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Natural Resources Inventory of East Kalimantan (Borneo) Indonesia by Side Looking Airborne Radar Surveys

Abstract

A natural resources inventory was carried out in the province of East Kalimantan (Borneo) for proposed transmigration projects. The paper discusses briefly the techniques and methods and presents short summaries on the most relevant results.

1.0 Introduction

East Kalimantan, one of the largest, least known and scarcely inhabited regions of Borneo has been chosen for major transmigration projects by the Indonesian government in 1977. In the initial stage the main objective was the delineation and location of potential areas for future development below the dense canopy of the heavily forested terrain. The primary problems arose from the fact that major parts of the province, comprising a total area of 211 000 square kilometres, belong to the completely unknown regions of the world. Due to the urgency of the project and lacking geoscientific information, only remote sensing methods could provide the needed data. Because of the time restrictions only limited field verification was carried out which concentrated of course on the most intricate problem areas.

2.0 Techniques and Methods

The geographical location of East Kalimantan on either side of the equator and the related effects of the Inner Tropical Convergence Zone impose serious restrictions upon the application of remote sensing tools.

2.1 Satellite Imageries

The particular climatic conditions explain the incomplete coverage of satellite imageries in this region up to now and the intense cloud cover on the majority of available imageries. Therefore, the evaluation of these data was restricted to some coastal stretches and major river courses for purposes of partial rectification and topographic control. Very few other information were obtained with relevance to the resources inventory.

2.2 Aerial Photography

The influences of climate and weather are also unfavourable for high altitude aerial photography. Out of this reason conventional aerial surveys were only carried out in medium scales for various purposes over selected areas of the province.

2.3 Side Looking Airborne Radar (SLAR) Surveys

The combination of negative factors resulting from climatic environment and dense vegetation cover necessitated the application of Side Looking Airborne Radar techniques. These surveys, covering the eastern half of the province and originally undertaken for oil exploration purposes by Aero Service, USA, were also made available for the inventory of the natural resources of East Kalimantan.

The Goodyear GEMS 1000 radar system which was used operates in the X - band at a frequency of 9.6 gigahertz, 3.12 cm wave length. This relatively long wavelength has the capability of transmission through clouds and moist air without significant losses. At flight levels of approximately 12 000 metres excellent imageries are obtained from the extreme edge of the far range at a distance of 30 nautical miles (55 KM) up to the near edge at a distance of 10 nautical miles (19 KM). The survey flights were flown mainly in North - South direction with a flight line spacing of 7.5 nautical miles (13.9 KM) and an average sidelap of 62.5 %.

The final SLAR imageries were produced in scale 1 : 100 000 and submitted as mosaics by Aero Service.

2.4 Principles of SLAR Evaluation

Radar surveys are quite unlike aerial photography. This technique applies an electro optical rather than an optical system. The radar returns which make up the radar imagery depend upon the energy supplied by the system, whereas the strength of the radar returns and the tones of the imagery depend upon the radar reflectivity of the target. This reflectivity in turn depends upon the complex dielectric constant, the surface roughness and the slope as determined by the position of the aircraft with respect to the target. Energy which is not absorbed when reaching the surface is reflected by the topography. In case of the reflection from a perfect plain, as for instance smooth water surfaces, the energy flows into a single direction, whereas reliefed surfaces cause a diffuse reflection. The amount of diffusion is influenced by the surface roughness and the dielectric constant which is a measure for the absorption capacity of the surficial material for the electromagnetic waves.

Within the swath width, from near to far range of the imageries, relief displacements occur in the slant range presentation of the depression angles as well as in the respective ground range. High terrain shows displacements towards the flight line , whereas topographic depressions are offset in the opposite direction. The displacements are intensive in the near range and decrease into the far range direction. In addition, slopes inclined towards the flight line exhibit strong reflections, however, high elevations may prevent the radar waves to hit the backside of such terrain, thus causing no reflection. These shadow effects vary of course within the swath width. On the other side, the shadows as well as the displacement effects and the changing reflections facilitate the evaluation of the SLAR imageries.

The evaluation itself concentrates on such recognition elements as tone, texture, pattern, and relationships of associated features, shape and size. The quantity of information which can be obtained is dependant on the type of terrain,

the geomorphic development, the climatic environment and vegetational conditions.

3.0 Results of the Surveys

The original evaluation of the SLAR imageries was accomplished in scale 1 : 100 000 and reduced later to 1 : 750 000 for final rectification, cartographic drawing and printing. During these various steps additional data obtained from satellite imageries and conventional aerial surveys were used to control or correct the evaluation of the SLAR maps.
According to the contract agreement the first series of maps was required with the following contents : Geology, Geomorphology, Mineral Deposits, Vegetation, Soils and Agricultural Potentials. All maps in common is the completely revised topography including the newly mapped major hydrographic pattern. These features in combination with the respective map topics provide in most cases and areas the first comprehensive information ever so far.
Beginning 1978 and throughout that year the test prints of each map were submitted in successive stages for the practical use in the projects.
Out of the great number of thematic maps only the basic facts of those shall be introduced briefly which are of major relevance.

3.1 Geology

In the case of the geologic evaluation special attention was paid to the definition of lithologic units and their composition. Sedimentary rocks and their surficial reaction reveal the greatest amount of information compared to metamorphic and igneous rock bodies. The age of the rocks encountered and analyzed dates back to Pre - Tertiary, the lithologic description of each mapped unit was accomplished with reasonable certainty. The definition of structural features like folds was made possible by the study of strike and dip of strata, whereas a wide variety of possibilities exists to delineate and to define fault and fracture pattern.

3.2 Geomorphology

The investigation of the geomorphology of the province was the first of its kind ever undertaken so far. Particular emphasis was placed upon the practical relevance for the natural resources inventory rather than to fulfill scientific standards of pure research. Without entering an extensive discussion of the broad series of landforms they can be grouped together under the following physiographic regions: Mountain regions, Piedmont -, Basin and Range -, Upland -, Volcanic -, Interior Basin -, and Coastal Region.

3.3 Mineral Deposits

The plotting of mineral deposits was accomplished

a) through compilation of existing knowledge, by counter-checking the data with the geological and geomorphological findings and by transfer of these results into the base map

b) by means of SLAR evaluation.

Thus, the geologically favourable regions for the economically most important occurrence of oil and coal could be delineated with reasonable certainty. The metallic minerals were mapped in a similar way, whereas most deposits of industrial minerals could be traced directly and reliably from the SLAR surveys.

3.4 Vegetation

Due to the intense and relatively uniform vegetation and its secondary importance for the project purposes at present, only major and dominant units had to be mapped. This is the only inventory, wherein the task of differentiation was defined already in advance by the project. Consequently the legend comprises: Primary forest above and below 500 metres; secondary forest; freshwater - swamp forest; brackish / freshwater - swamp forest; littoral forest; tidal mangrove forest; woods, brushwood, tropical grass; inhabited and developed regions.

3.5 Soils

Especially with regard to the proposed future conversion of

virgin forest into agricultural land, investigations into the little known soil conditions had to be undertaken. Although the techniques and methods applied cannot identify soil types, differing soil properties can be distinguished, and the definition of mappable soil units was accomplished while applying the FAO - UNESCO soil classification. The legend of the soil map comprises 24 units and additional differentiations in the accompanying text. The extraordinary time pressure prevented extensive verification of the findings in the field.

3.6 Agricultural Potentials

An important objective for the planning of the transmigration projects is the definition of agriculturally potential areas below the dense forest cover.

The presentation of these findings is in the widest sense practically a synthesis of most other maps discussed before which contain the respective details. Besides the inhabited and developed regions the potential areas suitable for agricultural purposes are depicted. All these zones are located on moderately rolling to even terrain in lowland to upland elevation above mean sea level and comprise the locally more favourable soils. In relation to the total area of the province, comparatively limited regions offer suitable conditions for a conversion into cultural land. The major restrictions result from the interaction of the main factors climate, relief, geology, soils and erosion.

4.0 Final remarks

The briefly summarized results of the foregoing chapters, especially the various maps and the related findings were submitted to the project in successive stages. So far, all maps are proof prints only to be used for various purposes and for field inspection. Until now, except for orthographic corrections, no other revisions have been reported. After the phase out of the first project stage the final printing of all maps will be started at the end of this year.