APPLICATION OF INFORMATION TECHNOLOGIES FOR LAND EVALUATION AND DEVELOPMENT

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Information technology (IT) in land-related matters comprises the geographic information system (GIS), global positioning system (GPS) and remote sensing (RS). GIS is a computer-based system that helps to manipulate georeferenced data. It involves the entering, storing, manipulating, analysing and displaying of geographic or spatial data (Congalton and Green, 1992). GPS is a satellite-based radio-navigation system (ANON, 1996). It is used for collecting field data, area mapping, and features positioning required to build a GIS database for oil palm plantations. RS refers to methods for acquiring information about an object without contact with it physically (Jensen, 1996). The methods include aerial photography, radar and satellite imaging. Satellite imaging data of the Landsat Thematic Mapper (Wahid *et al.*, 2005) and Système Pour d'Observation de la Terre (SPOT) (Wahid *et al.*, 2010) have been successfully used to identify oil palm-growing areas, and to determine the total oil palm area on peatland.

Land evaluation is a process of assessing the characteristics of the land to determine its suitability and viability for various aspects of development. For oil palm cultivation, land development involves planning, land clearing, planting, and developing infrastructures, road and drainage networks.

IT provides the quickest and cheapest way to evaluate and aid in the development of a tract of land for oil palm cultivation. IT enables planters to gather accurate data for budgeting new plantings. The plantation database that is generated can be used as a tool to minimise errors when developing a new oil palm plantation.

OBJECTIVE

This project was conducted to determine the effectiveness of IT in evaluating and developing a tract of land for new oil palm planting. The activities included mapping of the land, determining the extent of suitable and unsuitable areas for cultivation, and planning for land clearing, planting and development of infrastructures, road and drainage networks.

BENEFITS

IT allows the planters to predetermine the value and development requirements of a tract of land for oil palm cultivation. Information generated by IT can be used to create maps and plans for use in constructing roads, drainage system and terraces, and for determining the planting density. The information is useful in preparation of budgets and contracts for plantation development. The database developed can be used for future planning and monitoring activities of the plantation.

MATERIALS AND METHODS

Project Location

The project was conducted in Sungai Asap, Belaga, Kapit, Sarawak in 2009. The area is North-east of Bintulu, on the way to the Bakun Dam. The area is hilly and the highest elevation is 700 m above sea level.

Satellite Image

SPOT-5 satellite data with two different scenes – multispectral image (four bands) with 10-m spatial resolution, and panchromatic image (single band) with 2.5-m spatial resolution were used to map and determine the landuse of the project area.

Map

Topography information was extracted from the topographic map sheet No. 192 of the DNMM5201 series. The information was based on 30 m contour intervals and with a referral scale of 1:50000. Other

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supporting data used were the site survey map with a scale of 1:15000. These maps were used to determine the exact boundary, slope and elevation of the area.

Equipment

Two types of GPS, namely, a hand-held GPS and a differential GPS (DGPS), were used for mapping, ground truthing, tracking and developing a digital terrain model (DTM) of the area.

Software

The satellite image was processed using the Erdas Imagine 9.1 software. The GIS software, ArcGIS 9.2 with 3D analyst extension, was used for mapping, database development and GIS modelling to evaluate and plan the development of the land (ESRI, 2008). *Table 1* shows the initial cost of establishing IT capability for land evaluation and development. *Figure 1* also shows the overall flowchart of activities for land evaluation and development using IT.

LAND EVALUATION AND DEVELOPMENT

Image Information

The enhanced SPOT-5 image (*Figure 2*) clearly shows the networks of logging tracts, cultivated areas, rivers, streams, settlement areas, land

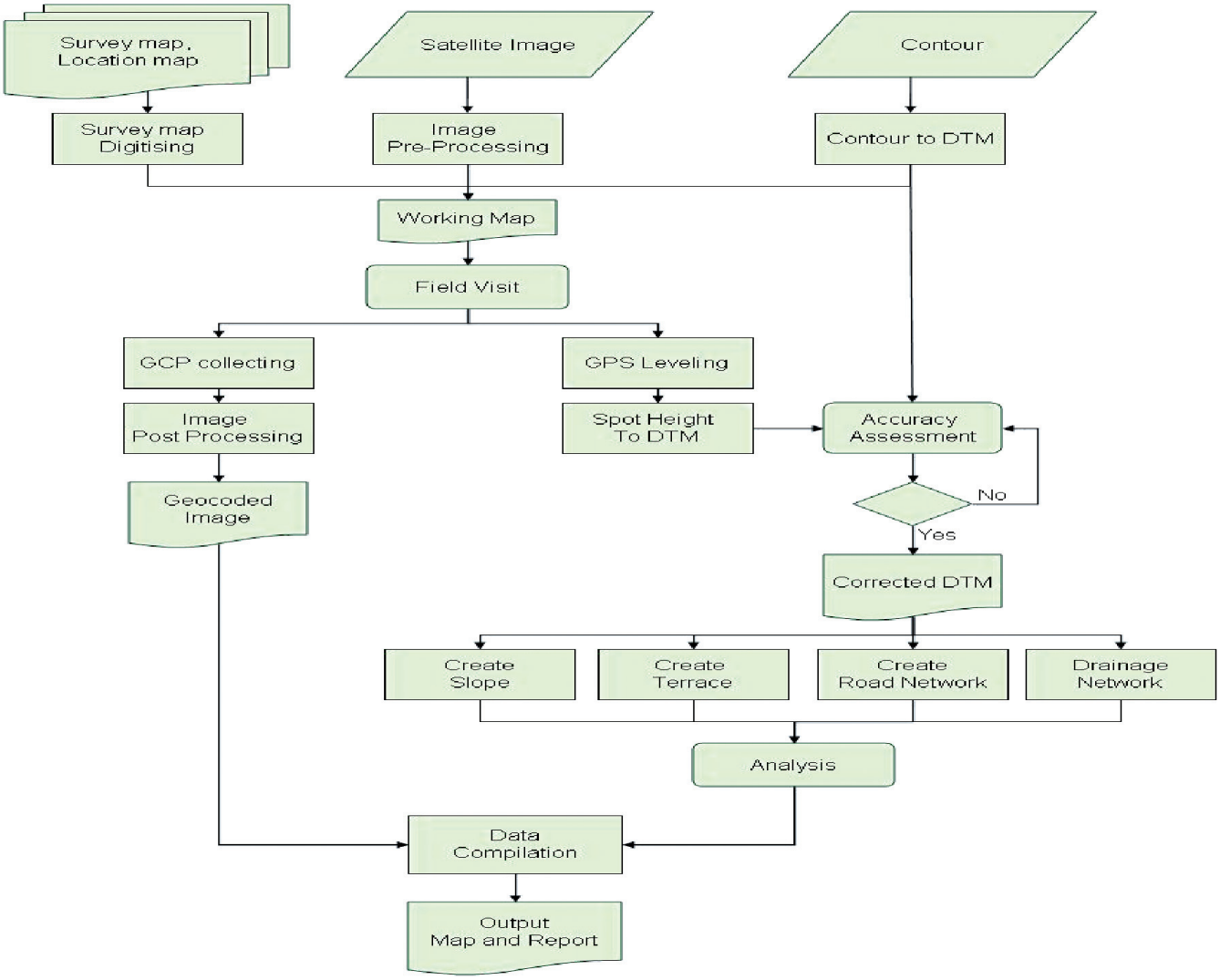

Figure 1. Flowchart of activities for land evaluation and development.

TABLE 1. COST OF PROJECT IN 2009

Item	Cost (RM)
Data:	
SPOT-5	5 000.00
Software:	
ArcGIS 9.2	40 000.00
Erdas IMGINE 9.1	40 000.00
Hardware:	
Differential GPS	20 000.00
Omnister signal leasing	10 000.00
Computer	5 000.00
Total	120 000.00

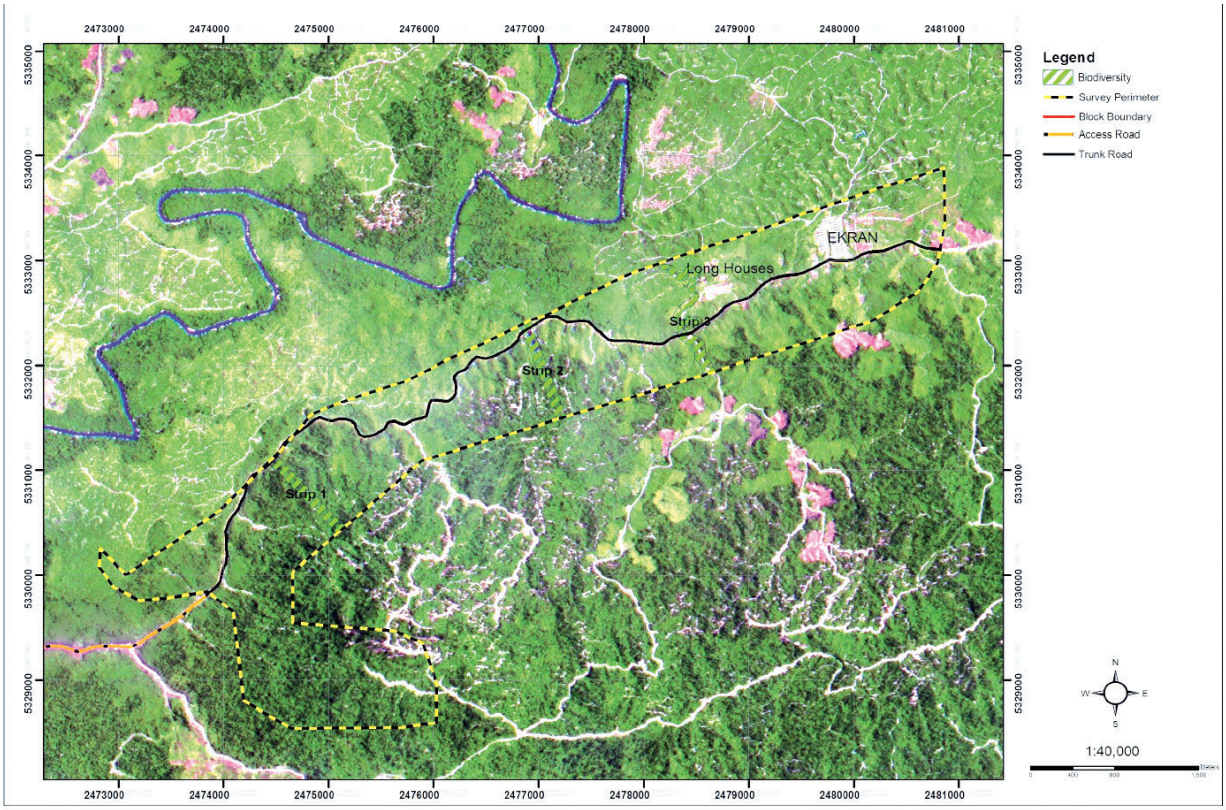

Figure 2. Enhanced SPOT-5 image of the project area in Belaga, Sarawak.

topography and landuse. The logging tracts indicate that the area had been logged. The topography of the area is hilly, and the land surface slopes from the North-west towards the Belaga River. Many parts of the area had been cleared and cultivated by the natives practising shifting cultivation. The image also indicates the existence of two settlements and a trunk road in the project area.

Land Evaluation for Suitability

The project area was mapped and divided into three land parcels (*Figure 3*). The total area of the land was 1009.35 ha. The elevation of the land was determined from the topography information. Agriculture and non-agriculture lands were differentiated using information on elevation, settlement areas and high conservation value (HCV) indicators (showing settlements, riparian zones and biodiversity conservation areas). Areas with an elevation higher than 300 m and/or containing HCV are not suitable for oil palm cultivation and are thus classified as non-agriculture land (*Table 2*).

Evaluation of Plantable Area

Out of the 717.25 ha of agriculture land, only 579.41 ha can be cultivated with oil palm. The rest

TABLE 2. AREA DATA ON AGRICULTURE AND NON-AGRICULTURE LAND OF THE PROJECT SITE IN BELAGA, SARAWAK

Land	Area	
	(ha)	(%)
Total area	**1 009.35**	
• Ekran estate quarters	38.99	
Project area	**970.36**	**100.00**
Non-agriculture land		
• Area > 300 m elevation	221.50	22.83
• Biodiversity		
- Strip 1	9.45	0.97
- Strip 2	9.70	1.00
- Strip 3	12.47	1.28
Total non-agriculture land	**253.11**	**26.08**
Agriculture land		
• Land division		
- Parcel A	130.51	13.45
- Parcel B	198.63	20.47
- Parcel C	277.42	28.59
Subtotal area	**606.56**	**62.51**
Native land	110.69	11.41
Total agriculture land	**717.25**	**73.92**

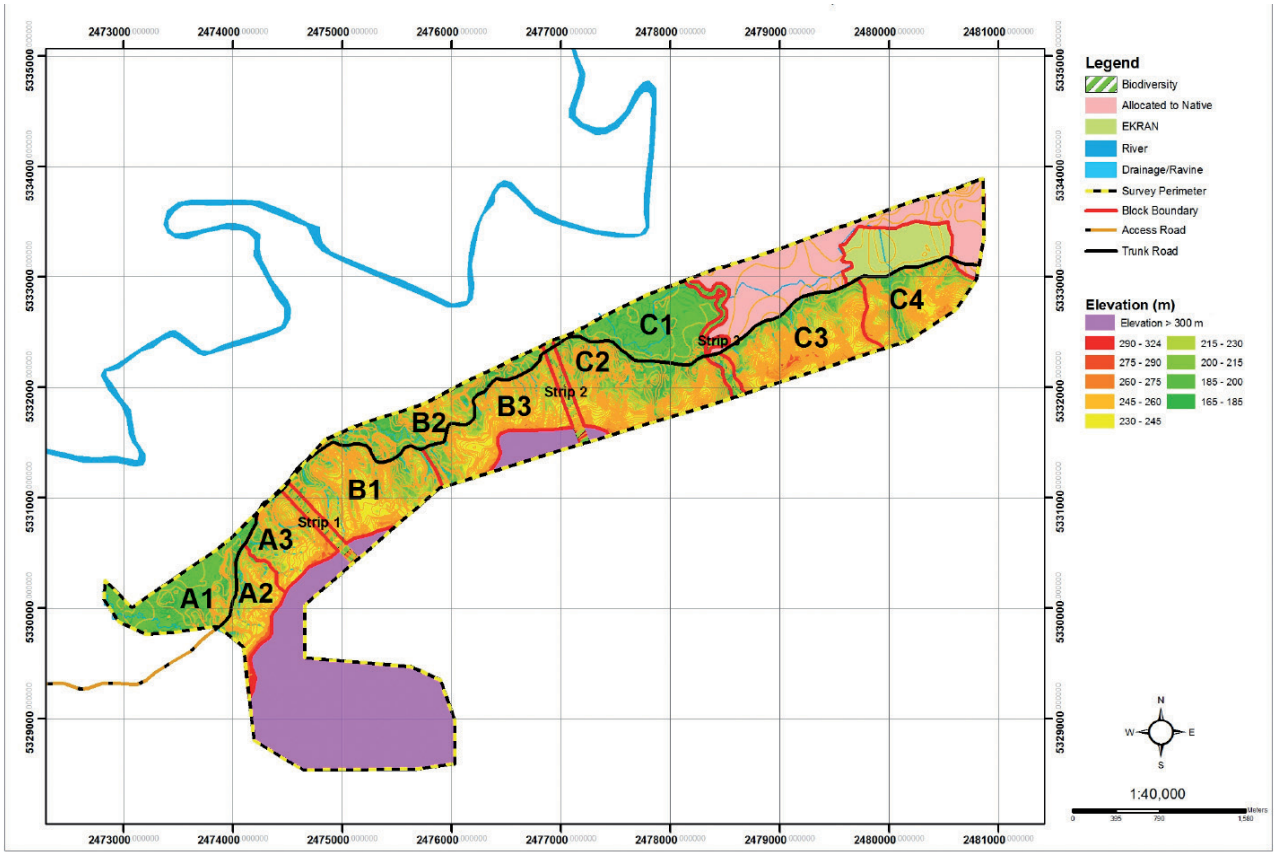

Figure 3. Map of land parcels and elevation of the project site in Belaga, Sarawak.

of the areas are unsuitable being too steep (>25°) (*Figure 4* and *Table 3*). Further evaluation of the agriculture land indicated that 135.97 ha are hill locks and are inaccessible (*Figure 5* and *Table 4*). After deducting the areas with steep land and hill locks, only 441.88 ha remain which are suitable for oil palm cultivation.

Land Development

The total area of Parcels A, B and C, excluding native land, is 606.56 ha with a plantable area of 331.04 ha (54.58%). The remaining 275.52 ha (45.42%) are non-plantable due to being either too steep (>25°), inaccessible or a conservation area. *Table 5* shows the predetermined development data for terracing, planting and road development of the project site.

CONCLUSION

IT has been proven to be useful for land evaluation and development for oil palm cultivation. With the IT, planters can evaluate and plan the best ways for developing the land. With these technologies, planters can map the site and predetermine the requirements for roads, drainage, terraces and the number of seedlings required. This information is useful for preparing budgets and contracts when developing a new plantation. The GIS database developed can be used for future management and monitoring of the plantation activities.

TABLE 3. SLOPE ANALYSIS OF THE PROJECT SITE IN BELAGA, SARAWAK

Land	Parcel A	Parcel B	Parcel C	Native land*	Total
Parcel area (ha)	130.51	198.63	277.42	110.69	717.25
Buffer zone (ha)	6.36	7.10	5.09	-	18.55
Slope class					
0°–6°	61.80	47.59	77.59	101.69	288.68
6°–15°	31.80	55.45	62.06	7.74	157.06
15°–24°	14.82	40.12	77.69	1.04	133.67
> 25°	15.72	48.37	54.97	0.22	119.28

Note: *Part of the project area was returned to the natives

TABLE 4. AREA PLANTABLE TO OIL PALM OF THE PROJECT SITE IN BELAGA, SARAWAK

Land	Area	
	(ha)	(%)
Agricultural area	**717.25**	**100.00**
Unplantable and reserved areas		
• Slope > 25°	120.82	16.85
• Inaccessible/hill lock areas	135.97	18.96
• Buffer zone	18.58	2.59
Total	**275.37**	**38.39**
Plantable area		
• Model plantation	331.19	46.17
• Native land	110.69	100.00
Total	**441.88**	**61.61**

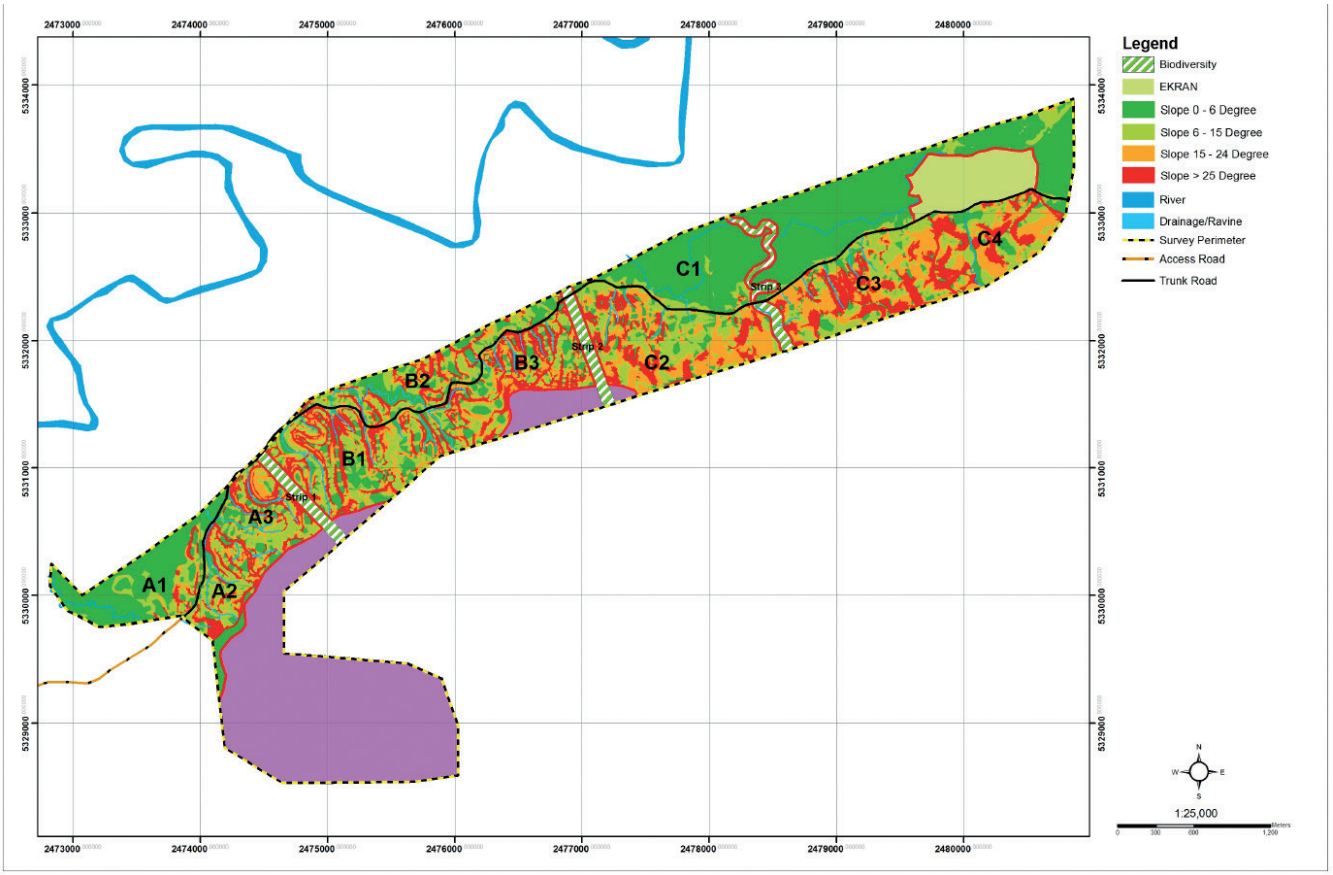

Figure 4. Topography map of the project site in Belaga, Sarawak.

TABLE 5. DEVELOPMENT DATA FOR ROADS, TERRACES AND PLANTING IN THE PROJECT SITE IN BELAGA, SARAWAK

Land	Parcel A			Parcel B			Parcel C			
	A1	A2	A3	B1	B2	B3	C1	C2	C3	C4
Total area (ha)	57.14	34.11	39.26	79.53	52.37	66.72	59.34	86.46	77.98	53.64
Slope > 25° (ha)	2.24	7.55	7.59	19.63	8.87	19.98	0.36	17.92	21.71	14.99
Buffer zone / drainage (ha)	1.60	2.03	2.73	3.06	1.71	2.32	1.73	1.16	1.43	0.77
Hill locks / inaccessible areas (ha)	-	10.56	15.03	31.23	7.7	16.35	-	21.68	18.75	14.66
Nurseries A and B (ha)	4.98	-	-	-	-	-	-	-	-	-
Plantable area (ha)										
- Flat areas	42.81	-	-	-	9.06	-	57.31	-	1.47	1.78
- Terraced areas	10.50	13.97	13.91	25.61	25.02	28.08	-	45.63	34.46	21.45
Field road length (km)	5.57	1.64	1.40	4.49	3.30	3.47	6.88	4.19	3.04	3.07
Field road density (m ha^{-1})	104.56	117.18	100.52	175.18	96.86	123.73	120.01	91.77	84.34	132.15
Terrace distance (km)	12.72	14.27	14.47	28.03	24.89	30.48	-	50.09	38.74	21.84
Terrace density (km ha^{-1})	1.21	1.02	1.04	1.09	0.99	1.09	-	1.10	1.12	1.02
Palm stand (No.)	6 344	1 804	1 841	3 544	4 278	3 790	7 470	5 692	4 557	2 940
Planting density (palms ha^{-1})	119	129	132	138	126	135	130	125	126	127

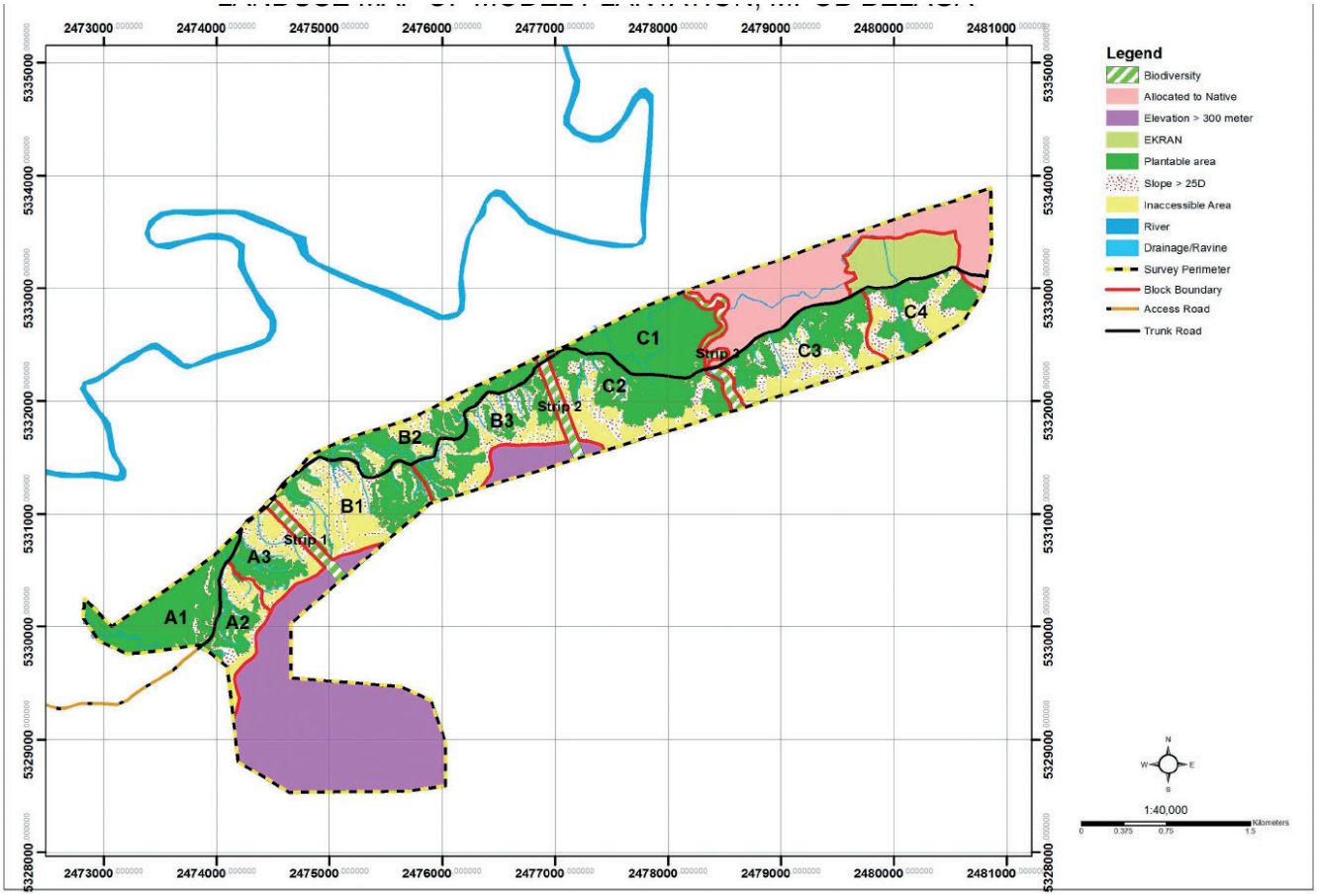

Figure 5. Suitability map of project land for oil palm cultivation in Belaga, Sarawak.

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