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Applying GIS for Mapping Agricultural Roads Network in Felda Trolak Utara for Oil Palm Plantation Management

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Abstract - Malaysia oil palm industry is the leading commodities and one of the major contributors to the Malaysia economic after oil and gas sector. Malaysia and Indonesia palm oil plantations are the major commodity producer with Malaysia currently being the world's second-largest area of oil palm after Indonesia. Together these two countries account about 84% of total world production and 88% of global exports. With the increasing price and demands for the Crude Palm Oil (CPO) and with the 4.69 million hectares that were planted with oil palm trees, plantation industry and estate managers has to look into the most crucial factor that will decide the yield and quality of the CPO that is being sent to the mill. Typically, palm oil plantations include production areas requiring supporting infrastructure such as buildings, roads and services/management. When there is a better management of the roads in the estates, better Fresh fruit Bunch (FFB) and CPO quality will be sent to mill and processed. Road transport has a fundamental meaning for the sustainable agriculture. Poor quality and inadequate coverage of roads, lack of maintenance operations and outdated road maps continue to hinder economic development in the plantation. This work focuses on studying the present state of road infrastructure and its mapping in Felda Trolak Utara, Perak. The road infrastructure of the study area is studied by GPS and GIS based methodology. Data of road infrastructure characteristics were collected from GPS device and road infrastructure of the test sites then analyzed in GIS environment. The results of this study may be applied to road infrastructure mapping in oil palm plantation in general context, although with certain limits. In particular, the "noise" of road network occurred and need to rectify the topologies of the network.

Keywords – *Agricultural Roads, Oil Palm, Mapping, GIS, Management*

1. Introduction

In Asia, the main oil palm producing country is Malaysia; the Malaysian oil palm industry recorded an impressive performance in 2008 and 2009. The total oil palm planted areas in 2006 were 4.69 million ha. While, the total exports of oil palm products were 20.13 million tons in 2008 and 2009. This scenario triggered the export earnings of oil palm products rose to a record of RM 31.8 billion in 2009. The industry also saw exciting developments shaping up in the local bio-fuel industry with the Honorable Prime Minister of Malaysia launching the "Envo-Diesel" which are combination of palm olein blend with diesel (MPOB, 2002). Due to the importance of oil palm to the country, accurate and reliable information is needed for oil palm plantation management, not just on plant quality, but also on phenology, health and yield prediction. It also involved the maintenance of agriculture road network in certain plantation area. Agricultural road are an important factor in plantation management. Agricultural road network deals with all aspects of everyday works of a well manage estates. It includes FFB evacuation from trees to platform, from platform to loading FFB loading ramp and from loading ramp to mill. Agricultural road also is a crucial and critical factor in determining the quality of FFB that was being sent to mill. Appropriate combination of primary agricultural road, secondary and tertiary can determine the effectiveness of the FFB evacuation in a particular estate and contributing in the high yield and oil extraction rate (OER).

Development of economic and production of palm oil yield is multi-phases series of events which influenced greatly by infrastructure and transport services. Infrastructure can deliver major benefits in economic development and reduction of waste and environmental sustainability (World Bank, 1994). Improvement of the productivity and quality of oil palm in operation is one of the toughest challenges for the oil palm mangers. A basic road network in oil palm plantation is considered absolutely essential for this objective and is a major concern to the FELDA. The construction or improvement of the road network is rightly regarded as one of the most effective ways of promoting production rate and quality of yield. The principal objectives of the study are two folds; (i) to study the possibilities of a GPS and GIS based methodology in the road mapping of the oil palm plantation and (ii) to update the road infrastructure of the Felda Trolak Utara.

2. Need for a GIS

Nowadays, the transport field has been dominated by the perspective of the modernization theory which sees transport and technological innovation as important and beneficial to the process of economic development (Simon, 1996). In fact it also generally proved that infrastructure promotes economic development most effectively in the way where there is already a high level of economic activity. Geographic Information System (GIS) is a branch of geoinformatics, become indispensable in modern agriculture. GIS is a technique that is quite relevant in agricultural development. There are numerous definitions of GIS in the literature (Maguire *et al.,* 1990; Ayeni, 1998; Abumere, 1997). For instance the biophysical components of the soil and agricultural environment can readily be deduced from information collected in the field and, which will in turn serve as the basis for determining site suitability for specific agricultural purposes when analyzed in a GIS (Iyalla, 2004).

Geoinformatic technology provides an important tool for the management of plantations. Prior to the introduction of global positioning systems and geographic information systems, data obtained in the field were difficult to obtain and in many cases inaccurate. Typical examples include plantation boundaries varying from government permits, and applied production areas different from actual. This has been a result of the problems in measurement and mapping of difficult terrain and remote, inaccessible locations. Furthermore, plantation management has to consider the changing nature of an estate that extends from initial land clearing, the production stage and finally the re-planting or conversion phase. GIS differs from traditional methods to provide alternative tools which can monitor and analyze data. By using a GIS mapping, plantation and yield production can be more efficiently and effectively managed to increase profitability. FELDA's human resources management is also a factor that needs to be considering in applying this technology. This is because Felda now consist of 60% senior staff that aging above 50% and 40% ranging from 21 to 36. This condition creates a state of denial when the senior staff is reluctant and prompt to accept the new technology in the way of mapping agricultural road network and parameter by using the GPS and GIS.

3. Material and Methods

3.1 Study Area

The study was carried out at FTPSB Trolak Utara. Felda Technoplant Sdn Bhd (FTPSB) incorporated in 2005 as private limited company under the plantation group fully owned by FELDA. In this study, the specific site is a Felda Trolak Utara located at Sungkai, Perak, Malaysia. Felda Trolak Utara consists of 475 registered FELDA settlers and 2,300 ha area planted with oil palm. Felda Trolak Utara geographical coordinates is 3^0 57' 12" N to 101^0 27' 38" E, respectively. Figure 1 showing the location of the study area.2.

Felda Trolak Utara is chosen because the agriculture road networks deteriorated over time. There was indication that FFB production was affected. The main reason was from 2,300 ha area that being planted with oil palm, not all is being maintained effectively by FELDA. Maintenance of roads in Felda Trolak Utara is very challenging process. With an average rainfall between 2300 mm to 3000 mm of rainfall, it was almost impossible for an agricultural road networks can be used for more than a year. Currently, there is 117.67 km of agricultural road network is being maintained by FELDA and another 134.35 km of road which is not well maintained.

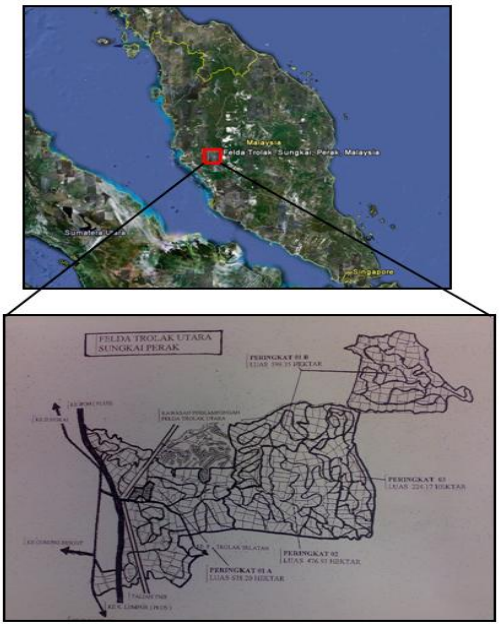


Fig. 1 Location of the Felda Trolak Utara in Perak, Malaysia

3.2 Methods

GIS hardware and software were used for field data collection. Three units o Garmin 60CSX obtained from the Faculty of Forestry, Universiti Putra Malaysia (UPM). Data collection is supported by five Felda Trolak Utara personnel. Collection of data involves acquiring geographical information of the study site such as Felda Trolak Utara topographical map, rainfall chart, costing involved in building agriculture road network, 2008 and 2009 yield data, and satellite image of Trolak Utara Phase 3.

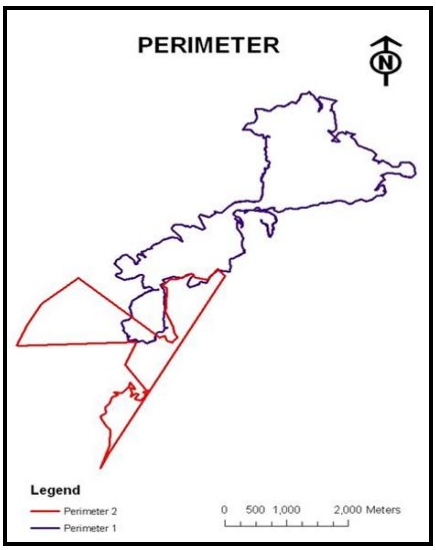
In mapping process the GPS receiver was switched on at a fairly level area at th boundary of estate. The receiver established a list of satellites (more than 4) that are currently above the local horizon. When the GPS device begins to acquire the satellite signals and when it has a good connection by displaying the signal strength from three satellites are being received, it may perform a first, rough calculation of the geographical position and give information about the longitude and latitude. It may also give the first estimation of the uncertainty.

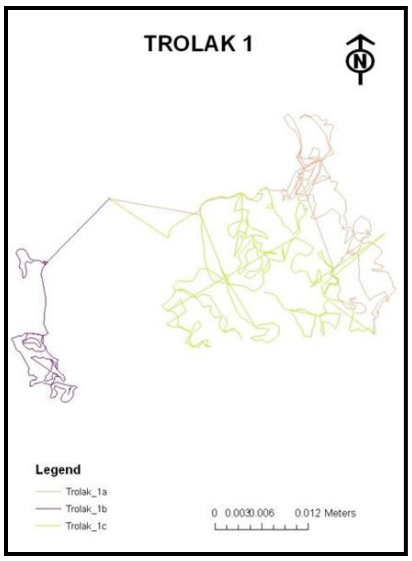
When the 1st position was established, staffs walked along with GPS receiver along the agricultural road network in the estates boundary. Agricultural road were mapped by using Tracks menu in GPS device. With a track, the GPS unit automatically recorded GPS coordinates along agricultural road direction of travel at a predefined distance. A route shows a path of waypoints that were collected. Perimeter of the estate is being plotted and saved. Return to the starting point, and stop the tracking feature through GPS unit's menu. Upload the GPS coordinates data to the computer. Data were stored, processed and displayed in ArcGIS 9 (ArcMap Version 9.2) referenced to the WGS84 datum with a Universal Transverse Mercator (UTM) projection, zone 47 North. Once drawing files were imported and converted into an ArcGIS geodatabase,

4. Results and Discussion

Figure 2, 3 and 4 showing the result of the mapping work. There are perimeters of the area, plantation roads in phase 1 and in phase 2. In general the initial mapping problem involved collecting data from the field to produce maps, which require intensive survey work by plantation staff. Due to difficulties in differentiating crop perimeter/area in field the task was done by the division assistant.

In this work satellite imagery might not be suitable for plantation boundaries, because tree coverage hindered boundary, divisional and block demarcations, especially when adjoining boundaries had similar crop type and/or encroachments. From the maps that have been created, and the time it took to complete the ground data collection, it seems that just phase 1 that being control by a junior plantation assistant manage to complete the ground data collection within time. Another three senior plantation staff unable to complete the task within time and the data is not accurate compared to the topographical map.





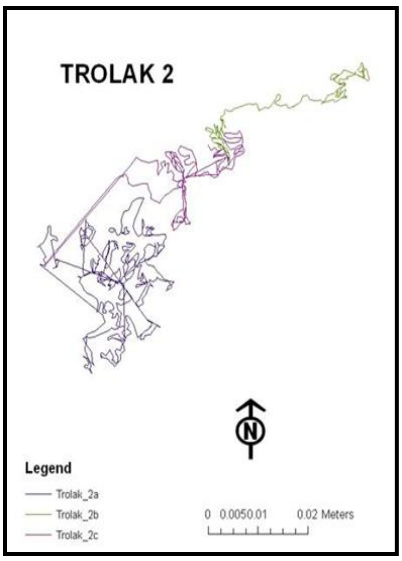


Fig. 2 Perimeter of the Felda Trolak Utar **Fig. 3 Plantation road in Phase 1** **Fig. 4 Plantation Road in Phase 2**

The benefit of using GIS in mapping agricultural roads is it is efficient for oil palm management and resource planning (Nordiana et al., 2008). Map from this study give reliable information to oil palm managers into meaningful information via GIS solution. Plantation companies have some awareness of using GPS, which give positional accuracy of +/-10m. Difficulties are encountered when transferring information from GPS units [usually in the form of waypoints] to map or GIS software. Plantation staffs typically do not have the software, hardware or enough knowledge to successfully complete this operation. This is one of the factors restricting the implementation of a GIS. Another factor is the general lack of knowledge concerning GIS and its potential benefits by management.

Concern should be focused to the human resources allocation for field/data collection and preparation of GIS database. Considerable time is required in verifying field data and design of the GIS database. However, once this phase is complete, mapping and graphical data display can easily be generated to suit the needs of management. The process of keeping data up to date should not be overlooked as results produced directly relate to the accuracy of the database. It is suggested that FELDA would spend some initiative on making staff and personnel aware on the important of using GPS and GIS in estates.

5. Conclusion

The initial GIS methodology for this work by the principles is suited for the diverse road infrastructure. Methods are practical, straightforward and cost-effective, appropriate, feasible and effectively utilized in the plantation operation. The focus is on the general road mapping. The data could be then completed by manual editing and used for updating the existing road data layer of the Felda Trolak Utara. These technologies were welcomed by plantation management, as GIS technology established a dependable basis on which to make decisions. Plantation companies involved in the case studies considered that the application of GIS would lead to greater efficiencies and therefore greater profitability. However, further education and industry exposure is necessary to bring greater awareness of this technology to the palm

oil plantation industry. In FELDA, there still a need to create awareness among the plantation staffs on how to use and to manipulate the GPS and GIS for operation work. The approach should expand and emphasis the provision of data for the management of in-field variability in soil fertility status and crop conditions. This is the goal of geo-informatics techniques. What is required now is the will, particularly on the part of the industry, financial and research institutes as well as tertiary institutions of learning to actualize the application of these techniques in agricultural development.

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