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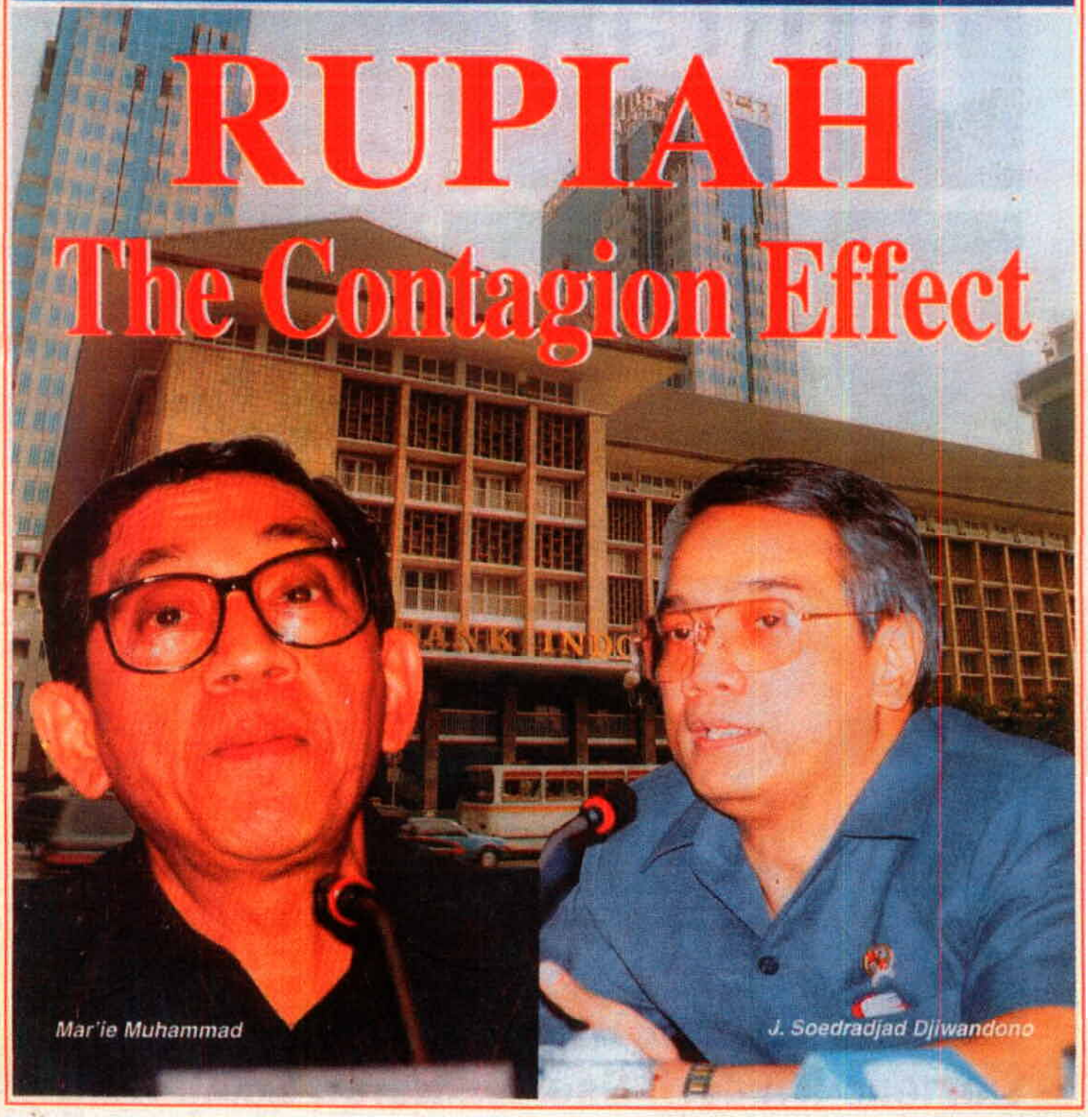
The Contagion Effect



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J. Soedradjad Djiwandono

Land use planning and environmental monitoring in Kalimantan using remote sensing data

In recent years remote sensing images from space have become increasingly important in land use planning and large scale environmental monitoring, especially in Indonesia, which still possesses vast rain forest resources. Optical sensors such as LANDSAT TM (USA), SPOT (France) and IRS-1 (India) acquire images from space with a ground solution of less than 10 meters. Up to 7 different channels, including near-infrared and thermal, allow the discrimination of all major land use classes and ecosystems and are especially useful for small-scale regional or urban planning. New radar sensors, for example, ERS-1 and ERS-2 (EU) or RADARSAT (Canada), are able to penetrate clouds enabling information to be obtained for areas that were formerly impossible on a regular basis.

Weather satellites such as NOAA deliver images several times a day, and these can be used for fire detection and monitoring. Major advantages of space-borne imagery are their high degree of accuracy, the available range of scales for mapping (1.25000-1.50000), the low costs per square kilometer and ability to deliver images from exactly the same area every month enabling information to be updated regularly.

Endangered rain forests

There is enormous economic pressure to develop Indonesia's remaining forest resources. Timber still contributes a major portion of that country's revenues although extensive plantations for palm oil and paper pulp production in addition to coal, oil, gold and other minerals are becoming increasingly important to the Indonesian export economy.

Large numbers of people from the fertile island of Java have been, and continue to be, resettled in other parts of Indonesia (for example, Irian Jaya, Kalimantan and Sumatra) where agriculture is not as feasible, thus creating a permanent need to slash and burn new virgin forest in order to survive. Shifting cultivation by people who, originally, were used to planting wetland rice (padi) is a particularly destructive form of agriculture, causing dramatic losses to the economy with associated disastrous consequences for the forest ecosystem and general environmental quality.

Many tropical soils are not suitable for permanent agriculture. They can be cultivated only when managed carefully. New methods — for example, agroforestry — must be tested extensively before wholesale implementation. Fast economic and population growth have resulted in increasing rain forest conversion rates not only in Southeast Asia but all over the world.

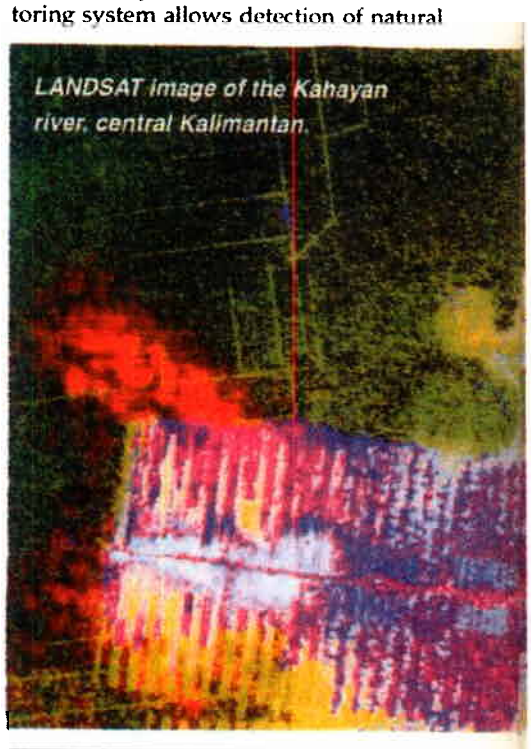
In contrast, the role of rain forests in the global ecosystem, and as a natural resource, is still widely misunderstood, underestimated and undervalued. Many people regard rain forests simply as a huge timber stock that regenerates quickly without the need for specific measures to sustain the resource. Others are convinced that complete removal of forest cover to establish plantations or agricultural fields will yield still higher revenues.

Both points of view, however, are one-sided and wrong as an increasing number of scientific publications show that "the tropical rain forests of Southeast Asia are the natural habitat of more than 10% of all plant and animal species on this planet, although the rain forests themselves cover only 2% of the total land surface". Hundreds of plant substances still undiscovered by scientists may provide medicines, antibiotics, bactericides and fungicides which could benefit future generations."

The need for control

Only recently has it been recognized that sustainable development and responsible exploitation of natural resources is mandatory in order to assure future survival and prosperity on this planet. The fast growing Indonesian economy creates an immediate need to control the progress of development on the vast islands of Sumatra, Borneo and Irian Jaya. Uncontrolled forest fires caused by shifting cultivators and over-exploitation of forests by logging concession holders lead to land degradation and substantial long-term economic losses while yielding large short-term profits for a few people.

Sustainable timber harvesting methods such as selective logging have to be introduced and controlled. The new satellite sensors now make possible investigation of the structural variation, quick change and economic potential of the remaining rain forest resource. Information derived from satellite images can facilitate evaluation of the environmental importance and agricultural potential as well as nature conservation aspects. A satellite based monitoring system allows detection of natural



LANDSAT image of the Kahayan river, central Kalimantan.

disasters and human over-exploitation. Changes in land use patterns and impacts upon the forest resource (including illegal logging and land settlement) can be quantified and mitigating action can be undertaken.

Cloud-penetrating radar

Passive electro-optical satellite sensor systems (e.g., LANDSAT TM, SPOT and IRS-1) have a major disadvantage in tropical regions because they cannot penetrate the cloud cover that masks these landscapes frequently. In more than 20 years of LANDSAT operation it has not been possible to acquire a cloud free image of certain parts of Kalimantan.

This problem can be circumvented by using active radar satellite systems, for example ERS (European Radar Satellite with C-Band), JERS (Japan Radar Satellite with L-Band), and RADARSAT (Canadian Radar Satellite with C-Band) that can penetrate cloud cover and deliver perfect images even at night.

Only single wavelength systems are available at present, although multispectral systems are on the way. Currently, sensor fusion is the best tool by which to obtain the most useful results for land use planning and environmental monitoring. For this to be achieved it is necessary to use both LANDSAT Thematic Mapper and ERS1+2 Radar images, linked to intensive field checking. Optical images serve for basic land cover classification, and radar images are used to update data bases periodically. Additional information can be extracted by using radar images of the same location at successive time periods. Since the whole of Indonesia is covered by radar satellites every month, and each image is of the same quality, it is possible to perform multi-temporal analysis to detect environmental impacts and land use changes as soon as they occur.

Case studies from Kalimantan

Despite the great potential, radar techniques are still in their infancy in Indonesia. This may be due to the fact that radar satellites have been made available only very recently and because of the high technological input necessary to process the complex radar data into images that can be understood by cartographers and foresters. However, there are several examples in which the new radar technology is applied in Indonesia, mainly in the form of research cooperations between Indonesia and nations operating these satellites.

Examples from Kalimantan are land use planning, change detection monitoring, forest resource assessment and peat swamp forest classification. The aims of the land use planning project — a close cooperation of BPN and German experts — are to analyze the potential of the ERS-1 radar system for land use planning and mapping. The results so far show that radar is very competitive in costs, allows mapping at a scale of 1:100.000 and is the only instrument which allows efficient change detection monitoring.

Another project deals with peat swamp forest mapping. Indonesia contains one of the largest areas of intact peat swamp forest in Southeast Asia. Preliminary assessment using LANDSAT TM and ERS-1 image classification showed that it is possible to classify the mosaic of forest types into 5 or 6 categories which have been related to differences in forest structure, peat depth and hydrology in the field. This information is extremely useful in land use planning tasks of the peat swamp forest resource. Furthermore, it is planned to supplement an existing forest fire monitoring and early warning system based on NOAA images with information from radar satellites.

The multitemporal ERS-1/2 change detection analysis will allow to produce a high resolution map of fire occurrences, to estimate biomass loss, to calculate financial losses in timber value and CO_2 liberation. The final output will be a fire risk map for efficient fire prevention measures.

Recommendations

Development of rain forests must proceed gradually and be limited by existing levels of technological and scientific knowledge, especially with regard to agronomic, economic and ecological viability and sustainability. Much more information is required on their long-term agricultural potential, sustainable management and nature conservation.

Radar systems like the European ERS-1/2 satellites close an important gap for large scale mapping and regular monitoring in regions without infrastructure. The most important advantage of radar compared to other remote sensing satellites is its capability to penetrate the cloud cover. This opens up the possibility to receive a set of new images of, for example, the whole island of Kalimantan every month.

Even with a lower resolution and less information content compared to SPOT and LANDSAT images, ERS-1 images can provide information about areas which are virtually unknown. Unique to the radar systems is the possibility to analyze series of 20 or more images acquired at successive time points over a certain area. This allows an extremely detailed change detection analysis.

In the framework of a multistage monitoring system to be developed, radar images can be used for initial mapping and monitoring. Areas of interest then can be examined in more detail using conventional survey methodology like high resolution optical images from space, aerial photography, and ground surveys. Such a procedure would save time and money, by looking only at regions where unwanted changes can be detected. Under these circumstances radar satellites can provide essential information in the most endangered and inaccessible regions.

This article was jointly produced by researchers Dr. H.D. Viktor Boehm, Dr. Florian Siegert, Dr. Jack Rieley and Ir. Suwido Limin. They are respectively from Eurocopter (Germany), University of Munich (Germany), University of Nottingham (UK) and University of Palangka Raya (Indonesia).