Remote sensing and GIS application in best harvest management planning in Sultan Idris Shah Forestry Education Centre (SISFEC), UPM

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Abstract. This study was carried out in UPM's field centre for education and research. First harvested in the 1960's, this secondary lowland dipterocarp forest should through the second harvest rotation. At the age of 50 years, the timber quality and revenue might decreases. The trees are also a risk to students, researchers and publics. Maintaining the ecosystem sustainability for the continual purpose of education and research, harvesting operation must be commenced by best harvest planning management. Respecting to this study, the application of remotely sensed imagery with the integration of available maps and associated databases have been used. Initially, the interactive feature of SISFEC have been developed in digital terrain model (DTM) identifying the physical and cadastral land classifications information. Several criteria derived from the DTM have been buffered subjected to harvesting practice and mitigation measures for sustainable timber harvesting operation. Eventually, the suitable harvest zones have been determined with total 677.7 ha and 4 km of new extraction road was proposed connecting to the centre of harvesting operation area. Overall, this study has been conducted in respecting the main purpose of this forest. Balance between the sustainability of the ecosystem and development needs of forest and communities are taken into consideration in strategic planning which is vital for continual usage.

Introduction

Sultan Idris Shah Forestry Education Centre (SISFEC) is UPM's field centre for teaching and learning, scientific research and provide recreation and visitor opportunities towards natural forests. Sustaining the forest resources in meeting the role of forest as education centre is always challenging. Also, ensuring the safety measures of users in using the forest is important. Such constraints may come from fallen dead wood of over 50 years old trees after final felling in 1960's. The fallen dead wood often threat the underneath layer vegetation and in worse, no timber trees are going to be dominant and sustainability of forest structure and diverse tree species might decrease. Managing the forest resources by removing the risked trees and reducing the trees density of allowable cutting limit are crucial for forest resource sustainability and user's safety [1]. Taking the practices of selective management system (SMS) harvest the forest for next cycle after 30 years, this education forest is highly recommended to undergone the second harvest rotation. Uncertainty of harvest intensity for many of 50 years old trees with number of trees to be harvested, species selection and minimum cutting limit may exist. Those trees can't simply harvested and removed without prior forest harvest planning entailed in harvesting guideline by forestry department. For this reason, comprehensive strategic planning for environmentally forest harvesting is

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IOP Conf. Series: Earth and Environmental Science **18** (2014) 012138 doi:10.1088/1755-1315/18/1/012138

necessary by considering the sustainable forest resources with the main role of SISFEC must be substantially improved.

Mitigating the harvest operation with minimum impact to forest environment is an early planning in ensuring the harvesting will successfully commenced [2]. [3,4,5] employing the best management practice (BMP) as a guideline in proposing the mitigation measure to support the practical means of their project and to achieve the desired objectives. A worth decision making for environmentally forest harvesting requiring sufficient information of physical characteristics and diverse forest resources. As stated by [6], a map presenting topography, resources and proposed road construction and harvesting describing on how to meet the objectives of forest operations proposed in strategic planning. The good plan with accurate information will later lead to a good decision making. Considering the accessibility of dense and diverse structure of large forest area, computer based application is crucial in spatial management planning [7,8 9,10]. For instance, remotely sensed imagery and analysis tool of geographic information system (GIS) consisting the attribute data of forest area are helpful in decision making [11,12]. This integration of remote sensing and GIS application would be beneficial in best harvest management planning in terms of effective time consuming and reducing costs. In addition, this forest can sustainably managed as education and research forest while maintaining the diversity of forest ecosystem.

Due to the growing importance of SISFEC to UPM's student and researcher, this paper aims to identify the best management practice for environmentally forest harvest operation by developing the comprehensive strategic planning with the use of remote sensing technology and GIS integrations as the planning tool. To be specific, spatial feature of forest area was developed to identify the information on physical and cadastral land classifications for the purpose of sustainable forest harvest management, and the suitable and non suitable area for harvesting operation was determined.

1. Methodology

1.1. Study site

The study site is Sultan Idris Shah Forestry Education Centre (SISFEC) which formerly known as Ayer Hitam Forest Reserve. This forest was categorized as lowland dipterocarp forest with 1190.3 ha. During the period of 1936 to 1951, this forest has undergone first harvesting cycle. In 1996, this forest has leased to UPM as education and research forest for 99 years by the Selangor State Government comprising six compartments. In 2008, SISFEC have through a development towards facility improvement for learning and research. Total of 3702.5 m^2 at compartment 15 are developed with environmental construction practices. Located about 24km from UPM campus, 35km from Kuala Lumpur city and 20km from country administration centre of Putrajaya, this forest become the biggest in situ conservation area in Klang Valley. Figure 1 show the spatial feature of this forest and its characteristics.

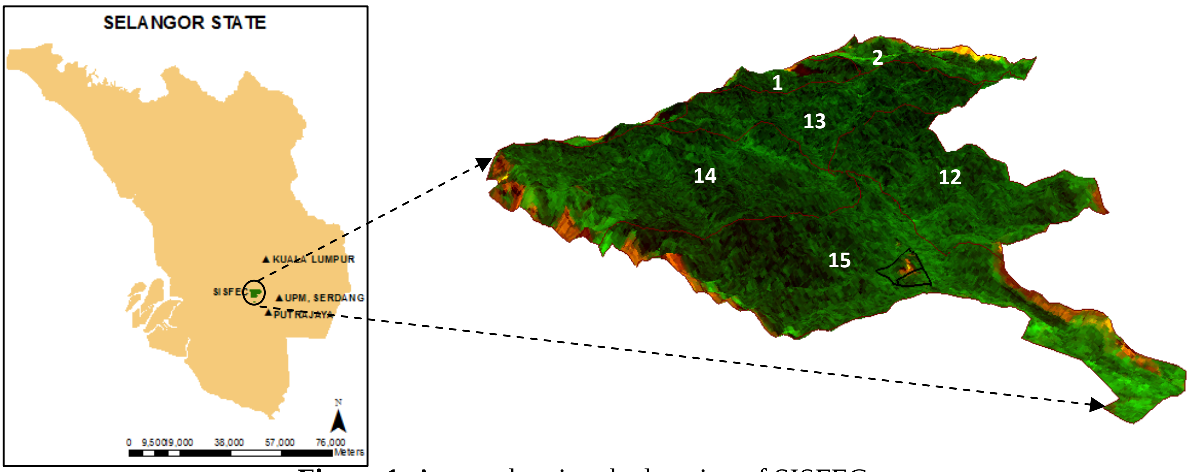


Figure 1. A map showing the location of SISFEC.

1.2. Digital terrain model (DTM) development

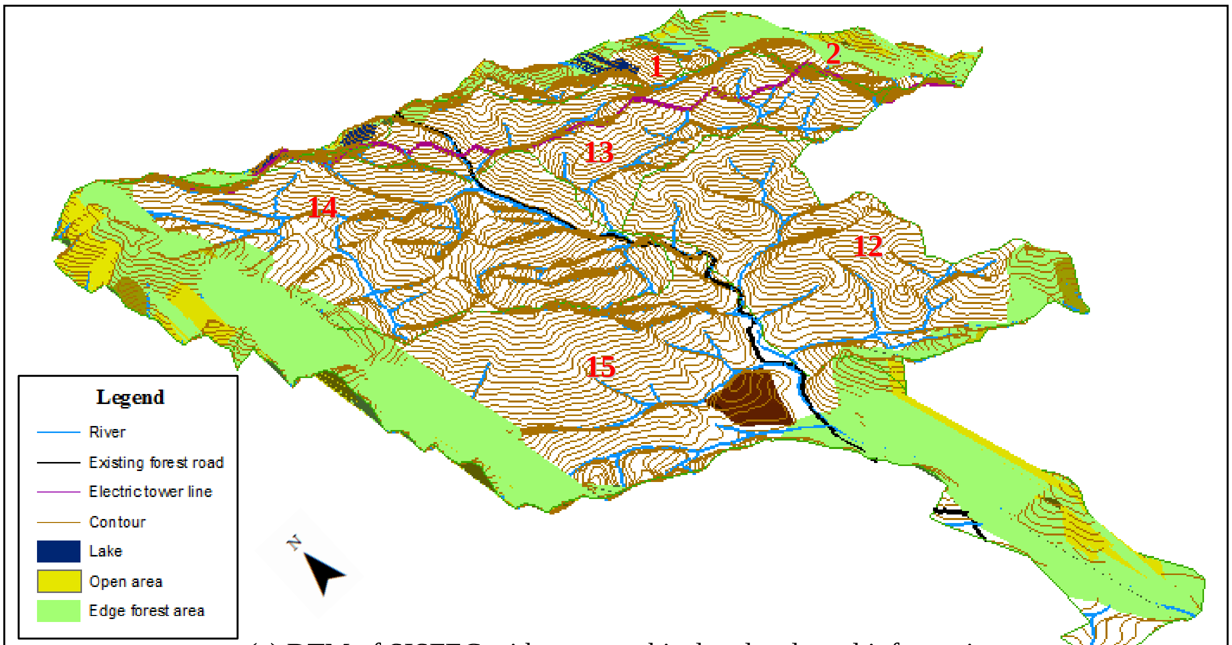
Integration of remote sensing imagery processing and GIS spatial analysis application were performed in developing the DTM. Pixel value of topology layer was allocated as 10m cell size similar with forest area imagery has. Prior the spatial analysis of raster image, estimation of different tree canopy resolutions were made based on different band combination of colour composites by 95% which eventually were used to automatically predict the spectral reflectance similarities [13]. Total of 4 classes were identified presenting different forest conditions. Along with GIS application, watercourses, contours, soil classes, future development plan areas and conservation areas were analysed for information driven of selection of harvest zone area. For the purpose of strategic planning, little ground inventory are required [14].

1.3. Harvest zone demarcation

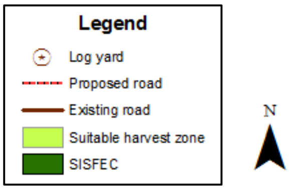
Determination of spatial pattern of proposed harvesting operation with time, location and type of road construction to be carried out was demarcated for strategic planning. The harvest zone was demarcated by using harvesting guidelines and SMS practices [15,16]. The specification of extraction road was following the guidelines proposed by forestry department [17]. Tabular data of slope constraints and buffer zone limitations was created from DTM development. Estimation for buffer zone width was calculated with the following equations; Buffer zone width = [7.6 + (0.6 m x % slope)].

2. Results and discussion

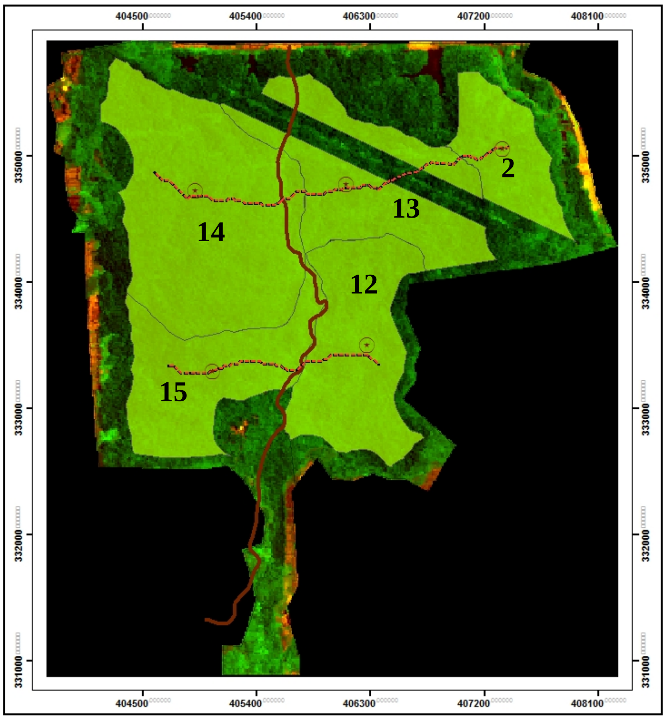
The spatial feature of SISFEC was presented in Figure 2. From the map, four forest classes of dense forest area, forest edge, open area and lake were illustrated; while, 54 km of river networks were also demarcated. Besides that, the proposed road networks for future harvesting operation were aligned to reach the respective harvesting area. The prerequisite criteria for the determination of suitable harvest zone area were shown in Table 1.



(a) DTM of SISFEC with topographical and cadastral information



Compartment no.	Area (ha)	Pre-F (10%) (ha)
1	-	-
2	86.6	8.7
12	116.2	11.6
13	102.7	10.2
14	243.1	24.3
15	129.1	12.9



(b) Harvesting operation zone and proposed road network

Table1. Prerequisite criteria for suitable harvest zone determination.

Criteria	Description
River	50 m buffer zone - As specified in forest road guidelines (FDPM 2010;1999)
Lake	50 m buffer zone - As specified in forest road guidelines (FDPM 2010;1999)
Open area	200 m buffer zone - Buffer zone demarcated on the basis of trees status which is not suitable to be harvested (Schmidt, 1978; Thang, 1978)
Forest corridor	100 m buffer zone - To protect biological corridor between the forest and neighbourhood area and meeting the MC&I standard
SISFEC building	100 m buffer zone - To ensure the safety of students, researcher and visitor while the harvesting operation taking place
Electric tower line	100 m buffer zone - To ensure the safety of worker during harvesting operation

With reference to Figure 1, the topographical and cadastral information have been identified with total of 677.7 ha are suitable to be demarcated as harvest zone from total of 1190 ha SISFEC area. Meanwhile, about 512 ha are retained for conservation purpose. The harvesting operation is proposed to be commenced at compartment 15 at initial. By constructing the road with good practice and specified to the guidelines, next harvesting compartments can be connected with less canopy opening for new road networks. Hence, to minimise the opening of forest canopy, next compartments to be in harvesting schedule is compartment 12, 14, 13 and 2, respectively. All information gathered from the imagery data were extracted to provide good decision for strategic planning at landscape level [18,6]. More than one planning can be used from the information gathered, instead. With number of alternatives plan, a plan with good quality can be obtained. According to [19] alternatives plan can be improved with quantitative measurement of forest stand such making assumptions about interest rates, process and costs of harvesting operation in the future.

Selective Management System is recommending as harvesting practice to be used in SISFEC. This system allow a selective harvestable tree and this ensure the optimum tree volume to be removed at one area based on pre-felling (Pre-F) inventory data [20]. In minimum 1% -10% pre-F inventories are required in strategic planning. From the six compartments analysed, 67.7 ha are recommended for 10% of pre-F inventory. Selection of trees to be harvested allow the quality of timber tree stand distributions improved for sustainable harvesting operation as well as controlling the trees stocking for education and research purpose [21].

When in doubt about reduce damage to residual stands and concerns toward ecological diversity of SISFEC, the direction of timber felling is a challenge in harvesting operation. According to [22] directional felling defined as felling of trees in a pre-determined direction or ‘desired lay’. From pre-F inventory data, the harvestable tree will be tagged with serial number and it determines the direction of felling towards pre-aligned forest road. Thus, construction of forest road will be minimised as directional felling facilitate the extraction process. The success of directional felling implementation leads to the less time consume during harvesting activity and increase the productivity of timber production. Moreover, as time consume for harvesting operation lessen, the purpose of research and learning are useable as soon as possible to SISFEC.

The forest road should be well planned and designed before the construction commenced. Well plans and designs of forest road network are anticipated to minimize the impacts or avoids disturbance to sensitive parts of SISFEC. There is a need to plan and design a forest road network as many alternatives networks as possible to eliminate the technical and economic problems in the future and for the maintenance purposes [23,24]. The multi-function of forest road use such for learning and research should be considered for a long-term purpose.

3. Conclusion

A map showing the harvest units to which compartment to be harvested first with the networks of extraction road is provided. Demarcation of suitable harvest zone, which is derived from the DTM development, allows strategic planning to be used as a guide for future activities in harvesting operation with reference to topographical and cadastral information. The integration of remote sensing and GIS technology enhanced the decision making process for a huge and dense forest area with assorted information. It is expected that this technology can be used as essential part of BMP of the harvesting planning. The good strategic planning having accurate information will later allow the responsible decisions making. Thus, this BMP will guide the overall harvesting operation whilst balancing the sustainable needs of the main purpose of SISFEC. Mitigation measures to the forest ecosystem are highly taken into consideration in outlining the BMP of harvesting planning in SISFEC. Yet, this planning may probably change through the real application in the future on the basis of meeting the sustainable uses of SISFEC.

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