THE DEVELOPMENT OF AN INTEGRATED SURVEYS AND MAPPING SYSTEM IN INDONESIA

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ABSTRACT

Indonesia has initiated a nationwide integrated resource survey and mapping program as part of its national development plan since 1969. When it started, topographic map cover and resources information (land use, soil, forestry, etc.) were grossly inadequate to permit a precise appraisal of existing resources.

Ideas have been developed to integrate basic mapping and resources inventory as more and more basic data, such as aerial photos, airborne and satellite imagery, are collected.

With the advancement of new technology in automation and digital analysis of imagery, a concept has been developed to integrate both activities into a georeferenced based information system.

This paper shows the problems as well as the progress made in this new technology.

1. INTRODUCTION

In the years before the Government entered into a comprehensive National Development Plan, no substantial mapping activities were carried out, both systematic or on a project basis (project mapping).

However, as soon as the First Five Year Development Plan was started in 1969, the need for maps at various scales, resources as well as topographic maps, was sharply felt and demand sharply rose. Because of the small coverage of systematic mapping at that time, and where available, mostly outdated and at small scales, it was quite clear that assessment of the country's resource endowment was difficult, not only for project planning, but for national and regional planning as well.

As a consequence, both activities are urgently needed. This was already evident in the past. Hence, these activities are aimed at acquiring what is considered a required classification of the available resources.

In view of the national needs, a comprehensive nationwide integrated resource survey and mapping program has been initiated.

In order to make the various national agencies to work as a co-ordinated whole, the various national agencies concerned with the various national surveys and mapping programs have been called upon to carry out this program.

2. THE NEED

Due to the fact that the country, which is in the process of achieving rapid economic growth, is still at its early stage of development, national and regional planning will have to serve as a guideline for the country's development.
As a consequence, the various projects had to undertake its own mapping, both at medium and large scales, to fulfill the requirements. This was also due to the fact, that most of the mapping agencies were not ready to support the sudden demand for maps. Hence, the situation caused further fragmentation in the mapping activities, resulting not only in low efficiency and inconsistency, but what is often more serious, in non-uniformity in map projections, scales, classifications, symbolizations, reference systems and other aspects which are required to facilitate comparative evaluation and interpretation as a firm basis for planning in a regional context.

In view of the above sudden increase in the demand of up-to-date maps, a national program was set up for the systematic production of base maps, providing at the same the base materials for initiation of a systematic inventory of the country's natural resources. In order to achieve effective co-ordination in the mapping activities of the various mapping agencies, the need was felt for a development-oriented national mapping agency, provided with the means to effectuate the needed co-ordination.

In this relation, BAKOSURTANAL, the National Co-ordination Agency for Surveys and Mapping, was established in 1969 and was given the responsibility to carry out the program and co-ordinate its execution. In this context, the Agency was provided with equipment to enhance the national capacity for the production of base maps and to support resources mapping agencies with specialized services, thus augmenting its capability to carry out effective co-ordination.

2. THE NEED FOR SYSTEMATIC RESOURCE INVENTORY

Due to the uneven distribution of our population of about 180 millions, of which 82 millions inhabit the Island of Jawa and the two neighbouring small islands to the east, Madura and Bali, there is a considerable overpopulation on these relatively small islands with an area approx-188,000 sqkms out of a total land area of about 1,959,200 sqkms.
This reflects in the extremely intensive resource use, in particular in terms of the forest and the land resources. This, in turn, brings about a detrimental effects, such as erosion, land-slides, floods in the rainy season and shortage of water in the dry season. Lands become critical and infertile.

On the other hand, much larger islands, such as Sumatera, Kalimantan, Sulawesi and Irian Jaya, are underpopulated, resulting in under-exploitation of resources and shifting cultivation, often creating expansion of fields covered with "alang-alang" grass (imperata grass) which makes lands, again, infertile.

As the agricultural sector will still be the one to provide in the greater part of the required job opportunities, habitat and food, extensification of agriculture and the transmigration from the density populated areas to the sparsely populated areas on the islands are contemplated to provide the most suitable solution. However, this does not imply that the other sectors, such as mining, industry and trade will not obtain proper attention. On the contrary, these sectors are to be developed not only to broaden the economic base, but more so to render a firm base as well as to back-up above agricultural and transmigration programmes.

Particularly, when the main national income from oil revenue is decreasing the boost to export agriculture commodity is strongly advocated, hence, the need of new land for plantations of oil palm, cocoa, coffee, tea and other horticulture is strongly felt.

In view of the above, and realizing serious deficiencies in the availability of the necessary up-to-date information on natural resources and the physical environment, a program has been set up for the systematic mapping and inventory of the entire national territory as well as the evaluation of land resources.

In view of the vastness of the territory to be mapped, the complexity of the problems to be solved, and, hence, the wide range of resource information needed, the program has to be carried out according to a concept of pragmatic approach.
3. THE PRAGMATIC INTEGRATED APPROACH

The Program consists of 3 components:
1. the base mapping
2. the resources inventories
3. the resources evaluation

The base mapping is the responsibility of BAKOSURTANAL.
The resources inventories are the responsibility of the respective sectoral resource mapping agencies: the Department of Home Affairs for Land Use and Cadastral survey and mapping; the Department of Agriculture for Soil survey and mapping; the Department of Public Works for, among others, water resources inventory; the Department of Mines and Energy for geological mapping; the Department of Forestry for forest inventory and mapping, etc. BAKOSURTANAL conducts also land cover and geomorphological mappings from imagery to fill the gap of information.

For resource evaluation, a Project Co-ordinating Committee (PCC) is set up as a steering committee to give guidance and co-ordination in the implementation. It comprises the officials representing resources, planning and financial matters from Government agencies involved directly or indirectly in the integrated resource evaluation and planning.

In order for the Program to reach the required goals in support of the sustained and rational development and management of the national resources, the Program is carried out along the following principles:

1. integration of disciplinary activities
2. integration of base mapping with the resources inventory
3. integration of survey techniques
4. integration of resource evaluation

4. INTEGRATION OF DISCIPLINARY ACTIVITIES

The various sectoral resource mapping agencies take part in the integrated Program in accordance with their respective functional fields, so as to
ascertain that activities are carried out according to their field of responsibilities, expertise and experience.

The integration of the functional participation is achieved by means of the goals and objectives set and the guidance provided by the PCC, the use of a standardized national base maps, the centralized acquisition of multi-level and multi-sensor "photographic" base and the channeling of the map based information through a computerized Resources Information System.

In view of the vastness of the territory to be covered, the inventory is carried out through a Regional Resource Survey approach, based on priorities and directed toward the acquisition of resource information necessary for the formulation of sound plans for sustained resource use and management in each ecologic region.

For the island of Java and other densely populated areas, where the intensive resource use has caused ecological imbalances, the development effort is directed towards rationalization of resource use and rehabilitation of critical lands.

For areas outside Java with low population density, the development efforts are geared toward finding new settlement areas for the transmigration program, mostly from Java and Bali, in conjunction with boosting agriculture production of food and cash crops, taking into account the environmental conditions and impacts. These goals determine what resource information is required for the relevant planning, and hence, the inventory activities from the respective sectoral resource agencies.

5. INTEGRATION OF THE BASE MAPPING WITH THE RESOURCE INVENTORY

To optimize efficiency and economy in data acquisition as well as in the relevant data processing, the base mapping and resource inventory activities are integrated through the following measures:

(a) the introduction of (ortho) -photo map as base map, facilitating the transfer of the resource information to the base map;
(b) the common use of the (same) photographic base for production of the base map as well as for resource interpretation;

(c) the introduction of a dual camera aerial photography system with different focal lengths and emulsions, providing as well a multi-stage base for resource inventory;

(d) the provision of the geographic grid in the UTM projection system as a reference system for the resource information, facilitating the computerized overlaying of resource information.

(See Fig. 1).

6. INTEGRATION OF SURVEY TECHNIQUES

The introduction of survey techniques through remote sensing from high altitude aircraft and from satellites, has opened new horizons for development of methodologies which could enhance efficiency and economy and even accelerate the acquisition of resource data. The multi-stage approach has shown to be effective as well as efficient, as it minimizes the need for direct on-the-ground checking, which for many areas outside Java with very limited transportation network would otherwise be very costly and time consuming.

For areas with persistent cloud cover, the side looking airborne radar (SLAR) as well as the Synthetic Aperture Radar (SAR) are utilized. At present, 15% of the land area where aerial photography never succeeded in the past due to persistent cloud cover, is now covered by SAR.

The introduction of other sensors than conventional aerial photography, such as the multiband camera, thermal scanner, etc. is incorporated into the existing survey techniques and integrated into a multi-stage and multi-sensor approach in the acquisition of data for the inventory of resources.

(See Fig. 2).
7. INTEGRATION OF RESOURCE EVALUATION

Besides the conventional single-resource map, composite maps are to be produced with requirements of decision makers and planners, combining resource requirements with consideration of social and environmental impacts. These composite maps will be generated from digitizing the resource maps produced by the sectoral resource agencies, and through computerized overlay techniques, providing alternatives for optimal resource use in conformity with economic, social and ecologic considerations. This will be carried out in the computerized Resource Information System, based on the national geographic reference system. In addition to its flexibility, the computerized information system provides continuous updating of resource information without the necessity to wait for the revised map edition.

8. IMAGERY FOR BASE MAPPING PROGRAM

A mapping program to provide a national topographic map coverage for Java and Bali at 1:25,000 scale, for Sumatera, Kalimantan, Sulawesi and Maluku at 1:50,000 scale was started in the early seventies with a view of obtaining up-to-date information. Considering the level of development in Irian Jaya, the map scale was decided at 1:100,000 scale.

Although the reconnaissance level resource inventory requires information at 1:250,000 scale, the above large scales were decided upon for the following reasons:

a. In Indonesian tropical conditions, the smallest photographic scale possible is 1:100,000, obtained through the use of superwide angle cameras. This is due to the cloud cover ceiling;

b. With the above photo scale, accurate 1:250,000 scale (orthophoto) maps can easily be produced through reduction (photographic reduction in the case of photomaps);

c. Densely forested areas may require at least 1:100,000 scale for forest purposes;

d. Though true reconnaissance level progress

With the above mention of the planning needs for the above mentioned, 100,000 scale drawings of Tengara and the Kalimantan have been obtained from film and photo Peta. Since approx. 90% of the false color peta is obtained from the same source and the entire peta has been simultaneously acquired without geographic overlap.

For Java, the 1:50,000 scale detailed topographic maps are already available. In the above mentioned, the superwide angle photos were obtained at 1:100,000 scale. The above mentioned simultaneously acquired 1:50,000 scale (eventually superwide) photos will be used for groundtruthing. Besides the above mentioned, the superwide angle photos of Southern Kalimantan will be flown at 1:250,000 scale.
c. Densely populated Jawa and Bali with intensive resource use, require at least 1 : 25,000 scale for resource and environmental management purposes.

d. Though outdated, the 1 : 250,000 scale JOG map still can be used, but progressively updated using new photography and Landsat imagery.

With the above approach, conceptional, regional as well as sectoral planning needs can simultaneously be accommodated.

For the base mapping program, the following aerial photography has been obtained systematically since 1974: Sumatera, Irian Jaya and Maluku at 1 : 100,000 scale, while for Kalimantan, Sulawesi, Jawa and the Nusa Tenggara islands a dual camera system was introduced. The scale for Kalimantan and Sulawesi was 1 : 100,000 on panchromatic black and white film and 1 : 60,000 scale on false color-IR film, flown at an altitude of approx. 9,000 m. This caused gaps of ± 20% between flightlines of the false color-IR photography, which was a compromise solution to simultaneously obtain both scales, without changing the flight plan and without gross increase of the budget.

For Jawa, Bali and the Nusa Tenggara islands the scales are respectively 1 : 50,000 for the panchromatic and 1 : 30,000 for the false color-IR photography, flown at ± 4,500 m altitude.

In the above photography, the panchromatic photography was taken with superwide angle lens, while the false color-IR with wide angle lens.

With the above dual-camera system, two-stage aerial photography was simultaneously acquired to facilitate the resource inventory, as part of the multistage approach, integrating where available Landsat imagery (eventually also radar imagery) with aerial photography and the necessary groundtruthing.

Except for the central and north-eastern part of Kalimantan, in the photographic seasons of 1981 and 1982 almost full coverage was obtained of Southern Kalimantan, Sulawesi, Jawa, Bali and the Nusa Tenggara islands, with insignificant gaps here and there, which are in the process of being flown at somewhat lower altitude so as to increase possibility of success.
For the central and north-eastern Kalimantan, as well as central part of Irian Jaya, Synthetic Aperture Radar of the Star-1 system of the Interan Technology Inc. from Canada was flown with great success in April/May 1986. The coverage was approx. 300,000 sqkms. (See Fig. 3).

9. THEMATIC MAPPING FROM IMAGERY

Considering the size of Indonesia, prevailing adverse weather conditions in some regions and the complexity of its vegetation and landuse pattern, multistage and eventually multisensor remote sensing, including the required ground checks is the most efficient method to collect the vast amount of data, particularly in the systematic approach.

Supplemented by existing results of resource inventories, Landsat imagery, aerial photography at various scales, airborn as well as space born Synthetic Aperture Radar and groundtruth surveys are used as components of an integrated system for the acquisition of up-to-date information.

Using this method, through conventional interpretation of enlarged Landsat imagery, complemented by the base mapping photography, quick classification of extensive areas in Sumatera, Kalimantan, Sulawesi and Irian Jaya into broad land system and land cover classes were carried out. A similar approach was carried out for the inventory of small holders estates, amongst other small holders rubber, distribution of sago palms, coconuts and other cash crops.

To increase accuracy and levels of classification, a computerized image analysis system, the DIPIX ARIES II System, is operational.

The system will be utilized for the productions of agro-ecological map and the agro-climatological map in the Land Resource Evaluation & Planning Program as well as in the monitoring of critical lands and the management of watersheds.
10. AUTOMATION IN PHOTOGRAMMETRY AND CARTOGRAPHY

To answer urgent requirements, simultaneously photomaps will be produced, by plane rectification for flat areas and orthophoto processing for the more mountainous regions, using the Wild Avioplan OR-1 system.

For the above operations, Wild E-4 and Zeiss Oberkochen SEG-6 rectifiers and a number of Wild B-8S stereoplotters are available. With this approach, urgent resources agencies will have earlier access to the required base maps to facilitate them in transferring the results of resource interpretation from imagery.

To make the system more versatile and speed up the cartographic process through automated cartography, the photogrammetric system at BAKOSURTANAL is developed into a Computer Assisted Photogrammetric Compilation and Drafting System (CAPCADS). The B-8S plotters are provided with tri-axis locators, digitizers and recorders.

This will enable direct drafting of hardcopies on the on-line connected AVIOTAB system, and simultaneously establish magnetic tape storage of all digitized data (planimetric and DEM data), thus enabling development of a computerized Topo Database.

In addition, through the SORA-OPS program the DEM data could be processed to drive the OR-1 for the production of orthophoto.

11. RESOURCE INFORMATION SYSTEM NETWORK

In view of the multidisciplinary character of development, and hence the need for cross-sectoral exchange and use of data, there is an apparent need for the development of a network of sectoral databases, maintained by the respective resource agencies as components of an integrated entity. Hence, the concept of a Resource Information System Network.

Besides the use of a common geographic reference system provided by the National Base Map, the development of common standards, of standardized classification systems and symbolizations, aiming at cross-sectoral
compatibility and hence, facilitating integrated analysis, the development of a legal basis and appropriate procedures are important aspects for its successful establishment and operation.

Since the final objective of the above information system is the integrated analysis, to facilitate the storage, retrieval and integration of the relevant data, a computerized system was established in BAKOSURTANAL based on the geographic referencing concept, hence the GIS is established. (See Fig. 4).

The computerized system includes:

a. the Resource Information System, storing digitized resources data for integrated analysis and presentation on integrated resource maps;

b. the Topo Database or the digital base mapping data

c. Map and Photo Library, including recording of resource surveys.

12. THE LAND RESOURCE EVALUATION AND PLANNING PROJECT

This Project, funded by the Asian Development Bank has been started since April 1986.

The ultimate objective of the Project is to improve land resource evaluation and planning to the long term benefit of the country and the large numbers of individuals who depend on the utilization of land resources both directly and indirectly. In order to meet these objectives it is necessary to provide to the planner all the data required for optimum planning, and the means by which these data may be managed.

The Project would, therefore, be concerned with three broad areas: the collection of new data, the organization and distribution of new and existing data, and the introduction of modern systems of data management for planning purposes.
In carrying out these objectives the Project would serve as a major institution building programme in many aspects of providing and using the data required to plan resource use. It would, further, greatly enhance inter-departmental coordination and sharing of information which is essential to fully integrated and rational planning, since planning of land resource utilization requires the complex integration of a number of factors - physical, economic and social.

It is recognized that it is at the provincial level - where local (bottom-up) and national (top-down) planning meet - that the facility for integration the multiplicity of factors required for rational planning is most urgently needed. A prime objective of the project would be to provide the technology now available for this and the skills to use it at the provincial planning level (BAPPEDA).

The man-power development would be an essential part of the Project and provision has been made for formal institutional training within and outside of Indonesia. The provision of technical assistance from developed countries would allow for extensive on-the-job training as well as for graduate studies. The new skills need also to be transmitted to a great number of people over a wide area.

To meet these requirements the Project would provide for the establishment of a training center for practical centralised training and the facilities for preparing training materials for "distance-learning".

To meet the objectives described above the Project comprises 11 components. Certain components are dependent on the output of others, while all components are strongly linked through the geographic information systems networking and in the provincial planning procedures. The eleven components are described briefly below:

1) National Base Mapping

Accurate and up to date base mapping is prerequisite to effective land resource planning. This component would provide new national
base map coverage at scale of 1:250,000 in addition to the already programmed 1:50,000 scale for outside Jawa.

(2) National Reconnaissance Soil Survey

All land resource planning requires a knowledge of soils and physiography. While individual projects need detailed soil mapping of specific areas, the initial selection of areas requires good reconnaissance scale mapping. Only 30% of Indonesia is covered by reconnaissance maps resulting in poor project site selection and wasted effort at the detailed survey level. This component would provide soil mapping at a scale of 1:250,000 over most of the country. In 1986 – 1989, about 30 million hectares will be mapped in Sumatera.

(3) National Forest Inventory

Forests occupy some 75% of the land area of Indonesia, they represent one of the country's major resources and are currently the second largest source of export earnings. However, part of the land currently under forest cover must in the future be developed for agriculture use in conjunction of new settlements from the overpopulated areas of Jawa and Bali. Detailed information is required on the forest to assess the total resource, to plan its exploitation and to resolve these land use planning and its impact on ecology and environment.

(4) Land Use and Coordinated Land Cover Mapping

Mapping of the various components of current land cover is undertaken by a number of organizations. Current land use is mapped by the Directorate General of Agrarian Affairs; forest mapping is carried out by the Agency for Inventory and Forest Use Planning of the Department of Forestry and smaller scale overall land cover maps are produced by BAKOSURTANAL.
There is overlap in these functions and greater coordination is required. A working group has been established to set up criteria of and guidance for an integrated land cover mapping. The availability of almost complete national aerial photograph coverage and new base maps provides the opportunity to update the larger scale land use maps for non-forested land.

(5) Improvement of Climatic Data and Agro-Climatic Mapping

Long term climatic records are essential to the selection of optimum use of land, formulation of environmentally adopted cropping and forestry systems, prediction of yield and identification of major erosion hazard zones. At present, the 1.45 million sqkms of Sumatera, Kalimantan and Irian Jaya are covered by only 67 climatological stations and even these are concentrated in coastal regions. The Project is to provide 200 additional climatic stations and 2,000 rainfall stations required in Sumatera, Sulawesi, Kalimantan, Irian Jaya and Nusa Tenggara for an acceptable coverage in the future for land resource evaluation and planning.

(6) Agro-Economic Base

Land use planning requires up to date and reliable data on potential returns from alternative uses of land. This component would develop a national program for monitoring a selected sample of farmers to provide data on agricultural production, parameters of production, and the effectiveness of agricultural policies. It would simultaneously strengthen the institutional capacity for data management and processing in the context of economic analysis.

(7) Matching physical planning characteristics - as defined by land units or agro-ecological zones - with the potential uses of the land needs objective assessment of the precise requirements of farming and forestry systems.
This component would establish computer facilities and programmes to collate all existing data and would collect additional data by field observation to enhance the data base.

(8) Land Evaluation Computer Systems

A computerized method for such land evaluation (LECS) has been developed in Indonesia since 1980 oriented to detailed planning. The objective of this component is to modify and improve the existing system for utilization over the whole range of planning levels. At the same time the use of geographical information system programs to identify land systems and land unit boundary to complement LECS would be studied. The outcome should be a capacity to provide a land evaluation service to all relevant government institutions.

(9) Data Centers and Information Networking

Information required for land resource evaluation and planning is distributed through a number of government organizations, and even within a single agency may be widely scattered. Planners must have ready access to all elements of the data which, as far as possible should be uniformly formatted. The objective of this component would be to strengthen the existing and establish new data base centers, and networking these through a central computerized directory. Centers would be strengthened or established for aerial photographs, base maps, soil, climate, crop ecology, agro-economics and hydrology. Coordination of the component management of the central computer and responsibility for establishing unified data formats would be with BAKOSURTANAL. Individual data centers would be directly controlled by the sectoral organizations concerned.

(10) Integrated Provincial Land Resource Planning Procedures

Previous components of the Project would make available the information required for integrated land resource planning.

CONCLUSION

Indonesia's growth and development cannot be achieved without a comprehensive and well planned land resource management program. The result of the evaluation of these resources will be incorporated into Indonesia's planning and development basic data and infrastructure. At present, these resources are not fully understood. Moreover, the current situation is not ready...
This would have been formatted for computer analysis in a geographical information system. Provincial level planning is the critical point at which national and local planning must be integrated. A recent Government's regulation confirms the requirement for all data relating to the development of resource and potential to be made available to the BAPPEDAs (Provincial Planning Agency) who must coordinate the planning of all sectoral units. This component would provide the data and the data management facilities to the BAPPEDAs to enable them to fulfill this function.

(11) Center for Training in Data Interpretation and Management

The project involves the introduction of new technologies to a large number of people in various government organizations. This must be supported by the provision of training in the range of new skills required, such as in the areas of aerial photo and image interpretation, geographical information system and computer-based data management.

BAKOSURTANAL is responsible for developing and running the training center because the emphasis in the Project on modern systems of resource evaluation in which BAKOSURTANAL is closely involved. Close liaison will be needed with training colleges and universities both in Indonesia and overseas.

CONCLUSION

Indonesia is dependent on its land resources to sustain its current economy and ensure its long term growth. Selection of the optimum utilization of these resources is a complex procedure requiring a considerable amount of basic data and the utilization of those data in a logical decision making process.

At present there are serious gaps in the data required for land resource evaluation and planning.

Moreover, the data which have been collected are widely dispersed and often not readily available to many of the potential users.
This leads to duplication of effort and conflict of interest, which cannot be reconciled to the optimum benefit of the Indonesian economy.

With the above condition, the Government has embarked on a conscientious program of resources inventory, mapping and evaluation to enhance the planning process in the utilization of the resources taking into account the impact on environment and ecology.

The implementation of the Program would effect substantial institution building in many aspects of land resource planning, from the provision of basic data to the implementation of planning procedures.

It would introduce or reinforce the modern technology which is now available. Furthermore, through the integrated implementation of this multi-disciplinary and interdepartmental project, a high degree of coordination would be brought to the long term benefit of all the organizations involved.

At the end, manpower development is an essential part of the overall scheme, aiming towards the development of the national capabilities.

Cibinong, 24 June 1986

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