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REMOTE SENSING, GIS AND GPS AS A TOOL TO SUPPORT PRECISION FORESTRY PRACTICES IN MALAYSIA

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ABSTRACT

Managing complex tropical forest requires up to date technology in ensuring sustainable resources utilisation. Much of the current forest management practices can be improved through the use of current technologies including remote sensing, GIS (Geographic Information System) and GPS (Global Positioning System) which may enhance any decision making process. This paper highlighted the use of current technologies including remote sensing, GIS and GPS in achieving sustainable forest management (SFM) based on current forest scenario in Peninsular Malaysia. At the top management level, forest resources database is developed in a GIS compatible format. These comprise both spatial and attribute data and information. The spatial information is continuously updated with the help of remote sensing input, maximising the usage of available satellite data such as Landsat TM and SPOT imageries. At operational level spatial data analysis is employed in order to identify areas that need to be protected and excluded from forest harvesting activities. Additionally, resource inventory is carried out and tree location mapping is done using GPS. The information on forest stocking, species distribution and location will be used in planning appropriate forest harvesting operation in the area in accordance with the Malaysian Criteria and Indicators (MC&I) and Standards of Performance for Forest Management Certification. It is envisaged that through these technologies, precision forestry practices can be carried out to achieve ecologically and environmentally sound forest management objectives.

1.0 INTRODUCTION

The basis and concept that underlines the practices of sustainable forest management (SFM) in Malaysia is to set aside adequate natural forest lands as Permanent Reserved Forest (PRF) that are strategically located throughout the country to be managed in perpetuity. In 1999 the total forested areas in Malaysia is about 19.01 million ha (about 60%) of which about 14.33 million ha is the Permanent Reserved Forest (PRF). The PRF is classified into two basic management categories – production and protection forests. Of that total about 10.84 million ha is a production forest where as about 3.49 million ha is a protection forest. The production forests are commercially logged and managed for sustainable timber production where as there is no logging in the protection forest area and they are maintained very much in their natural state to protect the hilly areas and to conserve biological diversity. The management strategy for the production forest relies very much on the types of the forest but based on common goal, which is to ensure forest renewal and sustained yield.

Forest Management practices can be improved through the use of current technologies including remote sensing, Geographic Information System (GIS) and Global Positioning System (GPS). Precision forestry practices can be carried out with the help of these technologies, which is inline with the SFM concept. For instance in practising SFM and anticipating Forest Certification, forest manager require more intensive, precise, and documented information about the forest resources and landscape features and attributes which can be gathered through remote sensing and GIS techniques. Forest surveys including inventory assessments and compartment maps are essential for effectively achieving long-term sustainable forest management planning goals. This can be done precisely using GPS technique. All this has been part and parcel of precision forestry practices. This paper highlighted the use of current technologies including remote sensing, GIS and GPS in achieving sustainable forest management (SFM) based on current forest scenario in Peninsular Malaysia.

2.0 GIS IN FORESTRY

The use of spatial data for forest resources management and planning has been recognised worldwide. However, the spatial data will be less useful if they are not transformable into information, which can be analysed and interpreted in a systematic and quick ways. Hence there is a requirement to transfer and keep spatial data related to forestry in a standard computer format preferably in a GIS environment. A GIS is an integrated resource data base system that has the capability to store, edit and process digital data; and that supports development planning and policy analysis. The use of GIS in forestry is becoming very important in which immense accumulation of data is unavoidable. Realising that, the Forestry Department (FD) Peninsular Malaysia has set up a Mapping and GIS Section at the Headquarters in 1997 with an objective to develop an operational GIS for more effective planning, management, conservation and sustainable development of the forest resources (Alias, 2001). To date much forestry related spatial data and information had been captured in the GIS database. The department is currently in the process of integrating all the informations for the development of Management Information System. It is envisaged that the system will be used to manage forest areas more effectively in accordance with the sustainable forest management concept.

2.1 Alignment of logging road

Forest harvesting in inland forest is generally carried out by a combination of crawler tractor-winch lorry whereby the tractors skids the logs from the felling sites to the skid trails where the winch lorry continues the transportation to the roadside landings. To mitigate the adverse effects of forest harvesting, the FD have adopted "Standard Road Specifications" and Forest Harvesting Guidelines" to be strictly adhere by all logging contractors both at the planning and implementation levels. This is particularly important especially with regards to the design and construction of forest roads so as to maintain environmental stability and quality in line with the Malaysian Criteria and Indicators (MC&I) requirements. It is anticipated that with the availability of GIS database of the forest area, better planning on forest harvesting activities including road alignment can be made.

For instance, a study by Musa and Mohamed (2001) shows that GIS can be used for selecting suitable forest roads in the hill tropical forest. The study area was located in Ulu Muda Forest Reserve, in the state of Kedah, Malaysia (5° 52' - 5° 49.5' N and 100° 58' - 101° 0.5' E). Various spatial data coverage was used including administrative boundaries, river networks, and contour line. The analysis was performed based on best-path modelling method. The study indicates that road alignment can be determined using GIS technique which enable forest harvesting be carried out with minimum environmental disturbances.

2.2 Determination of Suitable logging areas

Malaysia has been practising forest management strategy that is environmentally responsible, socially beneficial and economically viable. As a standard for assessing forest management practices in the PRF in Malaysia, the MC&I has been formulated. Among others, the MC&I comprise of various Activities and Standards of Performance. In the case of Standard of Performance, various specific laws, policies, regulations, procedures, processes, plans, guidelines, and threshold values which are considered relevant for certification purposes in the Malaysian context are incorporated. The MC&I will be used by the National Timber Certification Council, Malaysia (NTCC Malaysia) as the standard for assessing forest management practices in the Permanent Reserved Forest.

Some of the standard of performance in the MC&I include preventing logging activities in an area with slope more than 40 degrees. Adequate buffer zone should also be reserved within permanent watercourses (rivers) for soil and water protection purposes. GIS can be used to assist forest manager in achieving some of the MC&I requirements. As an example, to identify those protection areas a case study using GIS technique was conducted in a forest concession area in the state of Perak. The study area located in Temenggor Forest Reserve covering approximately 10,000 hectares of primary hill forest. Spatial analysis was performed on the different layers of digitised topographic map (rivers, contour, etc.). The findings showed that about 31% of the total area fall within the river buffer zone and 2% was categorised as very steep areas (more than 40°). This gives a total of about 33% of the forest areas (3300 ha) which need to be reserved for protection purposes. Using GIS technique not only the extent of the area can be identified but the exact location of the effected area can also be mapped and delineated which may assist forest manager in making forest harvesting planning in line with the MC&I requirement.

3.0 REMOTE SENSING IN FORESTRY

Realising the important of remote sensing technology for the country's future development, Malaysia has seriously ventured into the space technology programme. On the 26th September 2000, Malaysia successfully launched the first national microsatellite known as TiungSat-1. The microsatellite is equipped with three narrow-angle (with an 80m resolution) and one wide-angle (1.2 km resolution) cameras which will monitor and take photographs of environment to warn the country of any unusual activities. TiungSat-1 has three applications, which will serve various purposes including for forestry applications. The first application, using three narrow angle cameras which forms the Multi Spectral Earth Imaging CCD camera, will provide detailed information on earth resources, haze monitoring, environmental pollution and land or maritime surveillance. The second application, using the wide-angle Meteorological Earth Imaging CCD camera, is in monitoring weather patterns, cloud, coastline and underwater mapping and providing hurricane warning. The third application is the Digital Store and Forward system which can be used for communication via the E-mail, voice-mail, scientific data exchange, fax, images and Internet access to a range of small ground user terminals.

While there is limitation on the use of TiungSat-1 data for detail forestry application due to it coarse spatial resolution, the availability of high-resolution satellites (such as IKONOS) have currently increased the use of remote sensing data for forestry application in this country. Among others, application of remote sensing in forestry include mapping of forest cover types (Khali, 1999), forest fire detection, forest monitoring, detecting deforestation and forest degradation, and forest cover area measurement (Hussin, 2000). For Malaysia, currently the Forestry Department has taken necessary steps to operationalise the use of remote sensing for forest resource management. In fact the Forestry Department Peninsular Malaysia during the third National Forest Inventory project used Landsat TM data to determine the areal extent and location of forest areas according to the forest types stratification. However, to make full use of the technology, studies focusing on different aspect of remote sensing techniques for forestry applications using different sensors system (optical or microwave) is continuously being conducted in order to develop the most appropriate technique in using remote sensing data for various forestry applications.

One approach where remote sensing data can be used effectively to map forest conditions is by using Forest Canopy Density model (FCD Mapper). FCD Mapper is a semi-expert system developed by the International Tropical Timber Organisation (ITTO). The model utilises forest canopy density as an essential parameter for characterisation of the forest conditions. Hence it is possible to monitor forest conditions over time using multi-temporal satellite images base on this model. Landsat TM data is the main input to the model and the analysis focuses on four indices namely the Advanced Vegetation Index (AVI), Bare Soil index (BI), Shadow Index or Scaled Shadow Index (SI, SSI) and Thermal Index (TI). These four indices have direct relationship with the forest conditions. The model produces forest canopy density map, which may indicates the intensity of rehabilitation treatment needed in the particular area. This is very useful in planning and implementation of any forest rehabilitation programmes (Rikimaru, 1999).

4.0 GPS IN FORESTRY

The Global Positioning System (GPS) is a highly accurate satellite based radio navigation system providing three-dimensional positioning, velocity, and time information. In order to achieve GPS co-ordinate readings, the GPS unit transmitter must detect a minimum of four satellites and the more satellites detected by the transmitter, the more accurate the readings tend to be. Better accuracy can also be achieved if differential GPS (DGPS) is used. The idea behind the DGPS is to correct bias errors at one location with measured bias errors at a known position. A reference receiver, or base station, computes corrections for each satellite signal. Some of the potential and useful GPS applications in forestry include tree location mapping, forest compartment boundary survey, forest road survey, ground truth activities (remote sensing) and resources inventory.

4.1 GPS for Tree mapping

Using GPS as a tool to map tree location is becoming very important. Tree mapping utilises both qualitative and quantitative data collection techniques in order to create a database containing the spatial location and attributable information of the trees. In Malaysia, to date there is no large-scale tree-mapping project being undertaken. However, there are various pilot projects dealing with tree mapping both in urban as well as in natural forest environment (Khali et al, 2001).

Forest Research Institute Malaysia (FRIM) had successfully developed and tested Urban Tree Information System that combined digital tree maps and urban tree data base for urban street tree management purposes (Adnan et al, 2001). Tree location information, (collected using DGPS) and other tree biophysical information including species, diameter at breast height (dbh), height and tree conditions were also recorded. These informations were combined in a GIS database and specific computer programming was done to develop urban tree information system. The system can be used in promoting effective urban tree management by large local authorities in Malaysia.

A preliminary study was carried out to test the suitability of GPS for mapping of trees in natural forest environment in Ulu Sat Forest Reserve, Kelantan. As a pilot study, only trees with dbh greater than 40 cm were recorded. A DGPS technique involving the use of two GPS; a stationary base station receiver left at known reference location and a "rover" receiver used in the field to map the tree location was used to locate the tree position. The tree location information was transferred into forest compartment map in a GIS database system. The study indicates that DGPS can be used to determine tree position in the natural forest environment.

In a study conducted at Semangkok Forest Reserve, a combination of DGPS, EDM (Electronic Distance Meter) and GIS has been used successfully to map trees having dbh 10 cm and above (Ahmad et al, 2001). A total of 6000 trees were mapped in the six hectares plot of the study area. The EDM was employed for a traverse surveying to compliance accuracy of 1:5000 map and the GIS was used to produce the final timber inventories and harvesting plan. The benefits of this approach include increase in timeliness factors and accuracy of the forest spatial data collected.

4.2 Tree mapping in forest operation

Forest harvesting in this country is generally based on the Selective Management System (SMS). As part of the system, pre-felling inventory is carried out and trees identified to be felled will be marked on the ground. It is also required to retain at least 32 sound commercial trees per hectare with diameter ranging from 32 – 45 cm for the second cut. However, those trees to be felled and retained are not mapped. Hence, it is anticipated that in the near future trees to be felled or retained need to be mapped and its location precisely determined in the forest-harvesting plan. The information can be used to plan forest-harvesting operation in the forest area. Subsequently, it can be used to monitor harvesting operation is carried out appropriately and the potential second rotation trees left with no damage and be able to survive for the next cut.

Having tree mapped using GPS prior to harvesting operation will also facilitate reduce impact logging activities. It will contribute in making careful planning and comprehensive harvesting plan because tree distribution and location are known. For instance, road and skid trails planning can be done efficiently (density and distance might be reduced). It is also anticipated that directional felling can be practised precisely to avoid potential crop trees and watercourses by directing the felling towards existing natural gaps, thus minimising damage to the residual trees.

It is no doubt that tree mapping in forestry using GPS will become a very important issue in the near future. It is a part and parcel of any forest information system intends to be developed. By incorporating tree information in the harvesting planning it has its unique role in ensuring precision forestry practices and in achieving sustainable forest management concept.

5.0 CONCLUSION

Current awareness on the importance of sustainable forest management has pave the way for the Forestry Department to make full use of the latest technologies including remote sensing, GIS and GPS. Necessary steps have been taken to make full use of the technologies so that precision forestry can be practised in line with the sustainable forest management concept. It is anticipated that with sufficient research support, the findings will provide the opportunity to revolutionise the use of these technologies as a tool for forest planning. It may enhance decisions making process as well as contribute to the successful implementation of the management strategies in line with the sustainable forest management concept.

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