey was to determine how well technology created by MRB has been disseminated to the rubber smallholders. The survey was done for the whole country. The survey also allowed MRB to collect invaluable information on smallholders, and that information was developed into a very useful database for MRB. The information was quite detailed, but addressed only the independent rubber smallholders. The definition of ‘independent rubber smallholder’ is any smallholder who plants rubber without being attached to any scheme or agency. Independent rubber smallholders have their own land, and are self-managed.

The objective of this study is to introduce a practical method for indicating, calculating, and identifying rubber smallholder’s numbers and locations using a Geospatial application. The scope of this study is limited to the rubber land owners who have been granted full land title from the
Malaysian Land Department and who are recorded by Malaysian Mapping and Survey Department (JUPEM). The results can then be compared with the rubber smallholders database that has already been established by MRB.

2. Materials and methods
The materials used in this study were provided by other government agencies, under the belief that sharing information should be practiced among agencies in order to promote the optimization of government resources. The study area was chosen based on the availability of the data, resources, and manpower. The proposed method used in this study was the most practical and effective method for obtaining the rubber smallholders’ information. Figure 2 shows the overall method used in this study. All the pre-processing and analysis of the data in this study was carried out using ArcGIS software version 10.3, developed by ESRI.

2.1. Study area
The selected study area was the Malaysian state of Negeri Sembilan, located on the western coast of the peninsula (Figure 3). Negeri Sembilan has quite a number of rubber smallholders within its seven districts consisting of Seremban, Jelebu, Kuala Pilah, Jempol, Tampin, Rembau and Port Dickson. Jempol is the largest district, followed by Jelebu and the capital, Seremban. Negeri Sembilan’s economy was once dominated by agriculture, but manufacturing has quickly become a major contributor to the state’s income today [7].

The total area of Negeri Sembilan is about 669,506 hectares with the total rubber-producing area being about 20% of that. In the year 2010, the Department of Agriculture (DOA) reported approximately 158,836 hectares were planted with rubber trees. The Malaysian Rubber Board (MRB) and the Department of Statistics (DOS) also reported that in the year 2013, the total area used for rubber cultivation in Negeri Sembilan was 108,522 hectares. Based on MRB Independent
Smallholders Surveys in the year 2012, the total number of rubber smallholders in Negeri Sembilan was 21,593 smallholders. The Rubber Industry Smallholders Development Authority (RISDA) established the statistic of the total number of Negeri Sembilan rubber smallholders to be 25,548 smallholders. This study was piloted partly by the Malaysian Rubber Board Scientific and Economic Advisory Council (SEAC) project where the objective is to identify rubber-producing areas using satellite imagery. The coordinates of the Negeri Sembilan axis are 3°17.100' N, 101° 56.022' E and 2°24.948' N, 102°35.772' E.

![Figure 3. Negeri Sembilan, Malaysia.](image)

2.2. Data acquisition
Two important sources of data were used in this study. The first source of data was the Land Use Map produced by the Department of Agriculture Malaysia (DOA), which shared the map through the Government to Government (G2G) system. The Land Use Map was in shapefile format and a projected coordinate system of RSO Peninsular Malaysia (GDM2000). It contained all the information on land use, such as commodity plantation, fruit plantation, vegetable farm, road, highway, and mining area (Figure 4). The second source of data was the digital cadastral map created by the Department of Survey and Mapping Malaysia and known as the National Digital Cadastral Database (NDCDB) (Figure 5). The map shows the final parcels of land based on titles, and the layout, boundary and stone of surveyed lots in Cassini Geocentric projection. It can also be applied for in shapefile format. The NDCDB data were successfully acquired from Malaysian Centre Geospatial Data Infrastructure (MaCGDI), a Geospatial government agency that promotes sharing information bases.
Figure 4. Negeri Sembilan land use map.

Figure 5. Negeri Sembilan National Digital Cadastral Database (NDCDB).
2.3. Data pre-processing
The Land Use Map and the National Digital Cadastral Database (NDCDB) were not in the same coordinate projection system. Therefore, a pre-processing task was performed to overlay the two maps on top of each other. The chosen projection was World Geodetic System 1984 (WGS84) and both data were converted to this projection. The rubber land use map was extracted from original Land Use Map as this study is only interested in the rubber area.

2.4. Data analysis
The analysis of the data was started by overlaying Rubber Land Use with NDCDB data. The next step was to apply the selection by location and choose the ‘intersect’ option. The idea was that any NDCDB data intersecting with rubber area for Rubber Land Use would be selected. After that, the selected data were exported into a new file and generated Rubber Area Based on Land Parcel. The next step was calculating the total number parcels containing rubber area, which can be divided into two categories: namely the rubber smallholder’s area and plantation area. The definition of rubber smallholders is less than 40 hectares of land planted with rubber. A land parcel area greater than 40 hectares will be acknowledged as plantation area. The result of this analysis was the total number of rubber smallholders based on total parcel cadastral lot covered with rubber area less than 40 hectares.

2.5. Data verification
The generated rubber smallholder’s data from the analysis was compared with PAT-G database. The comparison method used was the ‘join tool’ in ArcGIS software. Both data sets must have a Unique Parcel Identifier (UPI) to provide basic information. The results show how many rubber smallholders are already registered under PAT-G and how many have not yet registered. The same process was carried out in comparison with the MRB Independent Rubber Smallholders Survey 2012 database. The estimation of the total number of rubber smallholders was based on the calculation of NDCDB lots. The PAT-G database is more likely to include rubber smallholders with mature tree stages, which already have cup-lumps or latex to sell. This database provides the latest information that MRB has on rubber smallholders. Meanwhile, the MRB Independent Rubber Smallholders Survey 2012 database provides information on immature and mature rubber area.

3. Results and discussion
The results of this study highly depend on the accuracy of the Rubber Land Use data provided by the Department of Agriculture (DOA). The extracted rubber area information from the original Land Use Map is shown in Figure 6. This data is from the year 2010. Even though this data does not represent the latest rubber land use, the method used in this study can be applied to more current data when it becomes available. Figure 7 shows the overlay data between NDCDB cadastral data and the Rubber Land Use Map.

The important task was to extract only the lots and parcels that had rubber area. Figure 8 shows the results of this extraction. The total rubber land parcels measured 145,938 hectares. As this study was only interested in smallholders, only the parcels and lots smaller than 40 hectares were selected. The total land parcels or lots smaller than 40 hectares stood at 140,516, as shown in Figure 9. The study assumed that each parcel or lot represents one smallholder. This means the total number of rubber smallholders at Negeri Sembilan was around 140,516 smallholders.

The final step was verifying the result. A comparison was made with the MRB smallholders’ database. The first database was MRB Independent Smallholders Surveys 2012. The total number of Negeri Sembilan rubber smallholders from this database stood at 22,729. This database was focused on independent rubber smallholders and did not cover the entire information on rubber smallholders. This data was merged based on the Unique Parcel Identifier (UPI) information. The result shows that only 7,041 entries were merged (Figure 10). The figure may be lower because of several factors. Not all independent rubber smallholder databases were successfully converted into the UPI format as it depends on the availability of information during the surveying task.
A comparison was also made with the Negeri Sembilan Permit Autoriti Transaksi Getah (PAT-G) database, which is the latest available smallholder database. The total records of rubber smallholders owning a rubber land parcel or lot according to the PAT-G database stood at 14,688. The result shows that only 2,929 records could be merged with the analysis results of the rubber land parcel (Figure 10) as it depends on how well this database was converted into the UPI format. This format should essentially feature detailed information on the state code, district code, sub-district code, section code, and lot or parcel number. The PAT-G database mostly focuses on the rubber smallholder owners who have a mature rubber tree as they need to register to sell their cup-lump or latex.

The estimated total number of Negeri Sembilan rubber smallholders based on the analysis result was quite high compared to the available Malaysian Rubber Board (MRB) database. This is mainly because it totally depends on how well the rubber land use map was produced. The changes in the latest Negeri Sembilan’s land use for the year 2010 may also have an impact on the result as the MRB database was developed in the year 2012 and 2015. The MRB method of developing the database was used as a survey method for the Independent Rubber Smallholders Survey 2012 and for voluntarily registering for the PAT-G database. Even though it is compulsory to register with PAT-G and bear a PAT-G card, ultimately it depends on the rubber smallholder’s decision and acceptance.

The NDCDB cadastral database also changes from time to time. The number of parcels or lots can increase because of reasons such as registration of new parcel lots, approval of new full land title, and separated parcels. Availability of a high-accuracy and latest land use map was important for this kind of study. It is the main factor to obtain the accurate estimated total number of rubber smallholders. The rubber land use map can be produced by aerial mapping and ground data collection. The Department of Agriculture (DOA) created the land use map based on aerial imagery specifically based on satellite imagery analysis. The resolution of the imagery should be as high as possible to capture the rubber smallholder’s area. The MRB’s vision is to go into as much detail as possible for acquiring rubber smallholders’ information using the Geospatial application.

![Figure 6. Negeri Sembilan rubber land use map.](image)
Figure 7. Rubber land use overlaid with NDCDB data.

Figure 8. Analysis results of rubber area based on land parcel.
Figure 9. Analysis results of rubber area based on hectarage.

Figure 10. Verification of analysis results with MRB database.
4. Conclusions

The estimated total number of Negeri Sembilan rubber smallholders based on the analysis results was 140,516. This number assumes that each NDCDB lot was owned by one rubber smallholder. The accuracy of this study and its results were highly dependent on the accuracy of the Land Use Map provided by the Department of Agriculture (DOA) and availability of NDCDB final title land parcel from the Department of Survey and Mapping Malaysia (JUPEM). This study successfully presented a method to estimate the total number of rubber smallholders based on the available data.

Acknowledgement

This study was partly conducted under the Scientific and Economic Advisory Council project code of S14EST0522 and was supported fully by the Malaysian Rubber Board. The researchers would like to thank the Malaysian Centre Geospatial Data Infrastructure (MaCGDI), Department of Survey and Mapping Malaysia (JUPEM), Department of Agriculture (DOA), Federal Department of Town and Country Planning, and the Malaysian Remote Sensing Agency for sharing data and information. Our special thanks to the Extension and Development Division staff and others who contributed to this study.

References

[1] Drabble J H 2015 Rubber in Malaya 1876–1922: The genesis of the industry Oxford University Press, Kuala Lumpur and Singapore, 1973. Pp. xx, 256
[2] Azmi I M and Alavi R 2013 Patents and the practice of open science among government research institutes in Malaysia: The case of Malaysian Rubber Board World Patent Information, 35(3), pp.235-242.
[3] Theriault V 2014 New Directions for Smallholder Agriculture Journal of Economic Issues, 48(4).
[4] Fox J and Castella J C 2013 Expansion of rubber (Hevea brasiliensis) in Mainland Southeast Asia: what are the prospects for smallholders? The Journal of Peasant Studies, 40(1), pp.155-170.
[5] Stubbs R 1983 Malaysia's Rubber Smallholding Industry: Crisis and the Search for Stability Pacific Affairs, 56(1), pp.84-105.
[6] Tan-Soo J S Adnan N Ahmad I Pattanayak S K and Vincent J R 2016 Econometric evidence on forest ecosystem services: deforestation and flooding in Malaysia Environmental and Resource Economics, 63(1), pp.25-44.
[7] "Negeri Sembilan" Portal Rasmi Kerajaan Negeri Sembilan Negeri Sembilan State Government, 24 Feb. 2016. Web. 24 Feb. 2016.