THE APPLICATION OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM FOR OIL AND GAS PIPELINE ROUTE PLAN

by
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I. INTRODUCTION

The application of the remote sensing and geographic information system was widely used in the oil and gas industry in Indonesia. These technologies have been recognized as a support/tool on both upstream to downstream, from geologic information extraction, logistic support to various activities of environment. Remote Sensing (RS) is defined as the science and technology by which the characteristic of the objects of interest can be identified, measured or analyzed without direct contact. Aircraft and satellite are common platform from which remote sensing observation are made. The term RS is restricted to method that employ electromagnetic energy as the means of detecting and measuring target characteristic (Figure 1). Geographic Information System (GIS) is actually unique system because it will manage both spatial and attribute data in one-reference entities (Figure 2). Spatial data is the kind of data that refer to certain geographic domain, or geo-information and usually display as thematic map. Attribute data refer to non-thematic map, such as table or other database.

In general, the oil and gas activity is divided into two parts, i.e.: upstream and down stream activity or on the exploration and production phase. On the production phase, the hydrocarbon is transported from production well to gathering station, refinery plant and or export facilities. Pipeline is one way to connect oil and gas activities in oil and gas transportation.

In Indonesia oil and gas fields are located at various physiographics, that vary from tropical forest to offshore area. So, they needs certain tool that can gather the earth surface condition efficiently. Remote Sensing and GIS technology offer a capability to support such needed. The capability of this technology is increasing in recording earth surface condition spatially and data variety.

The case studied lay between Merbau to Pagardewa, South Sumatera, generally covered by forest, rubber plantation, villages and local residences, limited road network and geologically dominated by Tertiary and Quaternary sediments. Remote sensing of medium spatial resolution was applied to gather the earth surface situation. GIS technology was applied to manage all data that have been collected.

II. PIPELINE ROUTE PLAN

The pipeline route plan activity is conducted to define the shortest length between the starting to end point by considering earth surface situation. This activity can be divided into two phases, i.e. desk activity and field activity. In the office or desk activity, planning is conducted based on the remote sensing and existing map. In the field activity, the pipe lay down is defined based on the actual field condition. In general the plans consist of minimized pipeline length, minimized and avoid certain situation, used existing route and make sure the pipe lay down correctly (Table 1).

III. METHOD

The activities in the pipeline plan using remote sensing and geographic information system consist of preparation, data collecting, data processing and analyzing, field work, and define pipeline route (Figure 3).

IV. DATA PROCESSING AND INFORMATION EXTRACTION

Image enhancement can be defined as the conversion of an image quality to a better and more understandable level for feature extraction or image interpretation. Image enhancement is applied mainly for image interpretation in the form of an image output. Since the imagery will be managed under GIS for future and other advances usage, a geometric correction is performed to the imagery therefore, each point on the image is located and matches with base map used.

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Table 1
Pipeline plan guidance

I	DESK/OFFICE ACTIVITY	
	1	Nature Resource
	a	Minimized pipeline length on the: Wet land; Water Body; Conservation Area
	2	Land use
	a	Avoid the pipeline route lay on the: Public Service; ex mining area; heritage landscape and culture; fill in area; cemetery; and waste area.
	b	Optimized crossing on the : Public garden; forest; commercial area; and developing plan area.
	3	Environmental Impact
	a	Avoid the pipeline route lay on the: Step slope and hard rock
	b	Minimized pipeline length on the: Pipeline length and side slope crossing
	c	Considering use the existing route: Existing pipeline route; existing power line route and road network.
II	FIELD ACTIVITY	
	1	Make sure the pipeline: Shortest length; perpendicularly crossing the river; exist protection tress along slope side; 20 m minimal distance to residence housing.
	2	Minimized pipeline contact with settlements area
	3	Avoid lay down pipeline on the slope side.

Image interpretation is defined as the extraction of qualitative and quantitative information in the form of a map, about the shape, location, structure, function, quality, condition, relationship of and between objects, etc. By using human knowledge or experience. As a narrow definition, "photo-interpretation" is sometimes used as a synonym of image interpretation. Image reading is an elemental form of image interpretation. It corresponds to simple identification of objects using such elements as shape, size, pattern, tone, texture, color, shadow and other associated relationships. Image reading is usually implemented with interpretation keys with respect to each object.

Image analysis is the understanding of the relationship between interpreted information and the actual status or phenomenon, and to evaluate the situation. Extracted information will be finally represented in a map form called an interpretation map or a thematic map. Generally the accuracy of image interpretation is not adequate without some ground investigation. Ground in-

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Table 2
Image reading to landuse and landcover unit on the Landsat TM 452

No.	Landuse and Landcover	Imagery	Field Condition
1	Forest	Dark, coarse, irregular, limited road network	Rubber tress and other high tress
2	Rubber plantation	Light – medium, fine – medium, green, regular.	Rubber plantation regularly plant, foot pad road, grass as subtract.
3	Palm oil plantation	Light – medium, fine – medium, regular, well road network.	Oil Palm plantation regularly planted, well road network
4	Transmigration area	Medium, regular, well transportation network.	Uniform housing with its farmyard, exist road network.
5	Settlement area	Light, coarse, irregular, road network	Dense housing with farmyard, transportation network.
6	Production forest	Dark – medium, coarse – medium, regular.	Uniform wooden tree, well road network, well maintained.

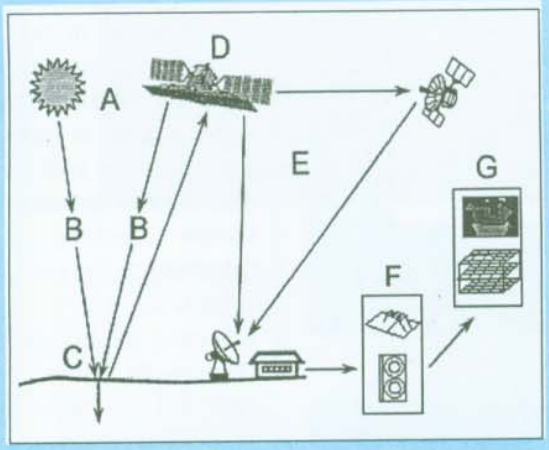

Figure 1
Electromagnetic path (Duraid Omar,-)

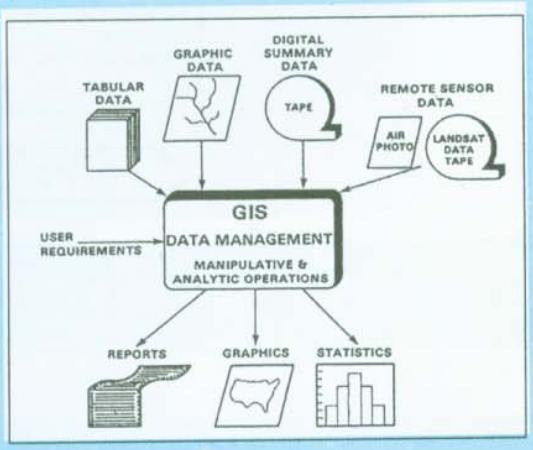

Figure 2
Data Input and output (Nicholas M. Short, -)

vestigations are necessary, first when the keys are not established and then when the preliminary map is checked.

Interpretation and field work activity in the study area reveal five landuse and landcover units. Relation between image appearance and field situation is summarized on the Table 2 and Figure 4. Landuse and landcover mapping between Merbau – Pagardewa based on the imagery data and support field data identified forest, production forest, rubber plantation, palm oil planta-

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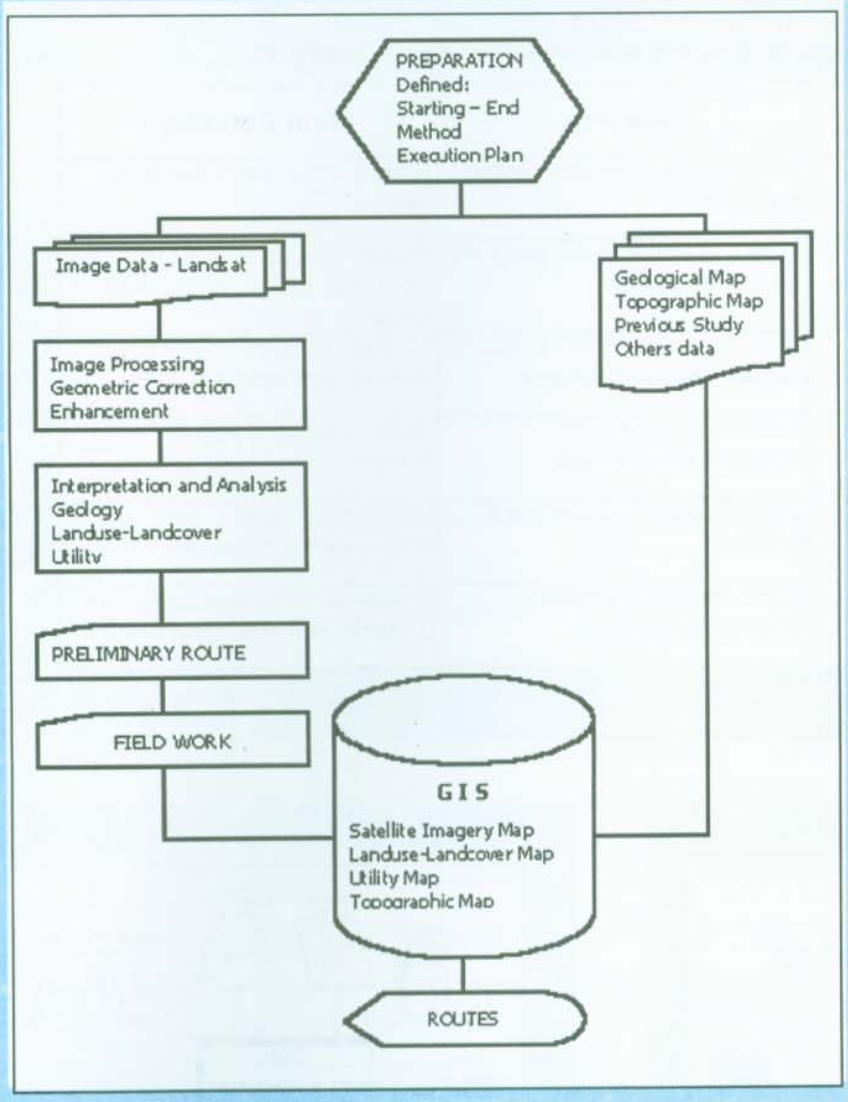

Figure 3
Methodology

Table 3
Pipeline plan lay down

Route	Number		Kilometer					
	River Cross	Road Cross	Prod. Forest	Trans. Area	Rubber Plant	Setl. Area	Palm Oil	Total Km
Purple	29	3	2.1	0.6	18.56	0.2	-	21.46
Blue	18	10	0.8	0.4	20.11	1.25	-	22.56
Green	21	7	-	-	21.79	1.25	0.6	23.64

tion, transmigration area, and settlement units.

Geological interpretation on the Landsat TM imagery that guided by some existing data identified lithology type and geological feature. The areas of interests consist of sedimentary rock of Late Miocene and Quaternary age. The formations consist of sand, silt, and clay stone. Folding structure is identified on surrounding the Merbau and Pagardewa Area.

Digitizing to the topographic map that covers the study area is conducted therefore suitable fit to the GIS platform. Contour line, road network, administrative boundary, drainage/ river is separated into each certain layer.

The pipeline route plan is conducted in the GIS platform. Using this platform an evaluation between starting to end point can be easily performed. The shortest distances between starting point (Merbau) to the end point (Pagardewa) will be achieved by straight line (Figure 5). Considering the nature resources, landuse and environmental impact are evaluated then an alternative route is defined. The alternative route must be efficient and effective both in engineering and cost operation. By evaluating the surface condition between Merbau – Pagardewa for oil and gas pipeline usage reveal three

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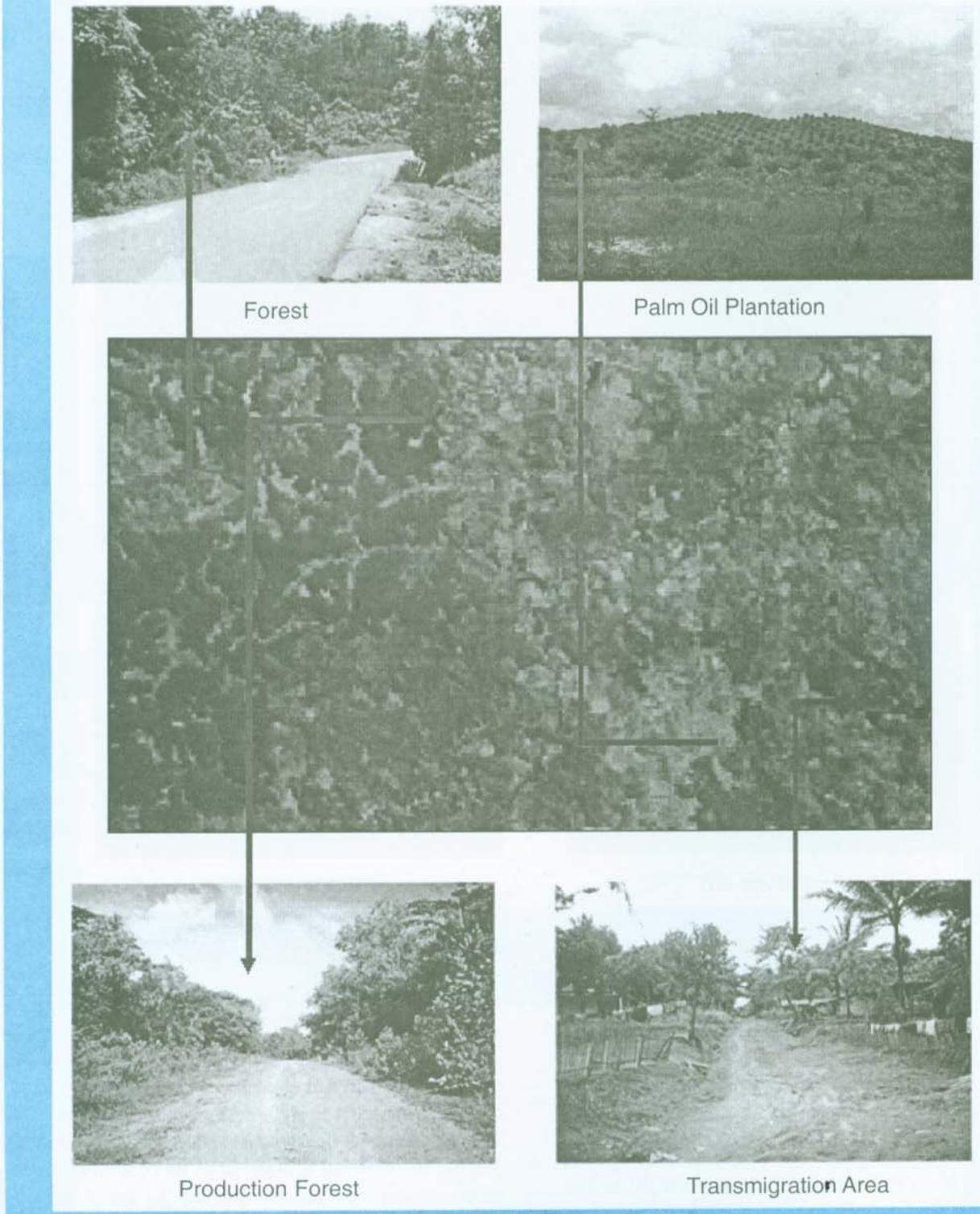

Figure 4
Relation image appearance and field condition (part 1)

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Relation image appearance and fied condition (part 2)

pipeline plans, i.e.: Purple line, Blue line, and Green line.

V. DISCUSSION

Morphologically, this area is classified as undulating to rolling of 15% dipping and elevation at 50 to 100 meter above sea level. Drainage pattern develop as dendritic to subdendritic (Figure 6). The surface condition between Merbau – Pagardewa is covered by rubber plantation, forest, production forest, palm oil plantation, transmigration area, and local villages (Figure 7). Geologically, this area is covered by Late Miocene to Holocene sediments that consisted of sand, silt, and clay (Figure 8). General evaluation of this condition, is focused on reduced river crossing and the use of existing routes.

Purple line (R1) connects Merbau and Pagardewa area as straight line hence, this plan reveals the shortest

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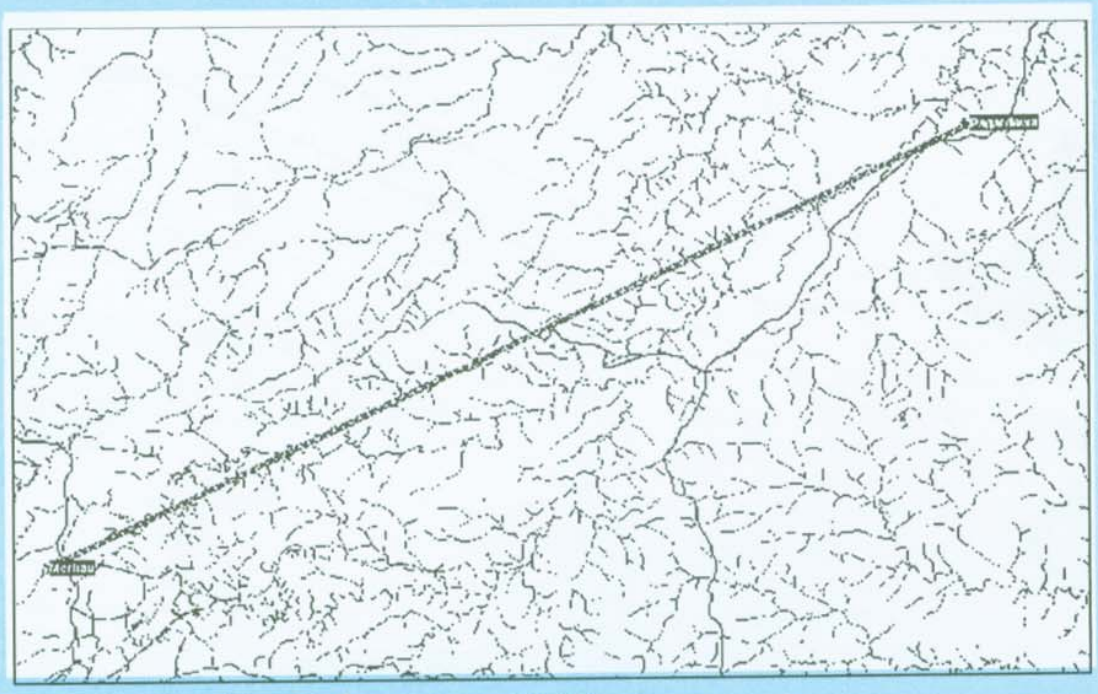

Figure 5
Straight route Merbau – Pagardewa plotted on drainage and road network

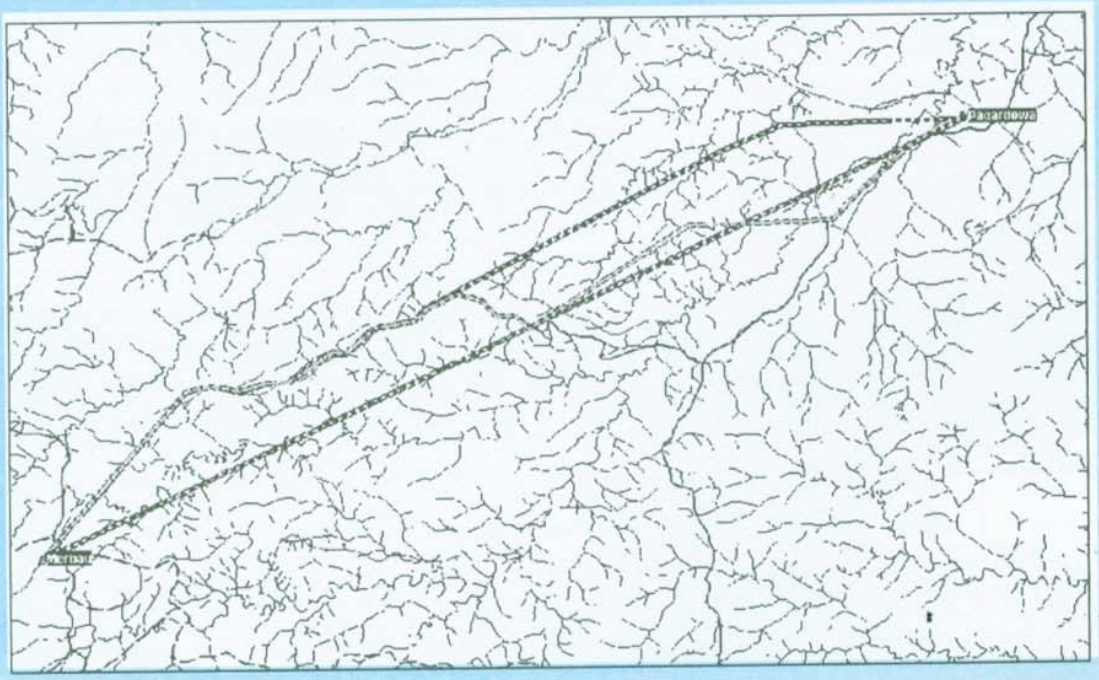

Figure 6
Straight and alternative route Merbau – Pagardewa plotted on drainage and road network

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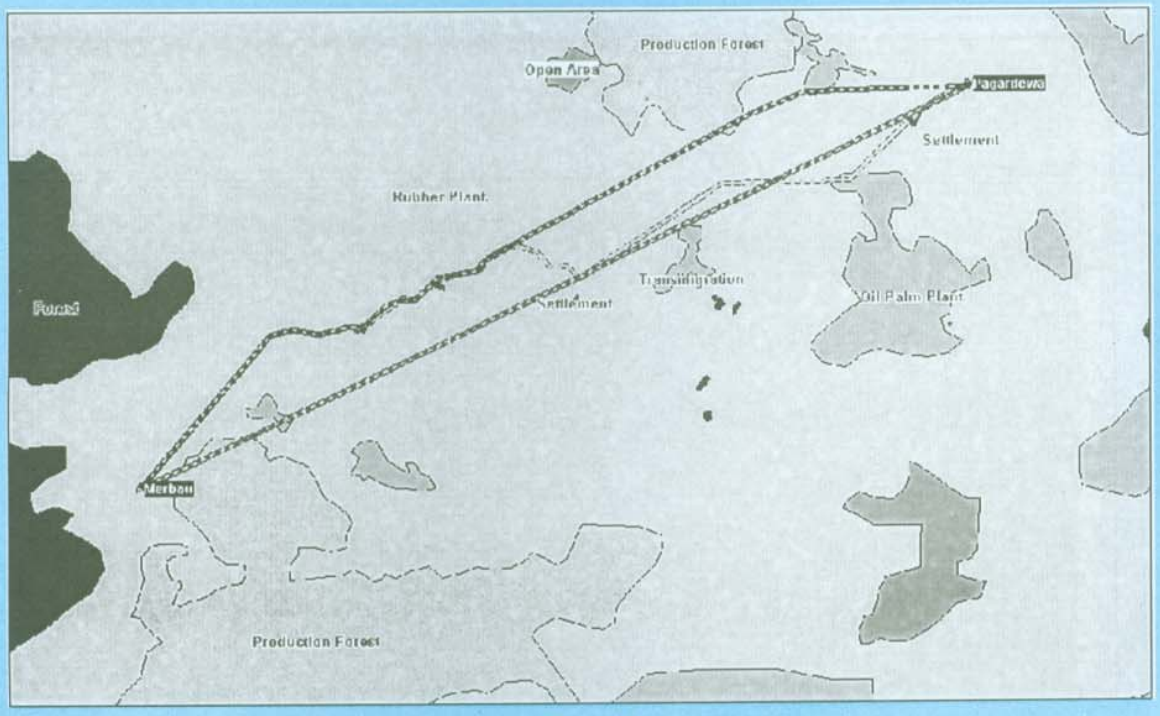

Figure 7
Straight and alternative route Merbau – Pagardewa landuse and landcover map

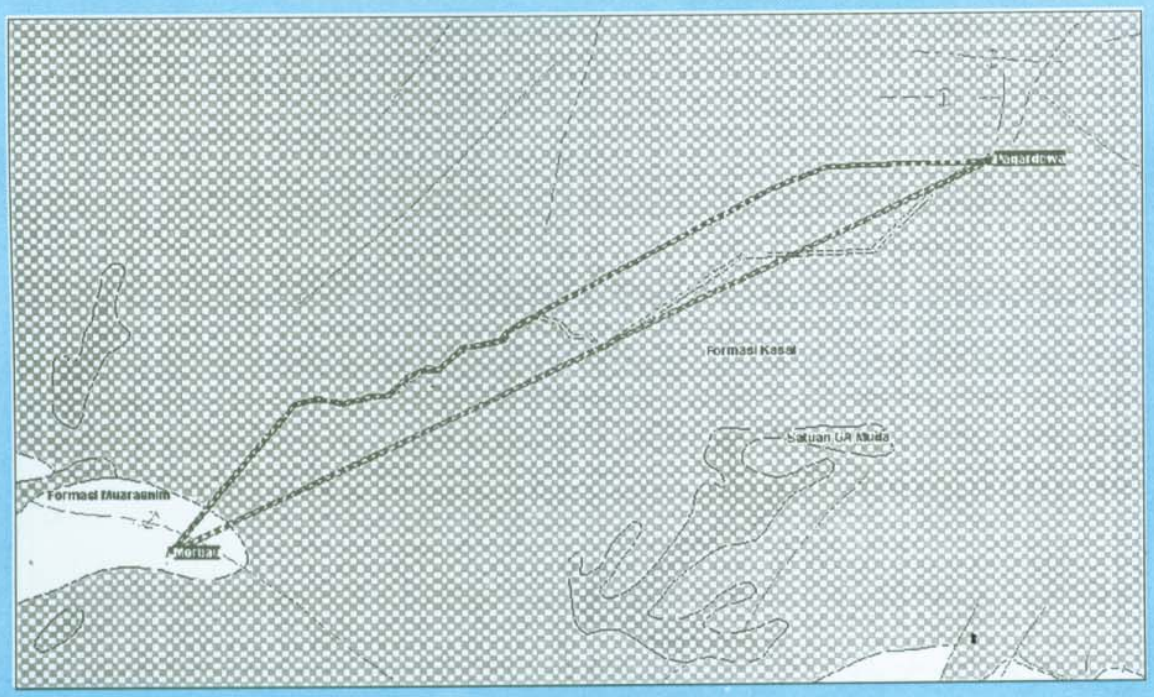

Figure 8
Straight and alternative route Merbau – Pagardewa plotted on geological map

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distance of 21.46 km. As this route is straight therefore it must cross 29 rivers and 3 soil road. This route does not use the existing road. Purple route is dominantly laid down on the rubber plantation unit and Holocene sedimentary rock. Blue line (R2) connects Merbau and Pagardewa area and is called as on an alternative route. Since river crossing is considered as one factor that must be reduced and existing route is considered to be used hence, this route has 22.59 km length. The blue line will cross 18 rivers and 10 soil roads. This route uses the existing village road as long as 6.2 km. As the previous line, R-2 line is dominantly laid down on the rubber plantation units and Holocene sediment rock.

Green line (R-3) as the last of the three plans has 23.2 km length. The green line for the first halfs equal to the blue line then turns south to avoid dense drainage. The Green line cross 21 rivers ands 6 soil road. Landuse and geological aspects are similar to the previous route plans. Important considerations of each route are resumed in Table 3.

Pipeline analysis of the study area is conducted by calculating each pipeline score. The landuse types and number of crossing are considered as the main aspects and other aspects i.e: geology, natural hazard and others are neglected. The relative score of the landuse and crossing defined ranges one to four that corresponds cheap to expensive (Table 4). Calculation of relative value of the Purple, Blue, and Green line reveals that the cheapest is Blue line followed by Green line and Purple line (Table 5).

Table 5
Relative scoring each pipeline plan

Landuse		
Units		**Score**
Forest		1
Production forest/plantation		2
Transmigration area		3
Dense settlement		4
Crossing		
River		
	Minor	2
	Major	4
Road		
	Minor	1
	Major	2

VI. CONCLUSION

The application of Remote Sensing and Geographic Information System is useful for gathering and analyzing the earth surface condition in effective and efficient way.

Pipeline plan that is located on the remote and limited facilities needs this technology hence, reveals the ideal pipeline plan.

As the study area in landuse and geology aspect there is uniform, analyses to the alter-

Table 4
Landuse and crossing score

Route	Score							
	River cross	Road cross	Prod. forest	Trans. area	Rubber plant	Setl. area	Palm oil	Total score
Purple	58	3	4.2	1.8	37.5	0.6	0	104.72
Blue	36	10	1.6	1.2	40.22	3.75	0	92.77
Green	42	7	0	0	43.58	3.75	1.2[1]	97.53

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native pipeline route can be concentrated to the drainage and existing route.

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