Guideline of Technical Transfer

on

Geographic Information System

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Table of Contents

Preface

Geographic Information System (GIS) technology is an information technology dealing with geographic information, has been beneficial in increasing efficiency in the planning and daily works of central and local governments mainly in developed countries. Recent benefits also include more efficient policy making through sharing of information, the provision of government information and other civil services.

On the other hand, development plans in some developing countries have to be formulated with insufficient information and few facts because of limited financial resources and/or personnel. This may have led to inappropriate political intervention. Therefore, efficient, scientific and appropriate planning using GIS applications with necessary information is greatly anticipated especially in some developing countries.

The necessary technologies in dealing with GIS are numerous and diverse. However, most of available materials on GIS are technical manuals and application examples that are intended for developed countries. GIS is now expanding into many application fields in many developing countries. However, there are still a lack of materials on GIS targeted for developing countries.

Secretariats of Japanese embassies, staffs of Japan International Cooperation Agencies (JICA) and Japanese experts have come to design and/or implement projects using GIS. Although they are not GIS experts, they are required to have an understanding general concepts of GIS.

When submitting budget request on project, mapping organizations are required to explain the benefits of GIS. Unfortunately, these organizations have a limited number of materials explaining these benefits.

This manual has been prepared to meet these needs. Special technical words are excluded as much as possible. Technical elements are described easily and simply. The manual focuses on benefits of using GIS in developing countries.

Outline of a GIS and its Benefits

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Summary

The following is an outline of GIS including background information, basic functions, various fields of applications, and the benefits of using GIS, such as information management, the visualization of information, information sharing and prompt and accurate decision-making.

1. What is a GIS?

A **geographic information system** (GIS) is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information (i.e. data identified according to their location).

It can present information in map form for easy interpretation and includes application software that can perform a variety of individual functions.

Geographic information can be classified into two categories: graphic information indicating positions of objects and attribute information including textual data, numerical values, and image data (geographic names and properties of roads, buildings, etc.). Since a GIS makes it possible to link graphic and attribute information, one can find an attribute of an object on a map, such as a road, building, etc. or display objects having a specific attribute on a computer screen.

2. History and Development of GIS

GIS was first developed in Canada in the 1970s. In the beginning, the development of GIS was hindered due to the fact that information technology was still in its infancy and the production of geographic information was costly. Today, however, the sophistication of peripheral information technology, the development of high-performance computers and software, the production of key digital data and the establishment of information and telecommunication infrastructure have enabled easy access and simple management of geographic information, which in turn have resulted in a rapid popularization of GIS. Today, GIS are being widely used in government offices, private businesses and a variety of situations in the lives of the general public.

3. Fields of Application of GIS

The most basic function of GIS is to record geographic data in layers according to categories, such as roads, buildings, drainage systems and so on. This makes it possible to display and map only certain data that is required.

A GIS is also capable of performing other manipulations such as overlaying different kinds of geographic information, retrieving objects that exist within a fixed distance from a road, determining the shortest route to a destination in a navigation system and so on.

As GIS are multi-functional, they can be applied to a wide range of fields. The fields of application vary between developed and developing countries. The following list shows possible areas of application in public administration that GIS may be useful.

- National and regional development planning
- Urban planning and regulations
- Planning for road construction and environmental assessment
- River system management and drainage basin management planning
- Planning for transportation systems and inland water management
- Irrigation planning and selection of crop plants suitable to a specific locality
- Forest management planning
- Disaster measures utilizing hazard maps
- Prompt responses to disasters such as fires
- Regional education planning such as distribution of elementary schools
- Regional medical-care planning such as distribution

of health care centers

4. Benefits of GIS

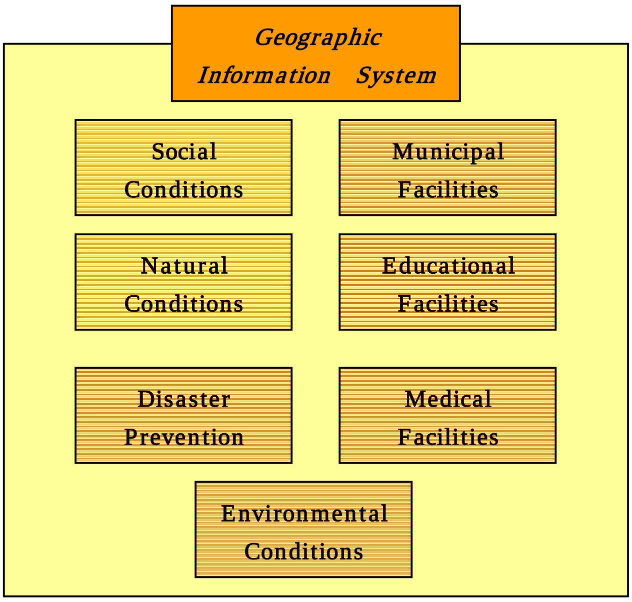
At present, a great number of international aid organizations are introducing GIS to their counterpart agencies and GIS is being widely used in a variety of fields. GIS may be considered a mere analytical tool, but because it can simultaneously handle cartographic data and attribute data by computer, it has benefits in areas such as the following:

(1) Information Management
(2) Visualization of Information
(3) Information Sharing
(4) Prompt and Accurate Decision-making

4.1 Information Management

A GIS makes it is possible to manage information with unprecedented efficiency. It has a database function within so that information can be updated and added to from a single point of access to provide the latest and most up-to-date information.

Take the field of agricultural development for example. In addition to cartographic data, various other kinds of information, such as present land use conditions, soil conditions, water systems, and population statistics are necessary. By using a GIS, it is possible to efficiently manage all this information from one location by storing it on the database.

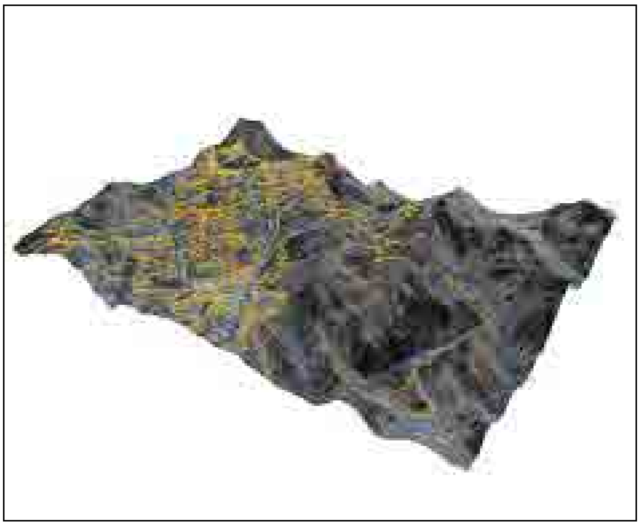


4.2 Visualization of Information

The second advantage is that by applying GIS technology, various types of information can be displayed in two-dimensional and three-dimensional forms.

Traditional topographical maps show the shape of the land's surface with contour lines but with only that it is difficult to grasp the actual shape of the area. However, by using the 3-D analysis of a GIS, you can create a DEM (Digital Elevation Model), compound it with an aerial photograph and prepare a bird's eye view map. This enables one to visibly grasp the topographic conditions. In addition, a GIS has an overlay function with which various kinds of other information can be superimposed making it possible to understand the cause-and-effect relationships among the different elements in the target area. Furthermore, statistical data, such as population and observation data, are usually kept in registrars but with GIS you can graphically display this information.

By applying GIS in such a way, it is possible to transform ordinary maps and statistical data into information that can be visualized.



3-D visualization of an image using a DEM

4.3 Information Sharing

The third advantage is that you can share the information in a database that is constructed.

For example, a department in a ministry or agency can effectively use a database it constructs by storing it on servers making it available to other departments through the network. However, as there is a problem of security, the system should be set up so that only the department that constructed the database can control the data (updating, deleting, etc.) while the other departments simply have access to the information.

In addition, databases can be used effectively in a variety of fields, such as education, by making them accessible to ordinary citizens through the Internet. It is particularly useful in the environmental field, as it is possible to create a GIS database for regional environmental conditions so that the public can have access to information such as how different areas are affected by pollution, and what policies are being implemented to cope with these problems.

4.4 Prompt and Accurate Decision-making

Finally, with a GIS, information can be interpreted quickly and accurately, when important decisions need to be made. For example, in the event of a disaster, (i.e. fire, flood, earthquake, volcanic eruption, etc.), the danger areas and where they are going to spread to have to be instantaneously analyzed and interpreted so that the public can be notified of escape routes and places of refuge. Without a GIS, it takes a considerable amount of time to speculate about the danger areas while overlaying various kinds of information on ordinary maps in order to work out the best routes of escape. However, with a GIS, information can be linked, or integrated to geographical locations so that present conditions can be grasped with precision. In addition, information that is gathered in the form of numerical values can be used to simulate the extent of the disaster, and if you go one step further and layer on road network data you can add in various other elements to determine the shortest and safest escape route.

By using GIS functions in such a way, it is possible to make prompt and accurate decisions.

Reference: Utilization of GIS in the near future, Japan Construction Information Center, April 1998.

The Development of National Spatial Database Infrastructure in Japan

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Abstract

Geographic information data used for GIS is called “spatial data”, which has information of geographic locations such as latitude/longitude, place name, and address. In Japan, National Spatial Data Infrastructure is designated as fundamental information, which describes characteristics of the national land, selected from various kinds of spatial data. National Spatial Data Infrastructure is categorized as spatial data framework, basic spatial data, and digital image data. Particularly spatial data framework is geographic data, which is considered as the framework for information used in GIS and can be utilized by linking to basic spatial data such as statistics and inventories. The Japanese government announced that National Spatial Data Infrastructure would be an infrastructure supporting higher information-oriented society in the 21st century and has made an effort primarily to develop spatial data framework as a part of the establishment of the environment to diffuse GIS in the entire society in general as well as government bodies. In addition, the improvement of data distribution and the environment for users have a very important aspect. Thus, the government has also been promote to achieve an effort to develop the environment for users, such as the standardization of geographic information, the establishment of clearinghouse, the provision of geographic information on the web.

1. Background

The Great Hanshin-Awaji Earthquake in January 1995 raised a substantial issue that associated organizations couldn’t share various types of information needed for the rehabilitation of the cities. Exchanging information among others was necessary to identify the condition of damages by the earthquake quickly, rescue casualties right after the disaster, propose the rehabilitation plan, and so forth.

Most information they needed was required to confirm geographic locations on the map. For example, it was essential to know what kind of damages and where they are, which shelter who stays, which building is destroyed and has to be removed, and where those buildings are located, how the rehabilitation of the cities should be geographically carried out in urban planning.

The national government recognized a lesson from above and the effort to develop National Spatial Data Infrastructure (NSDI) in the United States. “A Liaison Committee of Ministries and Agencies Concerned with Geographic Information Systems” was established in September 1995 so that government bodies could collaborate in terms of the diffusion of GIS. Two task force groups, i.e. Spatial Data Framework Task Force Group and Basic Spatial Data Task Force Group were formed, each of which had a few working groups to discuss more specific topics in detail.

The Liaison Committee formulated a Long-term Plan in 1996 for the development of NSDI in Japan. The Plan specifies actions to be taken by the Government during the two-phase period starting in 1996 up to the beginning of the 21st Century. The first phase focuses on development of the definition of the NSDI in Japan as well as standardization of metadata and clarification of the roles of the Government, local governments and the private sector, rather than actual spatial data development. The implementation of NSDI including spatial data set development for NSDI is expected in the second phase. Approximately three years are assigned to each phase, i.e. the first phase (1996-99) and second phase (1999-2001).

In accordance with the Long-term Plan, Geographical Survey Institute (GSI), a national mapping organization in Japan, started research on GIS standard of Japan in 1996. This study was intended to provide a technological backbone to the Japanese SDI standard discussed in the Liaison Committee. 53 private companies are involved in this three-year research project funded by the Ministry of Construction, now the Ministry of Land, Infrastructure and Transport, as one of the collaborative research project with private sector. Two kinds of standards were developed through this research: spatial data exchange standard and spatial data development standard. 6 working groups were established to discuss 8 work items including data structure, data quality, georeferencing, metadata, and cataloguing. Spatial data development standard includes a guideline to develop specifications for spatial data development contracts. The final drafts of these standards were completed at the end of FY 1998.

The Committee adopted Final Report of the First Phase of the Long-term Plan on March 30, 1999. The Final Report entitled “Standards and Development Plan of National Spatial Data Infrastructure” includes two standards of Japanese NSDI (i.e. a technical standard that is based on ISO/TC211 standard drafts, and a list of data items adopted as the framework data) and a development plan for the second phase of the Long-term Plan. The technical standard included in the Final Report was developed through collaborative research mentioned above.

2. The Concept of National Spatial Data Infrastructure

The Liaison Committee designates National Spatial Data Infrastructure as a basic data out of various kinds of spatial data and categorizes them into three, spatial data framework, basic spatial data, and digital image data.

2.1 Spatial data framework

Spatial data framework is fundamental geographic data that is applicable to GIS, such as data of topography, place names, political boundaries, and transportation network in the nation, and can be utilized by linking them to statistic data or information of inventories. It corresponds to national digital geospatial data framework in the concept of U.S. NSDI

Moreover, spatial data framework has the most frequent use of data than other types of data and gives a large impact on the society and economy. Therefore, the nation, local governments, and private corporations have to be cooperating together in order to develop items of data primarily, which are selected as “spatial data framework standard” (shown in table 1).

The governmental organizations have been developing geographic information, which is to be elements of the framework of data required to operate GIS, and begun providing them via online media like internet and electronic media like CD-ROM. The data of geographic information includes geodetic control points, road/railroad network, coastlines, public buildings, place names, administrative boundaries and so on.

Table 1. List of Data Items Identified as Spatial Data Framework

Categories	Items of data
Geodetic Control Points	National and Public GCPs
Elevation	DEMs
Transportation	Road Network, Road Boundary, Railroad Network,
Rivers, Coastlines	River Network, River Boundary, Coastlines, Low Tide
Land	Parcel Boundary, Forest Boundary
Building	Public Building, Privately Owned Building
Georeference	Geographic Names, Address, Administration Boundary, Census Boundary, Standard Cells

2.2 Basic spatial data

Basic spatial data is primary data from the public aspect, which can be open to public and link or overlay spatial data infrastructure. This type of data includes data of statistics and inventories described about the nation and thematic geographic maps. Data of statistics and inventories is what is associated with population, social/economic activities, the prevention for disasters, environment, while thematic geographic maps is what illustrates the distributions of native plants, land use, geology, topography, and etc.

Besides, items of data about basic spatial data is not selected unlike spatial data framework because it is expected that the items of data considered as basic spatial data will change according to the transformation in the society and economy.

2.3 Digital image data

Digital image data is designated mainly digital images obtained by aerial photos or image data by artificial satellite. These digital image data are not only utilized in obtaining and updating data for spatial data framework but also presumably applied to a background image in GIS by transferring into orthophotos.

It is expected that particularly satellite images will be utilized as a background image in GIS, since images from artificial satellite have been produced with high-resolution in the market, can be obtained data by digital type generally, and can be covered a larger extent than aerial photo can cover.

3. Perspective of the Development of National Spatial Data Infrastructure

As mentioned above, national spatial data includes maps, statistics and inventories, images and etc. In this context, the central government should not develop data independently but direct local governments and private firms to developing and providing data by assigning a part of role respectively. The goal is to share data among organizations as an infrastructure of the entire society.

Therefore, the central government not establishes a whole new database but compiles basic data out of the existing data already developed individually by other organizations. Since most data are provided on the web as a general role, users can obtain data they needed from database online network by downloading and apply these data by linking or overlaying depending on their purpose.

4. The Environment for Users of National Spatial Data Infrastructure

It is essential to allow users easily to pull out data they need so that users can obtain and apply data they need from database online network by downloading. In addition, all data are standardized and compatible to use among others. Therefore, in terms of the provision of data, it is ideally requested that everyone can obtain them without charge or for reasonable price and it has to be minimized constrains on the usage of data.

Above mentioned, it is important to arrange the environment to distribute data since spatial data are produced individually by different organizations. There is a reason why the government has made an effort developing the environment for these users. The environment for users of GIS is progressed surely by the efforts, such as the establishment of data clearinghouse to search the existing GIS data, standardization of GIS to promote data sharing with others, and the provision of data owned by the nation on Internet.

In a broad sense, the concept of National Spatial Data Infrastructure might include the environment for users.

5. Agreement on the Targets and Specific Actions

The Liaison Committee agreed upon the targets and specific actions of the members to facilitated development and utilization of GIS in October 2000. The first target is a digitalization of geographic information and its provision service through Internet. GSI develops Digital Map 2500 (Spatial Data Framework) by FY 2000 for urban planning area and Digital Map 25000 (Spatial Data Framework) by FY 2001. The National Land Agency (now the Ministry of Land, Infrastructure and Transport) develops georeferencing data for districts. The target year for starting Internet service is FY 2000 for georeferencing data, FY 2001 for Digital Map 2500 and FY 2002 for Digital Map 25000. The second goal is to develop metadata in parallel with basic geographic information and establish clearinghouse for data-sharing within the government to minimize redundancy and also enable an easy access from private sectors. The government clearinghouse operated by GSI was released in March 2001. The third point agreed upon is standardization of geographic information developed by GSI and privatre sector in accordance with the Japanese Industrial Standard.

6. Clearinghouse

The Long-term Plan also specifies the need of establishing a clearinghouse system for spatial data. In this context, GSI has been engaged in a Geographic Information Directory Database (GIDD) as a five-year project since April 1994. This database was designed to provide directory information (i.e., metadata) of spatial data through computer networks, and to function as a clearinghouse node by developing a search environment of distributed databases. The metadata standard, which was used in the GIDD, was developed as one of the work items of Spatial Data Exchange Standard of "Research on GIS Standardization" described above. This standard was determined as Japan Metadata Profile (JMP) after additional necessary modifications. A prototype of GIDD with limited search capability was developed and examined practically. It was followed by the development of the second-generation system by GSI, to enable users to place requests to multiple database servers on the global network using ISO 23950. It has been available since March 2000. ISO 23950 is a client/server type protocol and was incorporated into the Japanese Industrial Standard (JIS X 0806: 1999). The URL of this clearinghouse gateway is:
http://zgate.gsi.go.jp/

At the same time, GSI added a clearinghouse node server to the international geographic clearinghouse coordinated by the U.S. Federal Geographic Data Committee. Up to the end of September 2001, over 900 metadata are registered in the GSI node. In addition, GSI asked the other government ministries and agencies concerned with geographic information to prepare metadata and clearinghouse node servers. As a result, as of January 2002, 12 node servers were developed by government ministries and agencies, as well as relevant organizations, and 20 node servers including by the foreign and international organizations has been registered in the clearinghouse gateway managed by GSI.

7. Future Efforts

Although the effort to develop GIS in Japan has begun later than other nations, it is clearly seen the steady progress by that the Liaison Committee established in 1995 has organized the concept of National Spatial Data Infrastructure and has been developing basic data of GIS and the environment for users.

In the future, it is necessary to develop the present infrastructure further and achieve the effort to increase the use of GIS substantially by applying data and the environment of GIS to different fields.

In order to respond to these needs, the Committee has drawn up a new four-year Long-Term Plan starting from FY 2002 to promote further dissemination of GIS in Japan, aiming at realizing to: streamline office work and improve civil services in the governmental organizations; create a new business model and produce new employment in the industry; and have the people enjoy quality service in their general life.

NSDI, RSDI, GSDI and Global Mapping

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Abstract

The concept of SDI (spatial data infrastructure) has become popular since the middle of 1990s. It is that spatial data can be viewed as an infrastructure with the same rationale as roads, communication networks etc., which is needed to support the economic, social and environmental objectives. SDI includes the technology, policies, data, standards, human and financial resources necessary to acquire, process, store, distribute and use spatial data. The core components of SDI are: clearinghouse; metadata; standards; and framework data. There are three levels of SDI: national (NSDI); regional (RSDI); and global (GSDI). United States started the development of NSDI in 1994 under the coordination of the Federal Geographic Data Committee (FGDC). To date, more than 30 countries have or plan to have NSDI initiatives. In 1995, the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) was formed, and published a paper on the vision of the Asia-Pacific Spatial Data Infrastructure (APSDI) in 1998. Europe and the Americas are making similar efforts for RSDI. GSDI initiative is lead by GSDI Steering Committee. In 2000, it published SDI Cookbook for sharing the experiences in building SDI implementations. Global Mapping is an international collaborative initiative through voluntary participation of national mapping organizations, aiming to develop globally homogeneous geographic dataset at the ground resolution of 1 km. Currently, 10 countries have released their Global Map version 1.0, which are available via Internet at no cost.

1. National Spatial Data Infrastructure (NSDI)

The concept of national infrastructures is not new. In all nations, the major road and telecommunication networks, and basic health and education facilities, have been funded by governments. The rationale is that it is a legitimate role of government, on behalf of the community, to provide a common, consistent infrastructure upon which a variety of government, private sector and community activities can take place. Spatial data can also be viewed as an infrastructure, with the same rationale and characteristics as roads, communication networks and other infrastructure. A spatial data infrastructure (SDI) is needed to support the nation's economic growth, and its social and environmental objectives, underpinned by international standards, guidelines, and policies on access to those data.

The concept of National Spatial Data Infrastructure (NSDI) was firstly proposed in the Executive Order 12906 of the U.S. President Bill Clinton titled "*Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure*" published in 13 April, 1994.

According to the document, NSDI is defined as "*the technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data*".

An executive branch in the Federal Government was ordered to develop a coordinated National Spatial Data Infrastructure to support applications of geospatial data for public and private sector, in cooperation with State, local, and tribal governments, and the Information Infrastructure, avoid redundancy and promote effective and economical management of resources by Federal, State, local, and tribal governments.

Thereby, the Federal Geographic Data Committee (FGDC) chaired by the Secretary of the Department of the Interior and composed of 14 federal agencies that produce and use geographic data, was nominated as the coordinating body for the Federal Government's development of the NSDI.

The FGDC developed Strategic Plan for the NSDI in 1994, which was revised in 1997, setting out the vision for the NSDI as: *Current and accurate geospatial data will be readily available to contribute locally, nationally, and globally to economic growth, environmental quality and stability, and social progress.*(Fig.1)

Major initiatives were undertaken by federal agencies and by organizations outside the federal government to develop the NSDI:

- Creation of a distributed electronic network of data producers and users, known as the National Geospatial Data **Clearinghouse**;
- Development of **standards** for data documentation, collection, and exchange;
- Formulation of procedures and partnerships to create a national digital geospatial data **framework** that would include important basic categories of data significant to a broad variety of users;
- Development of new **relationships** that allow organizations and individuals from all sectors to work together to share geogeospatial data.

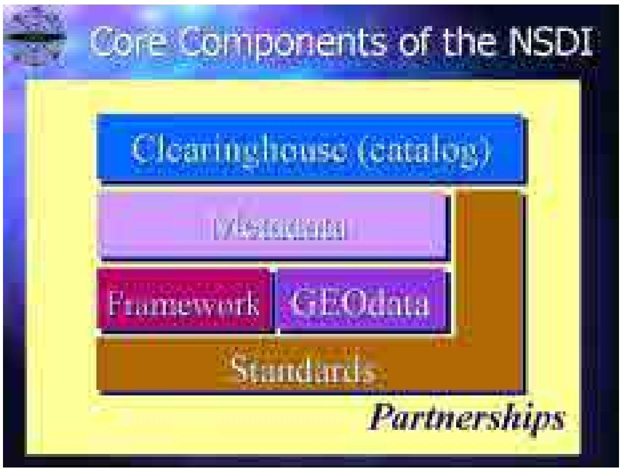

Fig.1 FGDC's Concept on Core Components of the U.S. NSDI.

National Geospatial Data Clearinghouse is a distributed network of geospatial data producers, managers, and users linked electronically. The clearinghouse was established by FGDC in 1994. Each federal agency was ordered to produce the document of all geospatial data ("metadata") which was stored, collected or produced, using the standard developed by the FGDC, and make that standardized documentation electronically accessible through the Clearinghouse network. The FGDC is also responsible for the establishment of the standards of geospatial data and promotion of use of the standards in the federal agencies.

Another important concept that this order firstly introduced was the implementation of a national digital geospatial data framework. The framework includes geospatial data that are significant to a wide variety of users within any geographic area or nationwide. The framework is a collaborative effort to create a widely available source of basic geographic data. It provides the most common data themes geographic data users need, as well as an environment to support the development and use of these data. The framework represents the best available data for an area, certified, standardized, and described according to a common standard. It provides a foundation on which organizations can build by adding their own detail and compiling other data sets. The framework's key aspects are:

- seven themes of digital geographic data that are commonly used, i.e. geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information;
- procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and
- institutional relationships and business practices that encourage the maintenance and use of data.

Stimulated by the success story of NSDI in the U.S., many countries have started the development of respective NSDI. To date, more than 30 countries have or are planning NSDI initiatives. Some examples of NSDI development are introduced in the "SDI Cookbook".

2. Regional Spatial Data Infrastructure (RSDI)

At the 13th United Nations Regional Cartographic Conference for Asia and the Pacific, held in Beijing in May 1994, it was resolved that "...*directorates of national survey and mapping organisations in the region form a permanent committee to discuss and agree on, inter alia, geographical information system standards, geographical information system infrastructure and institutional development, and linkage of the prospective committee with related bodies in the world.* As a result of that Resolution, the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) was formally established at its inaugural meeting in Kuala Lumpur, Malaysia in July 1995. The aims of the PCGIAP are "*to maximise the economic, social and environmental benefits of geographic information in accordance with Agenda 21 by providing a forum for nations from Asia and the Pacific to:*

- *co-operate in the development of a regional geographic information infrastructure,*
- *contribute to the development of the global geographic information infrastructure, and*
- *share experiences and consult on matters of common interest.*

As a first outcome of the committee's activity, PCGIAP published a paper on the vision of the Asia-Pacific Spatial Data Infrastructure (APSDI) in 1998. PCGIAP's vision for APSDI is of a network of databases, located throughout the region, that together provide the fundamental data needed to achieve the region's economic, social, human resources development and environmental objectives. Those distributed databases include geodetic, topographic, hydrographic, administrative and environmental data. They may, in the future, be linked electronically so that they appear, to the users, as a virtual database, but they will also be linked together in a number of other important ways such as:

- an intra-regional institutional framework;
- the use of common technical standards;
- the adoption of common policies and inter-governmental agreements; and
- a comprehensive and freely accessible directory.

It is this suite of administrative and technical linkages that distinguishes the APSDI from a collection of uncoordinated datasets, and which will make it such a powerful tool for the region's economic and social development. If all nations adopt a regional perspective they will not only avoid waste of resources but will be able to provide users with consistent, reliable data that can be used to address issues such as land use conflict, environmental issues and locating mineral deposits. The APSDI will build upon national spatial data infrastructure initiatives in the region and will be closely linked to other relevant international initiatives including Agenda 21, Global Map and the Global Spatial Data Infrastructure.

Similar efforts aiming to develop RSDIs are being made in Europe by EuroGeographics and European Umbrella Organisation for Geographic Information (EUROGI), and in American Continent by the Permanent Committee on Spatial Data Infrastructure for the Americas (PCIDEA) respectively.

3. Global Spatial Data Infrastructure (GSDI)

The definition of Global Spatial Data Infrastructure (GSDI) is the broad political, organizational, technical and financial arrangements necessary for global access to geographic information. This is achieved through the coordinated actions of nations and organizations that promote the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organizational remits, data, technologies, standards, delivery mechanisms, and financial and human resources.

To date, GSDI activity has been principally comprised of a group of individuals representing national mapping agencies, international organizations, and standards organizations. Five GSDI Conferences have been held since 1996. In the early stage, GSDI activity was only the voluntary talk by the participants in the ad-hoc conferences. However recently, GSDI community is seeking to form a permanent non-profit legal organization. The organizational model for GSDI in the long term is a global umbrella organization, which brings together national and regional committees and other relevant international institutions. GSDI is being advanced through the leadership of many nations and organizations represented by a GSDI Steering Committee. This multi-national Steering Committee includes representatives from all continents, and all sectors – government, academia, and the private sector.

The GSDI Steering Committee has identified a set of core goals to help advance awareness, acceptance and implementation of globally compatible spatial data infrastructures at the local, national, and regional levels:

- Articulate the operational environment needed to achieve Global SDI compatibility;
- Help build globally compatible SDI capacity around the world;
- Educate decision-makers on the benefits of GSDI inside and outside their borders;
- Assure that different SDI related policies can be facilitated by the GSDI;
- Advance the GSDI mission until a global SDI is achieved.

In July 2000, GSDI published “the SDI Cookbook (SDI Implementation Guide)” to clarify the SDI definition and to share the current experiences in building SDI implementations that are compatible at many scales of endeavor. To enable builders of SDI to make use of and build on existing SDI components in a way which makes their endeavors compatible with the efforts of other SDI builders, the SDI Cookbook identifies existing and emerging standards, free and commercial standards-based software solutions, supportive rganizational strategies and policies and best practices. Version 1.1 of the SDI Cookbook is available from GSDI webpage:
http://www.gsdi.org/pubs/cookbook/
cookbook0515.pdf

4. Global Mapping

Global Mapping project is an international collaborative initiative through voluntary participation of national mapping organizations of the world, aiming to develop globally homogeneous geographic data set at the ground resolution of 1km.

Primary objective of the Global Mapping project is to contribute to the sustainable development through the provision of base framework geographic dataset. At the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992, Agenda 21, an action program for addressing global environment challenges while continuing to support sustainable economic development, was adopted. Agenda 21 clearly mentions that there is need for improved coordination among environmental data and information activities, and it emphasized the transformation of existing information into forms more useful for decision-making. In particular, geographically specific spatial information is critical. Spatial information enables us to enhance our understanding of global and regional relationships inherent in present status and processes that lead to changes in key components of global environment. To this end, in 1992, then Ministry of Construction (presently Ministry of Land, Infrastructure and Transport) of Japan advocated the Global Map concept.

As the first international meeting on the Global Mapping, International Workshop on Global Mapping was held in Izumo, Japan in November 1994. As a result of the workshop, “The Resolution of Izumo Conference” was adopted, which consists of eleven items. Among them are: (1) promoting the preparation of Global Map by the year of 2000; (2) periodical updating of Global Map; (3) promoting technical cooperation for realization of Global Map; (4) establishing the Steering Committee for promotion and coordination of Global Mapping.

The Second International Workshop on Global Mapping was held in Tsukuba, Japan in February 1996. The main objective of the workshop was to establish the International Steering Committee for Global Mapping (ISCGM). Consequently, it was resolved to establish ISCGM chaired by Prof. Estes consisting of 14 directorates from 13 national mapping organizations (NMOs), to set the secretariat of ISCGM in GSI and to appoint 4 advisors. Number has increased to 18 members and 7 advisors now. Members are the heads of NMOs of Australia, Bangladesh, Canada, China, Colombia, France, Iran, Japan, Kenya, Republic of Korea, Malaysia, New Zealand, Niger, South Africa, United Kingdom and U.S.A. and representatives from SCAR and EuroGeographics. Advisors are representatives from international organizations and academic institutions such as UN, UNEP, UNU and ICA. ISCGM has three working groups to discuss more detailed plans. WG1 works for development of strategic action plan, WG2 for specifications, and WG3 works for data policy. ISCGM has held 8 meetings since its establishment to discuss action plan, specifications, data policy etc. for smooth implementation of Global Mapping Project.

ISCGM defined the Global Map as "a group of global geographic data sets of known and verified quality with consistent specifications, which is a common asset of mankind with scientific quality for world-wide distribution at marginal cost." This definition clarifies three basic and important ideas about Global Map: i) global coverage; ii) consistent specifications; and iii) easy accessibility.

(1) Global coverage

Most countries have national mapping organizations for mapping programs to ensure base map coverage of their own countries. Likewise, it is necessary to have global coverage of geo-spatial information to provide baseline data sets of our planet. To detect changes of the earth, frequent update of the data is also important. As for spatial resolution, Global Map has one-kilometer resolution on the ground.

(2) Consistent specifications

Better understanding of the earth sometimes requires direct comparison between one part to the other part of the world. However, if the geodetic datum, mapping accuracy, classification criteria etc. are not consistent worldwide, accurate understanding of the state of the earth may not be realized. For example, total area of forest or desert would be different if the classification criteria are not consistent between countries or regions.

(3) Easy accessibility

Even though global geo-spatial information is developed with consistent specifications, it would be almost useless unless it is made widely available to the international community and used among different sectors of the society. There exist a few data sets whose distribution is prohibited or limited to a specific community due to national security, political sensitivities and other reasons. Similar to the idea of national digital geo-spatial data framework, the Global Map should be open to the public and distributed at marginal cost. The spatial resolution of one kilometer on the ground would cause little concern for national security, as we are anticipating sub-meter pixel resolution imagery from commercial high-resolution satellites.

Complete coverage of the Global Map will only be realized by the participation of all the national mapping organizations of the world. In November 1998, the UN sent a letter of Prof. Estes, Chairperson of ISCGM, inviting NMOs of respective countries and regions to Global Mapping Project with a recommendatory letter of Mr. Habermann, Director of The UN Statistics Division, to heads of NMOs. The Global Mapping Initiative is a voluntarily based international collaboration activity. There are three levels of participation. Level A country will develop Global Map(GM) of her and other countries. Level B country will develop GM of her country. Level C country will provide data needed for development of GM. Currently, 89 countries and regions have participated in the project and 32 are now positively considering. The area covered by participated countries and regions exceeds 72% of the whole land mass and more than 80% are covered by including considering countries and regions. Member organizations participated in the project are mainly National Mapping Agencies because they have source of information of core geographical data as a result of their original duty. The Scientific Committee on Antarctic Research (SCAR) participates in the project and is developing GM of the Antarctica.

ISCGM sets the period of the first phase of the GM development to the year 2000, whose target is to make the Global Map version 1.0 available. Member organizations have been producing GM of their own territories, while GSI and USGS EROS Data Center have created global data set by converting existing global data, V-map Level 0, GLCC and GTOPO30. GSI, as a level A country, has also been developing GM of Asian countries collaborated with National Mapping Agencies of respective countries. As a result, Global Map version 1.0 for ten countries have been released at present. It is expected that some forty countries will complete development of GM by the time of Rio+10 conference(Fig.2).

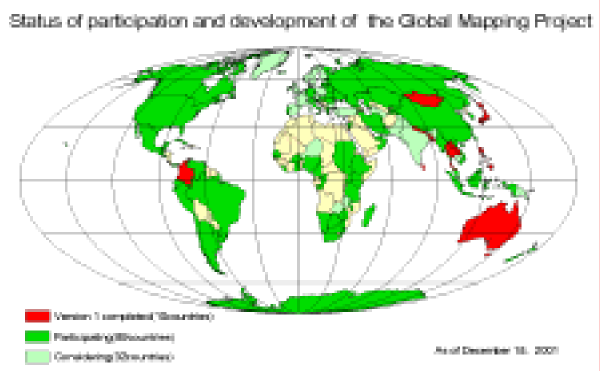

Fig.2 Status of Participation and Development of the Global Mapping Project

Global Map Specifications was firstly adopted at the Fifth ISCGM Meeting in 1998 and a minor amendment was made at the Seventh ISCGM Meeting in 2000. Full text of the Global Map Specifications is available at:

http://www.iscgm.org/gm-specifications11.pdf

Format for vector data shall be Vector Product Format (VPF) by United States National Imagery and Mapping Agency, and for raster data, Band Interleaved by Line (BIL) with separate header be used. The vector data consists of four layers such as transportation, boundaries, drainage and population centers, and raster data consists of elevation, vegetation, land cover and land use as well. Concerning the geodetic datum and ellipsoid, Global Map Specifications adopts combination of International Terrestrial Reference Frame 1994 (ITRF94) and the Geodetic Reference System 1980 (GRS80) ellipsoid as current world geodetic system. Besides, in order to manage the large amount of data, the Specifications adopts tiling system. Size of one tile is five degrees in latitude by five degrees in longitude in case the tile is located between zero degrees and forty degrees in latitude. There is no overlap or gap between tiles.

On 28 November 2000, release of Global Map Version 1.0 was declared at the Global Mapping Forum 2000 in Hiroshima, Japan. At the same time, WWW server of the ISCGM became operative and provision of the Global Map data was officially started.

Data firstly released were the Global Map Version 1.0 of 5 countries: **Japan**, **Lao P. D. R.**, **Nepal**, **Sri Lanka** and **Thailand.** **Philippines** followed in December 2000, **Colombia** in May 2001, **Australia** in June, **Bangladesh** in July and **Mongolia** in December. Global Map Version 0 data, which had been converted from existing global geographic information (GTOPO30, GLCC) according to Global Map Specifications, were also released.

Fig.3 Bird's-eye view processed from "Global Map Sri Lanka". Land Use and Transportation are overlaid and Elevation data are used for processing.

Non-commercial users, such as governmental institutions, research organizations as well as private researchers can download these data free of charge via Internet. In addition, more than 10 countries are nearly to complete their data for the Global Map Version 1.0. More than 2,500 users have registered with the download page of ISCGM and data have been downloaded nearly 18,000 times since its release. Global Map Homepage is at:

Fig.4 Land Cover, Transportation, Drainage, Administrative Boundaries and Population Centers of Bangkok and its Vicinity. Processed from "Global Map Thailand."

http://www.iscgm.org/

Thus, Phase I of the Global Mapping Project was successfully completed in 2000. Global Map will be updated and upgraded in the next phase. One of the advantages of Global Mapping initiative is the big number of its participating organizations. This advantage makes it possible to assure reliability of the final product through proper verification implemented by each NMO in the world. Recent progress in space technology gives us opportunity to revise global scale geographic datasets in more consistent way. Currently, ISCGM is discussing the practical plan for updating and upgrading of Global Map, making the best use of these benefits.

THE STUDY ON THE SUSTAINABLE GROUNDWATER RESOURCES AND ENVIRONMENTAL MANAGEMENT FOR THE LANGAT BASIN IN MALAYSIA

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ABSTRACT

The Study started in March 2000 and will be completed in the Fiscal Year 2001. One of the main objectives of the Study is establishment of Geographic Information System (GIS) for efficient and effective support to the groundwater resources and environmental management plan of the Langat Basin, and for future introduction of the system for the other river basins in Malaysia.

The final product by this Study will be the Management Plan, which includes human resources and institutional development plan for implementation based on a monitoring network and management information system, using GIS.

1. Background

JICA dispatched a Study Team to Malaysia in March 2000 for the purpose to establish a balanced, multi-sectoral and integrated groundwater resources and environmental management plan. The objectives of the Study include (i) formulation of a sustainable groundwater resources and environmental management plan for the Langat Basin; (ii) establishment of a monitoring system and Geographic Information System (GIS) to support the Management Plan; and (iii) formulation of human resources and institutional development plan for the implementation of the Management Plan, and to be able to utilize the Management Plan for other basins.

“Malaysia: the Way Forward (Vision 2020)” was presented by the Prime Minister in 1991 with an objective to get Malaysia a fully developed country by the year 2020. The Study Area (Langat River Basin) is located in Selangor State, which has set the target (Vision 2005) to achieve the status of a developed state 15 years earlier than the country’s target of Vision 2020. Information Technology (IT) is emphasized at Ministerial, Departmental, and States levels. A series of GIS application study projects have been carrying out. Internet and Intranet infrastructure are in place in many organizations. Through the National Infrastructure for Land Information System (NaLIS), data standardization and exchange of land information among the Agencies is practiced.

GIS is utilized in this Study in input and managing basic topographic maps, land use maps and the other relevant data, such as wetland, mining, forest reserves, and so on. Further, Theme Maps presenting the location of wells, monitoring results of groundwater level, groundwater quality, etc., as well as the Evaluation Maps presenting evaluation results referring to Groundwater Modeling are produced by using ArcView GIS software. In compliance with the existing systems in Malaysia, and also IT Strategy of the Counterpart Agency JMG (Jabatan Mineral dan Geosains), the Study Team proposes Management Information System as a tool for execution of the Management Plan. ArcIMS (Internet Map Server) is used for dissemination of information through the Internet.

2. Input and Managing Data

Topographic Maps at a scale of 1:50,000 published by the Department of Survey and Mapping Malaysia (DSMM) is used as the Base Map. This map series has been specified by NaLIS as the National standard for mapping land information. The standard map projection currently is the Rectified Skewed Orthomorphic (RSO).

Geology Map of scale 1:50,000 is provided by JMG in ARC/INFO format. Land Use maps published in 1995 at a scale of 1:50,000 are collected from the Department of Agriculture, and they are digitized in ARC/INFO (GIS Software) format. The Land Use data are then updated by using Landsat TM image of 1998.

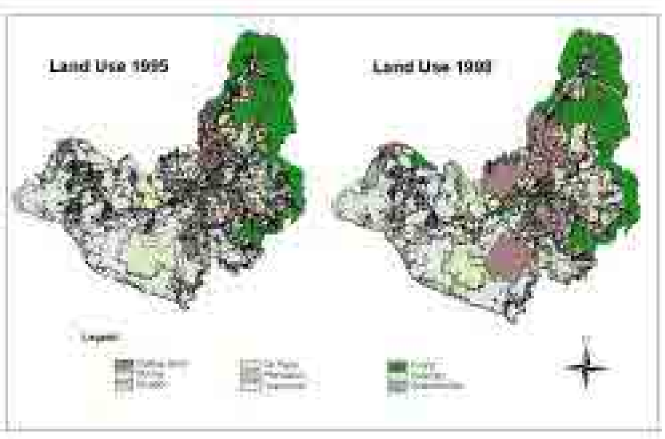

Figure 1: Land Use in Langat Basin

The digital topographic maps provided by JMG in DXF, AutoCAD interchange format are converted into ARC/INFO to prepare other relevant data such as, contour, roads, rivers, and so on. These data are also used to geo-reference Landsat TM image. Interpretation of Land Cover from TM image is further supplemented by the aerial photos. Figure 1 shows the resulting Land Use Maps of 1995 and 1998 covering the whole Study Area.

The other available relevant data such as, Paya Indah Wetland, Reserved Forest areas, Tin Mines, etc. are in different map scales. Those maps are digitized and stored in the common coordinate systems. Location of the existing wells utilized in the Study and the newly created wells are geographically referenced to the same common coordinate system, which is the RSO. All wells and attribute data are managed by Oracle DBMS (Database Management System).

3. Theme Maps and Evaluation Maps

Theme maps are produced by superimposing Theme Layer(s), such as Distribution of Aquifer, Distribution of Surface Water, Location of Monitoring Wells for Groundwater Level and Water Quality, Location of Land Subsidence Measurement etc. on top of the basic map. The basic map features include Major Roads, Highways, Railways, Rivers, Forest, Urban Areas, Basin Boundary, as shown in Figure 2.

Figure 2: Basic Map Features

Both Theme Maps and Evaluation Maps are printed in A3-size. The basic map features can selectively used in the background in preparing different kinds of Maps in the Study.

Evaluation Maps are graphical presentation of the evaluation results based on 3-D groundwater modeling (MODFLOW concept of USGS). Since all the GIS data in this Study are geo-referenced in a common coordinate system, it facilitates incorporation of topographical data such as, contours and land use data in modeling, as well as graphical presentation of the model results. Data transfer between MODFLOW and GIS is in dxf, txt, and MS-Excel formats. The evaluation results are transferred to GIS and Evaluation Maps such as; Equipotential Map, Map of Predicted Zone of Seawater Intrusion, Map of Predicted Land Subsidence, Pollution Dispersion Map, etc. are produced. Figure 3 shows one example of Equipotential Map.

Figure3 Equipotential Map

4. Management Information System

The proposed Management Information System includes four major functions; (i) Data Input and Maintenance, (ii) Monitoring, (iii) Evaluation, and (iv) Dissemination of Information to the public. A web application is developed by using ArcIMS. Groundwater level, water quality, land subsidence and the lowering of water level in reserve areas are the items to be monitored. Measurements are done by both automatic data-logger, as well as manual procedures. The web application will allow authorized web-users to query and display these data. Further, the geological profiles, groundwater model simulation results can also be visualized on the web for authorized users. General Internet users will be able to access the Annual Report. The web page will become accessible in the first quarter of next year, 2002. An example of Annual Report page is shown in Figure 4.

Figure 4: A sample page of the Annual Report

The web application is developed in Three Tier architecture; Client Front-End (User Interface), ArcIMS Middle Tier (Process Management), and Database Back-End (Database Management), as shown in Figure 5.

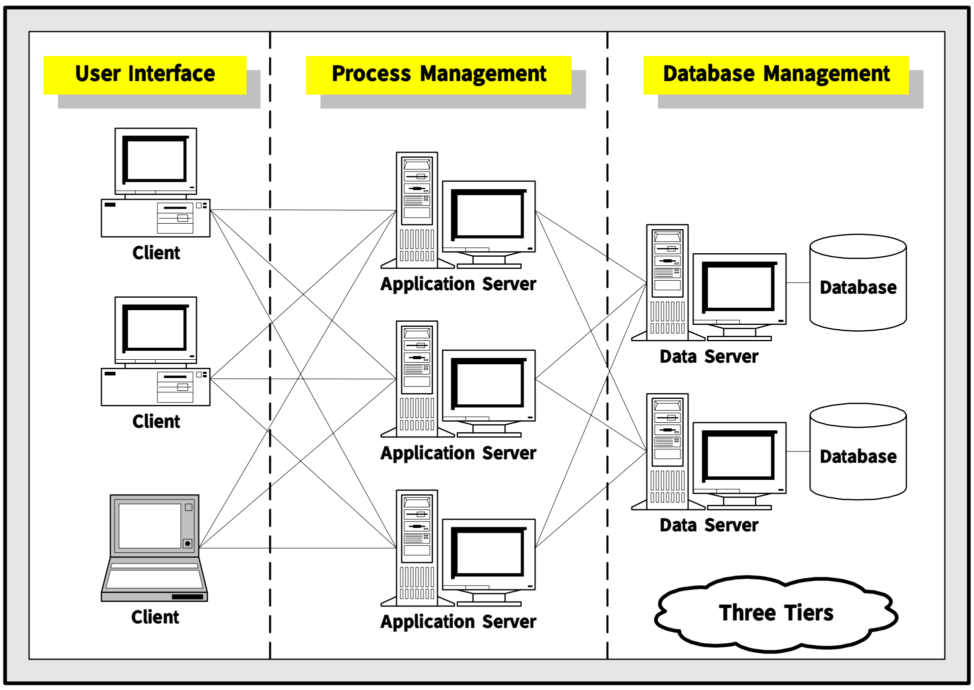

Figure 5: Three Tiers System Architecture

A client will send request to the server, and receive the reply from the server through a given Internet connection by a web browser. It is term as Client Front-End Tier. The system utilizes a thin client design, existing Internet connection at the Counterpart Agency, and Internet Explorer version 4 and higher. The middle tier of the system has Process Management component, which will control the information flow. ArcIMS version 3 is used. Database Back-End is managed by Oracle DBMS, and it is accessed by ArcIMS through the Database Gateway ArcSDE (Spatial Database Engine). The system is developed on Windows 2000 Servers.

The Development Study on Integrated Watershed Management In the Western Hills of Nepal

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Summary

This study, " THE DEVELOPMENT STUDY ON INTEGRATED WATERSHED MANAGEMENT IN THE WESTERN HILLS OF NEPAL " was implemented by Japan International Cooperation Agency (JICA) by the request from Nepal government. The study team, which was formed by Japan Forest Technical Association (JAFTA) and Kokusai Kogyo Co., Ltd., was dispatched to Nepal from November 1995 to January 1998. GIS technology was applied to produce a master plan for the Study for Integrated Watershed Management Plan, hazard maps and land use improvement plans. Furthermore, GIS database was developed as a way of effective use of the socioeconomic baseline survey results.

1. Objectives

The objectives of the Study were to prepare the Integrated Watershed Management Program (draft) for the conservation of forest and the environment on watersheds through the residents' participation based on reduction of mountainous disasters, maintenance of land productivity and effective use of forest resources and for a common use of forests and agricultural lands on the basis of improvement of residents' livelihood to establish its guidelines (draft).

2. Implementing period: 1995 – 1997

3. Study areas

This Study covered a region of approximately 120,000 ha., including the southern part of Kaski District located in the west of Nepal and Parbat District. For this Study, the southern part of Kaski District was divided into three areas and the Parbat District, into 2 areas, for a total of 5 areas.

4. Integrated Watershed Management Program and the GIS

Several kinds of maps were produced and a survey using a questionnaire on the socio-economic conditions was prepared. The scale of the produced maps was 1/25,000. The main maps obtained were as follows:

1) Topographic maps
2) Soil maps
3) Geological maps
4) Land use maps
5) Socio-economic baseline data

Based on the information of these maps, the hazard maps and the land use improvement plan database as well as socio-economic information could be produced using the GIS. These maps and data were converted into digital data for the application of the GIS, which was then used as thematic map data.

5. Production of Hazard Maps

Nine types of thematic maps necessary for the hazard maps were produced from the topographic maps obtained in the Study. For the production of thematic maps, (1) all thematic maps were in the raster form of 25m per cell; (2) the categories and ratings were standardized in each thematic map; and (3) the coordinate system of the raster data was in accordance with the coordinate system of the topographic maps. For the analysis, the locations of large-scale soil erosions and land collapses generated within the study areas were plotted as the location maps of hazardous areas through the field surveys and aerial photographs.

For the production of the location maps, one of the four study areas was adopted as a trial which was repeated through data corrections until the hazardous areas as defined from the analysis of thematic maps could correspond with those evidenced by the field surveys. The data corrections could be made through the analysis results and tendencies in correcting the rating values of thematic maps, adding some items and updating the data ranges.

Once the first area was completed, the hazard maps for the other five areas were produced using the same rating values and items. The five study areas were verified, the parameters were modified, and the results were analyzed repeatedly until the hazardous locations shown in the hazardous area location maps fully corresponded with those on the hazard maps.

When all the study areas were fully verified, the hazard maps were completed (Fig. 1).

The nine thematic maps used to produce the hazard maps are as follows:

1) Rock type
2) Weak zone
3) Consolidation of overburden
4) Thickness of overburden
5) Dip slope
6) Erosion front
7) Land use
8) Slope
9) Hydrology

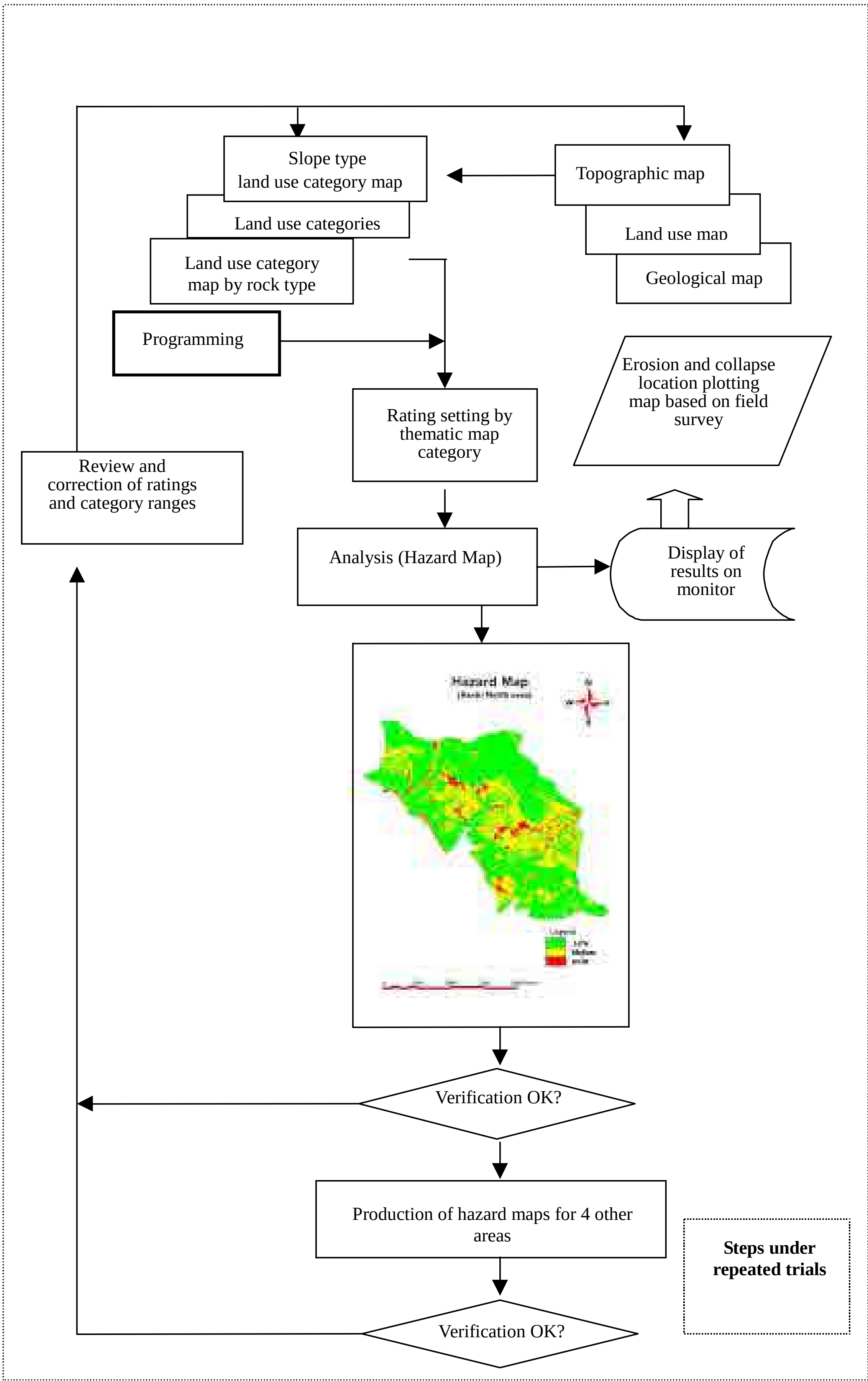

Fig. 1 Method for Hazard Map Production

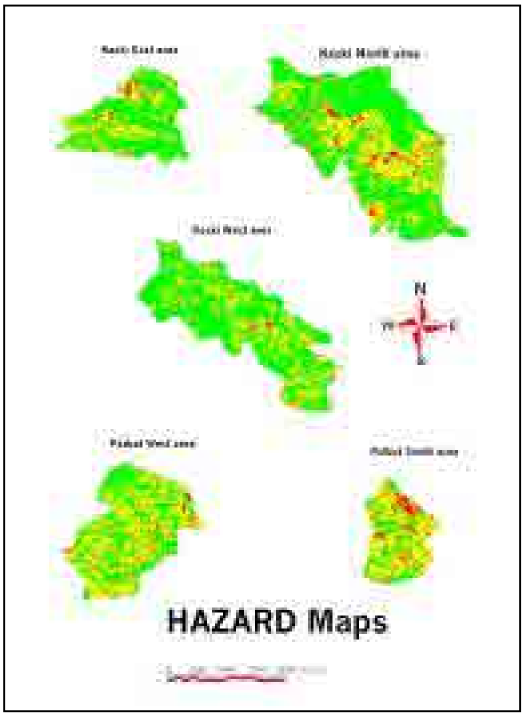

Fig. 2　　Hazard Maps for Study Areas

6. Production of Land Use Improvement Plan

In the existing form of land use, the land use improvement plan (draft) was drawn up in order to formulate the Integrated Watershed Management Program (draft) for the conservation of forest and the environment on watersheds based on reduction of mountainous disasters, maintenance of land productivity and effective use of forest resources and for a common use of forests and agricultural lands on the basis of improvement of residents' livelihood. The realization of the database as a basic tool for the land use improvement plan was required. The land use improvement matrix was set to improve the land use, for which a desirable plan is superimposed on the results of prediction of hazard districts and suitable land categories in the existing land use. Based on this concept, the matrix for the land use improvement plan was set using the GIS database of the soil category maps, hazard maps and slope category maps. (See Table 1. Land use improvement plan matrix.)

First, the suitable land category was defined by assessing lands that are appropriate for agriculture, stock raising, or sylviculture with respect to the relation that exists between slope category and soil category. The suitable land category map was produced using the slope and soil category maps. The land use improvement matrix was set based on the suitable land category map, hazard map, and land use category map, then the program was undertaken in accordance with this matrix. The database of the land use improvement plan (draft) was thus developed according the land use improvement matrix. The developed database could be verified through display and output function, and the total of areas and other required items were obtained. If the verification and area calculation are not satisfactory, the conditional formula was reviewed and the database was reproduced. Following the repetition of trials on all the study areas, until satisfactory results could be achieved, the final land use improvement plan (draft) was completed. (See Fig. 3 Land use improvement maps.) The method to develop the database for the land use improvement plan is shown in Fig. 4.

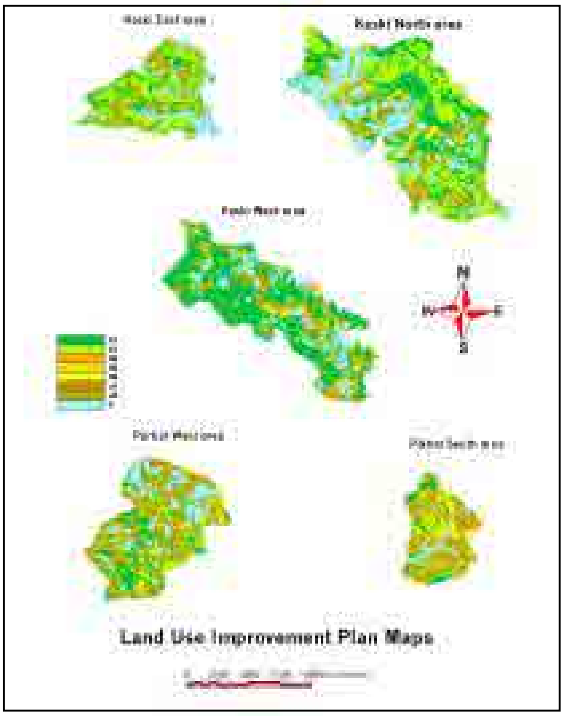

Fig. 3　　Land Use Improvement Maps

Table 1.　Land Use Improvement Plan Matrix

Hazard	Landuse / Site Class	Forest	Bush	Grass	Bari	Khet
High	Suitable	Forest1	Forest1	Grass3	Farm2	Farm3
	Interme	Forest1	Forest1	Grass3	Farm2	Farm3
	Unsuit	Forest1	Forest1	Grass3	Farm2	Farm3
Medium	Suitable	Forest2	Forest2	Grass1	Farm1	Farm3
	Interme	Forest1	Forest1	Grass2	Farm2	Farm3
	Unsuit	Forest1	Forest1	Grass2	Farm2	Farm3
Low	Suitable	Forest2	Forest2	Grass1	Farm1	Farm3
	Interme	Forest2	Forest2	Grass1	Farm1	Farm3
	Unsuit	Forest1	Forest1	Grass2	Farm2	Farm3

Note:　Interme: Intermediate
Unsuit: Unsuitable

7. Development of Socio-economic Baseline Database

A socio-economic survey of the villages located in the study areas was carried out. From the results that have been obtained, a socio-economic baseline database could be developed for a common use. The socio-economic baseline database was realized for display and output through the GIS. The administrative boundary data were also collected from the topographic maps. The socio-economic data category map was produced using the administrative boundary data.

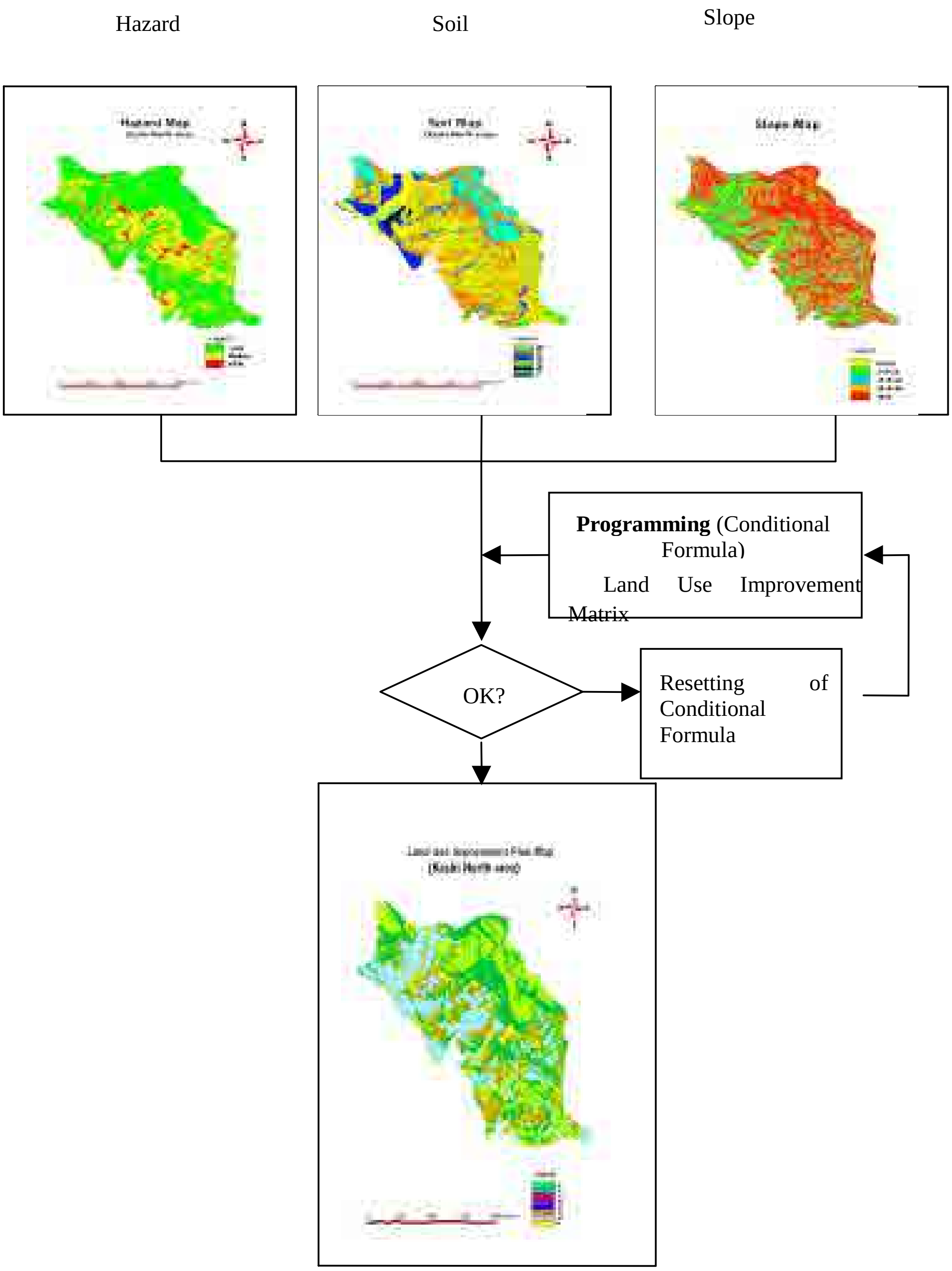

Fig. 4Method for Developing the Database for Land Use Improvement Plan

8. Conclusion

For the works related to the GIS in this Study, it was necessary to procure equipment and materials, produce various thematic maps, and develop several types of database. The full-scale database was developed in 1996, but the software and hardware environment at that time had limitations. The increasing use of personal computers allowed large volumes of data to be processed and operated simply. Further, the related types of database were developed along with the spread of the GIS in many countries. As the GIS-related environment will improve in future, the GIS will be used more widely.

An Example of Application of the GIS Database in Swaziland
- Wildfire Hazard Map and Suitable Place for Road Construction -

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Summary

In the "Study of Digital Mapping Project for the Smooth Implementation of the Development Plan in Swaziland", the JICA study team and its counterpart SGD produced digital orthophoto maps and the GIS database using orthophoto maps. The database is essential and it can be used in many ways in the future. At the final stage of the Project, we held a seminar to introduce the applications of the database. I could show an example for creating a hazard map of wildfire and for finding the suitable location for the road construction. The data concerning land-use and dummy wind were created for the said seminar, and the slope aspect and angle were calculated using the DEM data obtained during this project.

1. Background

This example of application constitutes a case of realization for "the Study of Digital Mapping Project for the Smooth Implementation of the Development Plan in Swaziland" (that was implemented for the period from July 1999 to July 2001).

The orthophoto maps were used widely in Swaziland instead of the conventional topographic maps. The GIS was introduced as a new land management technique, but the existing data were based on the orthophoto maps executed in the 1970's. Thus, the realization of orthophoto maps showing the present conditions and the introduction of the GIS based on the new orthophoto maps were imperative.

At the request of the Government of Swaziland, a technical cooperation was carried out for producing the 1/10,000-scale digital orthophoto maps, and building the GIS database based on the existing cadastral data and orthophoto map.

2. Definition of Wildfire Hazard Areas

The urban development in Swaziland is still on the way because of its historical background and national economy. In the capital city of Mbabane, the residential areas are adjacent to the natural areas. Since unnatural outbreaks of fire occur frequently, it is important to define the fire-spread hazard areas. A wildfire hazard level was thus determined as an example of applications of the GIS database.

The level of wildfire hazard could not be defined by estimating the probability of fire occurrences, but by taking notice of the easiness of fire spread. When determining a wildfire hazard level, the parameters for the prediction formula for fire spread, namely the distribution of combustibles (land-use status), slope angle and aspect, wind velocity and wind direction, which represent the standard parameters in Japan, were adopted. The prediction of fire spread is given by the following formula:

$$Ve = \{AU_1 \cos(\theta_1 - \theta_3) + B\}\, S$$
$$A = 2.00 \tan\theta_2 + 2.16 \tan\theta_2 + 1.24$$
$$B = 7.12 \tan\theta_2 + 1.44 \tan\theta_2 + 0.25,$$

where Ve : Velocity of fire spread
θ_1 : Maximum slope aspect
θ_2 : Slope's angle of inclination
θ_3 : Wind direction
U1 : Wind velocity
S : Combustible's ratio of velocity of fire spread

Note 1) The wind direction and velocity are not predicted, but the wind direction remains constant.

Note 2) In this prediction formula for fire spread,
- the (upward) velocity of fire spread will increase with the slope angle.
- the velocity of fire spread will increase with the approximation of the wind direction to the slope aspect (fair wind).

Along with the calculation based on the prediction formula, the following data could be obtained: ① Data of land use (combustible distribution) (through orthophoto interpretation); ② Slope data (processed from the existing data); ③ Slope aspect data (processed from the existing data); and ④ Wind direction and velocity data (dummy).

The data ① were obtained through the interpretation of orthophoto maps and the transformation of the polygon data into the raster mode. For the data ② and ③, the existing DEM was processed. The dummy data were obtained for the wind direction and velocity data. ArcView 3.2 was applied for all the jobs related to this case.

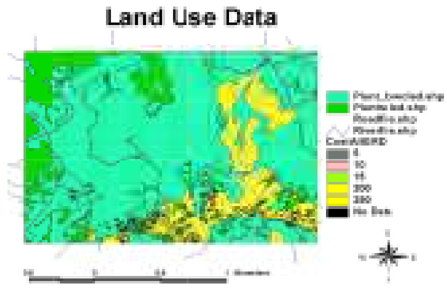

Fig.1 ①Land use status data
(combustible distribution) (Orthophoto interpretation)

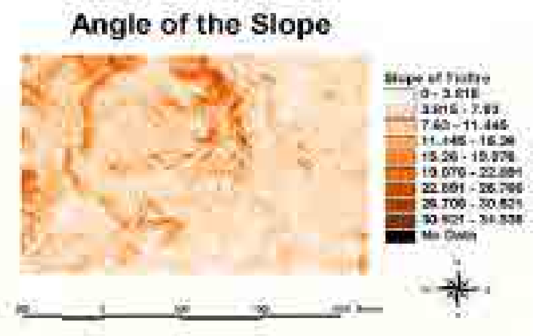

Fig.2 ②Slope angle data
(calculated from the existing DEM)

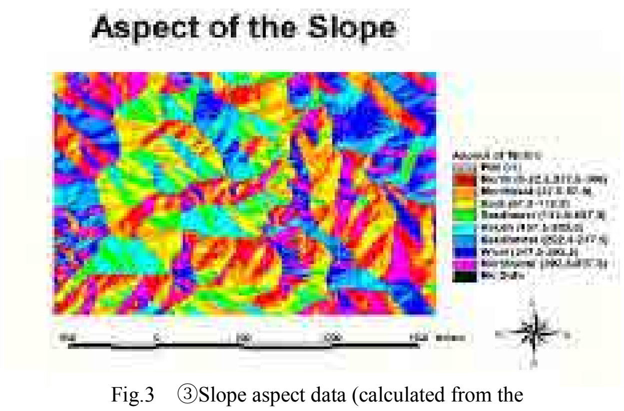

Fig.3 ③Slope aspect data (calculated from the existing DEM) Aspect of the Slope

Fig.4 ④Wind direction and velocity data (dummy)

The method for determining the hazard level is as follows:

1) To calculate the difference between the slope aspect and the wind direction in order to categorize a hazard level. (The smaller the difference, the higher the hazard level.)
2) To categorize the slope angle as a hazard level. (The higher the slope angle, the higher the hazard level.)
3) To calculate the product of the map data of the above two layers and to categorize it as a hazard level.

The above method was adopted to define an area with a value larger than the given reference value as a wildfire hazard area and the map as shown below could be obtained.

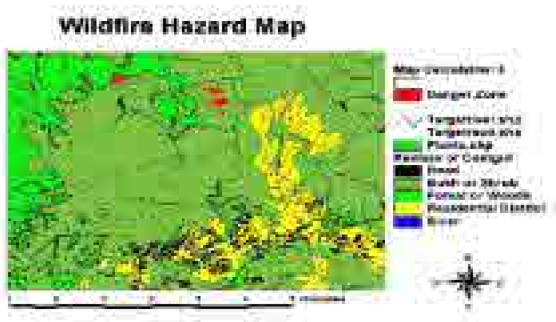

Fig.5 Wildlife Hazard Map

3. Selection of a Suitable Place for Road Construction

The development for road construction in Swaziland could not be fully achieved due to the conditions as mentioned previously. To this end, a simple method for selecting a suitable location in the establishment of a road construction plan was adopted and the selection of road locations could be made from the economic point of view, allowing the choice of the most economical route.

Based on the results of the selection of road routes, costs were added to the land use map as made up in Section 2 above. The costs would include the factors affecting the land acquisition and construction works, and individual costs for woodlands, grasslands, rivers, existing roads, and residential districts were broken down and added to the total cost.

Note 1) The present conditions were not fully monitored.
Note 2) The difficulty in land acquisition and construction work resulted in higher

Cost Map (land use map on which the cost information is added.)

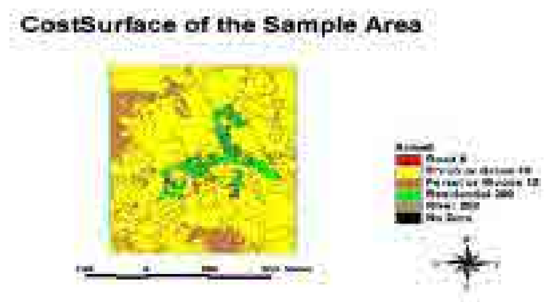

Fig.6 Cost Surface of the sample area

The start point of a road line was defined in the cost map and the cost distance map was obtained using the Cost Surface function.

Note: The cost distance map is the raster data representing the cost for the distance from the road start point to an arbitrary point.

Cost Distance Map

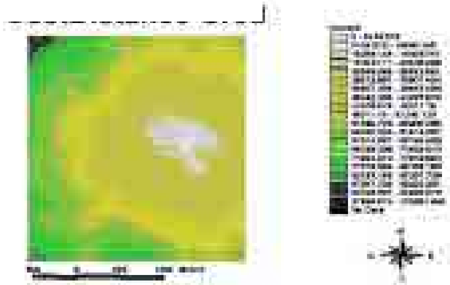

Fig.7 Cost Distance Map

Moreover, the data defined as the end point of the road line was superimposed on the Cost Distance Map to define the road line using the Cost Path function.

4. Conclusion

When selecting the example of application, an emphasis was placed on data that the counterpart could collect, process, and arrange independently. The newly added land use data in this example (information on combustible distribution and cost of road construction) could be obtained in a simple manner, but did not reflect clearly the existing conditions.

The data obtained through this technical cooperation project was essential, but the counterpart, SGD, and other administrative agencies may use them by processing them or by adding other information, such as land use data, in a variety of applications. This database will be a very important as a source of information and as a tool.

Fig. 8　Road Line Route at Least Cost

Selecting the appropriate sites for wind power generation systems
－The simulation of wind conditions by use of GIS data－

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Abstract

The wind power generation systems spread worldwide in these days as an infrastructure for renewable energy. Predicting wind conditions is important to select the appropriate sites for wind power generation systems in planning them. This paper shows the simulation model of wind conditions by use of GIS data, which is suitable for the islands' complex topography and the sea. This model calculates movement of atmosphere in the 3-dimensional virtual space inside the computer based on the GIS data. This simulation needs only the GIS data and the upper air atmospheric pressure distribution so that it can simulate every wind conditions all over the world. The accuracy of this simulation is 1m/s of the monthly average wind speed. We have calculated many wind power generation system sites in Japan, but none in abroad. Therefore we shall apply this model to wind conditions in foreign countries.

1. Background

In order to diminish green house gas such as carbon dioxide, an effective use of natural energy, a kind of clean energy, is important as well as promoting energy conservation. And this has become a globally urgent issue. In this effort, an active introduction of wind power generation has been encouraged in various countries as an infrastructure using natural energy.

In planning and designing wind power generation systems, it is regarded to be most important to select a site, the wind of which has high yearly average speed and stable directions. However, in an island country like Japan and lands which have complex topography, it is considered to be difficult to select an appropriate site for wind power generation systems compared with countries in Europe and America because of the complex wind conditions and unstable wind conditions influenced by the sea.

In designing wind power generation systems, at least one year of actual observation at the proposed site is essential to obtain data needed for the calculation of generating capacity. Understanding the wind conditions is also crucial to select observation points of the proposed site..

As a result, it is hoped to develop a computerized simulation to predict wind conditions suitable for the natural features of the island countries. At our institute, we have developed a simulation method to predict wind conditions by using prediction technique that we have been conducting for the predictions of heat island phenomenon of urban area and wind_tunnel. As this simulation can accurately reproduce influence of the sea such as land and sea breeze, it is suited for selecting an appropriate site for wind power generation systems in an area near to the sea and with complex topography.

2. Simulation of wind condition prediction

A conceptual chart of this simulation is shown on Figure-1. This model constructs a three-dimensional virtual space in a computer by entering GIS data on topography and land use. Then, the three-dimensional virtual space is divided into fine grids, and mass of atmosphere, wind power, thermal energy, moisture vapor, solar position and amount of solar radiation on the ground, as well as generation and annihilation of clouds in each grid are calculated from moment to moment. Thus, movement of the atmosphere is directly reproduced.

The data mainly needed for the calculation are GIS data on elevation and land use together with distribution of upper air atmospheric pressure (wind velocity in the upper air), which is seen on the meteorological chart, as dynamics to press the atmosphere of overall calculation area. In principle, this is the same methodology as the digital forecasting presently applied in weather forecasting.

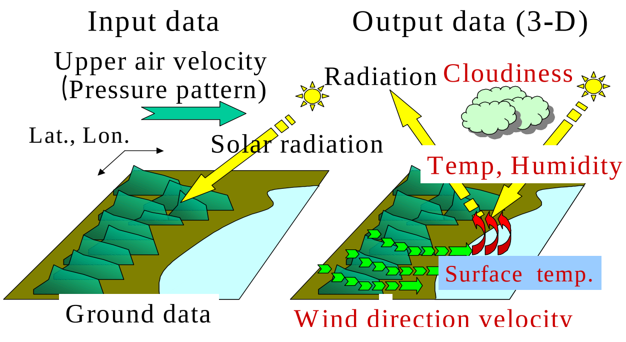


Figure 1 Outline of wind condition prediction by the simulation

On Figure-2, a methodology called "Nesting" is applied. The Nesting is the method to sequentially narrow down the calculation field starting from a large area. Using this method, area ranges from several hundred kilometers' square to several kilometers' square can be calculated in 500m grid at the smallest.

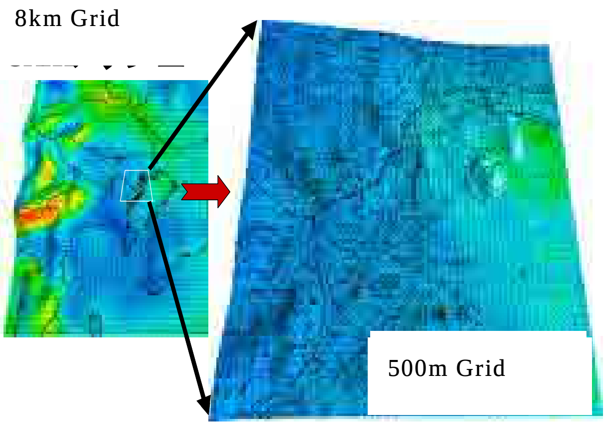
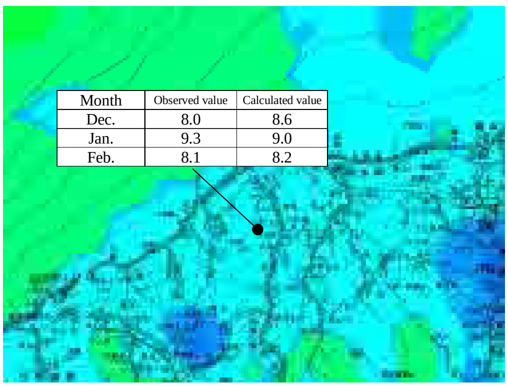


Figure 2 Image concept of Nesting

Thus, three-dimensional distribution of wind and temperature at the given point and the given time can be calculated if only data on land and atmospheric pressure are available. As shown on Figure-3, the comparison between the calculated values and the observed values at several points in Japan shows that accuracy of the calculation is within ±1m/s in the monthly average wind speed.



Month	Observed value	Calculated value
Dec.	8.0	8.6
Jan.	9.3	9.0
Feb.	8.1	8.2

Figure 3. Comparison with observed values (Nadachi Town)

Average velocity 20 m above ground (m/s)

3. Example of simulation

In Japan, predictions have been conducted to understand the outline of wind conditions for the entire country and the individual and detailed wind conditions at dozens of places.

Figure-4 is the countrywide wind condition summary map (average in winter). This figure roughly reproduces the state of local winds, such as "Dashi" and "Oroshi" (down slope winds called in different names in different places) observed in various places in Japan.

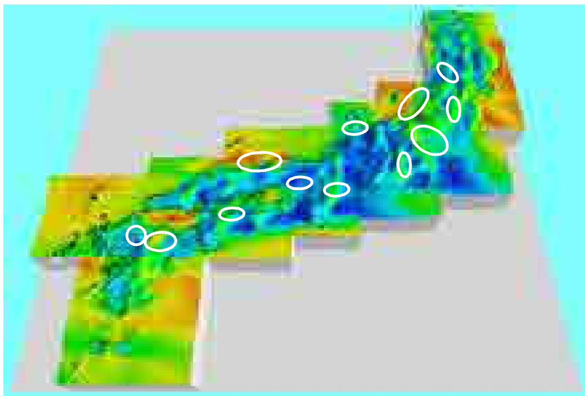


Fig.4 Wind condition map of the whole country: winter (White circles are the areas that have local winds.)

Figure 5 shows the wind conditions in Aomori Prefecture. The first wind farm in Japan called "Tappi Wind Park" is located in this area and the wind farm has a good power generation performance. The model shows that the point has good wind conditions.

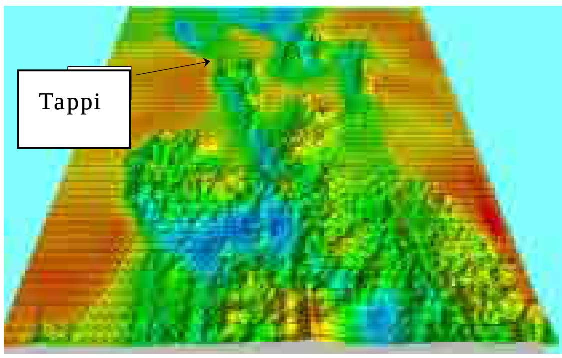


Figure 5. Wind Condition Map (in winter); Aomori Pre.

(Red to verdant green: area with strong wind, Arrow shows wind direction)

4. Expansion to foreign and developing countries

As mentioned before, the data needed for this simulation model are GIS on elevation and land use together with upper air atmospheric pressure distributions. For the upper air atmospheric pressure, global data have been released by WMO based on international agreement, which are accessible from anywhere in the world. Although various countries have various GIS data, the environment for the expansion has been becoming in good order due to the progress of the data development not only in countries in America and Europe but also in Asia. Further, high resolution satellite imagery in about 1m resolution has been commercially used and this makes it possible to make a calculation of all the areas by preparing GIS data from the imagery.

5. Conclusion

Wind condition prediction, which directly simulate the movement of atmosphere, has been most actively studied and developed in Japan. However, the numbers of simulations are limited and there are only several models in the world. Opposing to many domestic actual proofs and applications of this simulation, there are not yet any applications in foreign countries.

We intend active applications in foreign countries in the future and to grasp the wind conditions in each country while promoting accuracy validation on the calculation.

GIS analysis on slash and burn cultivation in Indonesia

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Abstract

A GIS analysis system for monitoring of “ slash & burn” cultivation has developed at the RSP (Remote Sensing Project), DPU (Department of Public Works) in Indonesia, which had been assisted by the JICA (Japan International Cooperation Agency). In this system, those elements (①decrease of vegetation between two period, ②size of plot, ③ shape of plot) are considered for detection of accurate “slash & burn” cultivation plots.

Outputs of this analysis are distribution map of “slash & burn” cultivation plot, area estimation table, dimension table of each “slash & burn” plot.This analysis system had applied on three areas in Indonesia.

1. Background and research areas

In recent years, amongst the growing awareness on environmental issues globally, slash & burn in tropical forest zone is regarded as one of the major factors in deforestation and considered to be a problem.

Information related to slash & burn in a region is not only important as a main indicator of environmental monitoring but also as basic information for conducting various investigation on forest conservation and agricultural development.

This slash & burn plot analysis was carried out at the Remote Sensing Project (RSP), Department of Public Works (DPU), in Indonesia as a project type technical cooperation assisted by Japan International Cooperation Agency (JICA). This paper deals with three application examples and introduces the methodology used and results of the analysis. The application areas are the upper reaches area of Negara River basin in South Kalimantan Province , the Wailalem Dam basin in Lampung Province, and the upper reaches area of Kampar River basin in Riau Province of Sumatra. (see Figure 1).

2. Method for detection of slash & burn plots

2. 1 Elements of detection method for slash & burn plots

It is difficult to detect slash & burn plots directly by spectral classification from satellite imagery data. Main factors that prevent detection is the existence of similar spectral characteristics to slash & burn, such as old logging site, site of forest fire, site of landslide and debris flow, site of factory or housing development, facility area like trial digging bore, road, and riverbed. Thus spectral information by itself cannot distinguish the land use of slash & burn from others.

Figure 1 Locations of analyzed slash & burn plots

In order to improve the accuracy of slash & burn detection avoiding these errors, a method focusing on the following three elements was developed and applied.

(1) Decrease of vegetation

In this slash & burn model, an assumption is made that before the burning of the site, the area has vegetation density of a natural/secondary forest. After the burning, there are M years of cultivation, followed by N years of fallow period and in this period will recover to the same vegetation level again. In this case, between after the two images of M years interval two images, the slash & burn site should be detected as a section in which the vegetation decreases from a natural/secondary forest to a bare/bush land. If the interval of two images is more than or below M, there might be cases where the slash & burn sites cannot be detected as decrease of vegetation; or land already with fallow land is misinterpreted as estimated slash & burn. In reality, the cultivation period of slash & burn is not uniform but has variation, therefore there are elements that cause errors. However, considerable improvement in its accuracy can be expected compared with classification from a single image.

(2) Size of plot

Given that a certain grid itself is estimated to be a slash & burn site and any of the eight surrounding grids are defined as to form a plot. The neighbouring relationships between all the grids is examined and sorted for analysis.

Classification of plots is made by their sizes. Plots up to a certain size are considered to be the estimated slash & burn site. If the size exceeds this certain size, they are considered much more likely to be the sites other than slash & burn, such as forest fire sites or large-scale land reclamation areas and are excluded from estimated slash & bum.

(3) Shape of plot

Discrimination/Classification of cultivated land from road/rivers etc. is carried out by the shape of estimated slash & burn plot. Aspect index (AI) for the plot is defined by the following formula. If a site has a small AI number and a rectangular/round shape, it is regarded as cultivated land. In case a site has a big AI number and extreme linear shape, it is regarded not likely to be cultivated land and excluded through processing. Following this formula, AI is obtained easily based on the ratio of length and width regardless of its direction. For example, AI number of a square is 1, and AI number of a shape with five grids in single horizontal line is 2.6 (see Fig. 2).

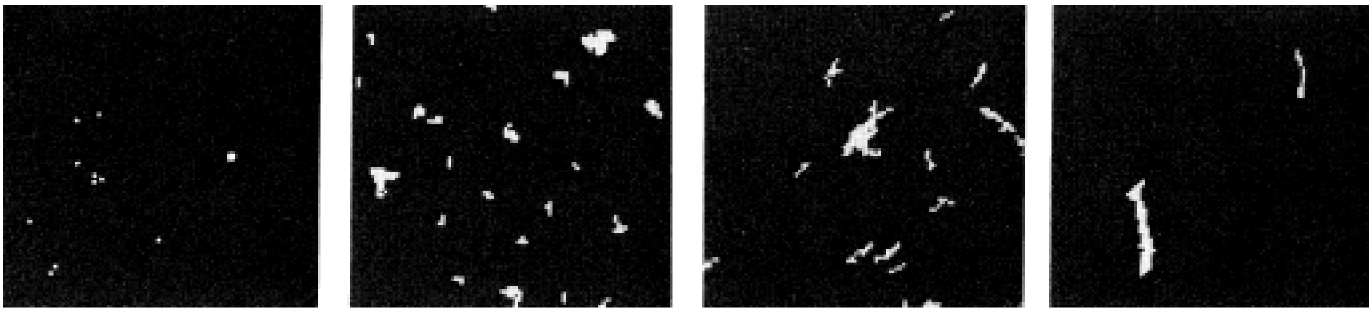
$$AI = (D1^2 + Dc^2)/2A \quad (1)$$

where AI: Aspect Index

D1: North-south width of plot (m)

Dc: East-west width (m)

A: Plot area (m^2)



1.0	1.5 ～ 2.0	3.0 ～ 4.0	5.0 ～ 7.0

Figure 2 Examples of AI of slash & burn plots

Detection method of estimated slash & burn site is applied in the following order. (see Figure 3)

(1) From the two satellite images taken at different periods, respective land cover maps are prepared by classifying the data supervised by ground truth data obtained from the field survey.

(2)Apply classification method using vegetation decrease, namely, to select the grids in the land cover maps which show remarkable decrease of vegetation between the two periods and estimate them as the primary estimated slash & burn plots. “Remarkable decrease of vegetation” is based on the following definition. At first, the land cover of the two periods is classified into four classes depending on the vegetation density as shown in Table 1. Next, “remarkable decrease of vegetation” is defined by the change in the decrease of two or more vegetation classes in the two periods. In other words, changes from Ⅰ to Ⅳ, Ⅰ to Ⅲ, and Ⅱ to Ⅳ correspond to this.

Table .1 Vegetation density classes

Level	Class of vegetation	Land cover classification
Ⅰ	Dense ve getation	Dense vegetation forest (natural forest)
Ⅱ	Moderate vegetation	Forest with less density (secondary forest) Mixed forest with trees and crops
Ⅲ	Grass/bus h	Grassland, Bush, Growin g stage paddy field
Ⅳ	Bare land	Paddy field without veg etation, Naked land

(3) In the case only one image data is available, there is no choice but to apply the site classified as bare land or equivalent to the primary estimated slash & burn. If the condition is good such as having few bare land other than slash & burn, a good result may be obtained.

(4) Apply classification method by plot size. Carry out plot size classification on the primary estimated slash & burn site and regard the area of up to 5ha, which is about the size of a cooperative farm of several families, as the secondary estimated slash & burn site. However in the mountain ridges, in the raw image data there are many cases where there are nosie-like bright points and shades, and slash & burn sites in single grids are excluded as it lacks reliability.

(5) Apply classification method by plot shape.
Classify the sites into cultivated land with small AI number and road/riverbed with large AI number, and allocate as tertiary (final) estimated slash & burn for analysis. Threshold value of the classification is aimed at AI number 5.

(6) Numerical sorting and image processing of the final estimated slash & burn sites are obtained by the above processes. From this procedure, the following results are obtained.

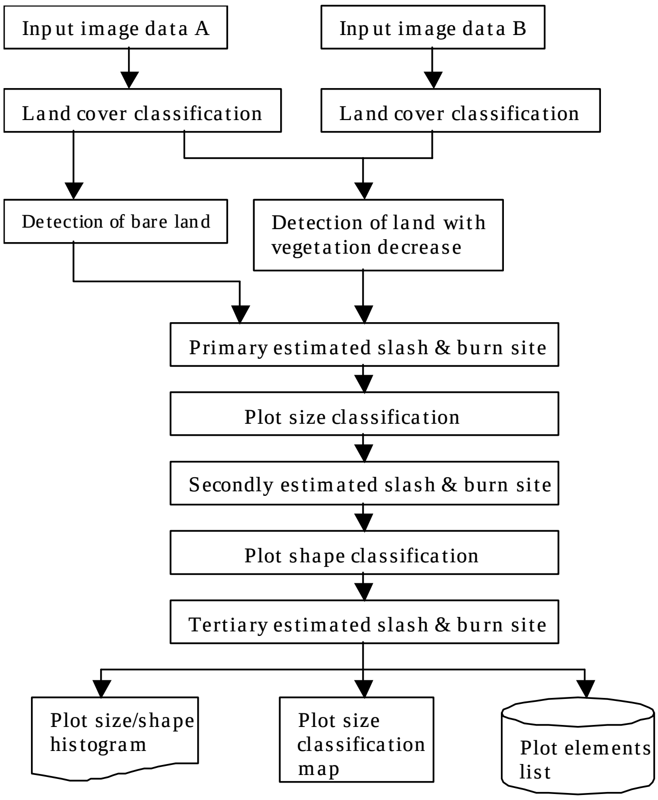


Figure 3 Flow chart of detection process of estimated slash & burn site

1) Histogram of slash & burn plot size

2) Histogram of slash & burn plot shape

3) Distribution map of slash & burn plot by size

4) Plot elements list (Serial number, coordinate value, area and AI number for all plots)

3. Applied examples

3.1 The upper reaches of Negara River basin, South Kalimantan Province

Using one SPOT (20m grid) image, the bare land obtained by classification as the estimated slash & burn site, plot size classification was applied. In this example, classification by AI number is not applied (see Photo 1 and 2).

Target area is about 10km square, where slash & burn sites are scattered in rubber woods.
Many rubber trees are not for harvest, therefore the area looks like an extremely extensive plantation or fallow land. There are not many permanent farm lands and most bare land are presumed to be slash & burn.

Therefore, the relisbility of classification from a single image is rather high. In the field survey, sites classified as estimated slash & burn were confirmed to actually bear the state of slash & burn.

Table 2 illustrates the processing results. Area proportion ratio shows that the plot size is concentrated from 0.4ha to 1.0ha. This implies that there are slash & burn sites of one family to several families per unit but due to the gentle peak from 0.4 to 1.0ha, 0.5ha is estimated to be the minimum unit for one family.

Field survey result shows that areas with old rubber trees are apt to be changed into slash & burn. Therefore, slash & burn cycle is assumed to be harmonized with re-plantation of rubber trees. Given that the area of present slash & burn to be 286ha, of the total area between 0.08ha to 4.0ha in Table-2, (assuming that all the estimated site to be real slash & burn), and the area was cultivated for three years after slash & burn, the life of rubber tree to be between 20 to 30 years, a land of 286÷3 x 30 = 2,860ha for slash & burn becomes necessary. On the other hand, the total size of the target area is approximately 10,000 ha, and even if the area available for slash & burn may be approximately one third of the total due to topographic condition and land ownership, it is estimated that slash & burn cycle of this area can be feasible.

Table 2 Counting list of estimated slash & burn in Negara area by plot size

Plot size (ha)	Number of plots	Area (ha)	Ratio of area composition (%)
0.00 - 0.08	585	32	8.99
0.08 - 0.20	255	39	11.04
0.2 - 0.4	148	55	15.54
0.4 - 1.0	107	71	20.18
1.0 - 2.0	37	53	15.13
2.0 - 4.0	24	67	19.10
4.0 - 8.0	3	17	4.85
8.0 <	2	18	5.17
Total	11,161	353	100.00
Total dimension of area		10,347	

3.2 Wailalem Dam basin of Lampung Province, Sumatra

An area of approximately 36,000ha of Wailalem Dam basin was analyzed by applying classification of vegetation decrease and plot size using Landsat MSS image data (resampled 50m grid) of two periods, 1978 and 1989. Classification by plot shape is not applied. The interval of the two data is 11 years and is not desirable interval. However, these data were used because of the limited availability of the images.

In this area, illegal settlement in the dam basin has been accelerating due to the improvement of traffic circumstances brought by the dam construction. Newly cultivated lands are conspicuous around the dam lake because of easily available irrigation water leading to acceleration of mud flow and water pollution to the dam lake. In the field survey, due to the lack of land and the existence of large numbers of illegal settlers, slash & burn was thought to be difficult and therefore permanent farms were expected to exist. However, as new field reclamation is being carried out in the form of slash & burn, the information on its characteristics have been organized and used as a material for considering the method of selecting the estimated slash & burn sites.

In accordance with the vegetation density class shown on Table 1, plots which showed decrease of vegetation between two periods were detected according to the decrease pattern. Then, it was identified as to which decrease pattern showed the characteristics of estimated slash & burn plot. Figure 4 is the graph denoting the processed result. According to the graph, decrease pattern Ⅰ to Ⅲ and Ⅰ to Ⅳ have remarkable peaks around 0.2 to 1.0ha, and also Ⅲto Ⅳ and Ⅱ to Ⅳ have gentle rise from 0.2 to 2.0ha. This shows that the area which have characteristics of a plot is detected. This fact is the basis for the adoption of the "vegetation decrease of two or more classes" as the standard to select primary estimated slash & burn site.

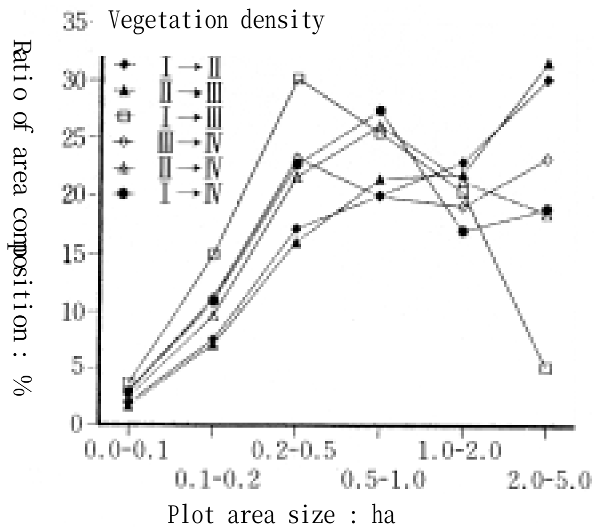


Figure 4 Ratio of area composition of estimated slash & burn site by plot size in Wailalem area

3.3 Upper reaches of Kampar River basin in Riau Province of Sumatra

This area has remarkable characteristics of slash & burn pattern out of many places in Sumatra. By using two images, Landsat MSS (resampled 30m grid) of 1985 and Landsat TM (30m grid) of 1992, approximately 330,000ha were processed collectively by applying classification by vegetation decrease, plot size and plot shape. Based on the impression of the field survey, it can be said that flat areas were relatively occupied by paddy field and rubber plantation, while food crops seemed to be planted on the side of the mountain. Although there are sites for shifting cultivation, there are many which seem to be permanent fields.

Besides the entire area, partial analysis and comparison were made in remote areas in the mountain, steep mountain sides near the village and mountain hill sides slightly far away from the villages with particular characteristics. (see Picture 3, 4 and 5: red plots are sizes of 2 to 5ha, and areas in khaki are the sites primary estimated but excluded for classification due to plot size and AI number.)

The size of estimated slash & burn plots in this area are generally large. Except for the steep side of the mountain which shows the peak from 1.0 to 2.0ha where large area cannot be occupied, size of the plot is larger both in the hill on the side of the mountain and remote place in the mountain. These larger plots seem to be cultivated by groups of several families.

The plots in the remote mountains, where people's access is not easy, have slightly irregular shape. Figure 5 is a graph that shows the area proportion in different AI classes. The graph shows that AI number of the plots tends to incline in the order of steep side of the mountain, hill on the side of the mountain and remote places in the mountain.

These phenomena could be caused by the following factors. Steep side of the mountain with limited land resources located near to the village is strongly influenced by the norms of the society, therefore the farm is in a regular shape. On the other hand, in the remote mountains, although they are designated as reserved forest by the government, they are reclaimed by unbridled slash & burn by illegal settlers, and the fields tend to be irregular in shape due to the spread of the fire. Correlation between the shape of the slash & burn plot and physical/social conditions of a location is a noteworthy issue.

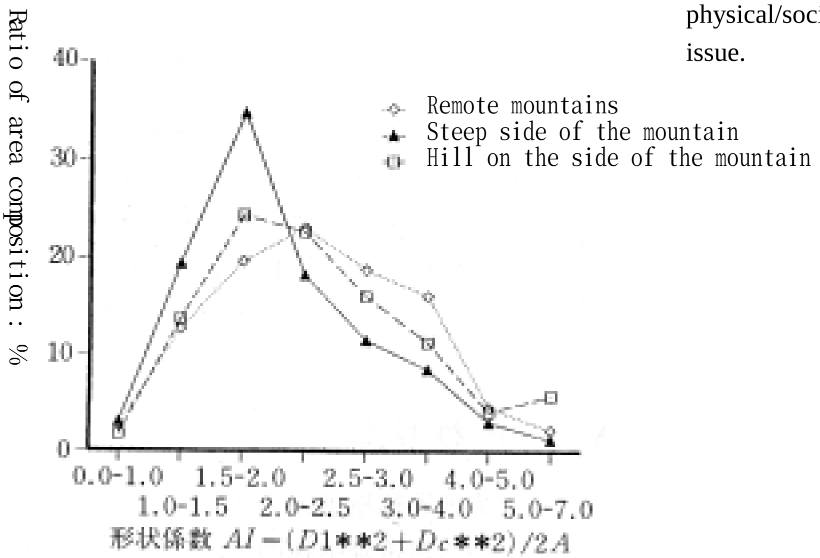
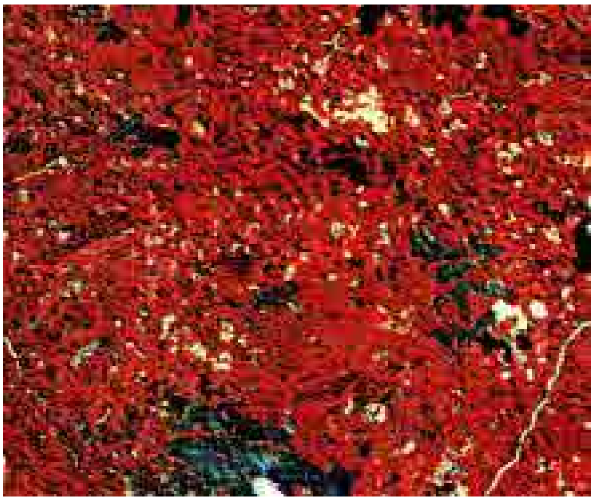
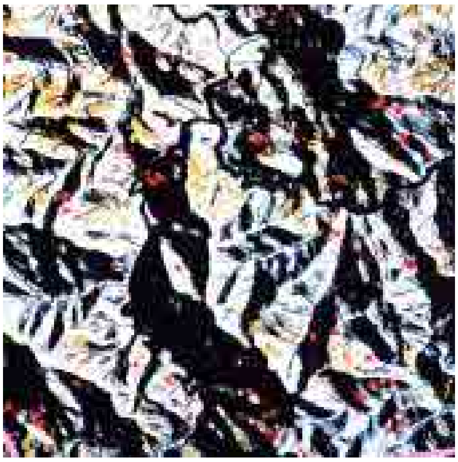


Figure5 Ratio of area composition estimated slash & burn site by plot AI class in upper reaches of Kampar River area

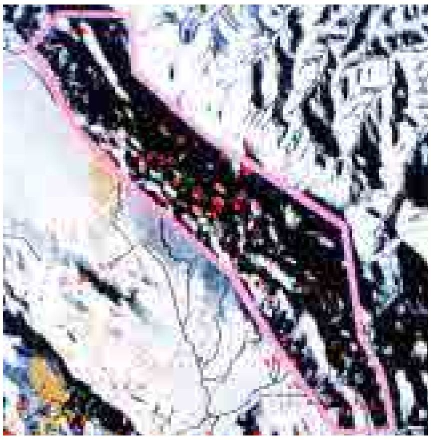


Picture 1 SPOT image on slash & burn distribution in Negara area
－Slash & burn sites are seen as white patches in red rubber plantation －

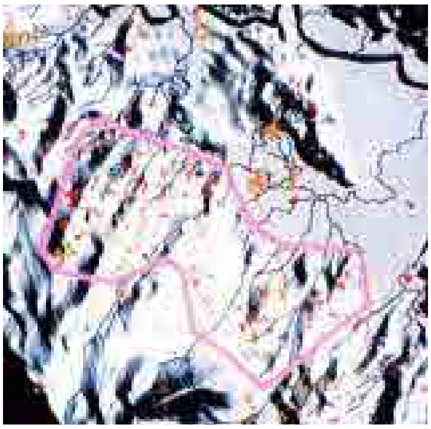
Picture 2 Picture of the slash & burn scene in Negara area
－ Upland rice, maize and young rubber trees are mixed.－



Picture 3 Upper reaches area of Kampar River
（Slash & burn in remote mountain）



Picture 4 Upper reaches area of Kampar River



Picture 5 Upper reaches of Kampar River

4. Consideration and Deduction

The following facts were obtained from the three examples introduced.

(1) It is apparent that detection accuracy of slash & burn is improved with the introduction of a new classification method. However, it is difficult to make quantitative analysis on each of the three examples because the field survey is limited in areas along the roads only and lack of adequate materials for accuracy validation. These are issues for future consideration.

(2) If the regional total area, estimated slash & burn area and location are considered, it may be possible to estimate sustainable slash & burn cycle or to decide forest maintenance/recovery function .

(3) The size of the estimated slash & burn plots often has its peak below 5ha. Long and narrow plots exceeding AI number 5 have small possibility of being slash & burn.

(4) In an area where slash & burn is common, the plot size is generally small (not more than 2ha). On the other hand, plot size is large (several ha) in areas where permanent farms are thought to exist.

(5) Plots in the unbridled slash & burn area are irregular in shape. Those in the area where social norm functions, there is a tendency for the shape to be regular with a difference in AI number.

Application of GIS Technique on Basin Irrigation Water Balance in Indonesia

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A river basin simulation system for estimation of irrigation water balance has developed at the RSP (Remote Sensing Project), DPU (Department of Public Works) in Indonesia, which had been assisted by JICA (Japan International Cooperation Agency).

Input data are digital elevation, drainage pattern, rainfall distribution, and land cover analyzed from satellite image. Data process includes correction of depression on digital elevation, tracing of rainwater runoff, estimation of evapo-transpiration, and estimation of annual average discharge. Output are a discharge map which shows estimated discharge of every grid coordinate points and a table for selected ground points. This simulation system had applied on the 350,000ha Jeratensuluna river basin area, Central Jawa.

1. Background and Target Area

his paper introduces a river basin simulation system utilizing GIS along with a case to which this method was applied. The system introduced here has following functions. First, tracing of rain runoff channel by using the existing information such as digital elevation models, existing river systems, rainfall distribution and the land cover classification analyzed from satellite image data. Second, simulation on catchment area for a small sectional basin and for any selected ground points in a basin, or calculation of annual mean runoff discharge, etc., can be performed. Lastly, the data processed in this way can be output in the form of figures, diagrams and tabulated lists.

This simulation was carried out at the RSP (Remote Sensing Project), DPU (Department of Public Works) of Indonesia, which was assisted by JICA (Japan International Cooperation Agency). A target area includes approximately 350,000 ha of Jeratensuluna river basin that extends from 110 ° 15’ E to 111 ° 30’ E Long. and from 6 ° 15’ S to 7 ° 30’ S Lat. in Central Java (See Figure 1) .

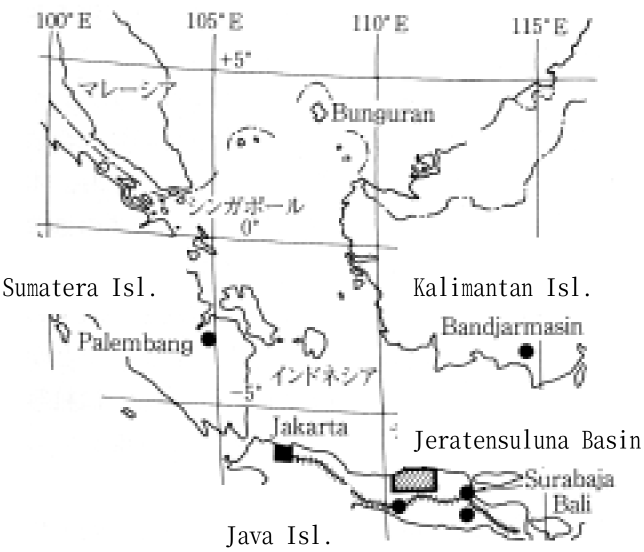


Figure 1 Location of Case Area

Figure 2 shows a basin pattern diagram of a target area. Lusi River, the main stream, has two head works and Serang River, a tributary river, has a dam and two head works. Construction of some of these facilities was completed and others are still in the planning stage. In this paper, the condition without these facilities is termed as “present” and the condition in which all these facilities have been completed is termed as “designed” for the purpose of arranging the results of basin elements calculation.

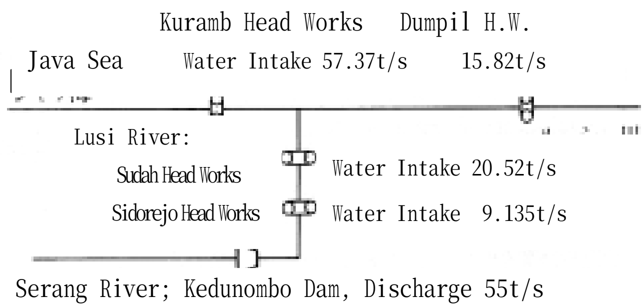


Figure 2 Pattern Diagram of Jeratensuluna Basin

2. Outline of the Process

2.1 Flow of the Whole Process

Figure 3 shows a flow of the process of this system. The process can be roughly classified into 4 stages.

(1) Adjustment of digital elevation model
Removing depressions to satisfy the rainwater runoff conditions

(2) Tracing of rainwater runoff
Production of rainwater runoff direction map

(3) Calculation of catchment area

(4) Calculation of runoff discharge

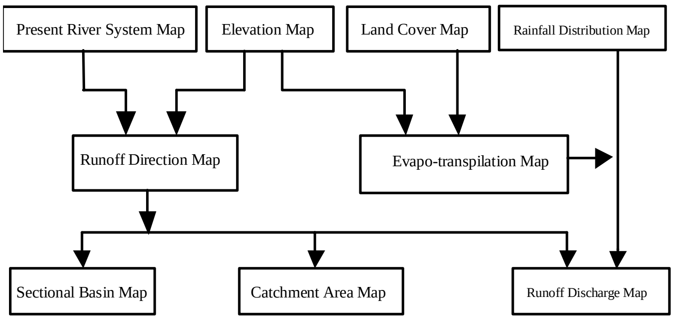


Figure 3 Flow Chart for the Whole Proce

2.2 Input Data

The following 4 kinds of data are input in a digital format.

(1) Digital Elevation Model

Digital elevation model was created from a 1:250,000 scale topographical map. A background image in Picture 4 is the one created in this way.

(2) River System Map

This map was produced by digitizing a 1:250,000 scale topographical map. The rivers drawn in this map have priority over other runoff channels in the output of river channels. It is also used for correcting depressions in the digital elevation model. This map is not indispensable and, therefore, a series of processing can be performed without it. Nonetheless, this map is helpful to avoid false results caused by the fact that quasi-rivers in a flat land, in particular, generated from digital elevation model do not always coincide with the true river channel. Main part of the river channels output in Picture 4 was created from this data.

(3) Land Cover Classification Map (see Picture 1)

This map was produced by classifying satellite image data (a mosaic of the Landsat TM images taken in June, 1991 and August, 1991).

(4) Rainfall Distribution Map

This map was produced by digitizing the existing maps. In actual application, rainfall distribution patterns were smoothened by applying a processing technique similar to the one that was used in producing a digital elevation model from contour data.

3. Processing Method

3.1 Removal of Depression in Digital Elevation Data

Many depressions are generally found in a digital elevation model. For example, when a valley stripe with steep cliffs on its both sides is represented with a large-size grid, a depression tends to be produced in the back of a valley. Size of a depression can be as big as one grid, or sometimes it can stretch out up to huge number of grids.

Such depressions were removed with the following two steps.

The elevation of a grid is compared with those of 8 surrounding grids. When the elevations of all surrounding 8 grids are the same height as the center grid or higher, a depression may be produced there. In such a case, the following examinations and process are performed.

ａ） First, define the coordinates and the elevation of a center grid as a searching center and the basic elevation, respectively.

ｂ）Among 8 grids around the searching center, look for a grid whose elevation is lower than the standard elevation (runoff point).

ｃ）When no runoff point is found, record in the memory the coordinates and elevations of all the grids that have been examined.

ｄ）Select a grid with the lowest elevation among those that have been recorded, and newly define its coordinates and elevation as a searching center and the basic elevation, respectively.

ｅ）Repeat the process from (b) to (d) on each grid except those that have been already examined or previously defined as a searching center until a runoff point is found.

ｆ）When a runoff point is found, the elevations of the grids that have been recorded in the memory are raised to the basic elevation if their heights are lower than the basic elevation.

ｇ）Next, shift a searching center to a new grid which has not been examined yet, and again the process from (a) to (f) mentioned above is repeated on every grid.

In case of the grid that has been previously defined as a runoff point is, in fact, found to be a part of a much larger depression, the following process is performed to remove a depression. Every time when shift a searching center to a new grid in process (g), clear the history “already examined or previously defined as a searching center” which is mentioned in the process (e).

In this way, regardless of the shape and the size of depressions, filling up process can be correctly performed. The maximum number of grids that can be processed in this system is dependent on the capacity of a computer. The system that was used in our study was able to fill up as many depressions as 1 million grids.

3.2 Tracing of Rainwater Runoff

For tracing rainwater runoff, there are presently two methods available, i.e. a quasi-river system method and a method that gives priority to the data of an existing river system if it is available. In the quasi-river system method, angle between the center grid and every one of the 8 surrounding grids was checked and the direction in the one with steepest gradient was defined as the rainwater runoff direction.

(1) Procedure for Creating a Quasi-River System

The following are the procedure to create a quasi-river system.

ａ）Select any point to start tracing and define it as the tracing center.

ｂ）Examine the surrounding 8 grids to find the one whose elevation is the lowest of all and lower than the tracing center as well. Then, this grid is defined as a runoff point and runoff direction. However, if there is particular grid in the 8 surrounding grids which has been defined runoff direction already, the direction toward the particular grid should prevail as the runoff direction.

ｃ）When the elevations of all 8 surrounding grids are same or higher than the tracing center, a tracing area should be extended as explained in (d) to (g) below to find a runoff point.

ｄ）Among 8 grids around the tracing center, the coordinates of the one having the same height as the searching center and the direction connecting with the searching center should be recorded. The grid with same height should exist if removal of depression is previously processed.

ｅ）Among the recorded grids, the one that was most recently recorded, except those that have already been defined as the tracing center, should be defined a new tracing center.

ｆ）Repeat the step from (d) to (e) until the runoff point can be found.

ｇ）When the runoff point is found, a sequent connection among the recorded grids can be traced back from the runoff point to the original tracing center defined in (a). The route thus traced back is determined as the runoff direction in that section.

ｈ）Select a grid that has no runoff direction, set new tracing center there and perform the process from (b) to (g) again until the runoff direction can been determined for every grid. The results are arranged in a runoff direction file, which has direction numbers from 1 to 8 that points to the one of the 8 surrounding grids. This file can be used in calculation of catchment areas and the volume of runoff discharge.

(2) Priority Process of Existing River System

By recording runoff directions of the existing river system in an output runoff direction file, in advance, of a quasi-river system process mentioned in (1), the priority process stated in the above (1)-(b), i.e. "However, if there is particular grid in the 8 surrounding grids which has been defined runoff direction already, the direction toward the particular grid should prevail as the runoff direction." becomes effective and the results that reflect the priority process of the existing river system over a quasi-river system are produced. If any grid without the existing river system is found, it is filled with a quasi-river system and thus no contradiction is produced.

In determining the runoff direction of the existing river system, the rainwater tracing method mentioned in (1) can be directly applied. Digital data of the existing river system has no elevation information and it is, therefore, expressed as a flat area. In such a case, tracing of rainwater runoff can be performed by placing at least one grid at the river mouth (or at the end of a target river basin) and setting its elevation lower than the area of the existing river system. Runoff direction can be also determined in the same process. In this case, complicated tributary streams or their size, for example, some of the tributaries may occupy only one grid width, or others may form a delta and thus occupy many grids width, cause no problem in creation of river system data.

3.3 Calculation of Catchment Area

If catchment area of any given point in a target area is calculated, it will be helpful in irrigation planning and other plannings. In fact, calculation of a catchment is easily done. In the course of previous operation for tracing rainwater runoff explained in 3.2, a runoff channel has been already known. Therefore, summing up all the grids where a runoff channel lies and then multiplying the sum by unit area will give a catchment area. Cumulative catchment area from a dividing ridge to a given point and a sectional catchment area between any sections demarcated by main facilities as well can be utilized for planning. In this system, cumulative catchment area as well as sectional catchment area in every grid in a target area have been calculated. Therefore, they can be recorded in a disk file and the data of all the grids can be freely output in graphic forms or tabulated lists. "Sectional Catchment Area" and "Cumurative Catchment Area" in table 2 show some of these examples.

3.4 Calculation of Runoff Discharge

Our system calculate runoff discharge of a basin. This kind of method belongs to a distributed runoff model. In this system, the runoff depth of a grid is obtained by subtracting the percolation to deep underground and the evapo-transpiration from the amount of rainfall. Then, runoff discharge is calculated by cumulating the runoff depth of every grid along the runoff direction. Since this system uses annual data, the results are expressed in the form of annual average runoff discharge.

(1) Calculation of Runoff Depth of Each Grid

The following formula is used for calculation.

$$P_i = R_i * (1 - B_i) - E_i \qquad (1)$$

where

P_i ：Annual runoff depth of grid "i"（mm）

R_i ：Amount of annual rainfall of grid "i"（mm）

B_i ：Percolation rate to deep underground of grid "i"

Due to the fact that no effective data was available, percolation rate was uniformly set as 10% of annual rainfall of a grid.

E_i ：Annual evapo-transpiration of grid "i"（mm）

Further, Ei is expressed in the following formula as a function of elevation and vegetation.

$$E_i = e_i * f_i \qquad (2)$$

where

$$e_i = F(h_i) = -0.30 * h_i + 1560 \qquad (3)$$

e_i : Annual evapo-transpiration capacity of grid “i” (mm/year)

h_i : Elevation of grid “i” (m)

Estimated evapo-transpiration capacity at the dozens of points in Central Java was calculated by Penman method. It is highly correlated with elevation, which is a major determining factor for temperature in a tropical region. Therefore, evapo-transpiration capacity of each grid is set by the above regression equation in which elevation is used as a parameter (see Figure 4).

f_i : Vegetation coefficient (see Table 1) to obtain the amount of evapo-transpiration from evaotranspiration capacity of grid “i”.

Annual amount of evapo-transpiration obtained by formula (2) is shown in Picture 3.

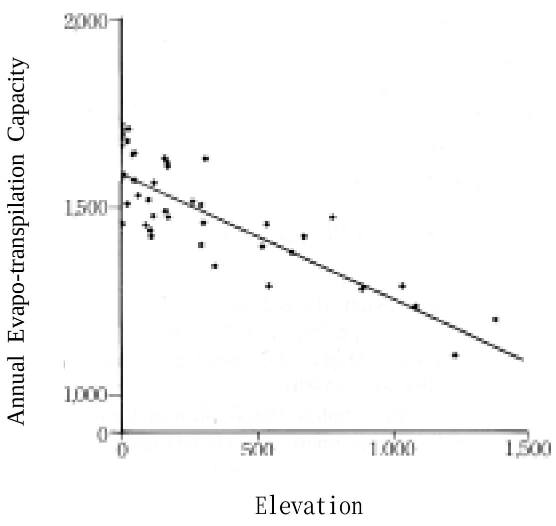


Figure 4 Correlation between Evapo-transpiration Capacity and Elevation

Table 1 Vegetation Coefficient for Evapo-transpiration

	Bare Land	Paddy Field	Upland Field/ Bush	Water Body	Plantation/ Forests
Vegetation Coefficient	0.45	0.85	0.95	1.10	1.20

(Coefficients were set by referring to the irrigation planning standards of the Ministry of Public Works)

(2) Calculation of Runoff Discharge

Runoff discharge at any given point can be calculated by, first, integrating runoff depth of each grid along the runoff direction obtained in 3.2, then multiplying the result by unit area of grid.

The following is the formula for calculation.

$$Q_C = \sum_{i \in C} P_i * A * k \qquad (4)$$

where

Q_C : Discharge (t/s) at the end of basin C (t/s)

C : Target basin

P_i : Annual runoff depth of grid “i” (mm)

A : Unit area of grid “i” (ha)

k : Conversion factor 10/(3600*24*365)

After this process is performed, annual mean discharge of each grid is obtained. The discharge at major points is shown in “Estimated Annual Mean Discharge ” in Table 2.

(3) Comparison with the Observed Discharge

“Observed Annual Mean Discharge (reference)” in Table 2 shows the values actually observed at the same points whereas the estimated runoff discharge is calculated by the above method. Due to the facts that the observed values of only 2 points are available and also percolation rate to deep underground is hypothetical, it is risky to draw a final evaluation, however, tendency toward low specific discharge rate in Dumpil basin, where arid climate prevails, can be found. Therefore, it can be safely concluded that, though a model introduced in this paper is very simple, our model has been proved effective.

(4) Displaying Water Balance Reflecting Water Utilization Plan

In addition to displaying annual mean runoff discharge, this system is able to simulate comprehensive discharge conditions when artificial operations such as water intake and water discharge were intervened at the midstream of a river, in accordance with plans such as River Basin Development Plan and so on. “Designed water intake/discharge” in Table 2 shows artificial operations, if any, and the results are shown in “designed discharge after operations”. Although there are contradictory values in our case between the annual mean values and the values limited to an irrigation period, this function allows us to compare and evaluate various water utilizations in a river basin. Picture 4 shows design discharge for all the grids. It also shows the balance of discharge resulted from discharge from a dam or water intake at head works.

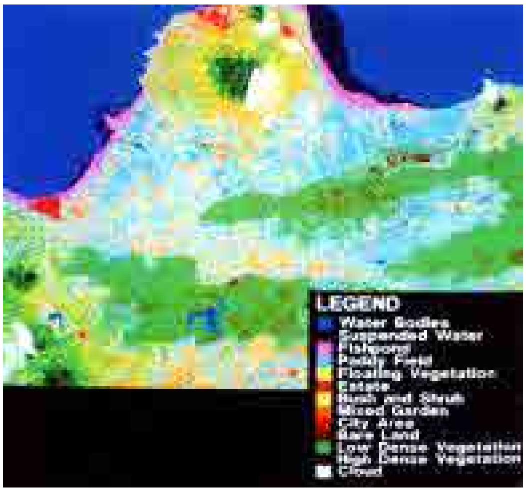
4. Farther target for Runoff Analysis by GIS

The method introduced in this paper has the advantages of utilizing updated information by remote sensing technique and high geographic resolution by GIS. Since this method does not require so many sort of information in application, it will be a powerful tool in the assessment of development plans in a developing country where limited information is available

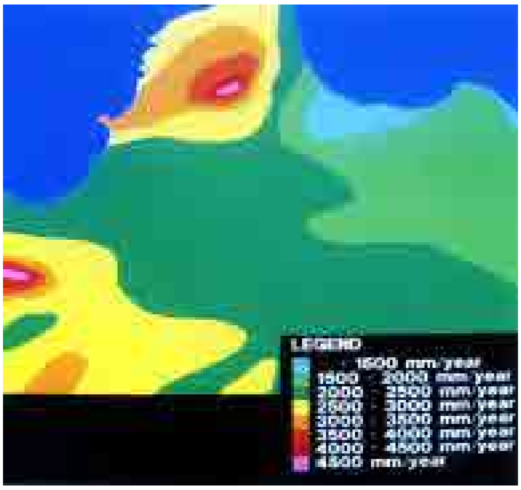
In this paper we treated hydrologic process with the distributed runoff analysis that utilizes a system of small size grids. This kind of approach has just started and, therefore, it is still in developing stage. It is expected that efforts be focused on the development of runoff model so that the model can adequately explain such phenomena as surface runoff, percolation behavior, hydrological transition of runoff, etc. by fully utilizing the advantages of GIS so as to produce fruitful results in the future.

Table 2 Basin Elements

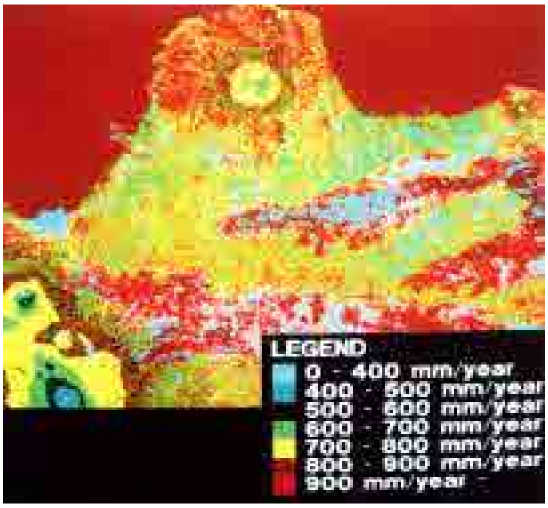
Watershed Outlet No.	Point Name	Sectional Catchment Area km^2	Total Catchment Area km^2	Estimated Annual Mean Discharge m^3/s	Observed Annual Mean Discharge (reference) m^3/s	Designed Water Intake/ Discharge m^3/s	Designed Discharge After Operation m^3/s
27	Dumpil Head Works	390	842	17.05	17.70	Water Intake 15.82	1.23
11	Kedunombo Dam	652	652	26.67		Dam Discharge 55.00	55.00
25	Sidorejo Head Works	24	676	27.46		Water Intake 9.14	46.65
26	Sudhadi Head Works	221	897	34.79	30.86	Water Intake 20.52	33.46
12	Kuramb Head Works	31	3,070	87.58		Water Intake 57.37	13.06
1	River Mouth	223	3,476	104.11			29.59



Picture 1 Present Land Cover（input）



Picture 2 Annual Rainfall Distribution（input）



Picture 3 Annual Evapo-transpilation（intermediate output）

Picture 4 Annual mean runoff drainage (out put)

GIS Application on Selection of Suitable Area for Agricultural Development in Indonesia

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Abstract

A GIS land evaluation system has developed at the RSP (Remote Sensing Project), DPU (Department of Public Works) in Indonesia, which had been assisted by the JICA (Japan International Cooperation Agency).

This paper describes some introduces a GIS applications on land evaluation for agricultural development in Indonesia. Collected raw data are existing soil map, geology map, rainfall distribution map, elevation map, slope map, and land cover map analyzed from satellite image data. Applied evaluation methods are the "Ranking method" which is based on the combination of categories in each thematic map and the "PATTERN" method which is based on the total of score correspondent to categories in each thematic map.

1. Background

Indonesia is the largest archipelago country in the world, which consists of 13,667 islands scattered in an area of 5,113km running east/west and 1,820km north/south. Around 60% of 195 million, the total population of Indonesia, is concentrated in Java Island with a population density of 800 persons/km^2, whilst on the outer islands (islands other than Java) it is 100 persons/ km^2. This remarkable regional difference in population distribution has been a problem. In order to solve the problem, the government of Indonesia has planned to develop agricultural infrastructure in the outer islands, aiming the promotion of transmigration from Java to the outer islands as well as the increase in food crop production.

For the effective selection of suitable areas for agriculture from the vast land on the outer islands, Remote Sensing and GIS was planned to be introduced as a tool for data collection and processing and analysis. In 1980, the Remote Sensing Project for the Development of Agricultural Infrastructure was established in the Ministry of Public Works in Indonesia as a project-type technical cooperation by the government of Japan through the JICA.

The project was completed in 1993 after going through phase I and II. Part of the project results are introduced here.

2. Target area for the study

In order to develop the method to select suitable areas for agricultural development in the outer islands, North Banten, the region situated in the northwestern edge of Java of approximately 400,000 ha (Figure 1) was selected as a test site to prepare an evaluation map. As shown on the LANDSAT image (Photograph 1), North Banten consists of an alluvial plain in the northeast, hilly land in the southeast and a mountainous area in the west. The plain is mainly used for rice paddy fields and the hilly land for plantations of coconuts, bananas, etc. The mountainous area including three volcanoes such as Mt. Karang is covered with forests. The distinction of dry and rainy seasons is clear. In addition, the rainfall distribution varies widely depending on topographic conditions (1,555mm/year in the northern coast and 4,500mm/year in the mountainous area). In the rainy season, the alluvial plain in the northeast is subject to constant flood damages.

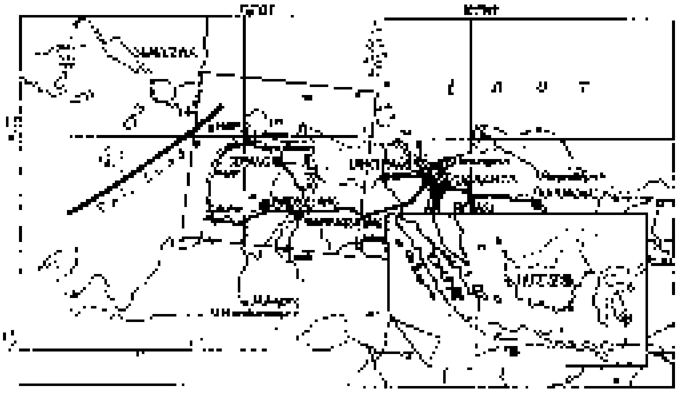

Figure 1 North Banten region location map

LANDSAT

Color composite image

- Blue parts on the mountainous area and low land areas are rice paddy fields.
- Bright yellowish white areas are arid areas.
- The blueish black belt along the coast is a group of fish ponds.
- The river slightly right to the center is River Ci Ujung.
- The peak covered with clouds is Mt. Karang (1,778m).

Photograph 1 ; LANDSAT Color composite image

Table 1 Thematic map production

Natural Factor	Thematic map	Main source of data	Production method	used to select suitable areas for agricultural development	
				Ranking evaluation method	PATTERN method
Land use	Land cover classification map	LANDSAT MSS	classify digital data with maximum likelihood method[1]	○	
Vegetation	Biomass classification map	LANDSAT MSS	compute vegetation index[2] by Rouse et.al model (1975) from digital data	○	
Geology/Geomorphology	Geology/geomorphology map	LANDSAT MSS	digitize the results of color composite image interpretation and prepare grid codes	○	○
Landform	Elevation classification map	Existing topographic map	read elevation on each grid	○	○
	Slope classification map	Existing topographic map	compute slope steepness and angles from elevation data	○	○
Soil	Soil map	Existing soil map[3]	convert the map into grid codes	○	○
	Soil depth map	Existing soil depth map[4]	convert the map into grid codes	○	○
	Soil moisture condition map	LANDSAT MSS	compute soil index[5] by Fukuhara model (1980) from digital data	○	
Precipitation	Precipitation classification map	Existing rainfall data[6]	convert the map into grid codes		○
Disasters	Flood potential map[7]	Various thematic maps	use various thematic maps to evaluate with the Typ2 Quantification Method developed by C. Hayashi (1961)		○

1) Maximum likelihood classification method: The results of field surveys and interpretation of infrared color aerial photos (scale 1/30,000) are used for classification as training data.

2) Vegetation index by Rouse et.al : the index to represent the quantity of living green plants.
VI= √(MSS7-MSS5)/(MSS7+MSS5), where, VI: vegetation index, MSS5, MSS7 : computed values of LANDSAT MSS bands 5 and 7 in the target area

3),4),6) Existing soil map, existing soil depth map, existing precipitation data : [Proyek A.P.B.D. Propinci Daerah Tingkat I Jawa Barat. (1977/1978); Perencanaan Tata Guna Tanah, Wilayah Pembangunan Banten.], precipitation data for 1931-1960

5) Soil index by Fukuhara et.al : This indicates the spectrum property on the soil surface which can be the index of soil moisture condition because of the generally strong influence by the surface moisture condition. SI=(PMSS7－MSS7)(MSS5－PMSS5), where, SI : soil index, PMSS5, PMSS7 : the values of LANDSAT MSS bands 5 and 7 related to vegetation, MSS5, MSS7 : the values of LANDSAT MSS bands 5 and 7 in the target area

7) Flood potential map : The flood potential is evaluated using 6-year flood frequency experiment data as external criteria and land cover, biomass classification, soil moisture condition, elevation, slope, distance from river, precipitation, geology/geomorphology, etc. as explaining variables.

3. Thematic map production

In order to evaluate suitability for agricultural development, it is essential to properly understand the distribution of regional resources. The information on such resources is mainly related to land and water resources. Regarding land resources, the evaluation on land stability (tolerance for disasters such as erosions, collapses and floods), productivity (efficiency of agricultural production) and workability (difficulty of land cultivation and possibility of mechanization) need to be considered. Table 1 is a list of the items of regional resources for evaluation selected under the above preconditions and the thematic maps to represent those items.

4. Evaluation map production

An evaluation map for the selection of suitable areas is obtained through comprehensive evaluation of various thematic maps. There are various kinds of evaluation methods, but they are roughly divided into two groups. One group is done by combining categories from each thematic map, and in the other by aggregating scores corresponding to each category. Both methods, Ranking evaluation method and PATTERN method, which are the representative methods of two groups are introduced in this paper. Since rice production is the most important in agriculture in Indonesia, the suitability for agricultural development here focuses on that of rice paddy fields.

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4.1 Evaluation with Ranking evaluation method

In Ranking evaluation method, a category group for each factor representing land characteristic (thematic map) is prepared and a comprehensive evaluation on specific land is done according to response combinations of those categories. For example, let the category in the thematic map A which corresponds to the comprehensive evaluation class i be Ai ; the category in the thematic map B be Bi, and so forth. If characteristics of certain land respond to all of Ai, Bi, ・・・, the land is evaluated as class i. This means that Ai, Bi,・・・can be combined using AND circuit.

Eight kinds of thematic maps shown on Figure 2 were used for the evaluation. Intermediate (1^{st} stage) evaluation is carried out to avoid complication of planner's decisions and the final (2^{nd} stage) evaluation to be more realistic. One part of the intermediate evaluation is a land condition map which shows land workability and the other part is a map which shows land productivity. These intermediate evaluation maps and a soil moisture condition map showing possible soil moisture content are overlaid and the suitability of land for agricultural development is evaluated.

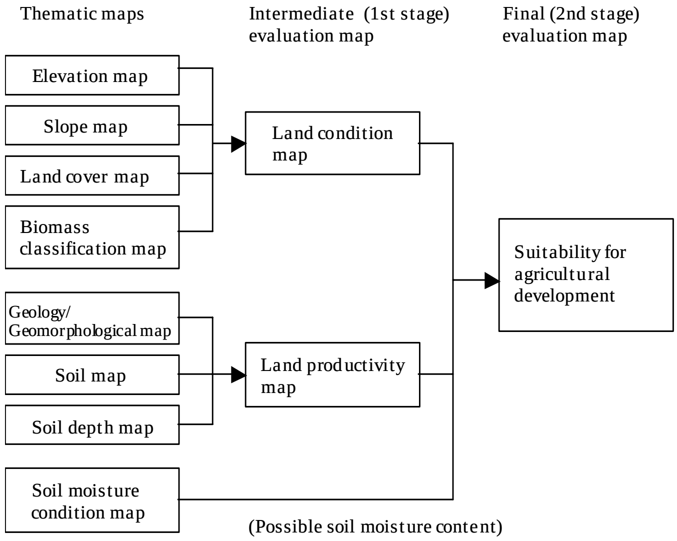

Figure 2 Evaluation of suitability for agricultural development by Ranking method

This method was applied using the following procedure:

(1) Cross aggregation of training data and thematic grid map

To know the relationship between each category of thematic map and suitability for agricultural development, cross aggregation of training data and thematic maps were done at target area. The area where suitability for development is already known through field surveys, etc. is used as training data. By investigating the characteristics of thematic map categories included in the zones according to the degree of suitability, it becomes clear what characteristics of categories combination suitable areas should possess, and at the same time, a guideline for utilizing the areas for agricultural development can be obtained.

(2) Establishing the evaluation criteria

Based on the relation between suitability for development and thematic map categories obtained by cross aggregation, opinions of agronomist and specific regional situations are taken into account to establish evaluation criteria. Table 2 shows the evaluation criteria for land condition, Table 3 illustrates those for land productivity and Table 4 shows the final comprehensive evaluation criteria which gives the suitability for agricultural development.

(3) Evaluation map production

Following the given evaluation criteria, each area unit data are classified into evaluation classes corresponding to response combination against each thematic map category. Figure 3 is a suitability evaluation map for agricultural development produced based on Ranking method.

Table 2 Evaluation criteria for land conditions, first stage evaluation (Ranking method)

		Thematic maps			
		Elevation	Slope	Land cover	Biomass
Land conditions	1. Best for paddy fields (Ideal conditions)	0－200 m	0－2%	Paddy (wet) Paddy (dry) Bushes	0－31 kg/m^2
	2. Moderate for paddy fields (Lack of workability)	25－200 m	0－15%	Bushes Garden crops	2－31 kg/m^2
	3. Moderate for paddy fields (Lack of irrigation)	0－200 m	0－15%	Paddy (dry) Grass Bushes	0－14 kg/m^2
	4. Moderate for paddy fields (Lack of drainage)	0－100 m	0－2%	Fish ponds Paddy (wet) Wetlands	0－6 kg/m^2
	5. Difficult for paddy fields (Upland plantations only)	25－1,000 m	2－40%	Paddy (dry) Grass Bushes Garden crops Forests	2－31 kg/m^2
	6. Useless for agriculture	1,000 m－	0 %－	All classes	0 kg/m^2－
		0 m－	40 %－	All classes	6 kg/m^2－

Table 3 Evaluation criteria for land productivity, first stage evaluation (Ranking method)

		Thematic maps		
		Geology	Soil	Soil depth
Land productivity	1. Good productivity	Alluvium Volcanic products Pliocene sedimentary	Alluvial Podosol Grey humus	60 cm－
	2. Normal productivity	Alluvium Volcanic products Pliocene sedimentary	Latosol Regosol Brown forest soil	60 cm－
		Alluvium Volcanic products Pliocene sedimentary	All categories Except grey-yellow Regosol	0－60 cm
		Miocene sedimentary	All categories Except grey-yellow Regosol	0 cm－
	3. Poor productivity	All categories	All categories	Rock
		All categories	Grey-yellow regosol	0 cm
		Miocene limestone Andesite Basalt Diabase	All categories	0 cm

Table 4 Evaluation criteria for suitability of paddy field development, second stage evaluation (Ranking method)

		First stage evaluation		
		Land conditions	Land productivity	Soil moisture conditions
Suitability for paddy fields	1. Best for paddy fields (Ideal conditions)	1. Best	1. Good	Wet Dry
	2. Moderate for paddy fields (Lack of workability)	1. Best	2. Normal	Wet Dry
		2. Moderate (Lack of workability)	1. Good 2. Normal	Wet Dry
	3. Moderate for paddy fields (Lack of irrigation)	3. Moderate (Lack of irrigation)	1. Good 2. Normal	Dry Extremely dry
		1. Best 2. Moderate (Lack of workability)	1. Good 2. Normal	Extremely dry

	4. Moderate for paddy fields (Lack of drainage)	4. Moderate (Lack of drainage)	1. Good 2. Normal	Extremely wet Wet
		1. Best 2. Moderate (Lack of workability)	1. Good 2. Normal	Extremely wet
	5. Difficult for paddy fields (Upland plantations only)	5. Difficult for paddy fields	1. Good 2. Normal	Wet Dry Extremely dry
	6. Useless for agriculture	6. Useless for agriculture	All categories	All categories
		All categories	3. Poor	All categories

(Notes)

・Lack of workability : The land cannot be highly efficient paddy fields due to the inclined land surface.

・Lack of irrigation : Though the land surface is currently dry, the land has a possibility to be good paddy fields with irrigation facilities.

・Lack of drainage : Though it is currently wet land, the land has a possibility to be good paddy fields with the drainage improved.

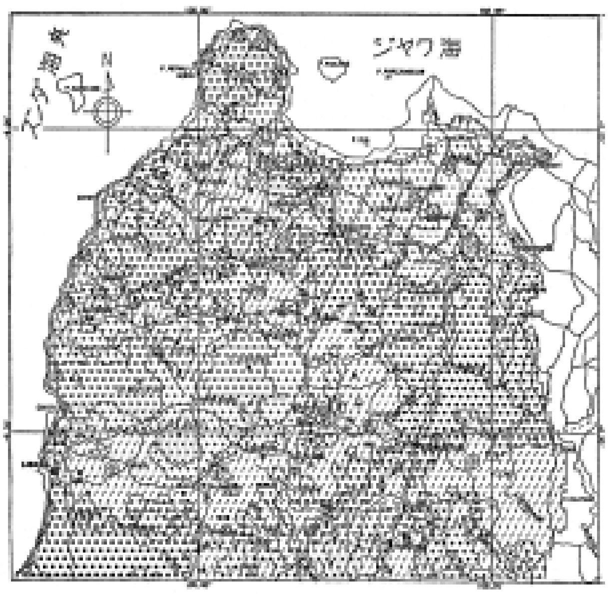

Figure 3 Evaluation map produced with Ranking method

1: Best for paddy fields, 2: Moderate for paddy fields (Lack of workability), 3: Moderate for paddy fields (Lack of irrigation), 4: Moderate for paddy fields (Lack of drainage), 5: Difficult for paddy fields (Upland plantations only), 6: Useless for agriculture

4.2 Evaluation with PATTERN method

(1) Characteristics of PATTERN method

The selection of suitable area for agricultural development is difficult to be dealt with a quantitative model because regional resources used for evaluation such as geography, geology/geomorphology and soil have qualitative characteristics. The PATTERN method described here quantifies the issues and has a different characteristic from a qualitative model described by the former Ranking method. In suitable area selection using the PATTERN method, evaluation is done on how much various resources in the region can be utilized with the objective for regional agricultural use. In other words, it is a method to numerically express the regional potentiality for agricultural use, an effective method for determining priority in regional development. PATTERN (Planning Assistance Through Technical Evaluation of Relevance Numbers) method is a method developed by the US company Honeywel in 1963 for planning a long-term project in the space section. In the Apollo Project, PATTERN method was used for selecting an observation system mounted on a rocket sufficient enough for accomplishing their objectives.

(2) Evaluation with PATTERN method

The evaluation using PATTERN method creates a pyramid shaped relevance dendrogram having the agricultural development suitability at the top and regional resource factors at the bottom of the pyramid, based on the importance of each regional resource factors' objectives. Following this, the total score is obtained for each regional grid to be used as development suitability evaluation value.

The relevance dendrogram in this project is shown in Figure 4 as an actual example.

If the final objective is the suitability for agricultural development, the relative weight of land capability and land limitation are 70% and 30% respectively. Land condition, land productivity and water resources are elements which influence land capability in the lower level and their relative weights are 20%, 40% and 40%. Moreover, elevation and slope elements are related to land condition with relative weight of 60% and 40%. Amongst the regional resource items, slope contributes to the final objective with an absolute degree of $0.4 \times 0.2 \times 0.7 = 5.6\%$. Thus, a target area unit of 'slope 2-15%' has a total score of 1.68, which is obtained by multiplying the category score of 30 by 5.6%. In the same manner scores of every land resources factor are computed, and the sum of the final scores is regarded as the potential of a target area for agricultural use.

Based on a relevance dendrogram in Figure 4, the suitability results evaluated using the PATTERN method is shown in Figure 5.

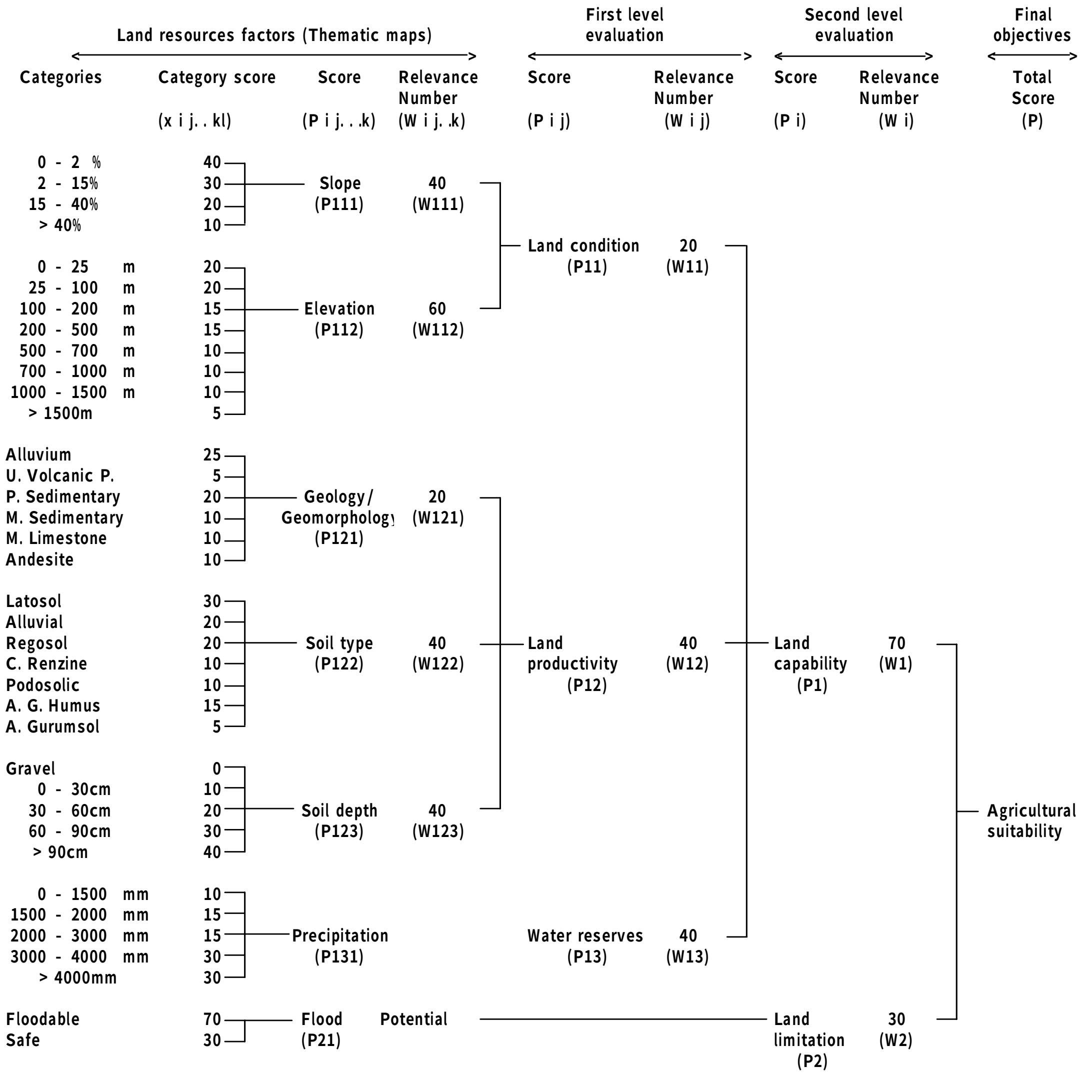

Figure 4 Evaluation model by PATTERN method (Nasu et. al, 1983)

5. Comparison of the two methods

Both the Ranking method and the PATTERN method are useful for understanding the land condition. They are able to evaluate suitability with enough accuracy for practical planning, as confirmed by field checks. However, each method has different characteristics. Effective guidance to improve land conditions for development can be obtained from the Ranking method because every evaluation class is shown in a qualitative manner and includes explanations of the hand characteristics. On the other land, the order for agricultural development can be obtained from PATTERN because the land potential is denoted in quantity.

Accordingly, it is suggested that PATTERN be applied to determine the order of development after the selection of suitable areas by the Ranking method.

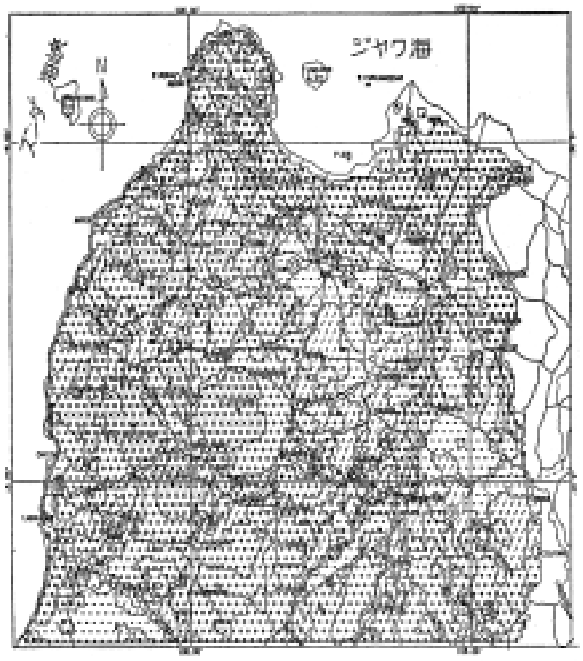

Figure 5 Evaluation with PATTERN method
1: Best, 2: Good, 3: Good – Moderate, 4 Moderate – Poor, 5: Poor, 6: Not good

Integration of GIS and Multivariate Statistical Analysis in Master Plan Study on Integrated Agricultural Development in Laos

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Abstract

The authors established the advanced analytical methodology for decision-making, using GIS and multivariate analysis (Principal Components Analysis and Cluster Analysis) in master plan study on integrated agricultural development in Laos. As GIS is increasingly used for overseas projects, GIS is naturally used for geospatial analysis while it is very important to be identified to use GIS as a function of database and the way of application and GIS is integrated as one of fundamental technologies in decision-making process. This method has become an outstanding attention from other development assistant organizations as well as the Ministry of Agriculture and Forest in Laos. In addition, all 141 districts are divided into 10 groups according to its grouping method based on the scientific and objective interpretation of these data set and derived a present condition of agriculture, constrains prevented development, and specific targets to tackle the constrains found in each district. Strategic development planning will work out effectively in a specified area when human and financial resources are invested in specific targets for development. This methodology will be highly applied for **strategic development planning** in other various fields as well as agricultural development and points out that GIS is an essential technology for the formation of a master plan.

1. Introduction and Objectives

The government of Japan had decided to conduct master plan study on integrated agricultural development in Laos after received a request of the Government of Laos. Japan International Cooperation Agency (JICA) dispatched a study team, which was included members of Nippon Koei Co.,Ltd., to Laos between November and Octorber 2001.

The methodology using GIS and multivariate analysis was applied to the identification of the agricultural conditions in each district of Laos. It is intended to use the results of analysis for **strategic development planning** to make realistic and area-specific projects/programs based on the scientific methodology applied here. The effectiveness of GIS was optimized by the combination of GIS and statistical analyses, which integrates agricultural, social, topographical, and natural environmental data, and by making decisions based on the scientific and objective interpretation of these data sets. It should be pointed out that GIS should not be an isolated technology but a part of an integrated methodology of analysis.

2. Methodology

2.1 Integration of GIS and Statistical Analyses

GIS derives digital data sets from an existing database and adds meaningful information to the integrated analysis. Essential data sets stemmed by GIS are topographical data sets including elevation, slope, the total length of roads, land use data derived from the satellite image analysis. On the other hand, the statistical analysis makes plenty of data sets (in this project about 20,000 data were used) easily readable and comprehensive.

The advantage of this methodology is derived from the fact that strategic development planning, which leads to appropriate decision making for planners, bureaucrats and politicians in both developed and developing countries, can be accomplished through the combination of GIS and multivariate analysis (in this project principal components analysis and cluster analysis were applied).

2.2 Flow of Analysis

Firstly, existing agriculture census 1998/99 and population census 1995 data and GIS data (both raster and vector data) were collected in Laos. The compilation of topographical data was conducted using ESRI ArcView Spatial Analyst.

After the data compilation using GIS, principal components analysis (PCA), one of the multivariate statistical analysis techniques, was carried out. PCA derives a number of principal components (five of which were extracted in this project) that explain the main factors related to the present conditions of agriculture in Laos. Then, all the 141 districts were classified into 10 groups based on the principal component (PC) scores of the five principal components by applying the technique of cluster analysis.

Then, the present characteristics of each group are identified in terms of various aspects of agricultural conditions, and then constraints, which prevent sustainable agricultural and rural development, were found out for each group. Finally, targets and appropriate policies were clarified to tackle the constraints found for each group of districts. Strategic planning of area-based agricultural and rural development can be made possible following the methodology applied here.

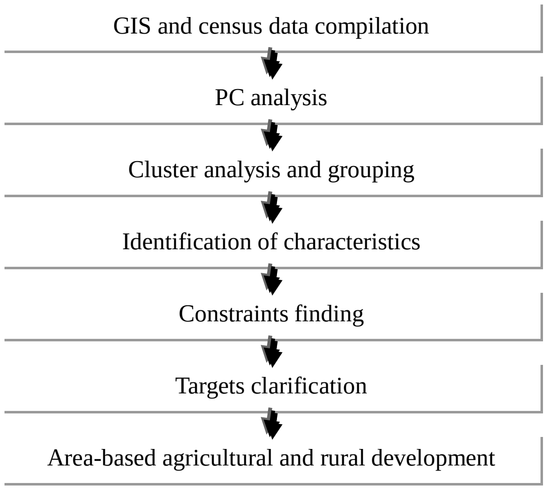

Figure 1. Flow Chart of Analysis

2.3 Principal Components Analysis (PCA) and Data used

PCA was applied to plural sets of variables to discover similarities and positioning of the variables. PCA involves a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

Since the possible number of PC should be the total number of variables (equal to 141 districts in this analysis) minus 1 according to the principle of PC analysis, about 140 data sets were selected as meaningful data to be applied to principal components analysis. The list of the data used in this project is presented below.

Existing GIS data was obtained from the National Agriculture and Forest Research Institute (NAFRI) in Vientiane that has conducted a number of GIS projects in cooperation with the Mekong River Commission to derive 50 m and 250 m grid digital elevation model (DEM) and other essential data for the analysis.

2.4 Cluster Analysis and grouping

After the identification of the five PC, cluster analysis was applied to the grouping of the 141 districts based on the PC scores of each district. Cluster analysis is also one of the multivariate analysis techniques that seeks to organize information about variables so that relatively homogeneous groups, or "clusters," are formed based on the Mahalanobis distance which determines the "similarity" of a set of values from an unknown sample to a set of values measured from a collection of known samples. The number of groups is determined on the trial-and-error basis, which finally comes up with the meaningful division of districts in terms of agricultural conditions over the country.

Table 1. Data Compiled and Used

Data Type	Description of Data	Data Format
Topographic data	･Roads in 4 classifications	GIS polyline data
Elevation and slope	･Digital Elevation Model (DEM) of 50 and 250 m grid in all Laos ･Slope of 50 and 250 m grid in all Laos	GIS grid data
Administrative boundary of provinces and districts	･District boundary containing 141 districts ･Provincial boundary containing 18 provinces	GIS polygon data
District level digital data from 1998/99 agriculture census	･Average area of holding and number of parcels, land use and land tenure conditions Cropping pattern and major crops cultivated ･Purpose of production ･Use of production inputs ･Average number of livestock raised by livestock type ･Number of holdings with aquaculture ･Others	DBF
District level digital data from 1995 population census	･Population density ･Percent distribution of population by sex ･Urban and rural population ･Percent distribution by place of birth ･Household size by urban and rural ･Population by education level and literacy rate ･Economically active population by occupational classification and unemployment rate ･Children born and deceased persons ･Electricity and domestic water supply ･Conditions and availability ･Others	DBF

3. Results

3.1 Derived Principal Components

The five sets of principal components identified as a result of PCA include: 1) Transitional Farming, 2) Market Orientation, 3) Water Resource Utilization, 4) Farm Intensity, and 5) Degree of

Diversification, all of which represent the present conditions of

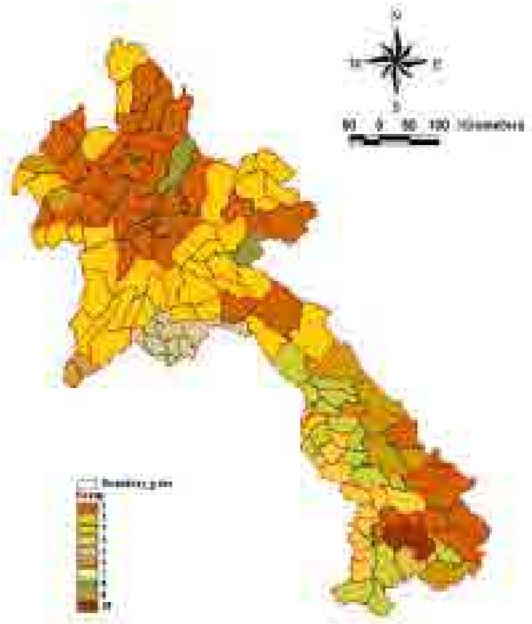

Figure 2. Grouping of district agriculture in Laos.

I[illegible] ponents derived here elaborate on each district's agricultural setting from the five perspectives.

Transitional Farming indicates a degree of farming system in transition from traditional to modernized agriculture, while Market Orientation designates a degree of farm production targeted for sale. Water Resource Utilization indicates a degree to which water resources are utilized for agricultural production, and Farm Intensity designates a degree to which farm resources are utilized for output of agricultural crops. Finally, Degree of Diversification indicates the extent of diversification in cropping, livestock, and aquaculture.

3.2 Grouping of Districts

All the 141 districts were classified into 10 groups by cluster analysis in accordance with the five PC of each district. The following table shows the number of districts belonging to each group and the scale of each cluster (group). (Table 2)

Table 2. Cluster Scale

Cluster Scale		
Group No.	Number of Districts	% of the total number of districts
1	41	29.08%
2	38	26.95%
3	19	13.48%
4	14	9.93%
5	10	7.09%
6	9	6.38%
7	5	3.55%
8	2	1.42%
9	2	1.42%
10	1	0.71%
Total	141	100.00%

The Table in the next column shows the distribution of 10 groups over the country. Groups 1 and 2 are distributed in the mountainous areas and constitute the similar agricultural setting. Groups 3 and 4 are located along the Mekong River and in the southern part of the country where rice paddies are abundant.

Groups 5 and 7 are positioned in the suburbs of Vientiane where market economy is a common practice for agricultural products. The other groups are particular for the regions and have special agricultural settings.

In addition, the scoring of each district's principal components provides the **quantitative** (numerical) criteria for the prioritization of regions and policies as shown below.

Table 3. Averaged PC Scores of Each Group

Group	Transitional Farming	Market Orientation	Water Resource Utilization	Farm Intensity	Degree Of Diversification
1	-0.87	0.20	-0.45	0.39	0.54
2	-0.41	0.07	0.92	-0.09	-0.70
3	0.72	-0.80	-0.33	-1.05	-0.01
4	1.26	**-1.33**	-0.69	0.32	0.03
5	1.51	0.33	0.56	1.25	0.03
6	-0.45	-0.06	0.03	-1.64	0.97
7	**2.32**	3.44	0.32	-0.10	**1.19**
8	**-1.00**	-0.33	-1.55	**2.78**	0.55
9	-0.14	0.18	**0.96**	1.16	-3.17
10	-0.48	**3.58**	**-6.56**	**-2.53**	**-5.63**

3.3 Example of group description

The following pentagons show the examples of the radar charts of Groups 1 and 5, to which the mountainous 41 districts and 10 districts north of Vientiane belong, respectively. The scale shown represents the magnitude of the scores of the principal components of each district.

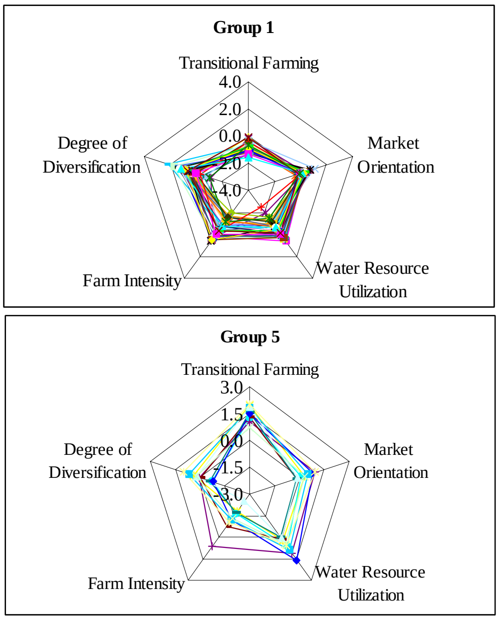

Figure 3. Rader Charts

The characteristics of Groups 1 and 5 are described in the following table based on the averaged score of each group's PC. The difference between the two groups is huge in terms of their agricultural settings. Group 1 is representative for the region where shifting cultivation and traditional agriculture are popular among the farmers, while Group 5 practices the modernized and market-oriented agriculture.

Table 4. Description of Agricultural Setting

Group	Principal Components: Components	Principal Components: Evaluation	Describe Characteristics
Group 1	Transitional Farming	Low	• Shifting cultivation is widely practiced on sloping land for production of upland paddy. • In order to supplement a lower productivity, non-paddy products (including livestock and home manufacturing products) are produced and marketed to a certain extent. • Expansion of irrigation area mainly for lowland paddy production is at mid to low level. • Resource management is poor and depletion is high. • Farming intensity is at mid to low level, and diversification is at mid to high level.
	Market Orientation	Mid. to High	
	Water Resource Utilization	Mid. to Low	
	Farm Intensity	Mid. to Low	
	Degree of Diversification	Mid. to High	
Group 5	Transitional Farming	High	• Districts that belong to this group are located near to Vientiane city, and production of market oriented crops are considerably well developed. • Irrigation system is also well developed and supports crop diversification. However, farm intensity is relatively low. • Floods occur frequently in the wet season along the Namgum River due to its topographic condition.
	Market Orientation	High	
	Water Resource Utilization	High	
	Farm Intensity	Low	
	Degree of Diversification	Mid.	

As shown in the next table, the constraints, rooted in the described characteristics, are found out, and the targets to be achieved are clarified. The comparison between the two groups exemplifies the necessity of strategic development policies to tackle the constraints focusing on some regions.

Table 5. Constraints and Targets Identified

Group	Found Constraints	Clarified Targets
Group 1	(1) Domination of unsustainable shifting cultivation which is a cause of forest cover reduction, soil erosion, etc. (2) Food crops are insufficiently produced. (3) Productivity of non-paddy crops is low, although they are important for cash income source. (4) Production and marketing infrastructure is poorly developed. (5) Degree of market orientation is still at mid. level.	**(1) To prevent expansion of shifting cultivation.** **(2) To develop adequate production systems for sustainable use of upland.** **(3) To promote production of cash crops to increase farmers' income both in upland and lowland areas.** **(4) To provide production and marketing infrastructure.** **(5) To improve productivity of lowland paddy.**
Group 5	(1) Further expansion of market oriented crops are becoming difficult due to small domestic market. (2) Quality of marketing crops is still at a low level for export. (3) Paddy productivity is still at a low level. (4) Flood damages are considerable in the eastern part of Vientiane municipality, although the largest market is close by.	**(1) To develop and introduce proper cropping pattern and production technologies so as to produce high value crops throughout the year.** **(2) To improve the quality of products so as to increase their competitiveness.** **(3) To assist farmers in marketing development.** **(4) To improve productivity of paddy by use of proper level of inputs taking economic return into account.** **(5) Some flood mitigation measures in the mid- to long-term are thus needed.**

3.4 Area-based agricultural and rural development

After clarifying all the necessary information on the agricultural setting of each group, the planning of area-based agricultural and rural development was conducted.

Group 1

Shifting cultivation, having a considerable negative impact on the land and forest, is widely practiced in the mountainous areas of Group 1. It is expected that such a negative impact may expand in future as a result of increased population pressure. Fundamental measures to stabilize shifting cultivation include the development of alternative production systems through the strengthening of research efforts and the dissemination of such systems to farmers through extension services.

In addition, the expansion of road networks is promising to promote infrastructure and marketing possibility in remote areas. For the lowland areas, the distribution of improved seed, and the improvement of cultivation techniques and existing irrigation systems are required.

Group 2

A part of Vientiane municipality and its suburbs are classified into Group 5 where vegetables for the largest market in Laos, Vientiane City, are intensively produced particularly in dry season. In this area, however, flooding due to its topographic conditions is one of the largest constraints to agricultural development. Flood mitigation measures in the mid- or long-term are thus needed for the promotion of wet season agricultural production, although this analysis is independent of the statistical results.

In addition, the introduction of new vegetable crops and varieties, cheaper plant management and quality control technologies and appropriate technologies for all-year-round crop production is indispensable to facilitate vegetable production in non-flooded areas.

4. conclusion

Necessity and urgency of agricultural and rural development projects/programs can be derived from the full understanding of the present conditions of agriculture, and prospective projects/programs are to be designed to fulfill the targets identified for each group.

4.1 advantages

The application of this methodology to the formulation of the integrated agricultural development plan derives the following advantages:

- Strategic development policies can be derived, which is to efficiently and effectively concentrate limited human and financial resources on a specific target and in a specific area (through grouping) to tackle poverty and promote agricultural production.
- It is possible for decision-makers to clearly prioritize both development targets for each group and geographical regions that should be addressed first, based on the principal component scores of each district.

4.2 limitations

- The quality of original data is of the utmost importance. In other words, the quality of this methodology heavily relies on the reliability of original data sets. Therefore, the importance of both data collection and data selection cannot be overemphasized.
- This methodology is not independent of other additional information, particularly, of field surveys. For a group of analysts applying this methodology, experienced experts who are familiar with the actual conditions should work on the analysis together. Otherwise, the analysis will not be sufficiently reliable at all.
- Political considerations should not be ignored at the time of final decision making. Priority actions or areas might be shifted from the results of the analysis due to the local politics.

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The Feasibility Study on the Forest Management Plan In The Central Highland In the Socialist Republic of Viet Nam

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Abstract:
The Feasibility Study on the Forest Management Plan in the Central Highland in Socialist Republic of Viet Nam was decided to be conducted by the Government of Japan in response to a request of the Government of Socialist Republic of Viet Nam. Japan International Cooperation Agency (JICA) dispatched a study team that included Japan Overseas Forestry Consultants Association and Pasco International Inc. to Viet Nam between February 2000 and May 2001. Digital data of topographic data, land-use/vegetation image data, forest type boundaries, communes, forestry enterprise boundaries of the study area were created. Using the GIS database potentiality/problem/constraint of forestry development was evaluated by geographical analysis. Furthermore, suitability analysis/evaluation of the existing surrounding villages were carried out in order to support the local inhabitants.

1. Study Objectives

The purpose of The Feasibility Study on the Forest Management Plan in the Central Highland in Socialist Republic of Vietnam (hereinafter referred to as the Study) is to prepare plans to realise long term Sustainable Forest Management. As a short-term plan, a forest management plan was to be developed in the most important forest of the region, Kon Plong County, Kontum province in the Central Highland. The survey area is located in Kon Plong county, Kontum province (some 233,000ha) in the Central Highland. The model area is 24,000ha in area and a district administered by Mangura forestry public corporation.

The purposes of the use of GIS in this Study are to investigate forestry potentiality (area etc.) and evaluate land suitability etc. for the formulation of forest management plans.

2. Data in Use

The data used in the Study are as follows.

2.1 1:50,000 Topographic Maps

GIS data were prepared from the topographic maps using a digitizer. The GIS data created consists of study area boundaries (polygon), rivers (line), roads (line), villages (point), contours (line), and elevation points (point).

2.2 1:10,000 Topographic Maps

GIS data of Mangura district were prepared using digitizer the topographic maps. The GIS data created consists of vegetation boundaries (polygon), buildings (line), rivers (line), roads (line) and contours (line).

2.3 Landsat/TM Image Data

Landsat/TM Image data, when given the same projection system (geographic coordinate) as that of topographic maps, are able to be handled in the same way as GIS data in the same computer system. Image data with this kind of projection are called Raster GIS data. In this Study, land use・forest type image data were prepared by image processing Raster GIS data. Raster GIS data were converted to GIS data.

2.4 1:20,000 Monochrome Aerial Photographs

They were used as reference materials to classify land use and forest types. Principal point position data in the photographs were converted to GIS data.

2.5 Other Thematic Maps

Forest type boundaries (polygon), communes (polygon), forestry corporation boundaries (polygon) were created in GIS database using each thematic maps. From land-use・forest type images, slash and burn field distribution maps were prepared and stored in the GIS database. Analytical maps of topography etc. were compiled by parting into grids (1cm×1cm) and by analysing topography and water system using a 1:50,000 topographic map as a base map. Analytic grids of topography etc. (polygon) were stored in GIS database as well as various thematic maps. Details of analytical grids of topography etc. consist of local topographic features, relative relief, river systems, and elevation classes.

The advantage of storing digitised data in GIS format from topographic maps is that information of text, numerical values and images can be processed simultaneously on the basis of position information on the computer. Thus it is characterised by integrated management of maps, field records, site photographs and analysis of various map data information in the same system.

Furthermore, different from paper maps, it is possible to reduce or enlarge the map sizes on the computer but it is important to keep in mind that the accuracy is heavily dependent on source materials, in this case the paper maps.

Figure 1 shows an example of commune boundaries and compartments displayed in layers against the background of contours, roads and rivers digitally inputted from 1:50,000 topographic map. Figure 2 shows land use・forest type image data referred to as Raster GIS. The boundaries of communes and compartments are overlaid as shown in Figure 1 and illustrates that land use・forest type image data and boundaries of compartments etc. data can be handled simultaneously on the basis of position information.

Figure 1: 1: 50,000 Topographic Map, commune boundaries and forest boundaries

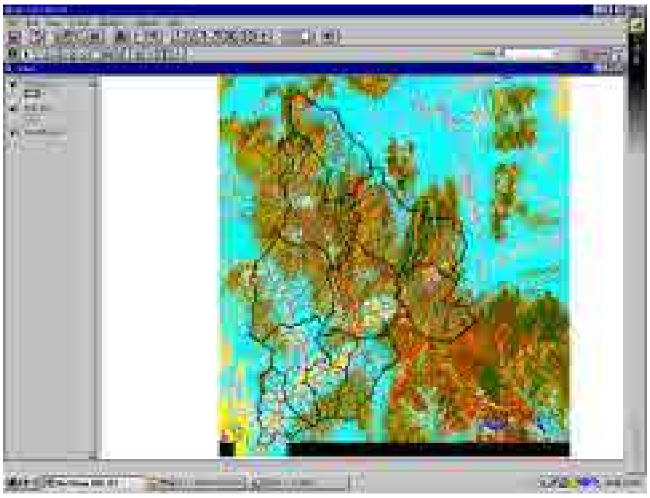

Figure 2: Land Use/Forest Type Image Data

3. Role of GIS and examples of its application

An example of GIS application in the field of forestry is forest planning information management system in which forest/forest survey inventories are added to a forest planning map as attributive information. This system enables users to comprehend existing forest conditions visually and systematically, to set up various plans (forest management plans, such as administration plans and implementation plans), and to calculate forest area and wood supply capabilities. By using GIS, it is possible to adopt other evaluation factors such as geology and topography other than forestry and carry out forestry capacity evaluation of water conservation, mountain disaster prevention, conservation of living environment, health culture, etc.

In this Study, evaluation of forest malfunction warning levels was carried out by applying GIS through comprehending forestry potentiality in each compartments/forest administration areas and evaluating various functions (water conservation, soil conservation, landslide prevention, outflow prevention) by using analysed results of topography etc. and forest type data. Furthermore, land suitability evaluation study of the existing peripheral villages was also implemented to support local inhabitants.

Figure 3 illustrates the results of topographic analysis stored as GIS data of the grid data and commune/forest boundary overlays. Both figure 3 and 2 shows that various data, such as area calculation of local topography evaluation in each forest boundary can be analysed on the same system. Figure 4 shows selected land use/forest type data of the periphery of villages, a part of the land suitability evaluation to support inhabitants. It is possible from this to identify land cover conditions within 1 km radius of existing villages and to prepare suitability analysis to support local inhabitants.

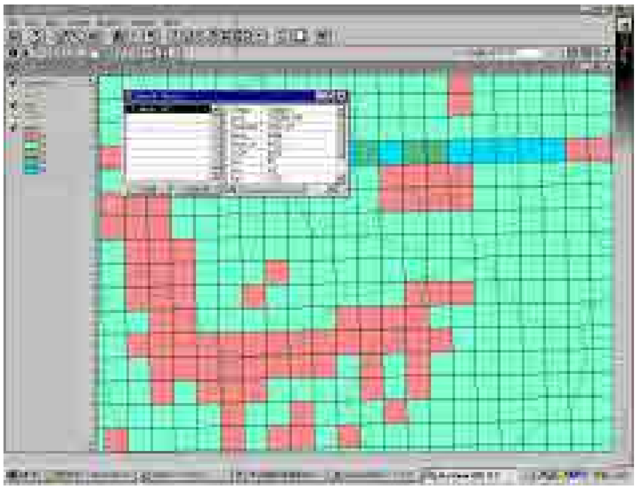

Figure 3: Results of topographic analysis stored as GIS grid data

Various collected map data and analysed results have been handled separately so far, but in this Study they were unified by the use of GIS. If GIS analytical technology transferred, it will be possible not only to implement forestry management, evaluation and planning in field offices whenever need arises, but also to apply all the process of evaluation methods and forest management planning adopted in this Study to other regions.

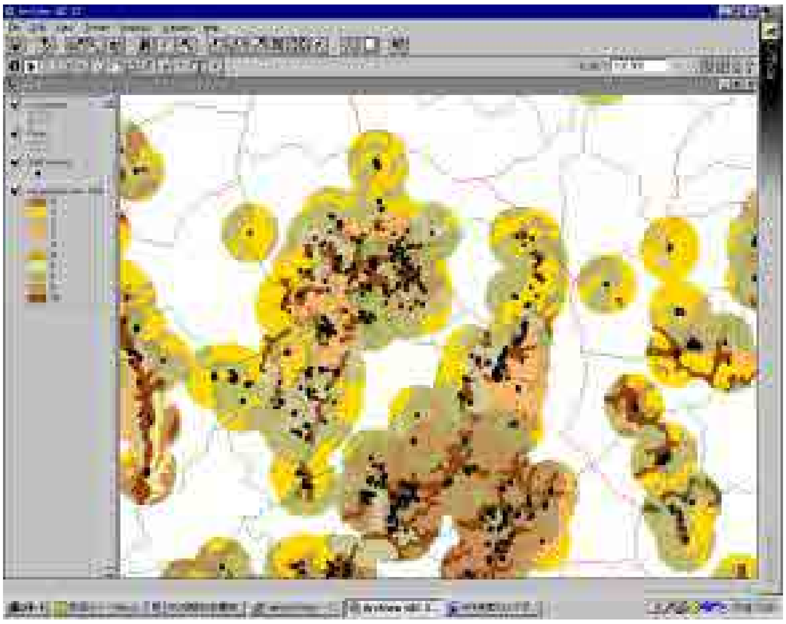

Figure 4: Land covering status within 1-km radius of villages

The Study of Infrastructure Information Management System of the Dakar Metropolitan Area in the Republic of Senegal

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Abstract

The Dakar Metropolitan Area has urban problems caused by rapidly increasing population, illegal housing, traffic problem, flooding etc. Individual effort by responsible organizations has not yielded desired results bacause data preparation effort is duplicated among different organizations, their data collection by them are often mutually incompatible. It was desired to establish an information management system in the provision of social infrastructure utilizing GIS in order to support the development of urban facilities and services in the Dakar Metropolitan Area. JICA implemented the technical cooperation programs to establish a working system actually utilized by related organizations in Senegal through technology transfer.

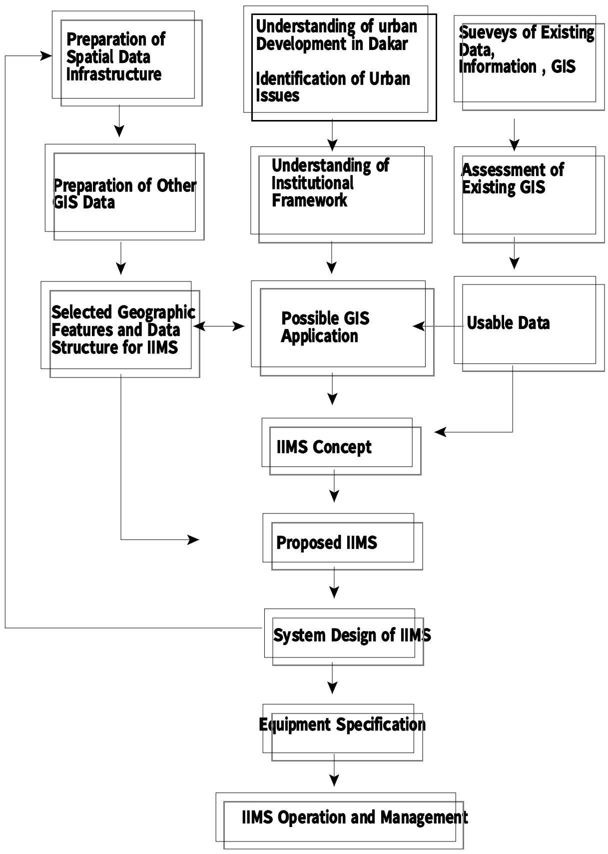
1. Background

The rate of population increase in the Dakar Metropolitan Area (its population projection of 1999 was 1,900,000) is 4 percents per year. The population density in the city is too high and the capacity for accommodating its population is too small to catch up to develop infrastructure and maintain environment. As a consequence, random urban sprawl and deterioration of environment in Dakar become serious social problems. Efforts by the responsible department of local governments couldn't achieve their primary purpose and its inefficiency is pointed out, such as duplicate efforts for information development and incompatibility of information among different departments. Thus, it is requested in development of urban infrastructure to establish the Information Management System (Infrastructure Information Management System: IIMS), so that data can be shared and compatible among responsible departments.

Japanese International Cooperation Agency (JICA) established the mission composed of PADECO, Co., Ltd. and Asia Air Survey Co., Ltd. and had conducted a field study for 14 months, from September 1999 to January 2001. The mission was sent three times for 9 months in total and built the system through field studies and technology transfer. Organizations as a counterpart include two departments, the Department of Geographic and Cartographic Works (DTGC) of the Ministry of Equipment and Transport and the Department of Urban Planning and Architecture (DUA) of the Ministry of Urban Planning and Housing.

2. Infrastructure Information Management System and a role of GIS

Descriptions of urban issues in the Dakar Metropolitan City were collected, that is called urban carte, in order to conduct evaluation and analysis of phenomenon in urban planning and consider the potentiality of GIS application as a solution of urban issues. As a result of consideration, at first, it was designed both of a database and system, which structured information management system associated with infrastructure, and then established the system and a constitution of its management and maintenance. Figure 1 shows the flow of the research.



Final report Volume1 p8 Figure1.4.1 System Establishment Process

Figure 1. The flow of research

2.1 Urban carte described urban issues and designing social information management

Carte described urban issues was made to deliberate about specification of urban issues, cause analysis, action programs and responsible departments, the necessity of data related to action planning, and the possibility of GIS applications.

The targets of carte include transportation, flood, water and sewer supply, sewage disposal, garbage disposal, residential land, the lack of multifamily housing and public space, low-quality housing, insufficient services for emergency, and poor public facility. Solutions for individual item above were considered based on a result of urban carte to settle urban issues. A support system to resolve urban issues by utilizing GIS was developed through designing database necessary for this application. Figure 2 illustrates an example of urban carte.

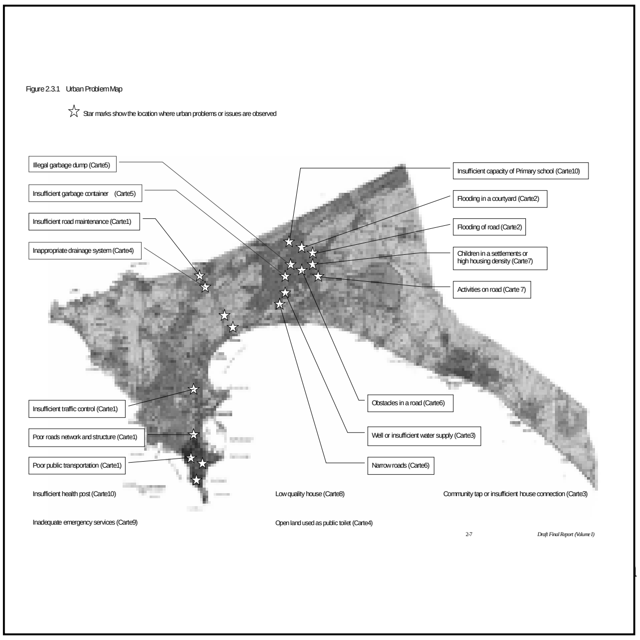


Figure 2. A distribution map of urban issues in Dakar as an urban carte

2.2 The establishment of an infrastructure information database

Datasets of infrastructure information was created by updating 42 sheets of 1: 5,000 topographic maps in the Dakar Metropolitan Area about 200 square kilometers. This database is composed of geospatial database and other types of GIS data. It was found out that these data among individual organizations were not compatible and difficult to import/export data straightforwardly, by developing an inventory of related departments in order to identify the availability of existing data. Because these datasets have the variety in terms of data's media and format, the extent of data, specifications and quality of data, reliability of the statistical data. Under these circumstances, it became clear that management and maintenance is a key subject for the establishment of database. The mission reconstructed new datasets, which is used 1:5,000 topographic map as a base map for geospatial database, which is updated existing topographic maps by utilizing aerial photos, and attribute data collected in the field on top of a base map. Through the collaboration with counterparts during the preparation of datasets, the recognition of sharing information among different organizations has increased. Figure 3 shows a map of current land-use distribution based on geospatial database.

3. The establishment and management of the System of Infrastructure Information Management Planning

The System of Infrastructure Information Management Planning derived several sub-systems like as below , which are established as a case study of GIS application employing data developed in urban planning.

3.1 A sub-system for urban information reference

It is established a sub-system that an application can query, display, compile, and prepare a thematic map for a purpose of information inquiry concerning urban planning. (Figure 4)

Thematic maps prepared for the system include information in public facilities, public services (garbage disposal and public transportation), infrastructure (roads, railroads, water supply, sewerage, and electricity), population, change of urbanized districts, the condition of land-use planning and zoning, and current land-use distribution.

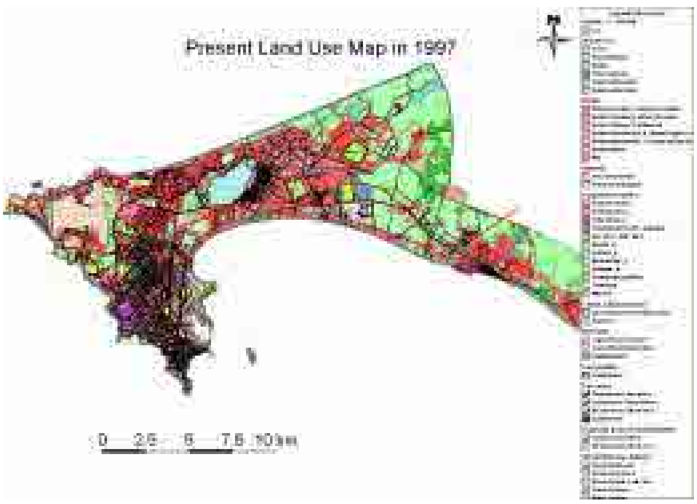


Figure 3. A distribution map of current land-use by using geospatial database

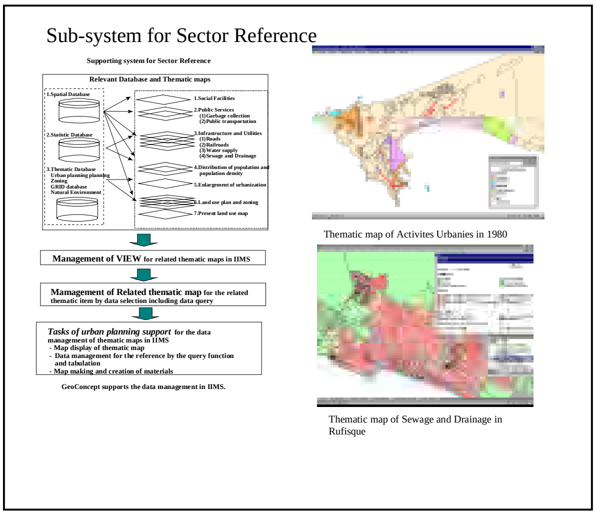


Figure 4. The Urban Information Reference System

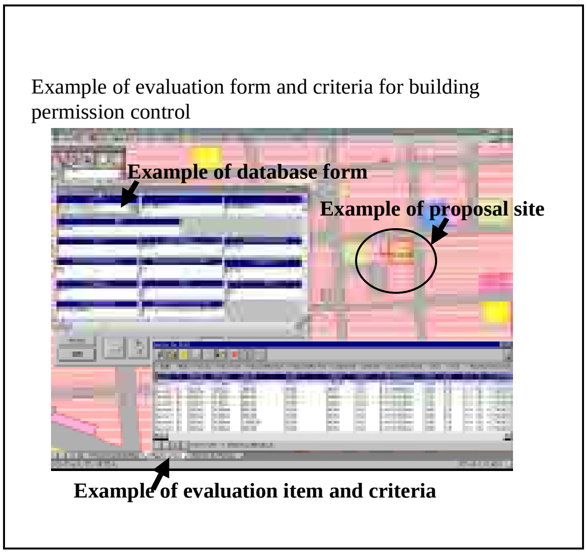


Figure 5. A sub-system for urban development management

3.2 A sub- system for urban development management

In order to standardize the management both of plans and appropriate criteria related to applications for construction permission, information filled out the application is putting into a database. The record management system was established to search and display information they need from the database. (Figure 5)

3.3 A sub-system for urban planning support

A sub-system for urban planning support was established as an application considered the best location of public facilities by utilizing several layers of administrative boundary, census data, and distribution of existing public facilities and present land-use. （Figure 6）

3.4 A sub-system for residentially suitable land evaluation

A sub-system for residentially suitable land evaluation was established as an application, which supports evaluation of residential environment and selection of a new residential district by means of geospatial database and GIS data, according to a current housing development plan (Figure 7)

3.5 Technology Transfer

The purpose to establish the system is to utilize the system more practically among associated organizations. Thus, there were enhanced efforts of holding seminars, workshops, and trainings in the field to transfer technology. The Department of

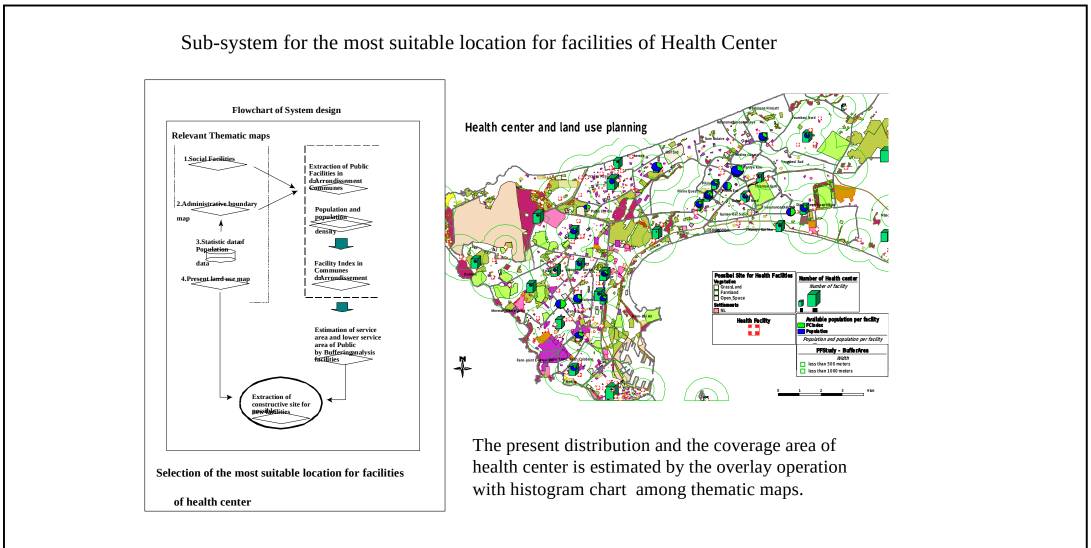


Figure 6. A sub-system for urban planning support (The best location for public facilities)

Geographic Survey and the Department of Urban Planning installed both hardware and software for the management system. It took two and half months to give trainings for responsible officers in both departments, such as setting up and operating hardware, installing software, establishing the Infrastructure Information Management System by creating a database, operating the system and holding practical trainings how to operate GIS. Figure 8 shows pictures of the room installed the system and training given to officers.

4. Outlook

It is essential for Infrastructure Information Management System to update database, develop the system and human resource, and maintain facilities and an important task in the

future to accomplish these assignments continually. It is necessary for an establishment of geospatial database in Senegal to enhance the consensus among different organizations for sharing data and practice the collaboration in an actual project. It is required to take an action for the standardization of GIS data discussed in the ISO/TC211. In addition, the sustainable development of the system is dispensable to continue technology transfer and develop human resource constantly. Currently, specialists are sent to the Department of Geographic Survey for long-term and carrying out follow-up for the research.

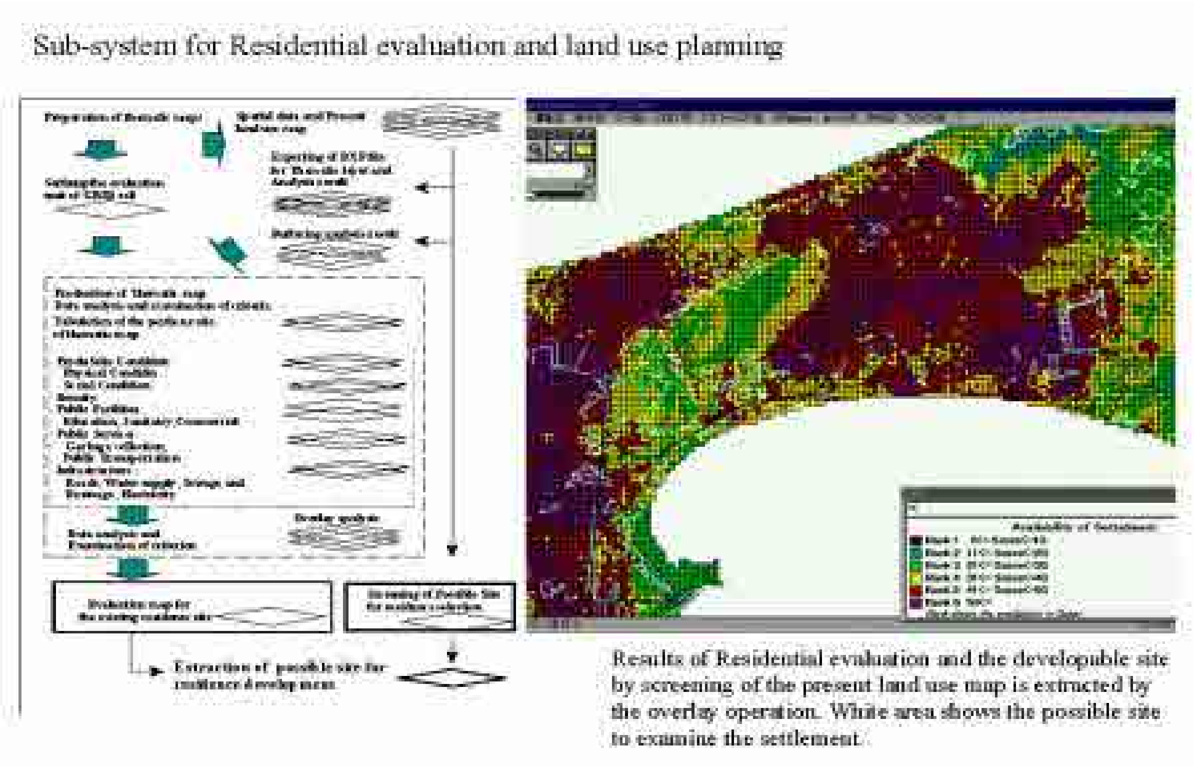


Figure 7. A sub-system for land evaluation of suitable location for residential development

Figure 8. Pictures of the room installed the system and technical training given to officers

ESTABLISHMENT OF GEOGRAPHIC INFORMATION SYSTEM FOR DKI JAKARTA IN THE REPUBLIC OF INDONESIA

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Abstruct

The DKI Jakarta GIS Project started in 1992 and completed in 1997 having had the objective of establishing a geographic information system (GIS) for the efficient and effective support of land administration within the local government of DKI Jakarta. The work on the project has evolved through Phase I and II, performed by Pasco International Consortium under the finance of OECF, Japan.

The end product of the project was an operational GIS, having eight (8) applications for four (4) "core" applications; (i) DTK Site Measurement Application (ii) DTK KRK Planning Advice Application (iii) DTK Planning Related Records Maintenance System, and (iv) DPPT Library Maintenance System; and four (4) "Remaining Priority Applications"; (i) The Map Creation System (ii) DPPK Building Footprint Update Module to Support IBM Permitting System (iii) DPPK Building Footprint Update Module to Support IPB Occupancy Permit System, and (iv) BPN Parcel Maintenance System.

DKI Jakarta realized many benefits from implementing GIS technology, the coordination of data activities among the agencies and the efficiencies brought by computerization.

1. Background

The local government of DKI[1] Jakarta, with an area of 657 square kilometers, had a 1997 population of 10 million and was growing at approximately 3.7% annually. Based on this annual growth rate, the population projection for 2005 is 13 million. Such a rapid rate of population growth has accelerated the need for land space, infrastructure, and public services. To plan for such growth, the need for increased administration management was required, especially in the land use and development. DKI Jakarta has been developing a geographic information system to facilitate improved administration management, major decision making, policy determination, and city planning efforts.

2. Project History

The DKI Jakarta GIS Project started in May 1992 and finished in July 1997. The project was financed from the Overseas Economic Cooperation (OECF, now JBIC[2]) Fund of the Government of Japan. Work on the project has evolved through Phase I and II, performed by Pasco International Consortium, which is an assemblage of Japanese, American, and Indonesian companies, primed by Pasco International Inc. DPPT[3] has served as the Project Implementation Unit under the coordination of the GIS Technical Committee chaired by BAPPEDA[4].

1) Daerah Khusus Ibukota (Special Metropolitan Area)
2) Japan Bank for International Cooperation.
3) Dinas Pemetaan dan Pengukuran Tanah (Surveying and Mapping Department)
4) Badan Perencana Pembangunan Daerah (Regional Development Planning Board)

3. Project Objectives

The end product of the project was an operational GIS for the efficient and effective support of land administration within the local government of DKI Jakarta. The GIS was developed for use at the dinas[5] level of local government and the suku dinas[6] level within the five Wilayah[7] that comprise DKI Jakarta. The participating dinas and suku dinas were included:

DPPT, Surveying and Mapping Department
DTK, City Planning Department
DPPK, Building Development Control Office
BPN, National Land Board
BAPPEDA, Regional Development Planning Board
KPDE, Electronic Data Processing Office

4. Project Approach

The objective of Phase I was to create the conceptual system design and a detailed physical design for GIS application and database. Phase I was followed by the preparation of a technical proposal for extending development of the GIS into a Phase Ⅱ. The objective of Phase Ⅱ was to implement the GIS according to the system design during Phase I. The Phase II was comprised of 16 tasks, i.e. 6 consultant tasks and 10 contractor tasks:

5) Sub-Directorate
6) Division
7) Region

Consultant Task

-Project Management
-Program Planning
-Database Development Pilot Study
-Application Development and Testing
-Institution Building
-Training Program

Contractor Task

-Aerial Photography
-Field Survey
-Base MapPlotting
-Data Collection & Compilation
-Structure Map Digitizing
-GIS Layer Digitizing
-Site Preparation of GIS Office
-Networking
-Hardware Installation
-Software Installation

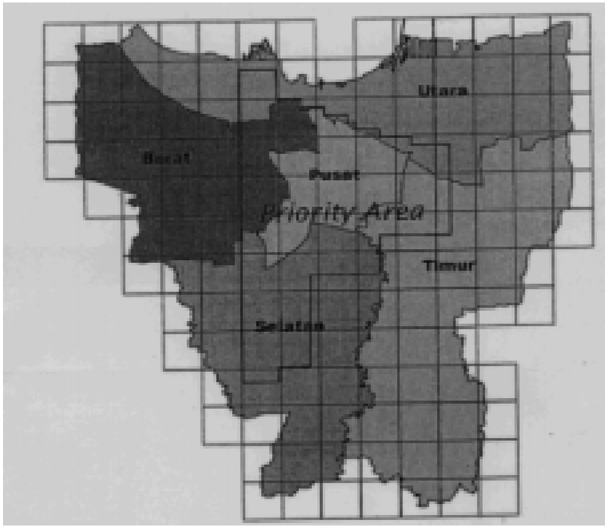

Figure 1. Project Area for Source Data Preparation and Automation

5. Priority GIS Applications

The 8 applications were split into two groups. One group was called the "core" applications and consists of the following:

1. DTK Site Measurement Application
2. DTK KRK[8] Planning Advice Application
3. DTK Planning Related Records Maintenance System
4. DPPT Library Maintenance System

The other 4 were placed in a group called the "Remaining Priority Applications" and consist of the following:

1. The Map Creation System
2. DPPK Building Footprint Update Module to Support IMB[9] Permit System
3. DPPK Building Footprint Update Module to Support IPB[10]
4. BPN Parcel Maintenance System

6. Benefits for DKI Jakarta GIS

DKI Jakarta realized many benefits from implementing GIS technology. These benefits arose from the coordination of data activities among the agencies and from the efficiencies brought by computerization. GIS brings special benefits because it combines maps with tabular data. This makes the computer-generated maps a very rapid method for viewing and analyzing a variety of information.

- Accurate geographical data supports urban development policy making, strategic planning and daily operations.
  Precise and properly controlled geographical information is critical as a basis for policy and supporting strategic planning and daily operations for urban development in Jakarta. The GIS brings together many types of map data based on the same coordinate system. This will speed up the development review and approval process for agencies.

- Accurate geographical data improve identification of taxable objects and improve capacities to increase tax revenues.
  Such information is also essential for identification, registration, valuation, and assessment of taxable objects. As such, these geographical data will be at the foundation of implementing laws targeted as increasing tax revenue from land, buildings, and other tax objects. Accurate inventories in the form of maps and related attributes can be established and rapidly updated as changes occur. Since the taxation agencies (PBB[11] and DIPENDA[12]) should receive more timely information about tax object creation and modification, the lag time to enter into these into the taxation system should be reduced.

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8) Keterangan Rencna Kota, Planning advise given by DTK for developers within Jakarta

9) Izin Mendirikan Bangunan, Building permit issued by DPPK within Jakarta.
10) Izin Penggunaan Bangunan, Occupancy permit for a building issued by DPPK.
11) Pajak Bumi dan Bangunan, Literally, Tax on Land and Buildings. Indonesian national tax authority.
12) Dinas Pendapatan Daerah, Local revenue.

- **GIS encourages agency coordination and data standardization**

  GIS is a data integration tool. For agency to make the best use of its capabilities, they will need to access the data of other agencies. For data access and sharing to be successful, agreement must be reached on data standards. The opportunities for this were particularly strong among the land registration (BPN), land planning (DTK), and building processing (DPPK), taxation (PBB and DIPENDA), and mapping (DPPT) agencies.

- **GIS will enable graphic (map) and nongraphic (tabular) data to be used together to support a variety of analysis, mapping, and reporting functions.**

  The GIS makes maps and analysis and display tools for all tabular data related to geographic locations such as buildings, parcels, roads, and utilities. These functions cannot be performed manually. This will enable immediate viewing of issues, such as delinquent taxes, and opportunities, such as coordination of development activities, that improves operations of DKI Jakarta agencies.

The Study on Urban Environmental Improvement Program in Bangkok Metropolitan Area

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Abstract

The economy of the Royal Government of Thailand grew at the rate of approximately 10 % a year for a decade from 1987. Environmental problems such as traffic congestion and air pollution caused by massive rural urban migration to Bangkok have become serious problems, which need to be fundamentally solved. Using GIS, Bangkok's urban environmental problems from five aspects, namely, land use/urban structure, urban transportation, air pollution, water related environment (floods, water supply and water quality) and living environment (housing/solid waste) were categorically evaluated. The Study recommends realizing strategic projects/programs based on the 6 planning policies.

1. Introduction

The Government of Japan decided to implement this study upon request from the Kingdom of Thailand and entrusted the study to JICA. JICA dispatched a study team from Pacific Consultants International and Suuri-Keikaku Co., Ltd to Thailand between 1995 and 1996. In Japan, Pasco Corporation has rendered GIS technology on the study. After returning from the country the study team worked in Japan and prepared the report in February 1997.

2. Objectives of the Study

The objective of the present study is to propose a new urban system and social rules for appropriate social capital and environmental resource use of the city with the aim of improving living standards of the people of Bangkok accompanied by sustainable development. The ultimate purpose is to prepare a master plan for Bangkok Metropolitan area's comprehensive urban environmental improvement by 2011.

3. Present Conditions of the City and Its Environment

The analysis on the present conditions and environment in Bangkok were carried out using GIS as follows:

3.1 Built-up Area

The built-up area was less than 100 square kilometres in the late 1950s but increased to 200 square kilometres in the early 1970s and to 482 square kilometres by 1993. The city centre has not expanded, but new built-up areas have been expanding along major trunk roads, where remarkable population growth has occurred in the last 20 years.

3.2 Present Land Use

According to the land use (Figure 1) made from aerial photos taken in 1993, the industrial areas (dark blue) tend to be located in outer areas of the centre, commercial areas (deep pink) are distributed in the center and large commercial areas in the suburbs.

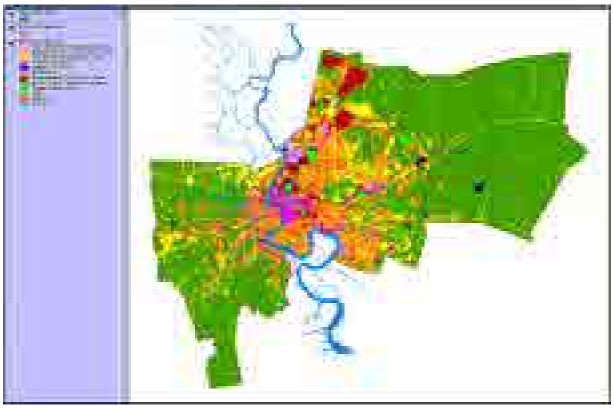

Figure 1. Existing Land Use (1993)

3.3 Land Subsidence and Floods

Rapid urbanisation and industrialisation accelerates groundwater use and land subsidence. The city centre has less subsidence by regulations, but in the suburbs there are noticeable subsidences. As a result, there are serious flooding problems occurring in the suburbs. Bangkok for a long time has been suffering from floods due to its location on alluvia and from 1983 to 1995 experienced large flood hazards. According to the GIS analysis, a flooded area in BMA (Bangkok Metropolitan Administration) in 1983 was 424 square kilometres. More than 80 % of the Phra Khanong district was flooded. More than one meter land subsidence is calculated to occur.

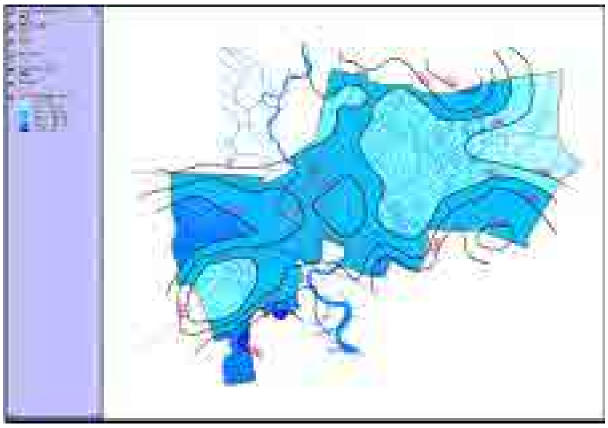

Figure 2.　Problem Areas on Natural Constraints

3.4　Air Pollution

About 50% of the total consumption of petroleum products in the country are consumed in BMA. Due to this consumption, heavy air pollution has been occurring continuously.　NOx, CO and PM-10 (Particulate Matter Smaller than 10μ) from traffic are the main pollutants. The simulation analysis of the air pollution confirmed that SOx, NOx, CO and PM-10, which were thought to be the main pollutants, were generated from vehicles, and their ground level concentrations are simulated.

3.5　Water Pollution

Water pollution areas are spreading in an east-west direction in BMA.　BOD (Biological Oxygen Demand) is between 20-40 mg/litre and DO (Dissolved Oxygen) is between 0-20 mg/litre. The water pollution in Khlong has lately been improved a little. However, the water pollution in Khlong has to be improved for water transportation for the residents in Bangkok and for tourism.

3.6　Distribution of Green areas

Distributions of green areas were analysed by Landsat TM image. Very few large green areas excluding parks and open spaces were observed in the built-up areas. And green areas seemed to be scattered mainly in private owned lands. In the suburbs, relatively large green areas remain along channels but decreasing due to development.

3.7　Urban Transportation

Of the average of 21,300,000 person trips per day in the BMR (Bangkok Metropolitan Region), trips which have origins or destinations within BMA occupy about 82% of the total trips. Within this 82%, 90% of them have both destinations and origins within BMA. From the point of the daily travel BMA is a relatively closed area. Therefore traffic problems in Bangkok are caused by socio-economic activities within Bangkok. Road/railway network and traffic zones in 1995 are shown in the figure 3.

Causes of traffic congestion in Bangkok are thought to be as follows;

- shortage of roads (road occupancy rates relative to land use are 5% in Bangkok, 15% in Tokyo, 20% in London),
- shortage in efficient subsidiary trunk roads,
- shortage in reliable alternative traffic system other than roads,
- imbalance between land development and road development, and
- shortages of restrictions and measures to meet traffic demand increases.

Figure 3.　Road/railway network and traffic zones in 1995

3.8　Integrated Environmental Problem Area Map

A workflow of the urban environment evaluation is given in figure 4. A field survey was carried out to collect existing data on urban environment, particularly on urban development, urban transportation, air pollution, water pollution and waste treatment, and ground survey to substitute the data. The GIS database was created. Analysis and simulation were made based on this database. Environmental problem areas were identified by overlaying these analytical results.

Urban environmental problems are extending in the whole Bangkok area but air pollution, water pollution, traffic congestion and population concentrations are serious in the city centre. In the suburbs, floods, land subsidence, water pollution, and overflow of waste products and urban sprawling are serious urban environmental problems.

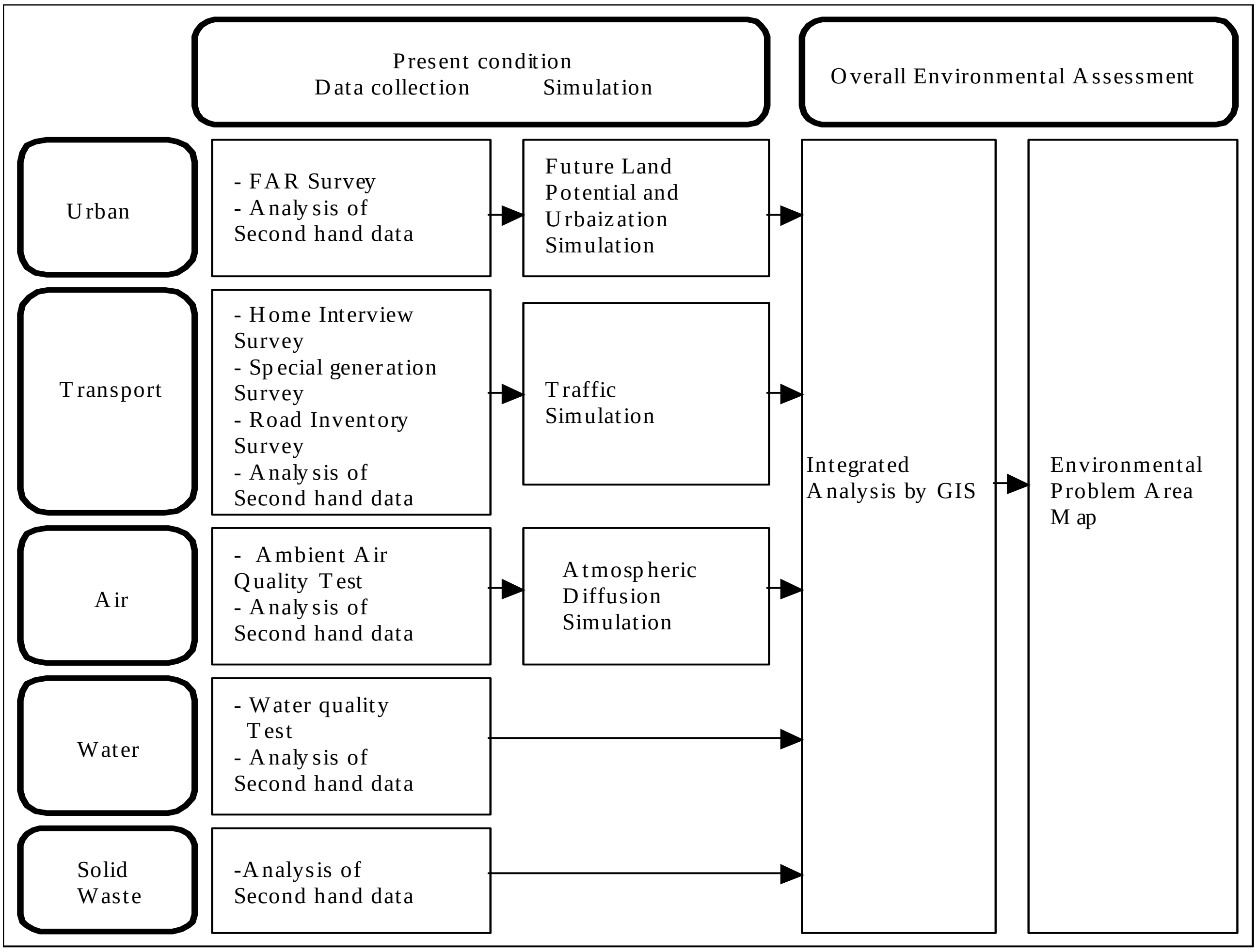

Figure 4 Overall Flow of Urban Environmental Assessment

4. Land Development Potential and Urbanisation

4.1 Analysis of Urban Development Potential

The analysis flow of urban development potential is illustrated in figure 5. An urbanisation model was constructed based on the existing factors influencing urbanisation of land. The whole Bangkok city was divided into one square kilometre grids. After each grid was given scores based on aspects using future infrastructure condition, future land potentials were simulated based on the developed urbanisation model. Future urban potentials were projected based on future land potentials and population frameworks. Each indicator’s scores were determined and indicators of the urbanisation model were calculated.

4.2 Distribution of Urban Development Potentials

The analytical results showed that Bangkok could be divided into four areas, namely,

- areas with more than 90% built-up areas, with limited open spaces
- areas with 76-89% built-up areas
- areas with 51-75% built-up areas
- areas with less than 50% built-up areas, with sufficient open spaces

5. Conclusion

Planning issues, based on the findings through the assessment of the present states, are identified into the following six issues;

- Sustainable Resource Utilization in Vulnerable Environment;
- Flood-free Urbanization;

- Environment-initiative Urban Transport System;
- Pursuance of "Fresh and Clean Air policy";
- Creation of "Water-friendly Eco-city"; and
- Up-grading of Quality of Living Environment.

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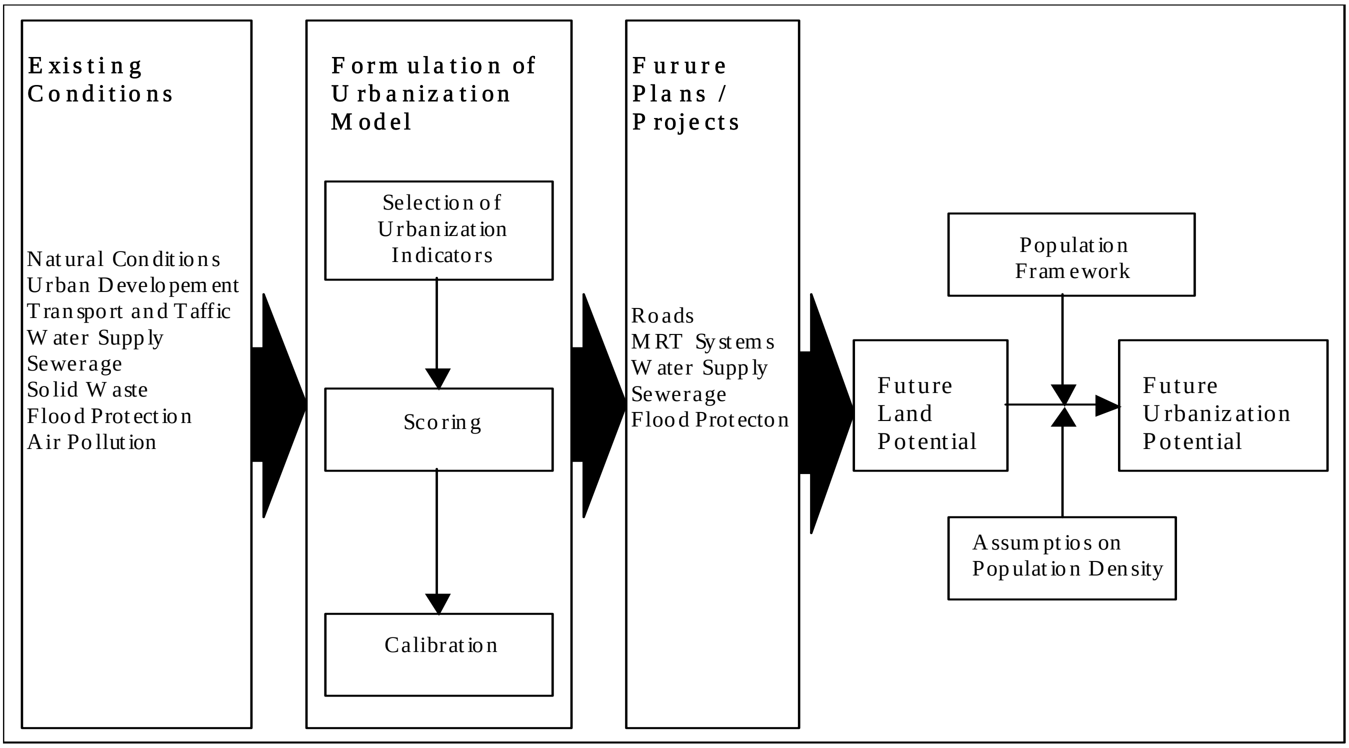

Figure 5. Flowchart for Urban Land Development Potential Analysis

6. Acknowledgement

The author would like to acknowledge appreciation to all those who extended their kind assistance and cooperation to the Study Team, in particular, relevant officials of Bangkok Metropolitan Administration and the Thai counterpart agency.

Kuwait Utility Management System（KUDAMS）

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An international tender was called at Kuwait Municipality to create the most sophisticated Geographic Information System (GIS) in the period of 6years. It contains the establishment of national geodetic network, creations of cadastral database, utility database, digital topographic mapping and delivery of software and hardware. Due to the weather conditions in Kuwait, aerial photography can be carried out in winter. Therefore, project area was divided into 4 progress areas in order to take aerial photographs every year. This paper describes the difficulties encountered to execute the big project.

1. Purpose

For the purpose of efficient execution of administrative activities with strategic utilization of Geographic Information System (GIS), Surveying Department of Kuwait Municipality drew up a project called Kuwait Utility Data Management System (KUDAMS) in 1983. Main objectives of this project are to establish national geodetic network covering the entire country and construct comprehensive management system for the cadastre data of the urban area about 580 km^2 as well as the underground utilities with the aid of computer technology.

The GIS for the KUDAMAS was not only the largest in scale but also utilized the cutting-edge technology in those days and, therefore, received high acclaim as the word first full-blown Facility Management System.

Figure 1. Location of Kuwait

2. Outline of the System

Graphical and non-graphical data about the topography, cadastre and underground utilities in the urban area of Kuwait were all digitized and recorded in the databank. Whenever necessary, these data can be output on the computer display or as a hard copy in the form of graphic images or tabulated lists.

Data maintenance can be performed in real time by various inputting and editing devices. The system has been maintained and managed by Kuwait Municipality officials themselves since its completion.

The following are the main operations related to the system construction.

1. Establishment of geodetic network
2. Creation of cadastre database
3. Creation of underground utility database
4. Digital photogrammetry
5. System construction (both hardware and software)
6. Training of Kuwait Municipality officials

3. Contents of Database

3.1 Establishment of Geodetic Network

Centralized information management, that is, to manage various data under the same coordinate system, is crucial for effective usage of data in GIS system.

Consequently, establishment of high precision national geodetic network was required. Surveys including the first-order geodetic network (101 stations), second-order geodetic network and first-order leveling network were carried out and permanent markers were installed accordingly at each station.

Furthermore, for cadastre surveying control points, data collection and investigation on 50,000 BTPs (Boundary Traverse Point) were carried out, and as a result, 6,000 BTPs were confirmed. Markers were installed at the confirmed points and their coordinates were measured in the course of digital map making.

All these results were input in the database on the basis of the KTM (Kuwait Transverse Mercator), the new national geodetic coordinate system, which would be the basis of all the data for the KUDAMS.

3.2 Creation of Cadastre Database

Instead of using traditional way of mapping i.e. graphic method, numerical cadastre mapping was introduced so as to manage cadastre data by computer. The scale for basic maps is 1/500, and information such as boundary points, boundary lines between parcels, the new as well as old addresses of the parcels and the name of parcel owners were recorded in the database. Other kinds of attribute information were kept in the Regional Legal Affairs Bureau, and, due to their confidential nature, the officials of the Survey Bureau themselves had to input such data. They include registration certificate numbers, names of parcel holders, ratio of ownership, cadastre map numbers and registered cadastre.

Underlying concept of constructing the database in Kuwait Municipality was to create “multi-purpose cadastre database”, which allowed efficient management of administrative activities. This means that the database could be used not only for registering parcels by digitizing cadastre maps but also used as a GIS system in urban planning, management of underground utilities and administrative activities.

In multi-purpose cadastre, in general, the present state of land ownership is clearly shown by simply selecting some of the graphic data prepared by other administrative organizations and overlapping them each other. These graphic data include topographic maps, schematic drawings, electric facility control charts, land use maps, transportation maps, agriculture-related maps, hydrographic maps, forest maps, mineral resources maps, etc.

In addition, one of the purposes of creating multi-purpose cadastre is that it stores attribute information (non-graphic information) in database and therefore, such information can be used to calculate cadastral statistic data, assess prices of land, evaluate taxation, and thus can be used as the basic materials for national census and economic statistics.

The following were used as source materials in data input.

- Surveying field notes: about 800 volumes
- Cadastre maps: about 4,000 pieces
- Schematic drawing: about 500 pieces
- Register control ledgers: about 3 meter

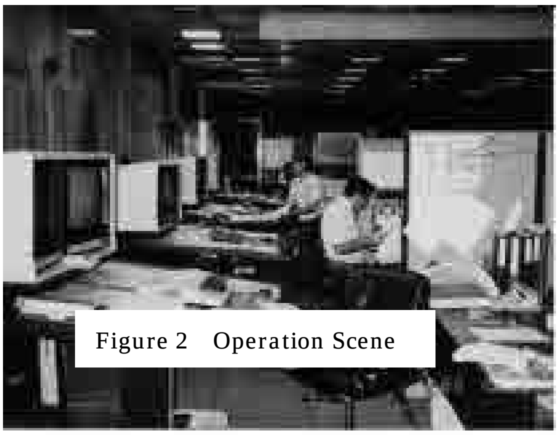

Figure 2 Operation Scene

3.3 Creation of Underground Utility Database

Field surveys and measurements were carried out on 12 items of each of 7 kinds of underground facilities.

Markers were set on all the structures such as manholes that could be seen on the ground so that they could be identified on aerial photographs. In digital photogrammetry their positions were measured and recorded in the database along with the results of field surveys. Later, they were output on a 1/500 topographic map for the management of underground utilities.

Items that constitute the database were city water (water supply and waste water reuse), street lams, telephone, electricity (high-voltage and low-voltage), gas, rainwater drainage and sewage.

Other necessary materials for database such as layout drawings, construction drawings, etc. were collected from the related government ministries and agencies. These materials were used to identify exact location of structures in the field surveys. As long as 3,000 km of city water was input in the database.

Information showing present state of underground utilities was recorded and saved in the form of layers to allow central management of these utilities along with cadastre database.

3.4 Digital Photogrammetry

An aircraft for aerial photographing was brought from Japan. Due to sand storms, the period for aerial photographing was limited only from December to March, and this was the most difficult job. Entire area was divided into 4 parts for annual aerial photographing. It took 4 years to complete shooting of the whole area.

In order to keep the same level of accuracy between underground utility maps and cadastre maps, it was determined the scale of topographic maps for the whole are should be 1:500.

Analytical plotters were used to measure topographic features so that their coordinates could be directly recorded in a digital format. This also contributed to maintaining of accuracy. Coordinates of building corners, walls, roads, curb stones, minor diameters, underground utilities, street lamps, counter lines as well as crossline information were measured and recorded.

Furthermore, entire country was covered with photomaps at the scale of 1:10,000, while residential areas were covered with topographic maps at the scale of 1:2,000.

Figure 3　Assembling an Aircraft

Figure 4　Investigation of Underground Utilities (sensor)

3.5　Systems (Hardware and Software)

GIS system in the KUDAMS project was expected to perform the following functions.

1. Various utility data (both graphic and non-graphic data) should be managed in a centralized manner.
2. Precision and reliability of utility data should be improved and uniformity among the data should be achieved.
3. Inputting, editing and outputting of various data can be performed in a simple manner.

As a result, the following were to be achieved.

1. Standardization of utility data
2. Quick updating of secular changes
3. Easy output of maps and statistic data
4. Prevention of accidents during the execution of the work
5. Facilitating inter-availability of various data among the different ministries concerned
6. Easy safekeeping

Upon completion, GIS system would exert great impact on the daily administrative task.

3.6　Training of Kuwait Municipality Officials

Upon completion of data production, the system was required to turn over to Kuwait Municipality.　Then, the officials of Kuwait Municipality were supposed to engage in system control and data maintenance.

Therefore, the same systems with the same functions were created both in Kuwait and Japan.　The one in Japan was exclusively used for data production and Japanese staff worked in three shifts to advance delivery date.

On the part of Kuwait Municipality, on the other hand, input of the classified data was carried out by the municipality officials themselves.　This is because such data were kept at Regional Legal Affairs Bureau and not allowed to take out.

The operations were carried out under the supervision of the Japanese.　Cadastre database was finally completed with 5-year of strenuous efforts of about 5 officials of Survey Bureau of Kuwait Municipality and about 20 Japanese engineers.

Figure 5　Staff of Survey Bureau

4.　Conclusion

All the contracted jobs were completed in 1990 and the final product was delivered to Kuwait Municipality in the presence of Director General of Survey of Kuwait.　Without a long cooperation with the officials of Survey Bureau of Kuwait Municipality for 7 years, we could not have accomplished such a difficult job.　Unfortunately, the system was damaged and most of its function was lost in Gulf War.　However, I heard that a new database was re-constructed from the backup data kept in Japan and now it is functioning very efficiently in day-to-day administrative work in the Survey of Kuwait.

Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar
- GIS Applications for Urban Facilities Management -

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Abstract
The Study of the "Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar" produced three types of geographic information database for urban base maps, land-use/land-condition maps, and urban facilities were built. This report relates to the development of the urban facility database and introduces the background for the development and database production. First, the target facilities (road, sewerage, water supply, electricity, and communications facilities) were selected. Then, the items and structure of the database were determined on the basis of the results of a hearing survey undertaken for the required GIS functionality at the related organization. Finally, the information necessary for urban facility management was entered into the database.

1. Outline

1.1 Outline of the Study

The Study of the "Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar" was carried out from October 1998 to November 1999, with the implementing organization being Japan International Cooperation Agency (JICA).

Various types of geographic information necessary for formulating city plans (including urban base, land-use/land-condition, and urban facility management maps) were produced digitally and stored in the database. The basic operation system provided for the database (Infrastructure Management System – IMS) was also developed.

1.2 Background

The living environment in the Republic of Madagascar varies greatly between the urban and rural areas, just like in any other developing countries, and the movement of the population from the rural to the urban area is remarkable. The Metropolitan Antananarivo shows a similar tendency, for which the increase in population was drastic. The resulting living conditions have since worsened, and the urban facilities could not cope with the demographic increase.

Under these circumstances, the City of Antananarivo and the Government of Madagascar decided to formulate a concrete city plan in accordance with the Master Plan prepared by the United Nations Development Program (UNDP).

1.3 Objectives

In the above-mentioned background, the Study of the "Establishment of Database for Geographic Information Systems of the Capital Area of the Republic of Madagascar" was undertaken with the objectives of developing the databases for urban base maps, land-use/land-condition maps, and urban facilities.

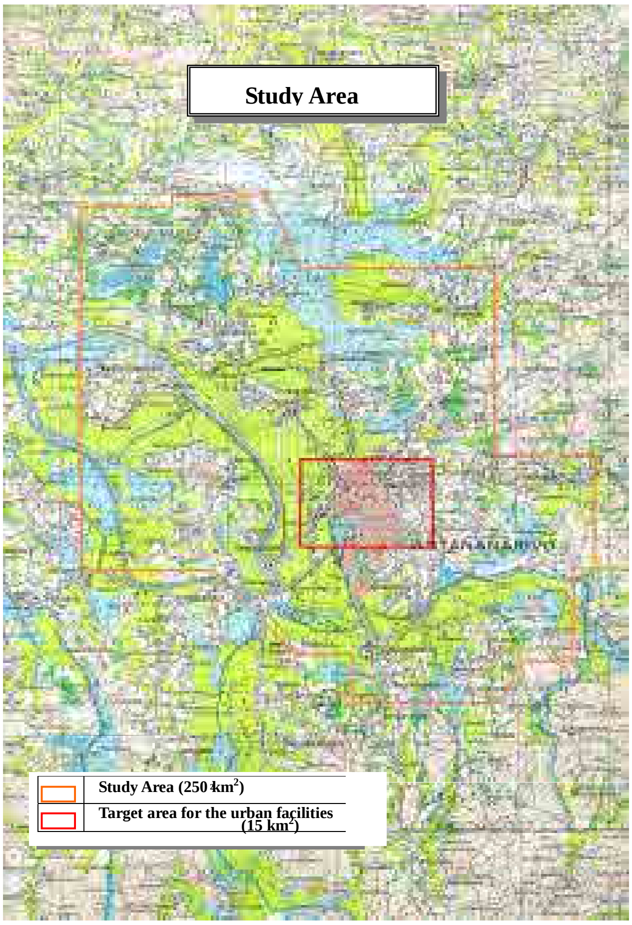


Figure 1. Study Area

2. Target Urban Facilities

2.1 Selection of Target Facilities

The guidelines for development of the urban facilities database were established as follows:

① To acquire the data that allow a better understanding of the existing conditions of the urban facilities in the city and surrounding areas.
② To develop the database that can be used effectively for city plans and urban facilities construction plans, as well as for the management and maintenance of urban facilities.

③ To develop the database with an architecture that allows the simple and fast building and updating of data.

Following these guidelines, a survey of the database functionality was made with the related agencies, and the urban facilities and related agencies to meet the said guidelines were selected for the database to be built as described below.

a. Roads: Agency, not specified
b. Water supply: JIRAMA (Electricity and Water Company of Madagascar)
c. Sewerage: AGETIPA (Executive Agency and Public Infrastructure Works of Antananarivo)
BDU (Urban Development Bureau)
TECSULT
d. Electricity: JIRAMA
e. Communications: TELEMA (Telecom Malagasy)

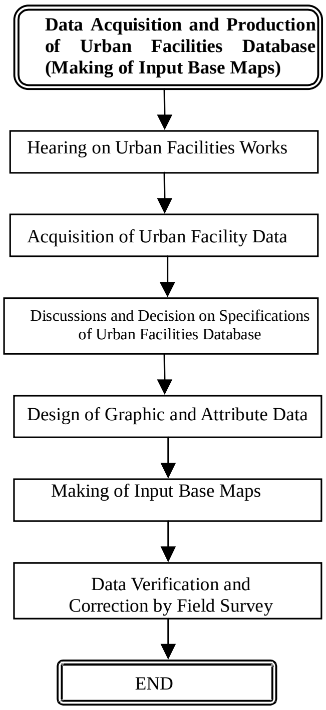


Figure 2. Flowchart of Data Acquisition and Production of Urban Facilities Database (Making of Input Base Map)

2.2 Study with the Related Agencies

A hearing survey with the agencies related to urban facilities was made for the following items:

① Procedures of urban facilities maintenance and management works
② Materials (data) used for urban facilities maintenance and management works
③ Issues and problems in urban facilities maintenance and management works
④ Relationship with other agencies related to urban facilities
⑤ Effective use of materials (data) following the establishment of the database

The survey on Items ① and ② shows clearly that the drawings of the facilities had often been used in the maintenance and management works, and that the retrieval of those drawings took considerable time.

The survey on Item ③ shows that it was important to efficiently update the drawings for maintenance and management of urban facilities, and that there were problems of lost drawings and method of taking custody of the drawings.

The survey on Item ④ shows clearly that the related agencies prepared individually the drawings for maintenance and management.

The survey on Item ⑤ shows clearly that, if the database of the materials (data) for maintenance and management of urban facilities is produced, then the works of maintenance and management would improve substantially.

2.3 Data Acquisition for Facilities Management

Two types of materials for the maintenance and management of urban facilities were collected:

① Drawing materials (data): Topographic maps and facility completion drawings as used for maintenance and management of urban facilities.
② Statistic materials (data): Forms and registers

3. Analysis of Collected Materials

3.1 Classification of Collected Materials

The materials that were collected from the agencies related to urban facilities were classified according to the following categories:

① Graphic materials from which the geographic locations can be specified: Piping and cabling drawings
② Graphic materials from which the geographic locations cannot be specified: Structural drawings
③ Text materials related to the graphic materials: Contracts and agreements
④ Text materials unrelated to the graphic materials: Various forms

3.2 Analysis of Collected Materials

The materials categorized as ① through ④ in 3.1 above were analyzed. The analysis clarifies the following matters:

- Dates of the materials, which were defined for almost all materials.
- From the materials ①, the locations of most facilities could also be defined on the city base map database. These graphic materials included the text information, which was deemed useful for the maintenance management works.
- The materials ② and ③ had a low frequency of utilization in the maintenance and management works.
- Some of the materials ④ were available following the production of the database.

4. Requirements for Facilities Management and Examination of GIS Functions

4.1 Requirements for Facilities Management

The hearing survey undertaken for the maintenance and management works at the agencies related to individual urban facilities clarifies the following requirements:

① The rational methods of custody of materials for facilities maintenance and management and retrieving the necessary materials, whenever needed
② The function for a fast retrieval of necessary materials for the facilities maintenance and management by designating the scope and number of copies.
③ The functions for a statistic process (such as addition, subtraction, multiplication, or division) of the numerical information in the materials for facilities maintenance and management and for obtaining immediate results.
④ The function of mutual correlation of the materials in a simple manner, since a large number of materials relate among them.

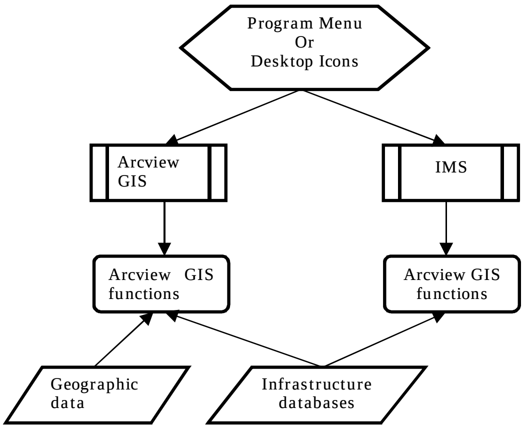
4.2 GIS Functionality

Based on the discussions on the requirements as described in 4.1 above, the following functions could be run on the GIS software (ArcView):

① Graphics-based functions: Scroll, zoom and scaling of graphics, display of specific items, and color designation.
② Retrieval functions: Retrieval through key codes, locations, and other conditions
③ Statistic functions: Data sum-up
④ Display (output) functions: Display and output of cut-out parts of drawings, specific items, and statistic calculation results

4.3 Infrastructure Management System (IMS)

The IMS was configured using the ArcView software. The IMS architecture is shown below.



IMS Configuration

Figure 3. IMS Configuration

① Input system
- Graphic input system
- Attribute data input system

② Management systems
- Urban base map IMS (Inactive database)
- Road IMS (Active database)
- Water supply IMS (Active database)
- Sewerage IMS (Active database)
- Electricity IMS (Active database)
- Communications IMS (Active database)

③ Functions of management systems

The four functions as described in 4.2 GIS Functionality were implemented.

5. Database Development

5.1 Decision of Data Items

The collected materials, the requirements for the facilities management, and the GIS functionality were examined to decide the following data items for each database:

① Road database
Graphic data: Road center line, road width lines, section lines, etc.
Text data: Road width, road number, road structure type, etc.

② Water supply database
Graphic data: Boundary, conduits, valves, and other facilities
Text data: Boundary name, conduit number, valve number, etc.

③ Sewerage database
Graphic data: Manholes, conduits, etc.
Text data: Watershed name, manholes, conduit number, etc.

④ Electricity database
Graphic data: Facilities (such as substation), power line, poles, etc.
Text data: District number, power line number, pole number, etc.

⑤ Communications database
Graphic data: Manholes, poles, armored cables, distribution units, etc.
Text data: Manhole number, pole number, armored cable number, etc.

Table 1. Graphic Coordinate Data Format

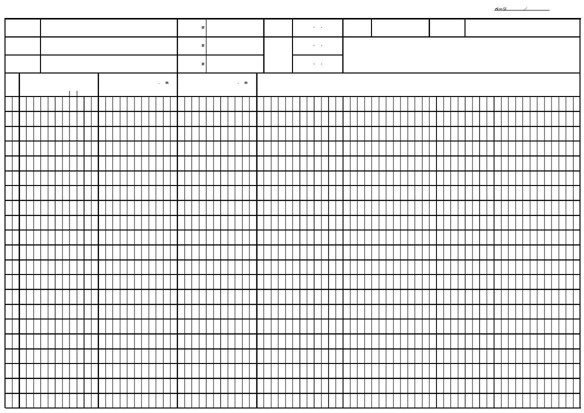
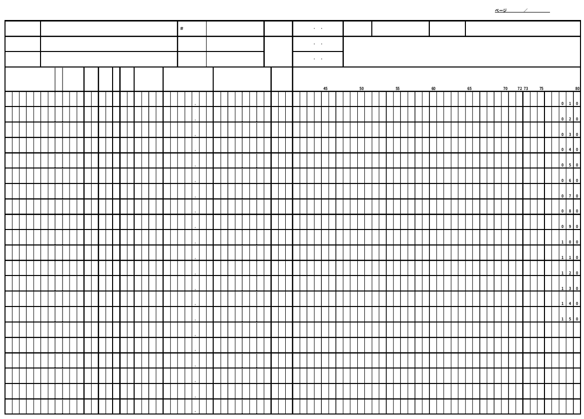


Table 2. Attribute Data Format



5.2 Design of Graphic and Attribute (Text) Data

The graphic and attribute data were built as follows:

① The graphic data were configured with points, lines, and polygons.
② The attribute data were defined by data type, display size, and number of characters.
③ As two or more data files are used simultaneously, the required key codes were set and the relational files defined.
④ The display windows for displaying graphic and attribute data were defined.

5.3 Data Entry

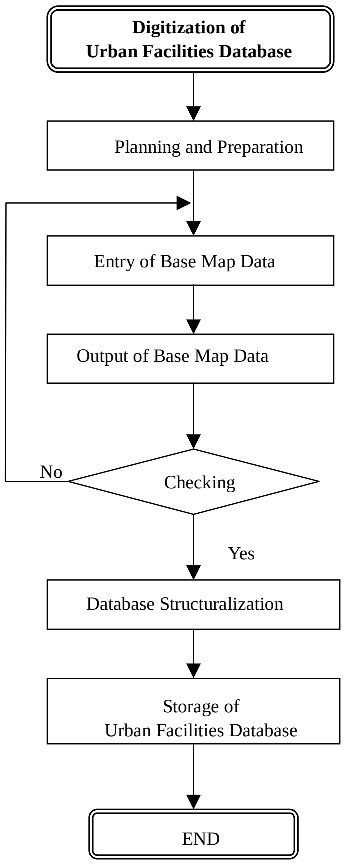


Figure 4. Flowchart of Digitization of Urban Facilities Data

The neat lines for a 1/2,000 map sheet were defined on the urban base map database and the data entry was made in the neat line unit.

5.3.1 Entry of Graphic Data

The input base map for the graphic data was prepared from a 1/2,000 map and the data were entered in the input map.

5.3.2 Entry of Attribute Data

A data sheet was prepared for the attribute data which were entered in the sheet before being input in the system.

5.4 Data Quality Control

5.4.1 Guidelines for Quality Control

Visual and logical checks were made for each process of developing the database and the minimization of data errors was adopted as the guideline for quality control.

5.4.2 Quality Control

In accordance with the above guideline, the data quality control was performed under several conditions, and various quality control methods (such as visual check, same check by two or more persons, and logical check through computer) were adopted and executed.

6. GIS and its Future Issues

For this Study, a limited number of data items, such as roads, water supply, sewerage, electricity, and communications, were selected from the urban facilities, and the database on those items was built for a limited range of areas of Antananarivo City.

6.1 Map Data in Building the Infrastructure Management Database

When building the urban facilities database, it is important to specify the geographic location of each facility. Should it be otherwise, the mutual relations between the facilities would be unclear, and operating the infrastructure management system would be hard to handle. Therefore, the urban base map database (map data) used to specify the geographic locations of urban facilities constitutes an essential instrument for building the infrastructure management database.

6.2 Operation of Infrastructure Management System (IMS)

(1) Validity of the IMS

Only five items of urban facilities in a limited area were adopted to develop the database. Though the database was built for a limited area and number of facility items, the GIS was used and the database became a powerful tool to understand the actual conditions and execute the construction or improvement plans for the urban facilities. The GIS will thus be instrumental in formulating the city plans in Antananarivo City.

(2) Review and Discussions on the IMS

A very limited basic infrastructure management system was configured in this Study. This system will allow a suitable management of the urban facilities. However, for an improvement of the system, it is necessary to carry out the study (work study) related to the detailed works of the administrators of the facilities, the procedures of the works, and the utilization of the materials (graphic and attribute information). Further, the functions of the IMS and the database design should be reviewed and discussed while taking into account the results of the study. When building the expanded database, the following issues should be treated:

① Discussions on expansion of the targets for the database development
② Discussions on information items to be covered by the database
③ Discussions on areas to be covered by the database
④ Standardization of material forms to be prepared for the urban facilities
⑤ Improvement of input base maps and attribute data creation

manual

⑥ Improvement of tools for building the database

⑦ Establishment of a method for systematic database quality control

7. Conclusion

A good deal of human resources will be required for the operation of the GIS that is usable for urban facilities management. To this end, the technology transfer must concern not only the building and operating of the Infrastructure Management System, but also the training of staff of the following categories:

- Engineers in the work-study and analysis
- GIS engineers
- Engineers in database development

The above issues must be dealt successfully for an effective use of the GIS, so as to cope properly with the actual situation of the Republic of Madagascar.

An Asset Mapping in East Timor

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Abstract

The riot, which happened after the local referendum held in September 1999, heavily damaged infrastructure in East Timor. An asset mapping system is a management system of water pipelines in East Timor on purpose of understanding a current condition of water supply and launching a new development plan as part of the rehabilitation plan of infrastructure. Information described the present condition related to water pipeline, which was heavily damaged over the country, has been entered into a database. The management system of water supply have begun operating in fall 2000, which would be a foundation of the development plan of facilities in the future.

1. Background of East Timor

East Timor is 14,609 square kilometers in area, whose population in 1999 is 890,000. Since it became a colony of Portugal in the sixteenth century and Portugal gave a half of the western part of Timor Island to the Netherlands in the seventeenth century, Timor Island has been divided into two parts under two different countries, the eastern and western part of the Island. Socialist regime of Portugal carried out liberation policy to colonies outside of the country in 1975. As a result, power between the moderate and the independent parties launched a civil war and the independent party declared the sovereign of democratic republic of East Timor. Soon after the declaration, pro-Indonesian militiamen occupied the entire land of the country and established the provisional government of East Timor. The following year, Indonesia integrated East Timor as the 27th province of their territory.

As East Timor has been ruled by the Indonesian government under the amalgamation policy, citizen’s resistance against the government has begun and force to seek their independence has grown. While UN deployed a mission in East Timor to keep peace and order in 1999, popular consultation to suggestion of special autonomy was held and the riot against the referendum happened by the pro-integration. The UN sent off Multinational Army to East Timor in September 1999 and established UNTAET. The establishment of UNTAET evacuated Indonesian Army from East Timor. The capital of East Timor is Dili, which has a population of 200,000. A common language is Tetung and about 90 % of the population is Catholic.

2. Water facilities in East Timor

It is not possible to find out details of the condition about the development of water facility in Dili during the government ruled by Indonesian because the storage building for government publications and documents was burned. But according to hearings to officers, who belong to division of water facility of UNTAET, it is said that three locations of facilities for purifying water and pipeline network in Dili was developed as well as water facilities and pipeline network in other few cities, by the assistance of Australian government since 1993.

At the same time, it began to operate a system to design water facilities in Dili, which is utilized such as CAD (Computer Aided Design), automated mappings, PC, and so on. The system makes it possible to register and manage data of drawings, which are designed and established in planning of a new water facility, and associated data, which are records of repairs and the maintenance expected in the future.

Water facilities became a target of the riot to cause serious damage since fall 1999 and three water purification plants in Dili have been torn down, and pipeline leakages were found everywhere because many water pipelines in the city was destroyed. In addition, the system was demolished, which designed water facility assisted by Australian government and already started operating, and there is no means to find out the system.

Numerous water facilities in cities other than Dili have been damaged and cannot supply water. Even if they can, the quality of water is not enough for drink.

3. The basic plan of an asset mapping system

The basic plan for an asset mapping system was established in Dili. The targets for the plan are Dili, the capital of East Timor, and other growing cities as follows;

Aileu, Ainaro, Atauro, Baucau, Ermera, Gleno, Liquica, Los Palos, Maliana, Maubisse, Manatuto, Same, Suai, Viqueque

3.1 Status of maps

Since it is not possible to find a map as the use of base map, it is collected topographic maps managed by UNTAET and maps developed during planning of the rehabilitation.

- Topographic map: 1/25,000 scale map printed by Australian Army in 1999 based on an original map, which is surveyed in 1990 to 1992 by BAKOSURTANAL Indonesia.
  Coordinate system: Origin of Indonesia (1974), WGS84 coordinate system is added.
  Projection: Transverse Mercator
- Topographic map: 1/2,000 scale digital map in the area of Dili created by JICA in 2000 through aerial survey.
  Coordinate system: WGS84
  Projection: Transverse Mercator
- Pipeline network map: scale and years of the preparation are not known and whose area covered only Dili.
- A map related to water supply and sanitary planning in East Timor: scale and years of the preparation are not known and whose area covered only Dili.
- Collection of plans related to the PETA LOKASI plan: scale and years of the preparation are not known and whose area mainly covered Dili, including some other rural cities. Descriptions of topography importantly related urban planning, natural environment, present conditions and future vision of public facilities. (Some part are damaged.)

Out of items above, the scale of 1/25,000 topographic maps was made enlarge or reduce into 1/50,000, 1/10,000, 1/5,000 and etc. so that it can be used for other different purposes.

3.2 Introduction of GIS

Since 1993 Dili introduced CAD by assistance from Australian government to carry out the development of facilities. This system has a main purpose to support designing and a consistency in designing new facility and estimating the cost at the same time. However, it is not effective in organizing data for the maintenance to update records for repairs of facilities. Since there is no database integrated drawings and associated data, it required making changes for two different databases individually. Because of that, it is often found such mistakes that CAD data were made changes while data associated with the construction history were not updated or wrong addresses were entered. This system employed GIS to make up for the disadvantage of CAD system and GIS software, called ArcView, can make both drawings and associated data integrate.

Following functions of geospatial analysis allow this system to apply for various goals in the future.

- Search drawings and retrieve tables

Identify dates established water facilities and find pipelines constructed more than 15 years ago

- Overlay

Create a plan to locate water facilities according to population data by overlaying topographic data and urban planning data.

- Buffering

Manage data about residents surrounding main roads

- Network

Analyze the pipeline network system

3.3 Hardware

PC (OS is Microsoft Windows NT) and a printer (connected to PC on network) are needed to carry out an asset mapping system.

3.4 Software

Applications used here to operate an asset mapping system are ArcView3.2, ArcPress3.0, and Office 2000.

4. Establishment of database

Most of data for an asset mapping system are geospatial data. Although it is necessary for the maintenance and management to establish a database of the data associated with drawings on a map, it has not been achieved yet since the demolition. This paper describes a target area, the city of Dili, and 14 cities in a different section.

4.1 The city of Dili area

Digital topographic data and 1/25,000 scale topographic maps produced a base map.

- 1/2,000 digital topographic data (digital topographic map created by JICA).
- Associated data··· data of facilities and pipeline network

Data for pipelines and water facilities (including river intake facilities, wells, water purification plants, distributing reservoirs, pump stations) are maintained on different layers separately using on 83 topographic maps of the city of Dili. Water facility has associated data (vector data), such as field photos, survey data, and etc. Although it is not certain when maps of pipeline network were completed and what kind of scale they were, they are converted into digital maps, identifying whether a pipeline is located or not according to results of field survey. Thus, data for pipeline network are established by rectifying victor data based on topography. Pipeline network has two associated data, diameter of pipelines and direction of water flow. Figure 1 shows one of pipeline network.

Figure 1. Pipeline network in Dili (displaying pipeline in bold)

4.2 Other 14 cities

Following topographic maps produces a base map.

- Raster data obtained from scanning 1/25,000 scale topographic map
- Associated data･･･locations of water intake facility, data for service area(vector), data obtained from field survey, data for sectional plans of facility location(vector), field photos, sketches(raster), etc.

The coverage to create topographic data is from the location of supply facilities to the service districts, which is identified by field survey in 14 cities. The size of coverage would vary among these cities because of following reason. The coverage would be lager in the region, which have long distance from service districts to source of water, while the coverage would be smaller in the cities, which have relatively short distance. In addition, data for supply facilities and service districts should be vector data and maintained as an independent layer, separating from topographic data. Figure 2 shows an example of displaying the map.

Associated maps of field survey and sectional plans of facility locations are scanned and converted into vector data by raster-vector conversion. Filed photos and sketches are raster data. Data of facilities include water intake facilities (rivers and spring water), wells, water purification plants, distributing reservoirs, pump stations, tanks for reducing pressure, and pipelines.

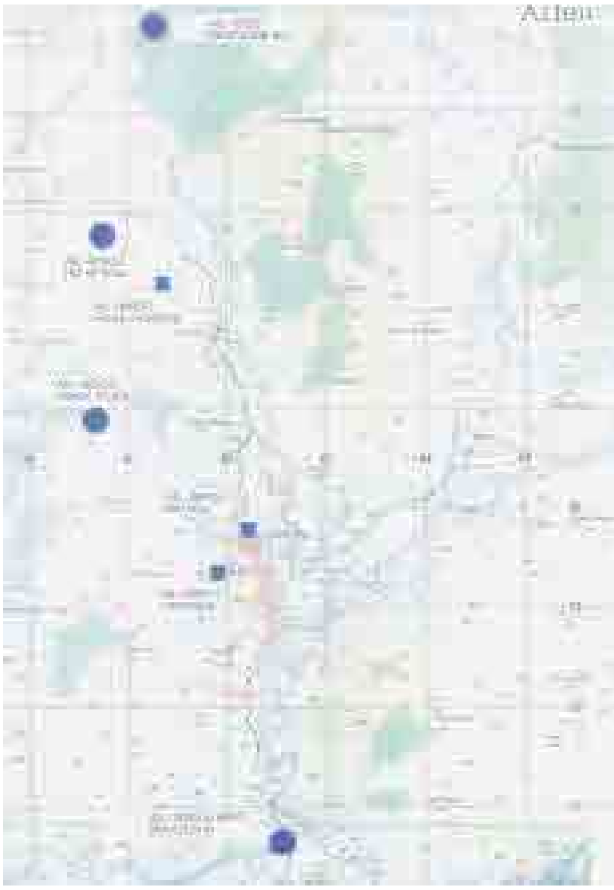

Figure 2. A present map described water pipeline in the rural area.

4.3 Data for the evaluation of facilities

It is raster data that entered as data of the evaluation of facilities, which describes the present condition and calculated cost to rehabilitate the deterioration in terms of entire water facilities from water intake facility to service area. Since Dili and other 14 cities have forms of data sheets in common, it is easy to display data through a filing function. Figure 3 shows a part of sheets.

5. Operation of the system

The operation of database has started after digital data were obtained from results of geographic survey. This system is operated by three PC, which is connected each other on network, and three PC are installed Office 2000 and two out of three installed ArcView. Although this system basically has functions to locate and search facilities, it is necessary in the future to increase additional functions, such as displaying drawings and updating database.

Town: Dili	No. & Facility: 23 - Bedoisi Resevoir	Year of Construction 1998	Financed by: Bia Hula

Existing Condition:
Structure: Reinforced Concrete
Shape: Rectangular
Dimension: 5.8m x 5.6m x 2.2m.
Capacity: 45m^3
Function:
Source of Water: Bedoisi well
Ground level:
Accessories:
overflow pipe
washouts

Photograph:

(Date: June 2000)

Evaluation:
No ventilation & level gauge.
Water leak was seen coming from the valve.

Rehabilitation Plan:
1) Basic Calculation
Reservoir is constructed close to private houses. For continuous use in the future, minor rehabilitation is required.

2) Civil Work:
Construction of securtiy fence

3) Piping work:
Installation of flow meter and controller

4) Mechanical work: none

5) Electrical work: none

6) Miscellaneous:
Installation of chlorine dosage devices

Estimated cost:	Construction schedule:	Priority:
US$7,379		A-2

Figure 3. Data for the evaluation of water facilities

6. Challenges for an establishment of setting the system

Summary of challenges to establish an asset mapping system are as below in targeting on technology transfer and the environment of setting the system.

6.1 Difficulties of technology transfer

Even though East Timor has been ruled by UNTAET since the riot, the political situation hasn't been settled yet and a significant amount of people still sheltered from East Timor to West Timor after an evacuation of Indonesian Army. Therefore, it has been little to give a chance to learn higher skills for ArcView, GIS software, and it was not enough to transfer advanced technology. There are several factors to emphasize as follows.

- Lack of personnel, who have experience to operate PC.

There are little specialists to learn how to operate the system, since the distribution rate of PC is low in general. It is not possible to find who had managed and operated the system to design water facilities before. Even if it is found a person who was responsible for the operation under the specialist before, the knowledge of hardware and software skills is poor.

- Lack of specialists, who have comprehensive knowledge of water system.

There are no specialists who know well about supply facilities in Dili ranging from water purification plants to houses of customers and comprehensive knowledge of water system in other 14 cities ranging from supply facilities to service areas.

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6.2 The environment of setting the system

Although it was possible to establish an asset mapping system under the condition that the rehabilitation of facilities for water management is still underdeveloped, it remains following issues in the environment of setting the system.

- High humidity and high temperature

PC is not necessary to prepare a special room for computer, but it is not possible to install PC in a room without high humidity and high temperature seen in tropical zone. When the power of PC is switched on, the thermometer shows 35 centigrade. Even if fan is set, it is not still efficient. It needs to be improved.

- Concerning of disk crash because of the instability of power

Electrical power often becomes out of service, although Dili receives a supply of electrical power from generating power plant. Or even not power down, there is clear evidence that the electrical power have unstable frequency on a regular basis. Although UPS is setting up between the system and a power source, it needs additional devices to stabilize frequency of electrical power.

- Time issues that it takes long time to recover the system because there are no extra parts to repair.

Since there is no shop in Dili to sell PC accessories and extra parts, it needs to go to Darwin, Australia or Bali, Indonesia to purchase these.

The Utilization of GIS Applications at Gas Companies in Japan and Other Asian Countries

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Abstract

It has been the most critical theme for gas companies to develop, manage, and maintain a network of gas pipeline accurately. Recent deregulations also make Geographic Information Systems (GIS) increasingly important. This paper describes overview of utilization and development of GIS at gas companies in Japan and other Asian countries and introduces case studies of the GIS development, the system development, and the specific applications (such as mobile and WEB GIS), which is applied by Tokyo Gas and Gas Malaysia.

1. Introduction

Turning to the twenty-fist century, the environment surrounding utility companies has become more difficult. A wave of globalization bringing deregulations, which is happening in particularly Europe and the United States, is pushing over to Japan gradually. This trend is already seen throughout communication industry and it is just a matter of time that energy and gas industry would have the same effect. To survive such an environment for utility companies, the most essential target strategy is exactly to realize infrastructure owned by the company and capture his own customers. It is true evidence that GIS will become most advantageous tool to achieve his strategy. Whether or not a company accurately realizes its own infrastructure is considered as not only a tool to survive this coming age of deregulation and competition but also a measurement to determine a company's rating.

This paper illustrates how gas companies of Japan and other Asian countries, introduce GIS, which plays an important role of strategy, and apply for their company strategy, giving examples of Tokyo Gas and Gas Malaysia.

2. The Utilization of GIS in Gas Company of Japan

2.1 History of GIS Development

There is no discussion to consider that the beginning of GIS development in Japanese gas business was from the gas accident of Tenroku, Osaka in 1969 and Itabashi, Tokyo in 1970. After these gas accidents, The Ministry of International Trade and Industry advised all gas companies to develop 1/500 scale map of gas pipeline. Tokyo Gas created gas pipeline maps, which had took ten years to complete since 1973, using a road map of local governments and Osaka Gas took aerial photos independently and developed gas pipeline maps. The effort to develop this gas pipeline maps was a major factor so that gas business could start GIS earlier than any other industries. Tokyo Gas has begun research and development of GIS since the end of 1970s, employed full-scale GIS in 1983; it was the first company amongst utility companies, and started data entry of 30,000 pipeline maps covered his own supply area.

Following Tokyo Gas, in the end of 1980, Hokkaido Gas, Seibu Gas, Osaka Gas, Touhou Gas, and Hiroshima Gas introduced GIS as well and began data of pipeline maps.

2.2 The Utilization condition of current GIS

Since Japanese gas companies confronted their necessity above mentioned, they have begun research and development and introduced GIS relatively earlier stage. Today more than 70 gas companies operate GIS system. Although the content of operations is a little different individually amongst companies, the figure 1 illustrates that GIS is applied for broad range of works as such as drawing plans, searching pipelines, maintaining facilities, preventing earthquake disaster, planning facility, and so forth.

GIS applications are particularly operated more important work associated with gas pipeline, such as drawing plans in plotter, searching pipelines, maintaining facility and calculating gas pressure and stream flow (network analysis).

In addition, 70% of gas companies introduced GIS use applications, which are integrated with Customer Information System (CIS), and it is clear that the form of integrated GIS combined with CIS is operated throughout all companies (Fig.1)

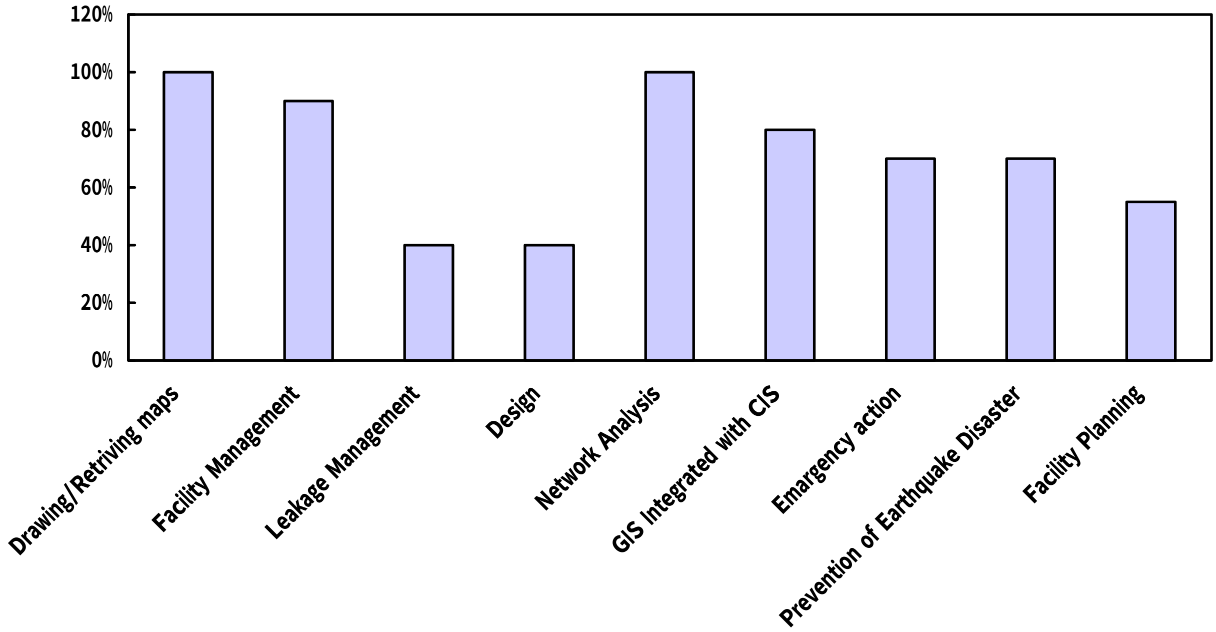

Figure 1. GIS Applications in Gas Companies

2.3 The utilization of GIS in Tokyo Gas

2.3.1 The Formation of GIS Development

The development process of GIS in Tokyo Gas has mainly three phases. Phase I is to achieve entry of 30,000 pipeline maps and the establishment of Automated Mapping and Facility mapping (from 1977 to 1987). Phase II is to integrate GIS with Customer's Information System; CIS (from 1988 to 1992). Phase III is to develop GIS in mobile and strategic fields (since 1993). Table-1 explains geospatial database and applications created during each phase.

Table 1. The Formation of GIS development at Tokyo Gas

		Subject	Geospatial Database	Specific Applications
Phase Ⅰ	Develop AM／FM	Conversion of Basic Maps and Development of Applications （from 1977 to 1987）	Build database for 30,000 maps of main/sub pipelines （main/sub pipelines, bulb, governor, topography, and place's names）	• Automated Mapping （AM） • Facility Mapping （FM）
PhaseⅡ	Develop integrated GIS	Completion of GIS integrated CIS and integrated database （from 1988 to1992）	Build database for 22,000 maps of supply pipelines （supply pipelines, gas meters, and shapes and names of houses）	• Integrated Information Retrieval System • Pipeline Network Analysis System • Design System
PhaseⅢ	Develop GIS	Mobile GIS and strategic GIS （Since 1993）	Enter strategic data （initial investment area and planning line, population projection data, and residential maps）	• Safety Planning System • Prevention and Rehabilitation for earthquake disaster • Emergency Safety Support System • Laser- Methane Locator System • Investment Planning Support System • Facility Investment Outcome Evaluation System

2.3.2 Total System Structure

Figure 2 shows the system structure of GIS in Tokyo Gas. It is clearly seen in the figure that both database of GIS and CIS are setting a computer located at the department of Information Communication in Makuhari, Chiba prefecture and each server of GIS and CIS is controlled by Compaq ALPH 8400 and IBM system respectively.

The host server is connected with each office in 64,000bps high-speed digital network and approximately 300 terminals including Engineering Workstation(EWS), Personal Digital Assistant (PDA), and mobile terminals and emergency car. The host server maintains a geospatial database and 80 terminals located at offices keep database update online and real time for every report for repairing work.

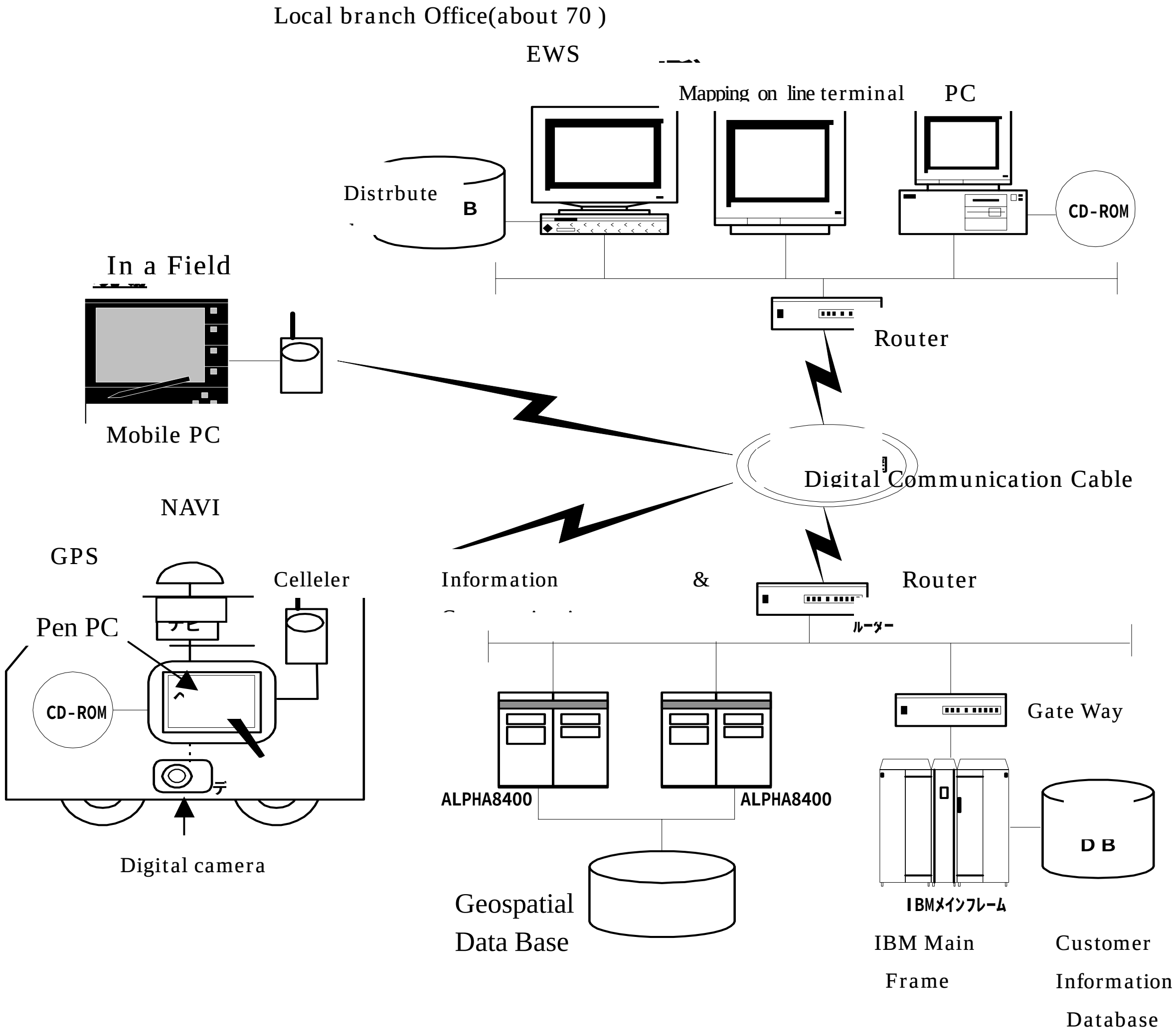

Figure 2. System Configuration

2.3.3 Mobile / WEB GIS Operation

The environments are called mobile and WEB GIS that everybody can simply and easily access to geospatial database by a personal computer at an office or PDA in a field. Tokyo Gas has run WEB GIS in about more than 5,000 OA terminals and PDA. Table 2 illustrates the utilization of WEB GIS in Tokyo Gas (Table 2).

Table 2. The Utilization of WEB / Mobile GIS at Tokyo Gas

Category of Systems	Applications /Subjects	Description	Use of Divisions
WEB GIS	Pipeline Facility Information Retrieval System	Show a view of a plan specified by addresses and the code of pipeline map and an information table of specified pipeline.	Company-wide
	Locating Residential Maps	Show a view of residential map, which is specified by addresses and landmark. In addition, it makes it possible to search the name of the closest station based on address automatically. (it is used as various guide maps like setting a ｌink to the company's bulletin board on intranet)	Company-wide
	Locating Gas Meter Guide Maps	Show a pass of the examination on the map when it is entered the examination code of the area assigned by responsible individual. (It includes information about individual vacation and relocation, education for a new staff, and etc.)	Division of Gas Meter Examination
	Business Information Registration/ Inquiry （has been developing）	Register locations of expecting new buildings on the map and show a distribution map of buildings adjacent to them.	Business Division
	Guide for local branch offices / service offices	A system for which a company can guide information of local branch offices and service offices and company's services to customers, when received a customer call. Search the closest local office to customer's address and inquire notes of direction.	Division of Customer Service
Mobile GIS	Emergency Work Support System	An emergency car, which is reserved and ready to go to the sites of accidents and constructions, are installed a terminal, which is able to enter data by pen, so that staffs make inquiries about information of gas pipeline in a field. It has a mobile function to take notes in a field and send reports to offices.	Department of Emergency Work Support
	Prevention and Rehabilitation for earthquake disaster (under consideration)	Show a map on a mobile terminal and enter description of damage on the map while the damages by a large-scale of earthquake is repaired for rehabilitation. In addition, it is possible to enter restoration information in the computer about gas pipeline damaged by earthquake in a field.	Division of Safety Support
	Methane Locator System	A car installed a terminal, which is associated with Methane Locator System and Car Location Management System, automatically record locations of gas leakage.	Division of Safety Support
	Regular Inspection Work Support System	Show a location of pipeline to extend or a gas meter of the building specified for a regular facility inspection. In addition, show a building on a map, which should examine and particularly need to inspect, and support work planning.	Division of Safety Support
	Business Support System	Inquire a map of gas pipeline in the field expected to build, conduct research about the condition of gas pipeline surrounding a target building for sale , and register information about a promising customer's building on the map.	Division of Business

Following section introduces case studies of mobile and WEB GIS.

2.3.3.1 Emergency Protection Work Support System: EAGLE24

Emergency Protection Work is to perform an emergency course of action when it is received urgent accidents like fire or gas leakage. In this context, Tokyo Gas has divided its own supply area into eight districts and established a special department called “Gas Light 24” for each district. Each Gas Light 24 is composed of an Emergency Call Center and several Sub Centers and emergency cars, which stand by each center and are ready to leave, can go to the front in emergency.

The Emergency Call Center maintains GIS for reserving emergency cars and supervising work condition and makes an order properly which emergency car should go to a place according to its location when an emergency call is received. Each emergency car can receive an order from Emergency Call Center, such as geographical information of the field and accident information, via a mobile terminal. Mobile terminal allows a field crew to inquire gas pipelines in a field, take notes or make reports of the condition of a field, and send them out to other centers (Figure 3).

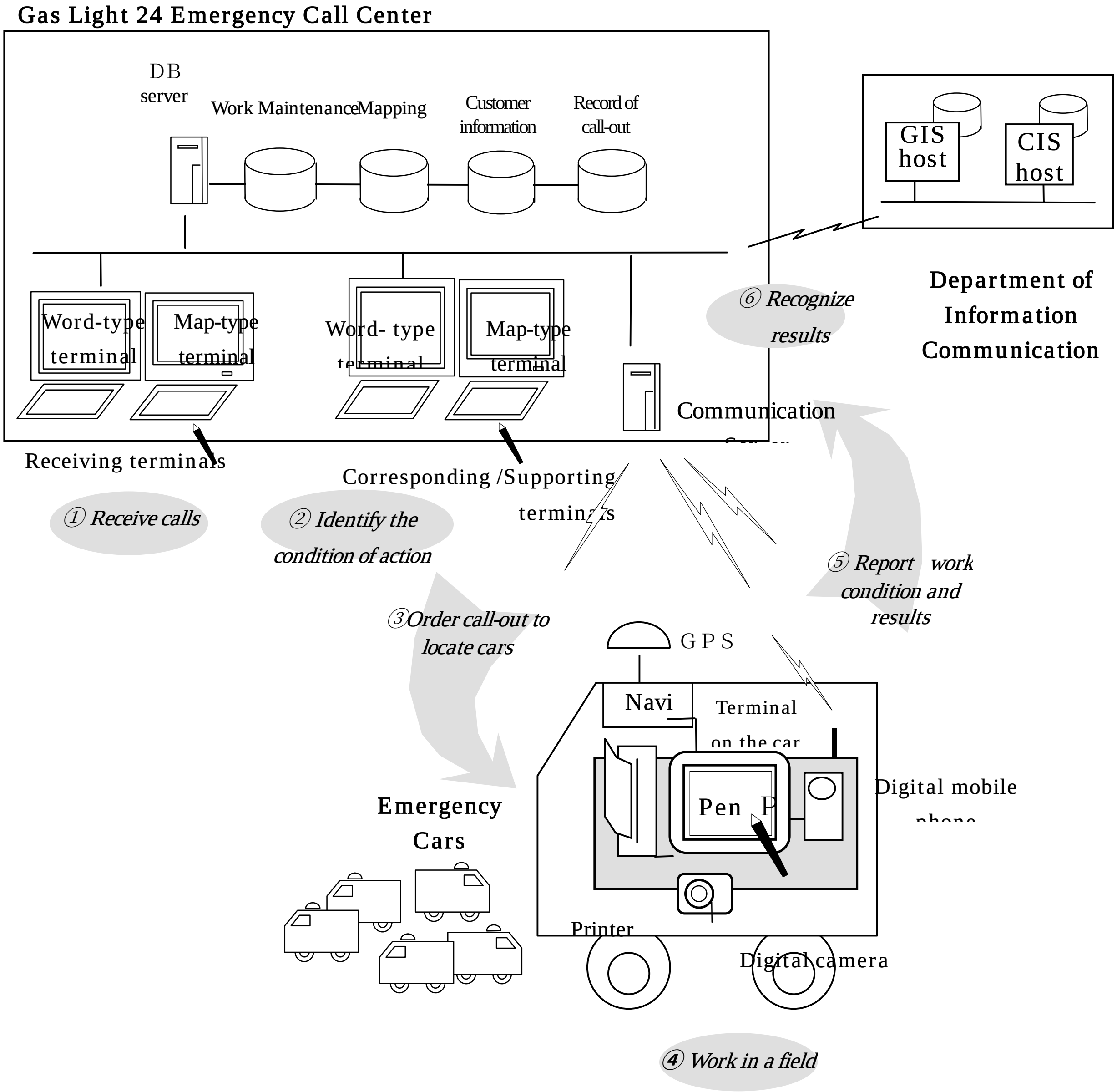

Figure 3. The System Structure Map of EAGLE

2.3.3.2 Business Support system

A system called Business Support System has been developing, which supports business operation with displaying status of gas pipes and customer information by means of PDA or mobile phones, when a staff sells services (solicit gas service, improvement and etc.) in a field. Figure 4 shows a pipeline map drawn by GIS (Figure 4).

Figure 4. The Utilization of WEB GIS on mobile phone

3. Present status of utilization of GIS in Asian Gas Companies

3.1 The Utilization of GIS at Gas Companies in other Asian countries

Introduction of GIS at gas companies in other Asian countries has begun since 1990s and GIS has been operated by a number of companies, such as Great Taipei Gas in Taiwan, Beijing Gas and Shanghai Gas in China, Seoul City Gas in Korea and others in Philippine, Singapore and Malaysia. Most of GIS applications are used the United States or European system like Intergraph, ESRI, and Smallworld, Inc. and the system architecture is applied for relatively new structure such as client/server system and LAN system.

3.2 GIS Operation of Gas Malaysia

Petronas Gas Bhd, Tokyo Gas, and Mitsui Company Limited. established Gas Malaysia in 1992 as a city gas business to employ abundant resource of Natural Gas in Malaysia. Gas Malaysia delivers gas to mainly Kuala Lumpur and industrial customers surrounding area, such as Shah Alam, Klang, and Seremban (Figure 5)

Although the number of customers are about 1,000, the sales of Natural Gas is approximately 600 millions cubic meters in volume per a year and the length of its pipeline is about 350 kilometer. Gas Malaysia introduced GIS in 1994 in order to maintain and plan its own Medium-High Pressure Network System and took five years to complete data entry of pipeline maps.

Currently, GIS is used for SCADA (Supervisory Control and Data Acquisition) as well as plotting and searching maps. Therefore, GIS performs pressure flow analysis (Network Analysis), one of geospatial analyses, and it is efficiently used for a primarily maintenance for Medium-High Pressure Network System and a future planning. In the future, it is expected that gas companies will implement mobile/WEB GIS to fulfill both works efficiently in fields and offices.
(Figure 6)

4. Conclusion

Although GIS initially introduced to manage their own infrastructure precisely, GIS has become an integrated type of application linked with a different system like CIS and play a very important role to backup the total management of a gas business. An important feature of GIS is that not only initial investment cost is huge for the entry of maps and plans into the computer but also the establishment of GIS brings a great advantage in the end. GIS makes it possible for companies to reduce cost in many work processes such as simplifying drawing plans and restructuring work outside of an office by mobile and WEB GIS.

Thus, it will be essential that gas companies in the world as well as Asia will introduce GIS system in the twenty-first century. Considered this situation, it is expected that GIS will be standardized by ISO/TC211 in 2002 to be able to manage system and data of GIS more easily. After standardized GIS, it is anticipated that more gas companies will operate GIS effectively.

Figure5. Supply Area of Gas Malaysia

Figure 6. The Result of Network Analysis

Study for Establishment of National Basic Geographic Data in The Republic of El Salvador

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Abstract:

The Study for Establishment of National Basic Geographic Data in The Republic of El Salvador was decided to conduct by the Government of Japan in response to the request of the Government of the Republic of El Salvador and Japan International Cooperation Agency (JICA) dispatched a study team organized by Pasco International Inc. to El Salvador, several times between March 1999 and July 2001. At the beginning of the study, main final products were digital topographic data for the whole country, however disaster maps and hazard maps were additionally added because the two large scale earthquakes occurred in January and February 2001.This study was an example how the several types of digital data for GIS were actually and effectively used.

1. Background

The Republic of El Salvador was heavily damaged by the Civil War from 1979 though 1992, the large-scale earthquake in 1986, the hurricane Mitch in 1998 and so forth. For the reconstruction and development, the Government of the Republic of El Salvador has been promoting economic development, reconstruction of infrastructure and protection of the natural environment, and requested the Government of Japan to establish national basic geographic data in digital format.

Accordingly, JICA undertook "The Study for Establishment of National Basic Geographic Data in the Republic of El Salvador" (the Study) in cooperation with the authorities of the El Salvadoran Government.

Meanwhile, in the course of the Study, an earthquake occurred in El Salvador on January 13, 2001 with a magnitude of 7.6 on the Richter scale, and another earthquake followed on February 13, 2001. For the urgent aid of the earthquake disaster, the additional preparation of the disaster maps of landslides caused by the earthquakes and hazard maps for landslides and debris flows to indicate potential danger of a secondary disaster were added to the objectives of the Study. The Study was started in March 1999 and continued to July 2001.

2. Objectives of Study

At the beginning of the Study, the main objectives were to create digital topographic data covering the whole country as the national basic geographic data, and to transfer the technology about the data creation and updating to the counterpart agency, Instituto Geográfico Nacional "Ing. Pablo Arnordo Guzman" (IGN), Centro Nacional de Registros, Ministerio de Economía in El Salvador.

Due to the two large-scale earthquakes occurred during the Study period, the final products were as follows:

1) Conventional topographic maps on a scale of 1/25,000 (approx. 3,700 km^2) for the area that there was not the existing 1/25,000 scale topographic maps
2) Digital topographic data for the whole country which positional accuracy is corresponding to the existing 1/25,000 scale topographic maps (approx. 20,740 km^2)
3) Digital disaster maps of the landslides resulted from the earthquakes in January and February 2001 (approx. 5,100 km^2)
4) Digital hazard maps for landslides and debris flows to indicate the areas susceptible to a secondary disaster (approx. 5,100 km^2)

3. National Basic Geographic Data

GIS spatial digital data was created as the national basic geographic data. The existing 1/25,000 scale maps were digitized, and for the areas where does not exist the paper maps, the new aerial photographs were used to create the digital data. A flow chart of the data creation digitizing the existing paper maps is shown on Figure 1.

19 layers of the digital topographic data were defined. Their categories and types were as follows:

- Administrative area, line and polygon
- Road, line
- Railroad, line
- Built-up area, polygon
- Building, polygon
- Settlement, point
- Well/Tank, point
- Utilities, line
- River centerline, line
- River, polygon

- Cartographic point, point
- Cartographic line, line
- Vegetation, polygon
- Land form, polygon
- Contour line, line
- Spot height, point
- Terrain, line
- Control point, point
- Annotation, point

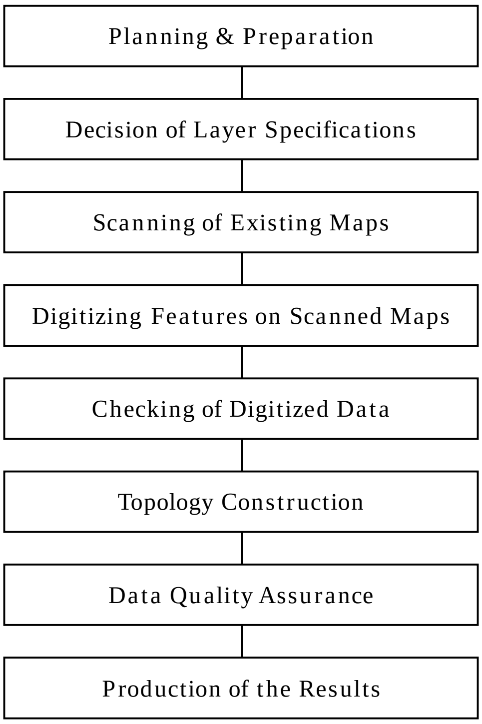

Figure1. Data Creation from the Existing Maps

4. Application to Disaster Prevention

When the digital topographic data were almost ready to be created, the two large-scale earthquakes occurred and El Salvador was seriously affected. Therefore, the urgent aid for the earthquake disaster was planed, and the creation of the following two data sets were determined as application of the digital topographic data: (i) disaster maps of the damaged areas resulted from the earthquakes and (ii) hazard maps of landslides and debris flows for the prevention of the secondary disaster.

However, there were some problems. The available digital topographic data should be updated because the data created from the existing maps had been prepared about 15-20 years ago. Moreover, there were not the recently taken aerial photographs covering the whole disaster areas and the study period left was very limited for updating the data.

4.1 Updating of the digital topographic data

Updating for limited major changes of roads, build-up areas and houses were decided and data collection was carried out in El Salvador for only three weeks.

Because the national basic geographic data created through the Study were digital data, it was rather easy and quick to update each layer , and variable reference data were used for updating by the same method. The topographic data were updated viewing the reference data like SPOT satellite images or scanned map images as background on a computer screen.

The reference data used to update the digital topographic data were the followings:

- SPOT satellite images
- Aerial ortho-photos (panchromatic, 1/5,000)
- The existing 1/5,000 topographic maps
- Tracking data of Mobile GPS

4.2 Extraction of Landslide Areas

Aerial photographs and satellite images were interpreted in order to locate landslides occurred by the earthquakes. The aerial photographs (panchromatic, 1/5,000 scale) were taken by IGN and the satellite images (panchromatic, 10 m resolution) were taken by SPOT IMAGE in France. The digital data of the landslide areas were prepared as follows:

1) The landslide areas were located by interpretation of the aerial photographs and the SPOT satellite images that were taken after the earthquakes.
2) Outlines of the landslide were plotted on the 1/25,000 scale topographic maps.
3) The extracted outlines of the landslide were converted to digital data and compiled with the digital topographic data.
4) Field survey sheets, field snapshots and the home page addresses that related to the two earthquakes were included as the digital format data.

4.3 Creation of Hazard Maps

The hazard maps for the steep slope and the debris flows were created. The existing 1/25,000 topographic maps were used to extract hazardous areas, and the extracted hazardous areas were converted to the polygon data and compiled with the digital topographic data. The extraction norms in the Study were as follows:

1) Hazardous area of steep slope

The area having the following conditions was defined as the hazardous area of steep slope:

- There is a slope of 30 degrees inclination or more.
- There are houses as protection objects on the existing 1/25,000 scale topographic maps within Area A and/or Area B in Figure 2. Here, H is the height of the slope.

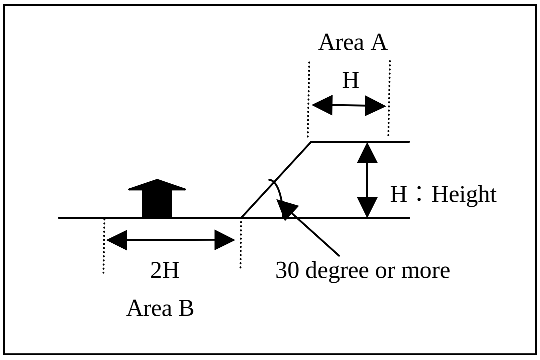

Figure 2. Hazardous Area of Steep Slope

2) Hazardous area of debris flow

The area having the following conditions was defined as the hazardous area of debris flow:

- The area from a place of 10 degrees streambed inclination to a place of 3 degrees streambed inclination (or 2 degrees streambed inclination in volcanic area).

An example of the disaster maps is shown on Figure 3, and an example of the hazard maps is shown on Figure 4.

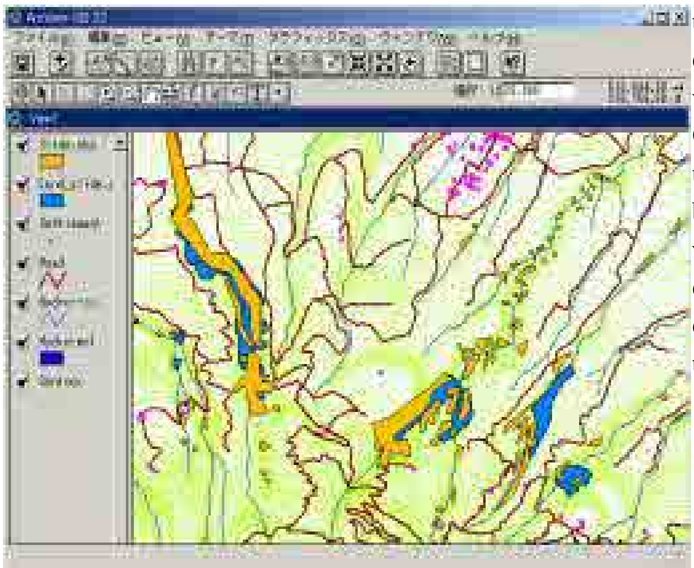

Figure 3. Example of the Disaster Map

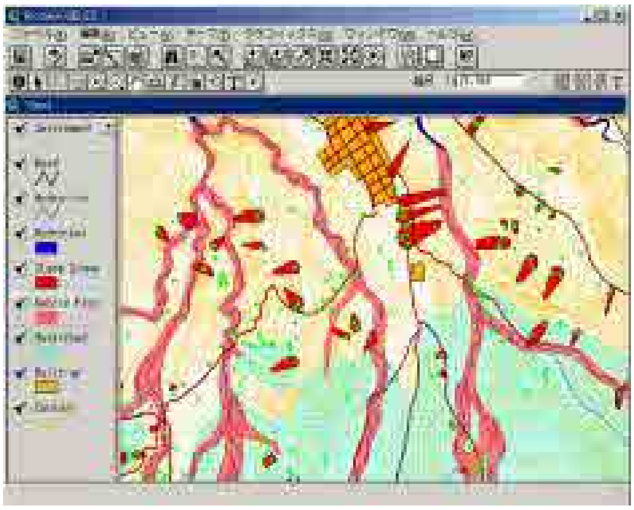

Figure 4. Example of the Hazard Map

5. Conclusion

Presentation of the Study and the products were held for related organizations several times in El Salvador, and samples of the digital topographic data were introduced worldwide through the Internet, so that the various parties can inquire for the digital data. It would be certain that the disclosed results of the Study will be effectively used by not only the El Salvadoran Government but the organizations of the countries encountering the same natural disasters. GIS digital data created as the national basic geographic data in the Study will be effectively used for variable spatial analyses and will be important for decision-making. Finally, it would be emphasized that any GIS data should be continuously updated and corrected for the use of the appropriate purposes.

Establishment of Base Map and Hazard Maps for GIS in the Republic of Guatemala

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Summary

Guatemala was hit by a large-scale hurricane in 1998 and serious damages affected the metropolitan city and its suburbs. In the aftermath of this disaster, a great number of supports for restoration and reconstruction were offered from several developed countries. The national topographic maps have not been revised and the old topographic maps have been used for the national effort to restore and reconstruct. A large segment of the population is still living in the stricken areas, as well as in other areas susceptible to similar disasters. There is a great fear that similar disasters may happen again. The Government of Japan is assisting in works for the development of a GIS database and hazard maps to be used in the national effort for restoring and reconstructing in Guatemala over the years, from 2001 to 2003.

1. Background and Outline of the Study

Some plate boundaries pass through Guatemala's national land and its periphery. The northern part of the country lies on the North American Plate, and the central and southern parts on the Caribbean Plate. Cocos Plate lies on the Pacific Ocean side in the southern part. There are many faults that run in parallel with these plate boundaries. The geological structure is thus very complicated. Furthermore, the geological features, such as volcanoes and volcanic ejecta sediments, which may cause disasters, are widely distributed in the metropolitan city of Guatemala, other main cities, and the neighboring areas of those cities. There are also many social problems in Guatemala that are caused by a weak social infrastructure resulting from the civil war that lasted for a long time, as well as from the poverty common in developing countries.

In such a fragile environment, the internal force of the earth can cause large-scale earthquakes and the eruption of active volcanoes. Meteorological disasters also have frequently occurred, such as the tremendous Hurricane Mitch that hit the Central American region in 1998. In particular, the metropolitan city tends to show high risk of disasters due to earthquakes, debris, mudflows, and volcanic ejecta.

This Study started in January 2001 with the aim to restore and reconstruct from the disasters caused by the Hurricane Mitch, develop the GIS database, create the hazard maps as basic materials required for countermeasures against such disasters, and manage and operate these resources using the GIS for national disaster prevention.

2. Details of the Study

The main items of this Study are establishments of the GIS and hazard maps. The counterpart agency for the GIS-related work is the IGN (National Geographical Institute) and that for the hazard map related work is the INSIVUMEH (National Institute for Seismology, Volcanology, Meteorology, and Hydrology). The objectives to build the GIS database and produce the hazard maps are certainly remarkable, but the final goal is to promote a disaster prevention reinforcement for each of the local governments and the residents, through an efficient use of the GIS and hazard maps, and to conduct the transfer of technologies in each stage.

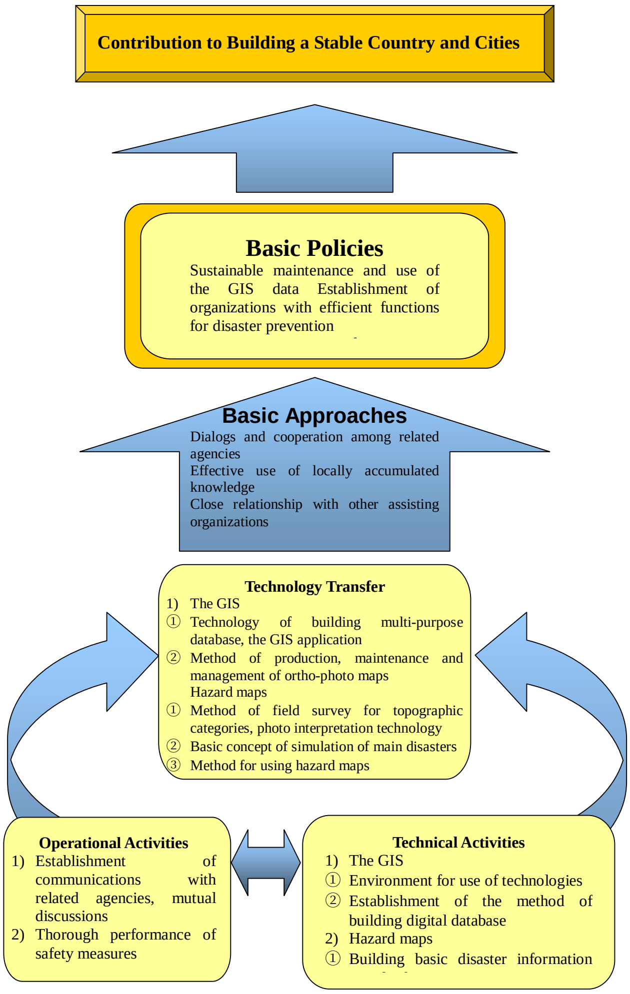

Fig. 1 Basic Policies of the Study

3. Production of Hazard Maps

The national land in Guatemala, with severe earthquake and volcanic activities, tends to be a passage for hurricanes, and cities and villages are distributed on that land. It is a well known fact that this country is prone to disasters. The demand for hazard maps is thus high and disaster prevention measures using the hazard maps must be taken.

The targets for hazard maps in this Study are earthquakes, volcanic disasters, hurricanes, floods due to heavy rain, and landslides (including slope avalanches, and debris flows).

Fig. 2 Image of Hazard Map (Assessment of risk of flooding)

4. Images of Hazard Maps

The hazard maps to be developed in this Study have not been completed yet within the fiscal year 2001, but the results obtained will be as follows. The disaster factors can be classified into those for which the dangerous districts can be predicted through simulation, and those that can be assessed statistically and qualitatively from the history of disasters, topographical and geological features.

5. Integration of Hazard Maps with the GIS and Total Disaster Prevention GIS

The basic data collected to produce hazard maps and the hazard maps are very important for the disaster prevention in Guatemala. There is a large volume of the GIS data that have been already arranged by the related agencies. The hazard-map GIS to be developed in the Study, that will be configured as a total disaster prevention GIS linking with the related GIS data, will be easier to utilize than the GIS configured as an independent system. It is thus preferable to build a total disaster prevention GIS based on technical discussions with the related agencies of Guatemala.

Items to be displayed by total disaster prevention the GIS (draft)

- Existing facilities
  Administrative organizations, police organizations, fire service organizations, military facilities, medical institutions, community centers, churches, parks and plazas, airports, heliports, highways, bridges, and ports
- Observatory facilities
  Meteorological offices, meteorological stations, hydrological stations, and seismographic stations
- History of disasters
  Chronological table of disasters, earthquake-stricken districts in 1976, Hurricane Mitch-stricken districts in 1998, volcanic ejecta distribution, past landslide points, table of damages, disaster photographs
- Disaster factors
  Topographical categories, surface layer geology, active faults, active volcanoes, and meteorological data
- Information on risks of earthquake disaster
  Districts with earthquake risks (districts in which an earthquake is easy to be amplified), districts with liquidization risks, and locations with landslide risks
- Information on risks of volcanic disasters
  Districts with risks of volcanic disasters
- Information on risks of landslide and flood
  Locations with risks of landslide and districts with risks of flood

6. Recommendations for Disaster Prevention Measures

The hazard maps should be utilized to inform the residents of the risks of various types of disaster and to take appropriate measures for their refuge in case of disaster. In addition, the hazard maps should also be drawn so that administrative officials can use them as basic materials for the area and facility development.

6.1 Promotion of Measures for Refuge using Hazard Maps

To minimize human casualties, it is most effective to establish a refuge system in case of disasters exclusive of abrupt earthquakes. First, the districts that are prone to dangers should be defined to regulate the land use in dangerous areas, and a refuge system to be applied in case of emergency should be established and the residents should be informed about it.

6.2 Support for the Establishment of Early Warning System

Various tasks are undertaken to establish the early warning system, including the installation of meteorological observatory equipment, establishment of a communication system, and development of an analysis system. For the establishment of an early warning system, it is necessary to understand well the wide-area atmospheric conditions, and it would be certainly rational to consider applying the warning system to the entire Central American area, and not only on a national level, since rivers extend across a wide region, flowing from one country to another.

6.3 Improvement of Building Standard Law and other Laws

The most serious consequences of earthquake are the collapses of buildings, especially the private houses. The structures of buildings in Guatemala are not designed to be earthquake-proof. Recent buildings use little adobe structure, but many of them are supported through lightweight blocks and reinforcing steel poles. They are thus not earthquake-proof. In case of serious earthquake, the collapse of buildings may constitute the main disaster factor. The revision of the Building Standard Law to ensure better earthquake-proof buildings is thus necessary.

In addition, laws related to river management, including construction of river structures, establishment of the flow observatory system, limitation of land use along a river, and promotion of appropriate land use, must be promulgated.

7. Conclusion

Through the arrangement of problems and tasks for the disaster prevention measures that have been evidenced by the results of this Study for three years, we can therefore recommend the kind of disaster prevention measures that is most suitable to a given disaster in Guatemala. The same technology used in Japan should not be provided, but the transfer of technology and the disaster prevention measures using hazard maps that are adequate for the local conditions of Guatemala will be recommended. In general, two methods for using hazard maps are to be considered, namely short-term use and long-term use of hazard maps.

① Short-term use

- Definition of dangerous districts requiring refuge, and provision of routes and place of refuge
- Disaster prevention training of residents

② Long-term use

- Disaster prevention facilities distribution plan
- Land use regulation
- Land use plan

In the short-term use of hazard maps, the protection of the life of the residents can be at least ensured. In the case of the long-term use, the land use regulation prohibiting residents to live in areas prone to disasters, the land use plan to reduce the eventual costs of damages, the installation and distribution of observatory equipment and the permanent disaster prevention measures such as construction of embankments and dams, should be considered not only for the protection of the residents’ lives but also for minimizing the loss of property.

Disaster Information Management Activities using GIS in the Hanshin – Awaji disaster area

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Summary

The effects on use of GIS in the Disaster Information Management was proved by the Academic Volunteer Activities using GIS in the Hanshin – Awaji disaster area. This chapter introduces them and explains about the two kinds of usefulness of GIS uses in the debris removal processing and the decision support for an urban reconstruction planning.

1． Disaster Information Management Activities using GIS

1.1 Academic Volunteer Activities using GIS in Nagata ward

The Hyogo-Ken Nanbu Earthquake directly stroked under Kobe city on January 17, 1995. The damage of this earthquake was serious in Hanshin -Awaji disaster area. At the Northridge great earthquake of U.S. California in 1994, the emergency rescue operation was made on the base in GIS, but in Japan, it was not used for, although it was used for restoration works, such as the information processing for debris removal from collapsed private houses at local and regional administration office.

The Disaster Information Management Activities using GIS (DIMA-GIS), was carried out at Nagata ward Office in the western parts of Kobe city.(Kameda ,1995) The professor of the Kyoto University, Hiroyuki Kameda who is a chief of the special working group for a disaster prevention GIS in Japanese GIS Association , took the lead of this activity and Sigeru Kakumoto who is a visiting associate professor of DPRI-KU, supported the operation and development of the Disaster Management Spatial Information System (DiMSIS). And also Kansai branch director of Japanese GIS Association, Teruko Usui (professor of the department of Geography, Nara University) supported this activities by creating GIS database of damage and restoration. This chapter attempts to illustrate how GIS was socially useful for the restoration in the Hanshin – Awaji disaster area.

1.2 Disaster Information Databases and Time series Surveys by NUDPSC

Disaster Prevention Research Institute of Kyoto University (DPRI-KU),and Nara University Disaster Prevention Survey Commission(NUDPSC) created many databases of damage and restoration in the Hanshin - Awaji disaster area using GIS. The dead, building damage and the damage of a lifeline were inputted into damage information databases. (Usui,1995, 2000) And also restoration databases have a serial information on the place of the debris removal from collapsed houses and traffic impossible roads by a debris occupation which were surveyed by NUDPSC.

NUDPSC is an academic volunteer commission which is located at Usui laboratory at department of geography Nara University, and about 100 students have registered. The first survey was carried out by NUDPSC at the Hanshin-Awaji disaster area covered by 17 sheets of the map 1:10000,on February 9, 1995. NUDPIC inputted each debris removal place of houses and roads into the large scaled electronic map,1:2500, using ARC/INFO. This time series surveys has been carried out at 1 month intervals from February 1995 to July 1995, and at 3 month intervals from July 1995 to April 1999, and at 6 month intervals from April 1999 to October 2001. (Iwai,1998)

2. How was GIS useful in Hanshin-Awaji disaster area ?

2.1 Situation of the Debris Removal of Collapsed Houses after the Big Earthquake

The Figure 1 shows the distribution of debris removal sites of collapsed houses in February 1995 and April 1995. The number of the debris removals at Nishinomiya City was the highest in February. It can be explained by the traffic condition or the accessibility from a large city as OSAKA. The total of the debris removals increases more at the city of the eastern parts such as Nshnomiya、Ashiya City and Higashinada ward. On the other hand, it is a few at a western area such as Nagata and Suma wards where the traffic access from Osaka is worse.

More noteworthy is that there are a few debris removals in February, and the number of debris removals increases rapidly in April, especially at Nagata ward. The processing of debris removal of many collapsed houses was unprecedented work at local government offices in disaster area. It, therefore, was gropingly started at the beginning in February which rescue activities had mostly finished. Figure 1 indicates that the processing of debris removal at local government office began to proceed in April, and increased in the number of debris removals. The rapid increase in Nagata ward is due to the use of GIS in the disaster information management for the debris processing.

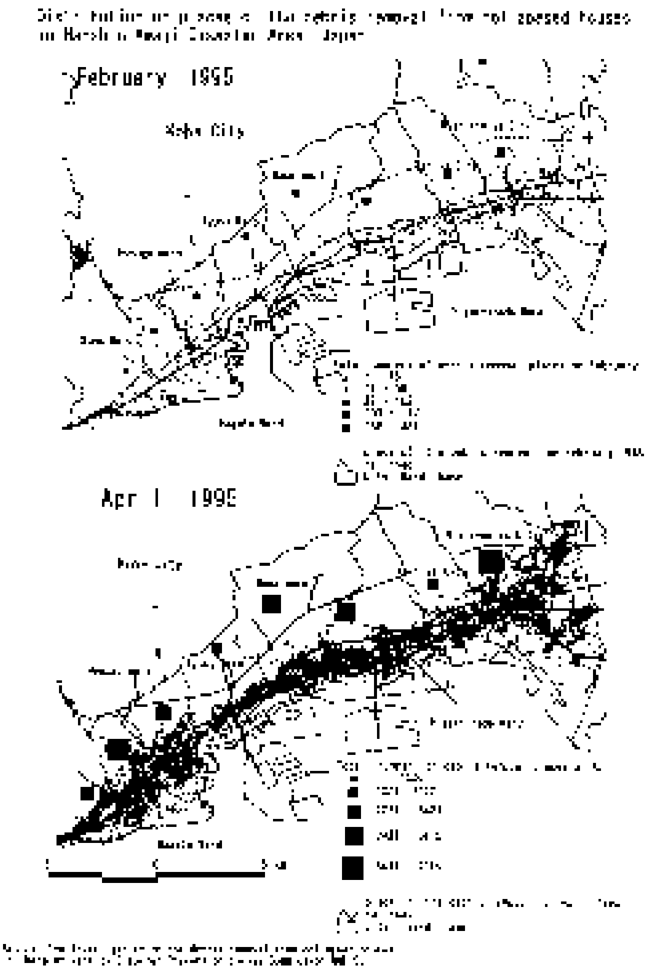
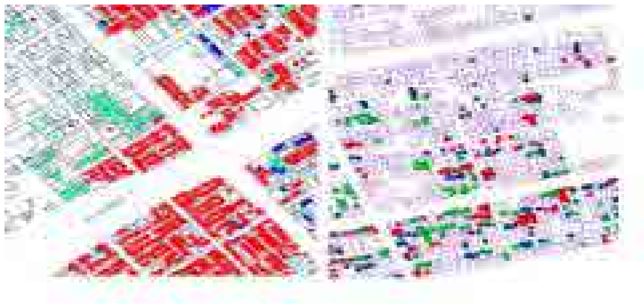


Figure 1. Distribution on places of the debris removal from collapseed houses in Hanshin-Awaji disaster area, Japan

2.2 The effects on use of GIS in the office work management of debris removals

Because many houses were private properties in Japan, the procedure of a legal application for a removal properties(collapsed houses) was necessary before the debris removal of the collapsed house. A local government checked whether there was no mistake in the declaration and had to confirm that an applicant was the rightful owner of the debris removal place. The office work for owner confirming, therefore, made it spend great labor and time. It seems reasonable to suppose that office works such as the checking and the owner confirming would cause a delay of the debris removal processing.

The DIMA-GIS, which was explained before, was carried out to help these office works at Nagata ward office from the beginning in March.



Nagata ward using GIS   Higashinada ward not using GIS

Red site:debris removal in April
Green site: debris removal in May
Blue site: debris removal in June

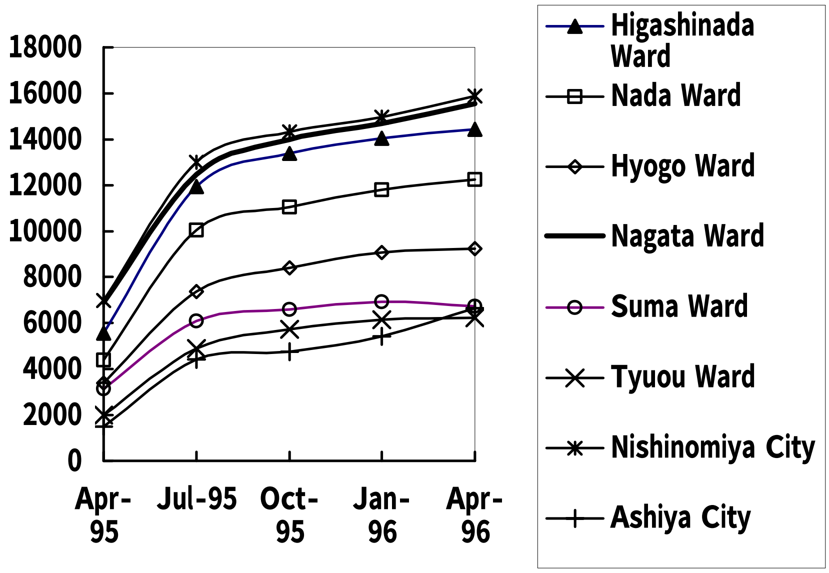
Fig.2 Different distribution of debris removal ites between at Nagata ward and Higashinada ward in Kobe City

The effects on use of GIS was appeared at the rapid increase in the total of debris removals in April. The two kinds of different spatial pattern on Figure 2 shows the different situation of the debris removals in Nagata and Higashinada ward respectively, which suffered the heavy strike with the almost same damage ratio of collapsed houses. It follows from this that the aggregated spatial pattern indicates the effectiveness of the debris removal processing, because local public service workers of Nagata ward could easily realize where the collapsed houses were aggregated by the map visualization of GIS. In other words, Figure 2 shows why it could be removed efficiently by the use of GIS.

2.3 The effects on the decision support for detailed urban reconstruction planning

One more importance of the GIS use is the effects on the decision support for detailed urban reconstruction planning. According to Figure 3, which shows the number of debris removal sites, Nishinomiya city, Nagata ward and Higashinada ward in Kobe city had large damage of wooded houses in order of number of debris removal sites. But the progress of the restoration after the earthquake in Nishinomiya city and Higashinada ward was different from the restoration at Nagata ward.

Figure.3. Different distribution of debris removal sites between at Nagata ward and Higashinada ward in Kobe City



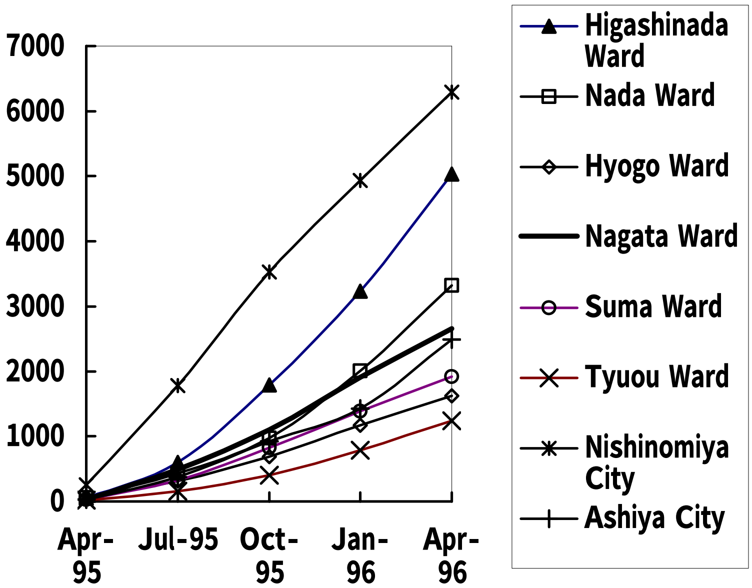


Figure 4. The numbers of places building new houses after the debris removal

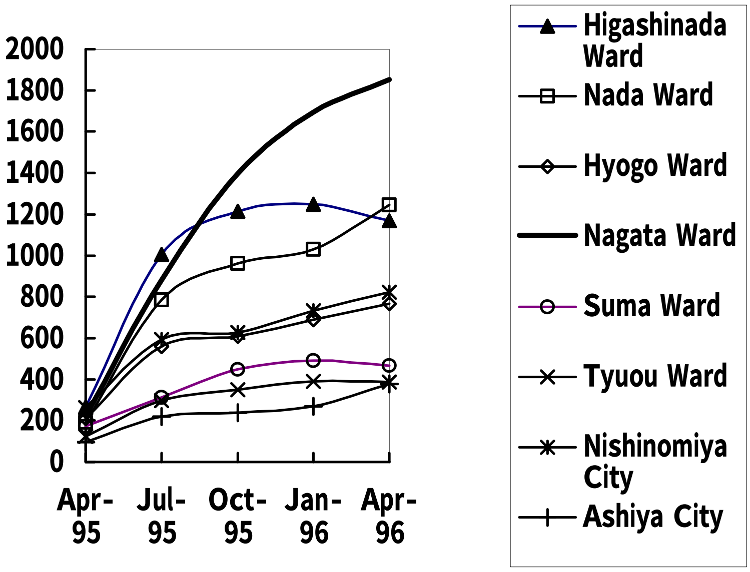


Figure 5. The numbers of places building temporal houses after debris

Figure 4 suggests that many private land owners built new own houses at debris removal site in Nishinomiya city and Higashinada ward . On the other side, Figure 5 shows the increment of the rented low price accommodations and apartments which were built temporarily in Nagata ward. The progress of housing after earthquake have varied considerably, not only by the damage, but also by region, being generally higher in Nishinomiya city and the western regions of Ｋobe city as Higashinada ward , and lower in the eastern region of Kobe city as Nagata ward.

Hyogo Prefecture home reconstruction division and Kobe City planning division used this GIS database which NUDPSC had produced, and realized the expansion of the gap of an eastern and western parts of Kobe city in the restoration progress after earthquake. It is no exaggeration to say that the local government could have produced the most suitable urban reconstruction plan for disaster area using GIS.

In other words, a more detailed urban reconstruction plan would be produced by the distribution map of the new and the temporary houses using GIS. GIS is an useful decision support system.

3, Conclusion

As mentioned before, the Disaster Information Management Activities using GIS (DIMA-GIS) in the disaster area was proved the GIS effects. Japanese GIS Association suggested the National Spatial Data Infrastructure (NSDI) to Japanese central government just after the earthquake and published a "Recommendation Paper concerning establishment of Social Infrastructure for Spatial Data" on January 31 in 1995.

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STUDY ON URGENT ESTABLISHMENT OF TOPOGRAPHIC MAPPING IN EAST TIMOR (CREATION OF TOPOGRAPHIC INFORMATION FOR ESTABLISHING CADASTRE IN EAST TIMOR)

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Abstract

- First digital topographic mapping in East Timor after the violence following the independence vote in September 1999.
- Cadastral and other necessary data for mapping were lost by the violence.
- Many houses and building were destroyed and burned out.
- Complicated land ownership and form of use of public facilities and building.
- Public facilities data using GIS.

1. BACKGROUND OF THE PROJECT

In response to a request from the United Nations Transitional Administration in East Timor (hereinafter referred to as "UNTAET"), the Government of Japan decided to conduct "The Study on Urgent Establishment of Topographic Mapping in East Timor" (hereinafter referred to as the "Study").

This Study was carried out by Japan International Cooperation Agency, the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan. Asia Air Survey Co., Ltd. sent the Study Team to East Timor under the contract with JICA and executed field work in East Timor and office work in Japan.

The Study area covers Dili City and its surrounding area in East Timor and the total study area is 107 square km for 1:2,000 scale digital topographic mapping and digital GIS data preparation（Fig.1）. The Study was started in February 2000 and ended in September 2000. It was the first digital topographic mapping in East Timor after the violence following the independence vote in September 1999.

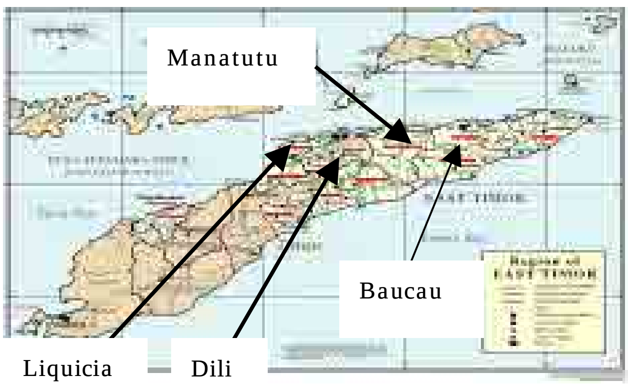


Fig.1 The Study Area

2. PROBLEMS IN EAST TIMOR

East Timor and Dili City have the following serious problems in the field related to topographic maps at present.

2.1 The available topographic maps in East Timor had basically been only the 1:25,000 scale topographic maps that were prepared by BAKOSURTANAL (Indonesian Survey and Mapping Authority) of the Republic of Indonesia in 1990's (the aerial photos taken in the 1980's and the 1990's were used for 1:25,000 scale topographic mapping). In addition, other topographic maps of larger scale had also been partly available, but those maps had been expanded and compiled from the 1:25,000 scale topographic maps.

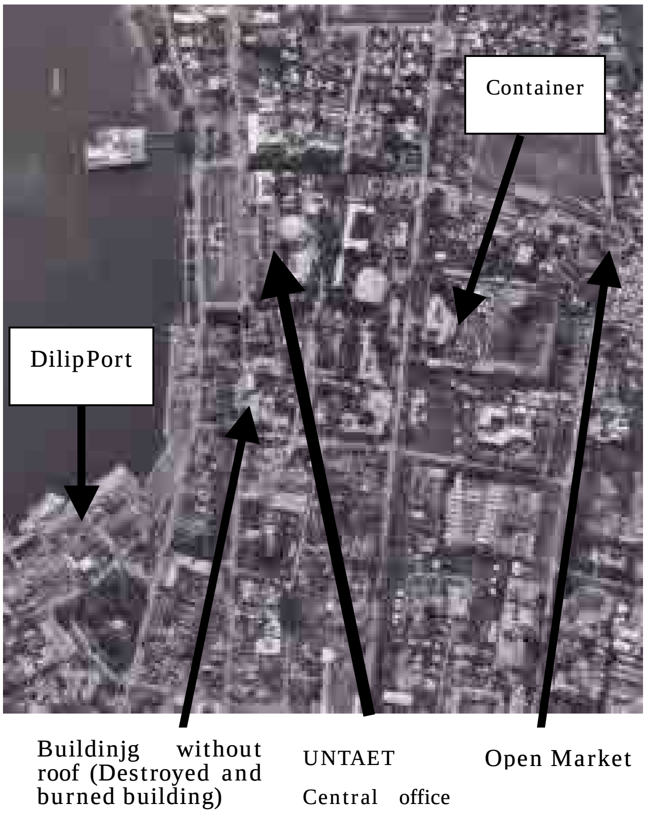
2.2 The leveling network and GPS points network had been established by BAKOSURTANAL during the Indonesian period. The concrete monuments of benchmarks and GPS points still exist in East Timor. However, the documents such as description of benchmarks and GPS points, coordinates list and so on were lost by the violence.

2.3 Furthermore, Indonesian Government's documents such as statistic data, land registration data, resident registration data and so on were lost by the violence.

2.4 Since the land use data was damaged by the violence, many disputes have arisen in connection with land ownership within Dili City. In order to settle these disputes, it is required to develop large scale topographic maps, to make a land-use survey promptly and to build a database system ensuring the results of the land use survey to be properly arranged on the newly developed topographic maps of large scale.

2.5 The facilities and buildings owned by the former Indonesian Government belong to East Timor after its independence, but the number, nature & location of these facilities and buildings are not clear as the Indonesian Government's data was lost. Therefore, it is required to define these unclear facilities and buildings to become the national properties of East Timor, before UNTAET turns over its reins to the future Government of East Timor.

2.6 A number of public facilities, building and houses within Dili City were damaged and burned out by the violence in September 1999. Therefore, it is required to make a survey of the levels of damages and their location and to prepare the survey report promptly as the basic materials for the reconstruction plan of Dili City.



(Date of photography;12:15 PM,April 2000)

Fig.2 Aerial Photograph at the center of Dili city

3. FORMS OF USE OF PUBLIC FACILITIES AND BUILDINGS

Many houses and buildings in Dili City were destroyed and burned out by the violence following the independence vote in 1999 and most of them remained as damaged at the time of map creation.

There were over 450 public facilities and buildings, and approximately 50 schools in the mapping area. Most of the facilities and buildings were owned by Indonesian Administration. Some of them were burnt, destroyed and closed down, and others were not burnt but simply closed down, or used for other purposes.

The ownership and forms of use mainly of public facilities and buildings are complicated having the past background compared with those in other areas, and the form of use of public facilities and buildings are classified into three types as follows:

a. Public facilities and buildings in the Indonesian period that remain damaged and unused since they were damaged by the violence following the independence vote in September 1999.

Example:

Indonesian Period: Office of Ministry of Public Works of Indonesia

Present time : Remains damaged and abandoned

b. Public facilities and buildings in the Indonesian period that were damaged or undamaged, but restored by any UN organization, being in use.

Example:

Indonesian Period: Indonesian Provincial Government Office

Present time : Central Office of UNTAET

c. Public facilities and buildings in the Indonesian period that were damaged or undamaged, but are now used for the same purposes as in the Indonesian period.

Example:

Indonesian Period: Elementary school

Present time : Still used as an elementary school.

Fig.3 Panoramic view of Dili city

Fig.4 House destroyed and burnt in September 1999 in Dili

4. CHARACTARISTIC OF DIGITAL TOPOGRAPHIC MAPS

In the background as described above, the Study Team determined that the 1:2,000 scale digital topographic maps to be created in this Study should be different from the general topographic maps for other areas and decided to create those maps under the following method:

Method of creating 1:2,000 scale digital topographic maps -

4.1 Damaged and undamaged buildings and houses

It is necessary to classify the damaged and undamaged buildings and houses on the 1:2,000 scale digital topographic maps to be created. For this purpose, following methods were applied

1) Ordinary houses

To classify those ordinary houses by photo interpretation in plotting based on whether the roofs exist or not as follows:

Example:

Ordinary houses with roofs: Undamaged houses – drawn by full lines

Ordinary houses without roofs: Damaged houses – drawn by broken lines

Damaged house Undamaged house

2) Public facilities and buildings

To determine damaged or undamaged public facilities and buildings basically in the same way as ordinary houses using photo interpretation in plotting. However, many of those public facilities and buildings are now being used by UNTAET or PKF after they have been restored.

Therefore, in addition to the ordinary field identification, further detailed data and information were required for 1:2,000 scale digital topographic maps. Inventory study data sheets were prepared to verify each of the public facilities and buildings on the spot and check whether it has a roof, whether burnt or not, its restored status and whether in use or unused. These inventory data sheets were attached to each public facilities and buildings as an attribute data on 1:2,000 scale digital topographic maps by using GIS.

4.2 Representation of symbols for public facilities and buildings

As mentioned previously, there are three forms of ownership and use of public facilities and buildings. Therefore, it is necessary to represent a facility or building in any of those forms. In the 1:2,000 digital topographic maps, the following methods of representing the public facility and building symbols were adopted.

1) If the ownership and the purpose of use of any public facility or building in the Indonesian period were same as those at present, the symbol of the currently used facility or building is used.

Example:

Indonesian Period: Elementary school

Present time: Elementary school – Use the symbol for elementary school

2) If the ownership and purpose of use of any public facility or building in the Indonesian period were different from those at

Present time: Unused and abandoned

Ordinary building

Building with the symbol used in Indonesian period, but not in use now

4) For the buildings and facilities owned or related to the Indonesian military, the symbols for the facilities of Indonesian military were created.

5. INVENTORY SURVEY AND URBAN FACILITIES MAPS USING GIS

In addition to the ordinary field identification for 1:2,000 scale digital topographic mapping, inventory survey for public buildings and facilities to obtain the further detailed data and information including the former (Indonesian Administration) names of buildings and facilities, their present names, locations or addresses, conditions of damages and usability and so on were executed, and inventory survey data sheets were prepared for GIS data. The items of inventory survey were as follows:

- Bridges
- Churches, Temples and Cemeteries
- Schools
- Government Offices and Public Buildings
- Historical Sites and Objects
- Specific Crops and Vegetation; and
- Underground or Hidden Canals and Drainages

The inventory survey data sheets were attached on the urban facilities maps as attribute data using GIS software Arc View (Ver.3.1) (Refer to the attached “Flow Showing Map Features and Their Attributes Using GIS in the Study”).

6. CONCLUSION

One of the important objectives for creation of the 1:2,000 scale digital topographic maps and GIS data in this Study was that those maps and GIS data should be prepared as soon as possible for use as basic materials to promote the reconstruction of urban facilities in Dili City which is about to start and to solve the problems (especially dispute related to land ownership) that Dili City, the largest city in East Timor is facing. .

However, the existing materials necessary for creation of digital topographic maps and GIS data had mostly been lost in the violence of September 1999. Thus, the Study Team had to collect various types of information necessary for creation of digital topographic maps and GIS data through the field identifications.

In addition, many of the urban facilities, buildings and ordinary houses that had been damaged in the violence in the target areas are to be covered by the digital topographic maps and GIS data to be created in this Study. Some of the governmental facilities and buildings used in the Indonesian period are used by UNTAET and PKF, but others are abandoned.

Therefore, the specific circumstances that Dili City is currently situated and other many conditions had been considered in regard to the applications of the topographic maps and GIS data to be created. The Study had also been made through many trials and errors in determining how the information on these new conditions should be represented on the digital topographic maps and GIS data.

As described above, there were many difficulties in this Study for creation of digital topographic maps in terms of the required time and its contents compared with the works for other ordinary areas. It is also anticipated that those topographic maps will be subject to secular changes as the reconstruction of Dili City is making progress.

Dili City is in the course of rapid restoration from the disaster following the dispute in September 1999 owing to the assistance by many countries and investment by the private sector. However, the 1:2,000 digital topographic maps and GIS data created in the Study are based on the information from the aerial photos taken for a short period from the beginning to the end of April 2000 and the results of field surveys carried out for a period from the middle of April 2000 to the end of May 2000.

The restoration from the disaster in Dili City is now speeded up compared with that at the time when the Study Team started the Study in East Timor. Therefore, the digital topographic maps and GIS data will shortly have many discrepancies form the actual conditions unless they are modified continuously.

Master Plan Study on the Integrated Environmental Management in Baku City in Azerbaijan Republic
- Environmental GIS Database Building -

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Abstract

The Metropolitan City of Baku and its surrounding areas of Azerbaijan have witnessed a tremendous economic development since the second half of the 19th Century, thanks to its wealth in petroleum resources available in Baku and other oil fields. Unfortunately, the drastic economic development undertaken without the proper environmental considerations caused various problems, such as wide-area environmental damages. To solve these problems, the Government of Azerbaijan made a request for formulation of the Master Plan Study on the Integrated Environmental Management in Baku City, to the Government of Japan.

In the formulation of the Master Plan for the Integrated Environmental Management, a large number of information related to maps, the nature, society, and environment is handled. This Study was implemented to introduce the GIS (Geographic Information System) for an efficient management and use of the diverse information, and to build the environmental GIS database. In addition, the website to disclose the environmental information was launched by the counterpart, namely the Baku Committee on Ecology and Nature Utilization Control or "BCE".

1. Outline of the Study

1.1 Background and Objectives

The economy of the Metropolitan City of Baku and its surrounding areas of Azerbaijan has witnessed a drastic development since the second half of the 19th Century thanks to a wealth in petroleum resources available from the Caspian Sea and its shore area. However, environmental considerations were not adopted properly for the technology used for oil drilling and refining, and this results in adverse impacts on the environment. Especially, since the independence from the former Soviet Union in 1991, a wide range of environmental damages were caused, such as harmful sediments in abandoned oil fields and old industrial zones, impacts on human health, and aggravated natural environment disasters.

Under these circumstances, the Government of Azerbaijan made a request for formulation of the Master Plan (M/P) for the Integrated Environmental Management in Baku City, to the Government of Japan. The Study Team built the GIS database on environmental pollution based on various types of information (mapping, natural, social, and environmental data) that were collected and obtained in formulating the M/P to provide the basic data necessary for BCE (Baku Committee on Ecology and Nature Utilization Control) as the counterpart (C/P), to offer a guidance and proposals on the environmental issues.

1.2 Study Area

The study area covers the lands that fall under the jurisdiction of BCE, as shown in Fig. 1. It amounts to approximately 2,192 km2 and has a population of 2.02 million inhabitants (as of 1999). The study area consists of 11 zones.

1.3 Organizations for Implementing the Study

The organizations for implementing this Study are as follows:

For the Japanese side: Kokusai Kogyo Co., Ltd.
For the Azerbaijan side: Baku Committee on Ecology and Nature Utilization Control (BCE)

1.4 Period of the Study

From January 2000 to March 2001 (15 months)

Fig. 1 Study Area

2. Environmental GIS Database

The database on the environmental pollution was built using the GIS to ensure the C/P, BCE to offer guidance and proposals on the environmental issues to other national agencies in charge of city planning and land use plans.

The environmental GIS database built in this Study was divided into 6 layers, namely (1) Basic data; (2) Natural conditions; (3) Social conditions; (4) Environmental information (pollution sources); (5) Environmental information (pollution diffusion status); and (6) Environmental information (pollution maps). These layers of information were configured on the standardized coordinate system to use the overlay function of the GIS. This ensures an easy retrieval of data on the same points; for example, the observed information and the environmental passport on factories can be retrieved momentarily. The contents of each layer of information will be described below.

Fig. 2 shows the configuration of the environmental GIS database built for this Study.

2.1 Basic Information

The basic information is used to understand the geographic conditions of the area under study, including the main roads, rivers, and geographic names.

2.2 Natural Conditions

The information related to the natural conditions is used to define the relations of the pollution sources and pollution diffusion conditions with the natural conditions, and it allows to understand easily the relations of air pollution with topographic and meteorological conditions, and of water contamination with the groundwater.

2.3 Social Conditions

The information related to the social conditions is provided to understand the relations of the administrative boundaries with the corresponding population, specified districts, land use plans, water supply facilities, and health statistics. The digital data of this information facilitate its statistic processing and its visual display, for a better understanding.

2.4 Environmental Information (Pollution Sources)

Each factory located in the study area is compelled in submitting its environmental passport to the relevant agency. The environmental information related to the pollution sources includes the digital data on environmental pollution, to be managed as the environmental pollution information using the GIS. Through the retrieval function of the GIS, any factory that causes emissions exceeding the reference value involved in the environmental pollution can be monitored momentarily. In addition to the environmental passport, the information related to other environmental pollution sources, such as power generation plants, oil fields, large-scale agricultural lands, waste disposal facilities, drainage facilities, are provided as digital data.

2.5 Environmental Information (Pollution Diffusion Conditions)

The pollution diffusion conditions depend upon air, water, and soil pollution. Since the observed data is point-by-point type, it is difficult to monitor the pollution conditions over a whole area. The digital data can be represented two dimensionally using the GIS, and the pollution diffusion conditions over an entire area can be monitored.

2.6 Environmental Information (Pollution Maps)

The environmental pollution maps represent the conditions of air, water, and soil pollution using the environmental GIS database built on the information, as obtained in 2.1 through 2.5 above. The integration of the above types of information with any simulation models imported into the GIS allows the production of an integrated environmental pollution map.

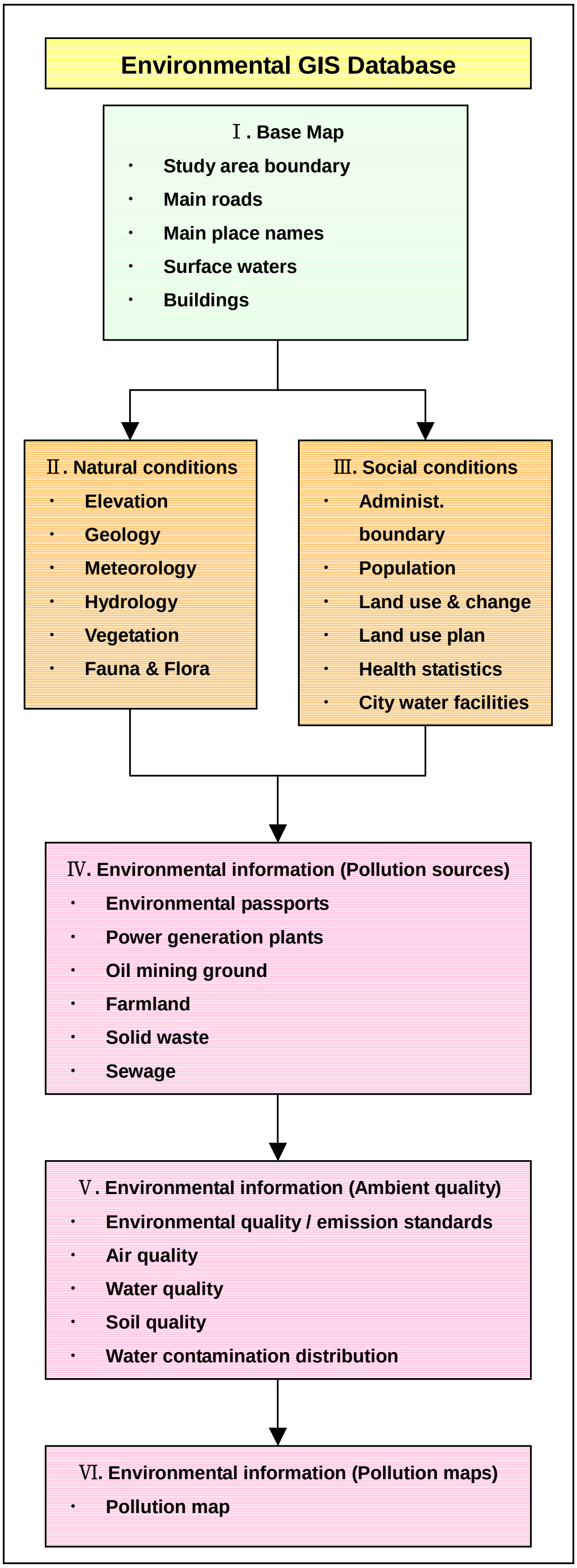

Fig. 2 Configuration of Environmental GIS Database

3. Hardware and Software Used for Building the Environmental GIS Database

3.1 Hardware

The hardware used for building the environmental GIS database is as follows:

(1) PC server: 1 unit
(2) PC client: 2 units
(3) A0-size color plotter
(4) A3-size color scanner
(5) A3-size color printer
(6) Networking equipment (hub, LAN cable)
(7) Power supply stabilizer

The PC server is used to manage the built database, but normally, only the manager can use it.

The PC client is used for the operators to build the environmental database.

All the PCs and their peripheral equipment were networked.

3.2 Software

In selecting the software to build the environmental GIS database, the software used in other international organizations within Azerbaijan was examined. In consideration of the GIS software widely used in many countries, the ArcView GIS 3.2 from ESRI was introduced in this Study, as listed below.

(1) ArcView GIS 3.2 : 2 sets
(2) ArcView Spatial Analyst 1.1: 2 sets
(3) ArcView 3D Analyst 1.0: 2 sets
(4) Microsoft Office Professional: 3 sets

4. Environmental GIS

Some applications of the environmental GIS are described below.

4.1 Output Example of Environmental Passport Database

The environmental passports collected and incorporated in the database are provided for about 290 companies. As shown in Fig. 3, the distribution of factories holding the environmental passport and the types of information possessed by those factories can be monitored momentarily using the GIS.

4.2 Output Example of Air Quality Database

In the study area, there are 9 monitoring stations that are provided to control the air quality. The air quality data observed during 10 years, from 1990 to 1999, are available for monitoring. The observed air quality data consist of approximately 15 items, including NO_x and SO_x. All the air quality data were incorporated in the GIS to build the air quality database. As a result, the information could be displayed using the GIS, as shown in Fig. 4, allowing the atmospheric changes of NO_2 for 10 years to be monitored momentarily.

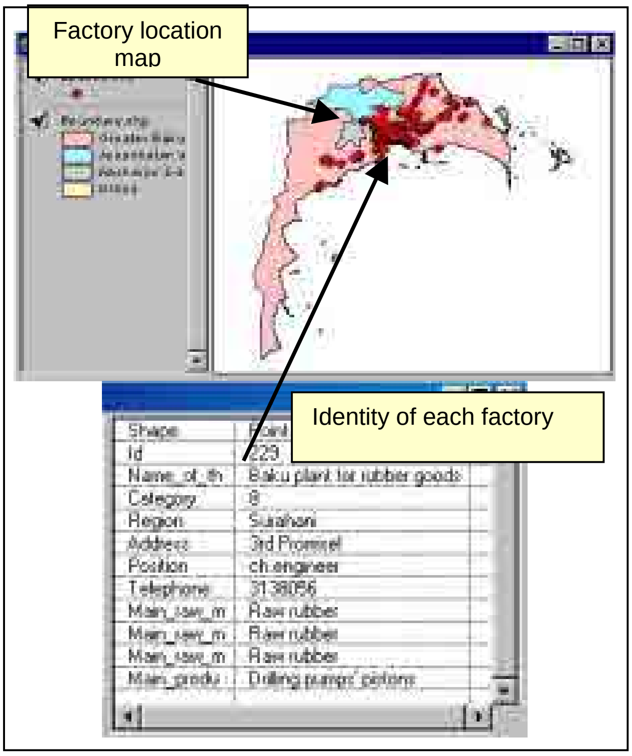

Fig. 3 Output Example of Environmental Passport Database

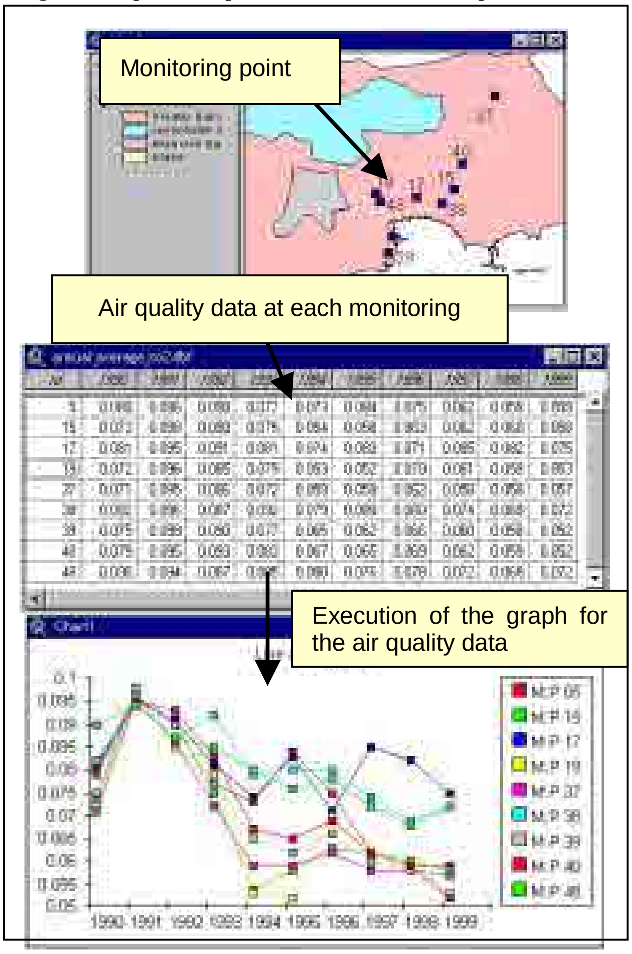

Fig. 4 Output Example of Air Quality Database

4.3 Output Example of Administrative Boundary Database

When considering the environmental pollution, the change of population represents important information. The study area consists of 11 zones, and the statistic information on the population in each zone had been provided every 5 years, since 1972. However, this information had been managed through an analog method (paper) and it is hard to verify the changes of population in each zone in such a manner. Therefore, the statistic population information was digitized and displayed using the GIS. Fig. 5 shows an output example of population database by administrative unit.

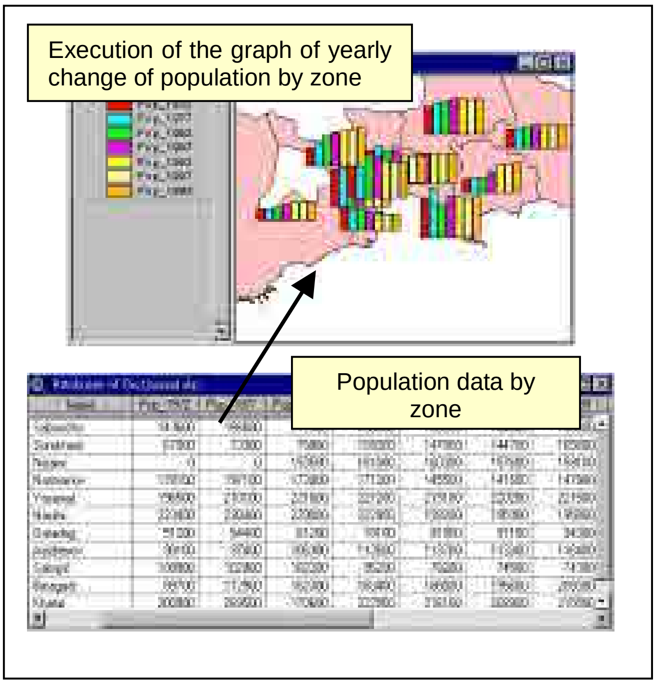

Fig. 5 Output Example of Population Database by Administrative Unit

5. Considerations in the GIS Introduction

All the foreseen problems would not be solved by digitizing the information through the GIS. However, when building the database, it is necessary to define the objectives and to digitize the necessary data in order to attain the desired objectives. What is needed for establishing the GIS database is not only to complete the system, but to update also the information from time to time, through addition, deletion, and correction. An organization to manage and operate the system would be also required. Therefore, the following three points must be considered for introducing the GIS, namely (1) Maintenance of GIS; (2) Use of GIS; and (3) Management of GIS.

5.1 Maintenance of GIS

It is necessary to update the database regularly for the maintenance of the GIS. Further, one must recognize that the database contains two types of data, namely the data available from the organization operating the GIS and those available from outside the organization. The data available from outside, in particular some environmental ones, may be non-disclosed confidential information, which should always be considered.

5.2 Use of the GIS

The environmental problems represent a great concern for the citizens. The GIS database in the environmental field is not only used within the organization responsible for the environment, but it should be used also by outsiders. For instance, the environmental GIS database built in this Study should be disclosed to the external organizations, such as the educational agency, for the environmental education and the knowledge of the citizens, using the Internet.

5.3 Management of the GIS

Several proposals for introducing the GIS in many countries have been undertaken, but some have failed to introduce the GIS properly. The reasons for failure were as follows: (1) An insufficient budget for the GIS maintenance; (2) An inadequate education of the staff in charge of the GIS; and (3) a retirement and transfer of staff in charge of the GIS.

The three reasons as mentioned above should be considered carefully when carrying out the introduction, maintenance, and management of the GIS.

6. Conclusion

The Master Plan on the Integrated Environmental Management in Baku City in the Azerbaijan Republic was formulated, and the GIS database on various types of environment information was built.

It would be preferable in the future, that BCE updates and manages this environmental GIS database for an effective use in order to solve the environmental problems in the Baku City and its surrounding areas.

Lastly, we would like to thank sincerely for the precious cooperation offered to the Study Team by the Government of Azerbaijan and its related agencies, the Japan International Cooperation Agency (JICA), the Ministry of Foreign Affairs, the Ministry of Environment, Japanese Embassy in Azerbaijan and JICA – UK Office.

GIS OF NATURE CONSERVATION INFORMATION CENTER, THE MINISTRY OF FORESTRY, INDONESIA

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Abstract

Nature Conservation Information Center (NCIC) of the Ministry of Forestry, Indonesia, was established in 1997 as a part of Biodiversity Conservation Project (BCP) being implemented by JICA. NCIC is responsible to collect, store and disseminate various data on the conservation areas in Indonesia which are under the administration of the Ministry of Forestry. In order to improve the use of map data, NCIC has introduced a GIS. The GIS is being used mainly to digitize existing maps and transform them into a single coordinate system. And in the future GIS at NCIC will also be used to analyze collected map data to provide information for planning and decision making practices. In this paper, background of the BCP and the role of NCIC's GIS are being introduced.

1. Introduction

Indonesia consists of nearly 17,000 islands which are distributed over a large area. In latitude the area extends nearly 45 degrees and in longitude 20 degrees. Elevation also ranges from 0 meter to 5,000 meters. Because of this geographic diversity Indonesia has one of the richest biodiversity in the world.

However, its natural environment is deteriorating in an alarming pace due to various development or natural resource exploitation activities. Deeply concerned with this rapid deterioration of natural resources, Indonesian government signed Convention of Biological Diversity in 1992 and Indonesia Biodiversity Action Plan was enacted in 1993**.** Following these initial and basic actions aimed at the protection of biodiversity, the Indonesian government asked the Japanese government for its technical assistance in the field of biodiversity conservation. The purpose of the requested technical assistance was to strengthen the capability of two government organizations playing important role for biodiversity conservation in Indonesia. One is the Directorate General of Forest and Nature Conservation in the Ministry of Forestry which is responsible for the administration of conservation areas and the other is Biological Research Center of the Indonesian Institute of Science which is collecting and storing basic data on biological resources in Indonesia.

In complying with this request, Japan International Cooperation Agency (JICA) commenced the Biodiversity Conservation Project in 1995. This project is being implemented as a project type technical cooperation program. At the same time, buildings, facilities and instruments were provided by Grant Aid program of the Japanese government. Now, the project is in its Phase II and will be completed in June 2003.

Project activities can be categorized into three components. One of them is information processing component.

In every activities for biodiversity conservation, it is very important to know the exact situation of target areas or target species. Without having correct data on the subject of conservation rational and efficient actions cannot be taken. A large number of scientific researches and conservation activities have already been conducted in Indonesia, but the results of such researches and activities have not been managed well and therefore have not been used efficiently.

For example, the Biology Research and Development Center has nearly 4 million specimens of flora and fauna but the center did not have any efficient system to search and use specimens and related research papers. Also, the Ministry of Forestry did not have any system or efficient mechanism to collect and use data on conservation areas.

To improve these situations, two information centers were established under the Biodiversity Conservation Project. One is Biodiversity Information Center (BIC) of the Indonesian Institute of Science and the other is the Nature Conservation Information Center (NCIC) of the Ministry of Forestry. Main activities of BIC within the project is the establishment of databases of flora and fauna specimens and as well as publications such as research papers and books. Therefore, their database is basically for non-spatial information.

On the other hand, NCIC's main activity is to establish databases which can support the activities of the Directorate General of Forest and Nature Conservation. For the management of conservation areas, maps are most important information. In this paper, the activities of NCIC is introduced.

2. Role of NCIC

Role of NCIC can be summarized as follows:

1) Collection of existing data on the 385 conservation areas in Indonesia which are under the administrative control of the Ministry of Forestry.
2) Storage of collected data in spatial information database and non-spatial information database. Map data are converted into GIS formats before storage.
3) Analysis of collected data.
4) Promotion of the modern skills in conservation area management. The promotion activities include technical training of field office personnel.
5) Provision of data to users outside NCIC.
6) Publication of data to the general public.

Following the adoption of de-centralization policy by the Indonesian government and also due to serious economic down turn, forest resources in Indonesia have been exploited in an alarming pace particularly by illegal operations. Illegal logging operations are rampant even in conservation areas. Under these circumstances, the Ministry of Forestry is expected to carry out rational counter measures based on accurate information in a short period of time. NCIC is the organization which can make this possible by providing up-to-date data for planners and decision makers.

3. GIS in NCIC

In order to fulfill its duties as described above, NCIC is now constructing two computerized database management systems. One is Relational Database Management System to store and use non-spatial information and the other is GIS to handle spatial information.

3.1 System Configuration of GIS at NCIC

Hardware and software for GIS at NCIC are as follows:

Major hardware:

- Windows work station :4
- SUN UNIX Workstation: 1
- Large size digitizer: 1
- Large size scanner: 1
- A0 size plotter: 1

Major software:

- ArcInfo, ArcView, MapInfo, ERDAS Imagine, ER Mapper

3.2 Data Collection

Most of maps being used at field offices are analogue maps which cannot be updated easily. And if maps of various scale, coordinate system or accuracy are used, comparing the contents of the maps or overlaying them for detail analysis is impossible or difficult.

NCIC is trying to standardize maps being used for conservation area management. NCIC is also trying to store and manage all the maps of conservation areas at NCIC in order to store and provide high quality map data to users. GIS of NCIC is now being used mainly for this data standardization and storage purpose.

3.3 Data Provision

NCIC can provide map data to field offices, main user of map data, in the following two modes according to the capability of users.

3.3.1 For field offices which already have GIS

NCIC provides base maps or thematic maps in digital formats. Even the field offices which have GIS, only very limited number of them have large size digitizer to digitize A0 or A1 size maps. It is not practical that a field office is equipped with large size digitizer which should be transported to Jakarta for repair or maintenance. It is practical and economical that NCIC undertakes such digitizing work and provide processed data.

3.3.2 For field offices which have not introduced GIS

NCIC will provide map production and data analysis service. In this case map data will be provided in the form of paper maps or raster format data which can be used on ordinary computers.

The similar service can also be used for the preparation of presentation materials to be used in conferences and data to be presented in reports.

4. Future Activity Plan

4.1 Establishment of a method of using GIS for conservation area management

NCIC is trying to establish a method of using GIS for the management of conservation areas in Indonesia. In general, GIS is a useful tool in the following two types of job.

- Preparation of thematic maps
- Map overlay analysis

In the case of conservation area management in Indonesia, samples of above two jobs will be as follows:

(1) Preparation of thematic maps

Mapping of habitats of endangered species or eco-tourism spots will be good examples. Rangers will measure locations by GPS. Both location data and attribute data will be entered into GIS to make new thematic maps.

(2) Map overlaying analysis

Typical example is the preparation of a zoning plan. In many Indonesian national parks, villages exist within the park boundary. And because park boundary is often not clearly defined or marked, land use conflict occurs. In making a zoning plan, a series of discussion with local residents is essential. GIS can make alternative zoning plans reflecting the development of discussions. This cannot be done easily if paper maps are used.

Another example is the preparation of trails plans for eco-tourism. One of the most important factors to be considered in eco-tourism activities is not to disturb habitats of endangered species. If GIS is used, both habitats and eco-tourism trails can be displayed on a single map and, therefore, route plans can be laid out easily.

4.2 Transfer of techniques for the extensive use of GIS

In order to improve the skill of C/P in GIS operation a number of training has already been carried out. Now, most of the C/P of NCIC can teach basic GIS operational skills to rangers and officers of local offices and NCIC started to function as a GIS technical center. Training of C/P of NCIC will be continued so that capability of GIS can be fully exploited.

Picture 1 The exterior appearance of the NCIC

The Study on Coastal/Marine Habitat and Biological Inventories in the Northern part of the Red Sea Coast in the Kingdom of Saudi Arabia

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Abstract

The object of the study is to conduct a basic inventory survey on the coastal and marine habitat in the Northern part of the Red Sea coast in Saudi Arabia in order to supply basic information of the conservation and management of the natural environment and its biological diversity.

1. Introduction

This Study aims to conduct a basic inventory survey of the coastal and marine habitats and bio-data in the northern part of the Red Sea coast, in order to provide basic information and its biological diversity. The results of the Study through socio-economic survey will be utilized to devise a framework for the conservation and sustainable management of this coastal marine environment, which is having an inevitable impact on the marine ecosystems.

This study has been conducted to help the Kingdom of Saudi Arabia to develop the database and construction of the GIS system for marine creature protected areas in the Red Sea.

2. Study Area

The Study area is covering the northern part of the Red Sea coast, encompassing approximately 1,000 kilometers (Fig.1) long, from Jeddah to the Gulf of Aqaba Jordanian border. The Study Area has a width of 1 km from shoreline to land and up to 15m depths in the marine environment.

An Model Area is selected to conduct a detailed biological study in order to understand the ecosystem of the area.

Fig.1 Study Area

3. Study Frame

This Study consists of the following four phases.

Phase I: Gathering existing Data (Dec.1997 - Jan.1998)
Phase II: Inventory Study of the Entire Study Area (May1998 – Nov.1998)
Phase III: Model Area Study (Feb.1999 – Jun. 1999)
Phase IV: Preparation of Biological Inventory maps (Jul.1999 – Jan.2000)

The objectives of Phase I which was conducted from December 1997are to accumulate and review references and existing data, to carry out a reconnaissance field survey in the Study Area and to obtain an overview of the entire Study Area.

The objectives of Phase II are to conduct an inventory survey and a socio-economic survey of the Study Area, categories the habitats, analyze aerial photographs in order to draft a habitat map for the entire Study Area, digitize 1:150,000 chart for the GIS, and input some of the results of the inventory and socio-economic surveys. This Phase considered the preparatory stage for Phases III and IV.

Phase III aims to supply basic information on the conservation and appropriate management of the natural environment of representative area in the Study Area and its biological diversity based on collected information and the results of the analysis in Phase II.

In Phase IV, all data collected during Phase I, II and III are analyzed and this information presented as GIS database and habitant maps of both the entire Study Area and the Model Area.

4. Field Survey

The aerial photo was utilized because the study area is large. Although the aerial photo includes information, such as distribution of vegetation, land use condition, sea bottom condition, and coral reef and algae distribution, the photography area has being restricted to the belt near the coastline. So, by utilizing video photography from airplane and satellite imageries habitant maps was completed. Further information obtained by the ground truth surveys was also added to finalize the maps.

In order to achieve successfully the objectives of the Study, the Study Team is divided into the following three groups, each with its own specific role and objectives.

Marine team: Coral, seagrasses/algae, fish, benthos, marine mammals and marine turtles

Terrestrial team: Mangroves/ terrestrial vegetation and birds

Social Environment team: Dealing with social and economic considerations that either influence, or are influenced by the natural resources of the Study Area

5. Utilizing GIS

User-friendliness is one of the most important factors in computer software. If the software is user-friendly and easily accessible for use by persons with little programming experience, users will gain maximum advantage from GIS.

Commercial GIS software meet a wide variety of GIS need, but you might still need to customize a simple, easy-to-use. In order to obtain the maximum capability for use with GIS, it was necessary to customize the software. For example you can combine a series of steps you can frequently perform and execute them with a single click button (Fig.2).

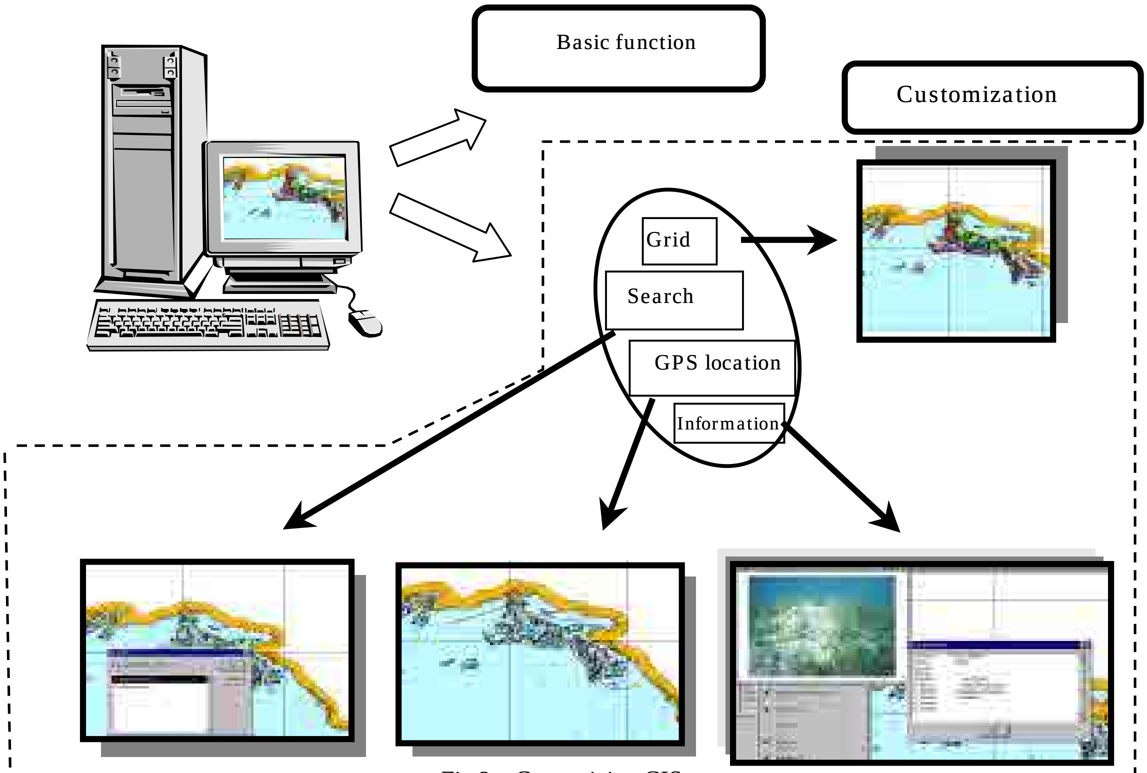

Fig.2 Customizing GIS system

5.1 Customized items

Grid: Icon to overlay mesh on the map.

Search: Icon to search inventory data (using inventory code, classified name, scientific name, observed date and location)

GPS location: Icon to draw a line using GPS data.

Information: Icon to show inventory information

5.2 Counterpart Training

GIS is a tool for processing and displaying digital information. Therefore, a series of GIS counterpart training sessions was conducted to improve counterpart's skill and allow them to make better use of this system.

6. Result of GIS

By collecting, analyzing and managing data on the natural resources of an area, the current status of those natural resources is made understandable. In order to do this smoothly and effectively, the GIS is employed. Data from dozens of sources can be consolidated on GIS overlays and the relationships between various factors such as social environment and biological resources can be examined. It is also possible to monitor changes in those factors over time. This enables us to understand environmental issues affecting the target area. Another advantage of using GIS is that it can present very complex and technical data visually, making it very easy to understand for not only professionals but also non-specialists.

6.1 Habitat maps

The habitat maps made in this study were based mainly on the aerial photographs. Further information obtained by the ground truth surveys was added in order to drown up the habitat maps of the Study Area (1:100,000) and the Model Area (1:50,000).

With this habitat maps, basic information for the environment and biological diversity in the northern part of the Red Sea coast was revealed. This provides a very clear idea of the marine environment of the Study Area (Fig3).

6.2 Summary Map

In order to make preliminary site assessment using the Study results, a series of habitat map data were integrated for conservation of a summary map. On the summery map, areas of special interest in terms of conservation of the natural environment are to be identified. The compilation of appropriate data from the Study into one map is the easiest way for decision makers or protected area planners to gain a visual understanding of the current status of the natural environment (Fig.4).

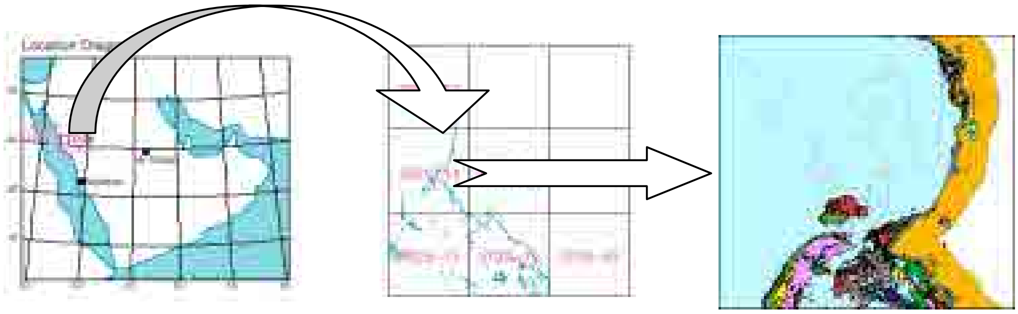

Fig.3 Making Habitat Map

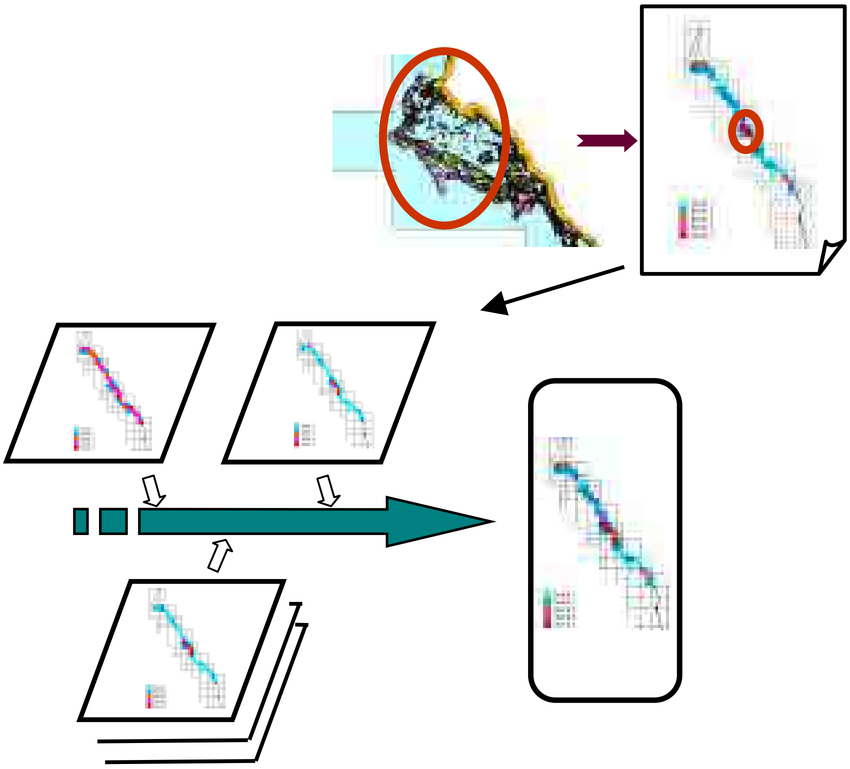

Fig.4　Evaluation using Summary Map

7.　Acknowledgement

This study was implemented by Japan International Cooperation Agency（JICA）.　Also the Study Team would like to express grateful acknowledgement to the Kingdom of Saudi Arabia and National Commission for Wildlife Conservation and Development.

Case Study of GIS Application in the Field of Health Care

- The Malaria -

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Summary

This case study focuses on GIS application to the field of Healthcare. The specific interest here is Malaria and people being at risk. In Africa, Malaria is still a great threat to people's living. The distribution of Malaria can be geographically explained by outbreak potentials attributed to climatic and social-economic conditions. Given the opportunity to use the data from the project, "SWAZILAND: THE STUDY ON DIGITAL MAPPING PROJECT FOR THE SMOOTH IMPLEMENTATION OF THE DEVELOPMENT PLAN IN SWAZILAND" by Surveyor General's Department (SGD) of Swaziland and Japan International Cooperation Agency (JICA), it is demonstrated how the final products can be used and also how they can be of use for GIS analysis in the specific field such as health care issue.

1. Background

The JICA project, "SWAZILAND: THE STUDY ON DIGITAL MAPPING PROJECT FOR THE SMOOTH IMPLEMENTATION OF THE DEVELOPMENT PLAN IN SWAZILAND", which started on June 1999 and finished in 25 months, produced the digital orthophoto maps (1/10,000) of the whole country. To finish the project, SGD and the related agencies were invited to the seminar that demonstrated how the project's product can utilize their tasks and also what kind of GIS functions (calculation, analysis, planning) can be applied to the real needs. This case study was primarily prepared in order to present in that seminar.

2. Purpose

The Malaria preventive action shows its effect considerably in some parts of the world, however in Africa mortality rate due to Malaria is still relatively high (WHO1994: 1-2 million annual death due to Malaria is reported in Africa, 3-5 million are infected). This phenomenon derives from the natural environment of Africa that is favorable to Malaria transmission and also from the lack of implementation the systematic approach of preventive plans. As a result, the cost of preventive plan and medical treatment becomes enormous burden on GDP and individual economy. At the same time economic productivity of the individual is declined due to Malaria infection. (WHO: 0.6% of total GDP of Sub-Saharan countries is spent on Malaria control plan), the average family of 5 spends US$55 annually on Malaria prevention and treatment). In Swaziland, the government stated in the development plan of 1996 that it targeted of declining Malaria transmission rate and death rate by 1997.

Based on this circumstance, timely and precise information of Malaria outbreak, transmission, and infection is desired in order to effectively implement a Malaria control plan. Accordingly, the latest topographic maps, meteorological and environmental information, and social-economic census data are most important.

In this case study, the primal intention was to make the people of the related agencies and organizations of the Swaziland aware of how analytical functions of GIS can utilize their works. In addition, by applying the final product data to the case study, it was hoped that all the attendants of the seminar know those data is available to them and they are the ones who need to maintain and expand those data in the future.

3. Data and analysis flow

In this case study, elevation, road network, river network and population census were used as sample data from the project's final product data. Additionally meteorological data that was obtained through SGD was applied in assessing the factors of Malaria outbreaks.

The data and analysis flow is shown in Fig1. Firstly the areas where Malaria is likely to occur was evaluated by geographical conditions and sited (Fig2: Malaria risk map). Also the distribution of population under the Malaria risk was estimated (Fig3: Below 10 years old population distribution), and final map

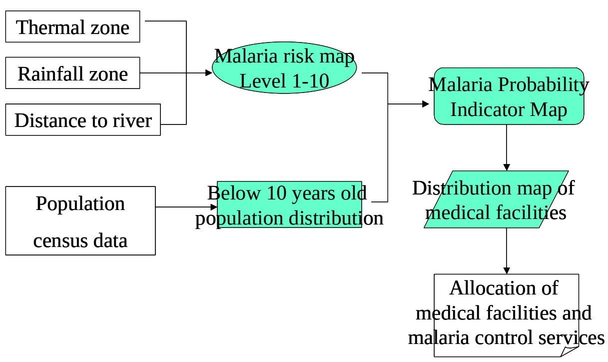

Fig.1 Data and analysis flow

that shows Malaria Probability indicator was created (Fig4: Malaria Probability Indicator Map). By comparing this indicator map and the location of the existing medical facilities, the areas where need to enhance medical facilities and control plans were sited for the future planning (Fig6: Allocation of medical facilities and malaria control services).

4. Thematic map production

4.1 Malaria risk map

This case study focused on temperature, rainfall, and distance to rivers as the factors of Malaria outbreaks. The Malaria outbreak and stable transmission requires the environment with temperature above 22 degree, monthly rainfall above 80mm, and proximity to rivers. Based on this fact, the study area is classified into 10 (1=not suitable for Malaria outbreak…10=suitable) for each factor and zoning maps of each factor were created.

By overlaying those three zoning maps, the factors are integrated and the risk of outbreak is mapped (Fig2). The dark orange part in Fig2 shows the area of high Malaria risk by the evaluation of three factors above.

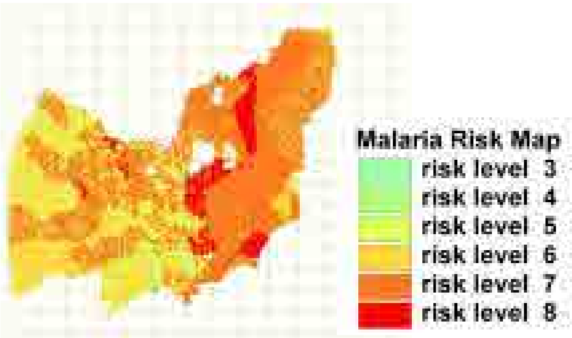

Fig.2 Malaria Risk Map

4.2 Population distribution map (below 10 years old)

Apart from the risk map, the distribution of below-10-years-old population was mapped by the use of population census data (Fig3). The reason I focused on this age group was that mortality rate of infants and children below 10 years old is reported to be higher once they are infected by Malaria. Therefore I believe the medical treatment and preventive controls should be emphasized in those populated areas.

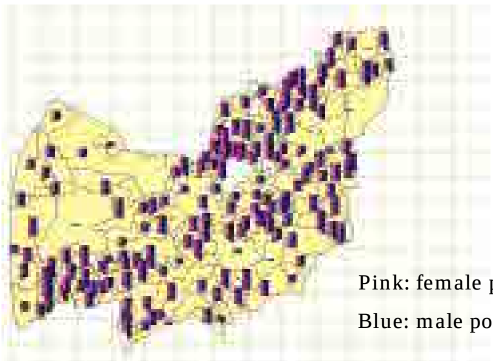

Fig.3 Distribution of blw10 pop

4.3 Malaria Probability Indicator

In assessing the area in urgent need of medical facilities and services to fight against Malaria, the probability of outbreaks based solely on natural conditions is not sufficient but social-economic factors, such as population distribution, should also be included. Because only then, you can site the area where there's high risk of Malaria and at the same time where are populate with people at risk. By the use of ArcView3.2, Malaria risk map (Fig2) and Population distribution map below 10 years old (Fig3) were multiplied and Malaria probability indicator map (Fig4) was created.

Green part in Fig4 shows the area where is at high Malaria risk and populated with age group of below 10 years old. It can be said that those areas should be given priority when implementing Malaria prevention plans and medical services.

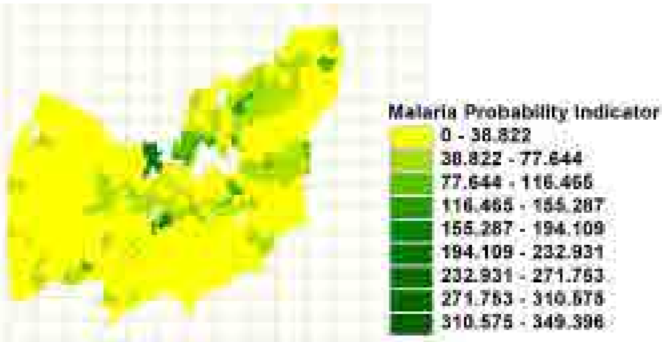

Fig.4 Malaria Probability Indicator

4.4 Medical facility location map

Fig4 illustrated the area of high risk and of populated. In addition, it is necessary to uncover the potential needs and the location of existing medical facilities so that allocation of the new facilities can be done effectively. Therefore I mapped the existing 21 medical facilities and the study area was divided into 21 zones by Euclidean distance according to the distance to the nearest medical facility (Fig.5).

Fig.5 Proximity map to 21 medical facilities

5. Analysis results

Fig.6 shows the value of Malaria indicator for each of the coverage of 21 medical facilities. As the red allows point out, zone 3, 6, 11, and 15 marked high value of Malaria indicator, which can be said that those areas should be given priority on preventive actions and medical services (Fig.7).

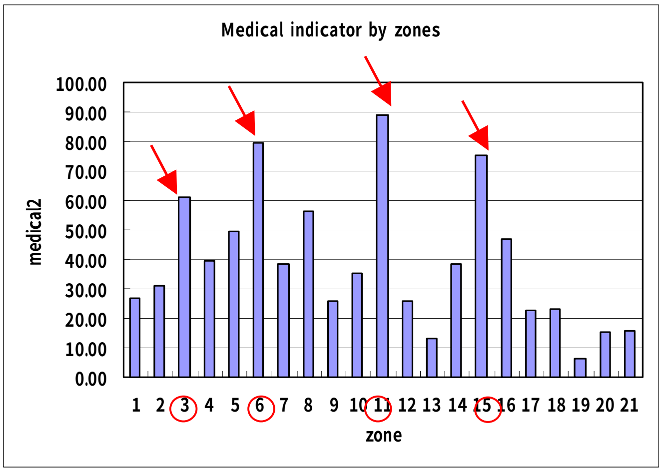

Fig. 6 Medical indicator value by zones

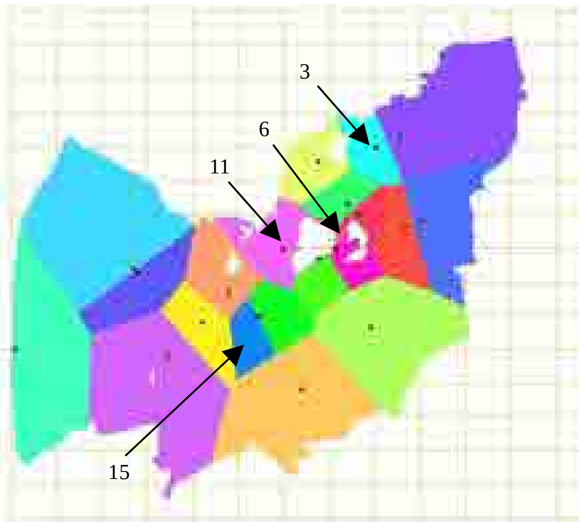

Fig.7 Location of Medical facilities that need priority

6. Conclusion

This is a case study that primarily aims to demonstrate GIS application onto health care field, hence the Malaria outbreak model adopted is very simple (only three factors: temperature, rainfall, proximity to river). In order to improve the model, other natural and social factors should be included and statistical validation should be applied. Also analysis results should be examined and fed back to the model so that it would perform better.

The Swaziland acquired the knowledge and whole country data of GIS and digital mapping through this project with JICA. Hereafter, it is strongly hoped that the people of the Swaziland maintain and expand their data, knowledge, and capacity by their efforts. And I firmly wish this case study and the seminar made the attendants realize the possibility and brought them new ideas for their future.

Planning of the elementary school construction in the Burkina Faso

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Abstract

Supporting the maintenance and management of educational facilities by using map information is the main purpose of this study. House data from 1/50,000 scale national base map, the number of children obtained from the statistic of population for each administrative area, 500m grid mesh data and questionnaire result from each existing school are used for the analysis. According to the result, the school children's location, and then support the planning for class addition and new construction of elementary school were grasped.

1. Introduction

Burkina Faso is a landlocked country located at the southern end of Sahara Desert in West Africa. The agriculture and stock farming of the country has had been seriously influenced by the desertification from north side of the country. Therefore, Burkina Faso government has started the maintenance of the map, which used as the base data for developing agriculture, forest, water and other resources, for the purpose of continuous development and economical growth, which harmonized with environment.

Especially, the southwest part of the country, where development potential is higher than other parts of the county, the technology transfer of digital-mapping (DM) for 1/50,000 scale national base map creation was made by the Japan International Cooperation Agency (JICA), and the map maintenance with Burkina Faso government is under enforcement now.

Under those circumstances, the demand and supply of school children and school facilities is analyzed with created DM data at the southwest part of the country, where population are rapidly increasing.

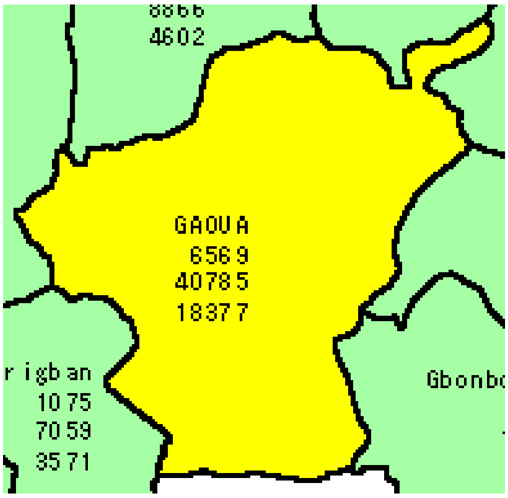

Fig.1: The number of households and population for each area (Upper:the number of house holds, Middle: total population, lower: the number of school children)

In concrete, following themes about school children in the school district are inspected with GIS. Base data for the inspection are house symbols displayed on the map and number of school children in each area from the report of population-statistics office.

-- Whether number of elementary schools are enough or not

-- Which existing school shall be select, in case class has to be added.

2. Data for analyzing

(1) Population data grouping by age and area

(2) Positional information of school facilities (GPS data)

(3) 500m grid mesh data which including the Area

(4) 1/50,000 scale national base DM data (Distribution of House)

(5) Questionnaire data for every school

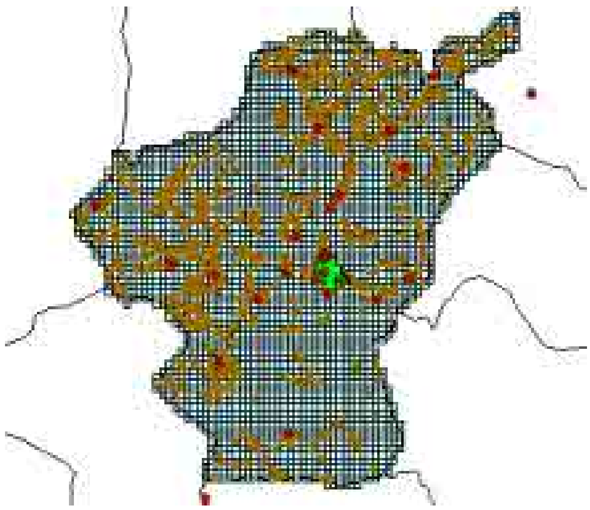

Fig.2: 500m grid mesh, house (brown) and existing school (red)

3. Work method

3.1 Simplified conditions and assumption

(1) All school facilities have no differences in quality and scale.

(2) Every school child is attending to the nearest school.

(3) Every school child are supposed to live in the center of each 500m mesh, so the distance to each school are calculated from the center of each mesh. Moreover, the distance from house to school facilities is measured as simple straight line, and road network is not taken into consideration.

3.2 Work method details

(1) Determination of school district from the existing school location. (Fig. 3)

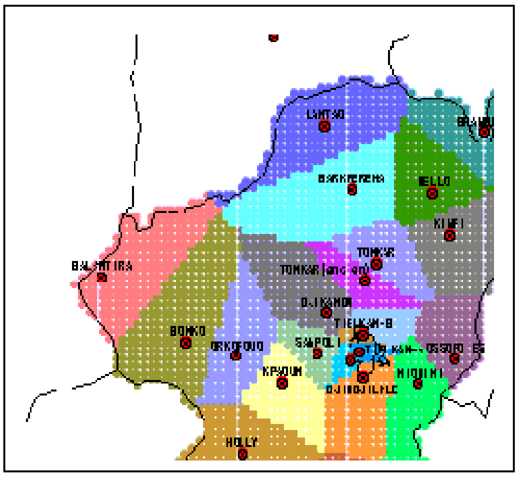

Figure3.　Location of existing schools

(2) Measuring of distance between each school children's residential area and nearest school.

Each mesh is colored in gradation according to the distance to each existing school, and house symbols are displayed over the mesh. Consequently, children who live in the long distance from every school are figured. As a result, each school location　shall be estimated basis on the distance

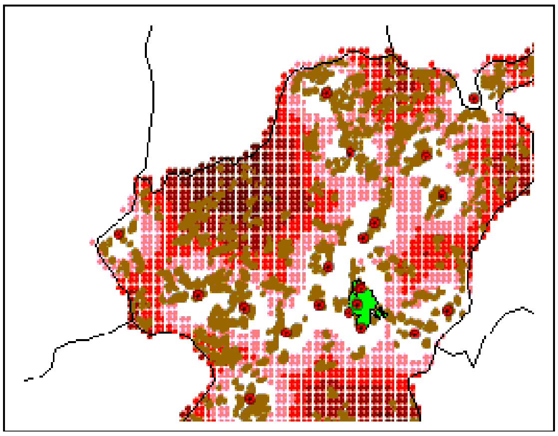

Fig. 4: Distance to each school　(deeper red is further)

(3) Estimation of new school location and schools, which has to add classes.

Number of children who are out of accommodation has shown on a chart, by using the questionnaire data such as the number of accommodation children and classes for each existing school. From this result, whether built a new school or add classes have been examined.

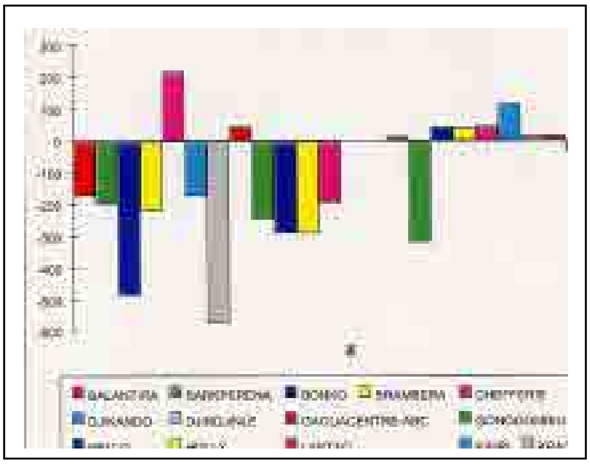

Figure 5. Gap between questionnaire result and number of children at each existing school.

(Minus value: Number of children who are out of

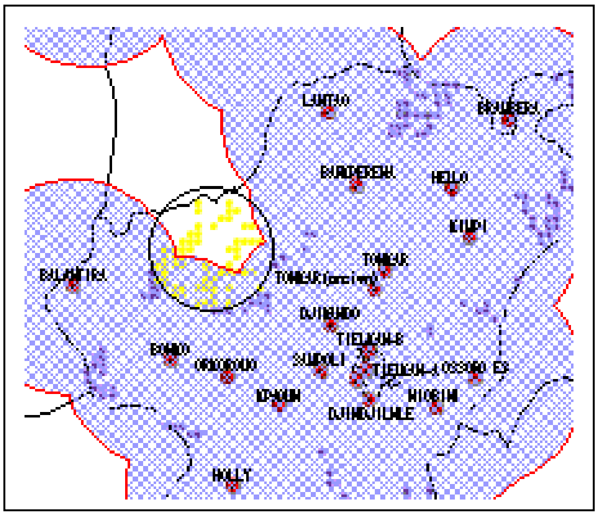

Fig. 6　Location of houses ,which are far from any school

(4) Search houses, which are not covered within 4km circle from each existing school.

Number of children whose home are out of the circle are calculated, and the new facilities adapted to the number of children are planned (Fig. 6).

4. Conclusion

New school construction and adding classes were inspected by using 1/50,000 scale topographic map and GIS function. For the habit of topographic map, houses in city area are generalized in mapped features. And, distribution of houses can roughly be grasped, though house symbol is not drawn one by one.

Therefore, it is considered as proper procedure to replace populous distribution with mesh data, to grasp the tendency and manage as GIS data.

On this project, distance between house and school was calculated with straight line from the center of each mesh to the

nearest school facility. In case of school route is fixed, producing new map with the distance will make evaluation more accurate.

Moreover, the land use potential analysis can be carried out by road, house and contour data, which are extracted from 1:50,000 topographic map data, together with land slope data and soil map data. The result allows evaluating appropriately the agricultural development, forest prevention and relationship between regional village and agriculture. Therefore, demand of GIS basic data is considered to be higher in the future.

The Study on Digital Mapping Project of the Smooth Implementation for the Development Plan in the Kingdom of Swaziland
- GIS for Cadastral Database Management -

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Summary

Swaziland consists of four regions, namely Hhohho, Lubombo, Manzini, and Shiselweni, and ten urban areas are distributed across them. The cadastre of Swaziland was provided separately for the said four regions and ten urban areas. The boundaries for the cadastre were line data that were created using an old-version GIS (Geographic Information System), called UNIGIS, and its cadastral attributes were managed by dBASE. The graphic and attribute data were updated using the individual software, resulting in a poor integrity between both types of data. Therefore, this Study was undertaken to convert the existing cadastral database into a format that ensures an easy management and operation on the GIS. The converted cadastral database should be analyzed together with the topographic and social information, and be widely used in the various fields of development plans, disaster prevention, and medical care.

1. Outline of the Study

1.1 Background and Objectives

Instead of the line maps (topographic maps), the orthographic photo maps (orthophoto maps) were used widely in Swaziland. However, the orthophotos possessed by the SGD (Surveyor General's Department) were produced in the 1970's, offering old data and they could not be used effectively for planning. The data on the cadastre for the whole territory of Swaziland (graphic and attribute data) were managed through computer at the SGD, but many errors were caused and the graphic information could not be linked thus with the attribute information.

Under these circumstances, it was imperative to introduce the GIS based on the latest digital orthophoto maps. In June 1997, the Government of Swaziland made a request to the Government of Japan for a technical cooperation to produce 1/10,000-scale digital orthophoto maps for the national topographic maps and development of the GIS. The Study Team was entrusted with the "Study on Digital Mapping Project for the Smooth Implementation of the Development Plan in the Kingdom of Swaziland".

1.2 Study Area

The Study area covers the entire land of Swaziland located at long. 31° to 32° E and lat. 26° to 27° S, (with an area of 17,363 km^2; equivalent approximately to the area of Shikoku, Japan). Fig. 1 shows the study area.

1.3 Study Implementing Agency

The agencies that implemented this Study are as follows:
For the Japanese side: Kokusai Kogyo Co., Ltd.
For the Swaziland side: SGD (Surveyor General's Department), Ministry of Natural Resources and Energy
(SGD：Surveyor General's Department)

1.4 Period of the Study

From June 1999 to July 2001 (two years and two months)

Fig. 1 Map of the Study Area
(Original map: From the website of the Ministry of Foreign Affairs)

2. Hardware and Software

The hardware and software as described below were introduced to manage and operate the existing cadastral database possessed by SGD on the GIS and to build the cadastral database for the GIS.

2.1 Hardware

(1) Computer: 2 units
・CPU: Intel Xeon
・Memory: 1GB
・HDD: 40GB
・CD-ROM, CD-RW
(2) 21-inch monitor: 2 units
(3) A0-size plotter: 1 unit
(4) Power supply stabilizer: 1 unit

2.2 Software

(1) ArcView GIS 3.2: 2 sets
(2) ArcView Spatial Analyst: 2 sets
(3) ArcView 3D Analyst: 2 sets

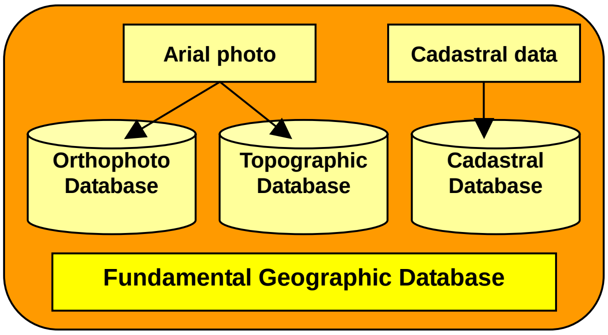
(4) ArcView Network Analyst: 2 sets
(5) MrSID Worksation: 1 set

3. Building of Database

To operate the orthophoto and line map data that were developed in this Study and the SGD's own existing cadastral data on the GIS, the following three types of database were built using ArcView GIS 3.2 and MrSID Workstation:

(1) Digital orthophoto database
(2) Digital line-map (topographic map) database
(3) Cadastral database

ArcView GIS 3.2



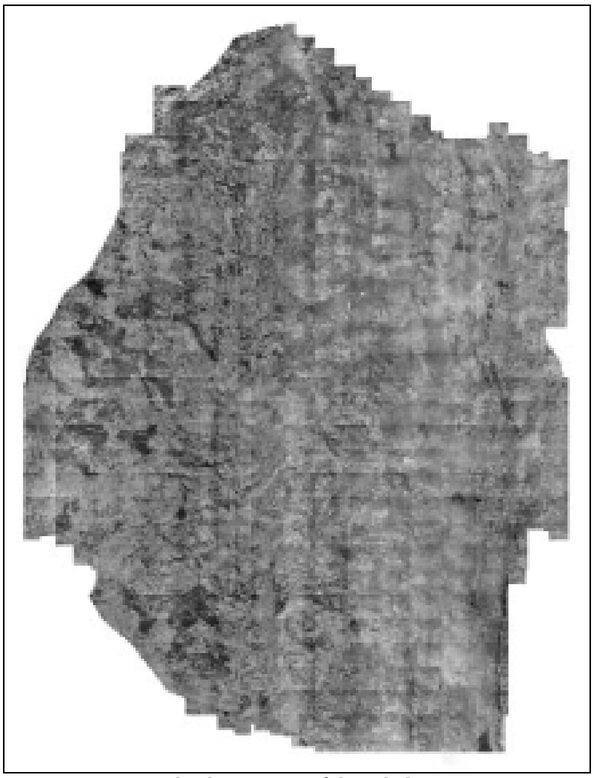


Fig. 2 Orthophoto Image of the Whole Territory

3.1 Building of Orthophoto

In Swaziland, orthophoto maps were widely used for a long time instead of line maps (topographic maps). In this Study, an aerial photography was undertaken and negative films were scanned to obtain the orthophoto data for the whole territory of Swaziland. Orthophoto maps with a scale of 1/10,000 were produced based on the orthophoto data. However, the data size of these maps was excessive (8 km x 6 km per map sheet, approx. 300MB) and could not be processed using the ArcView GIS. The orthophoto images were thus compressed using an image compression software, namely the MrSID Workstation, to allow an easy operation on the ArcView GIS.

Theoretically MrSID is capable to compress the original images without any restriction. The orthophoto data of approx. 300 MB per map sheet were compressed to one-fortieth, that is approx. 8 MB, for this Study. Fig. 2 shows the MrSID-compressed orthophoto image of the whole territory of Swaziland. (The original image of the entire land was equivalent to 100 GB or more.)

3.2 Building of Topographic Map (Line Map) Database

As mentioned previously, orthophoto maps, but not line maps, were used widely in Swaziland. However, this Study includes data, such as contours, roads, rivers, lakes, swamps, woodlands, and geographic names, which were produced as information to be represented on orthophoto maps and converted into the format for the ArcView GIS. It became thus possible to output and display the DTM, slopes, and the slope directions from the contour data, and the road networks from the road data. Fig. 3 shows a DTM obtained from the contour data, while Fig. 4 illustrates a road network using the road data.

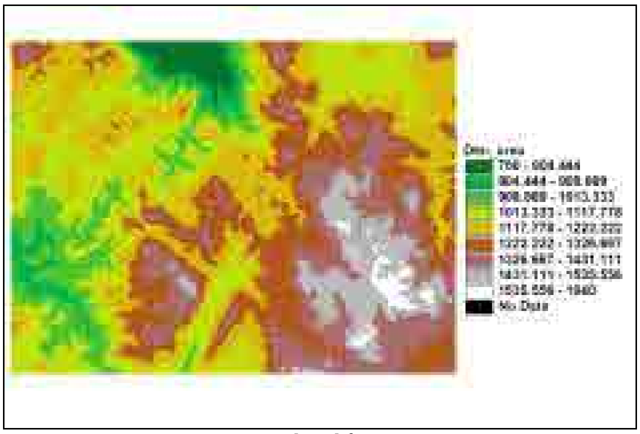


Fig. 3 DTM Image Produced from Contour Data

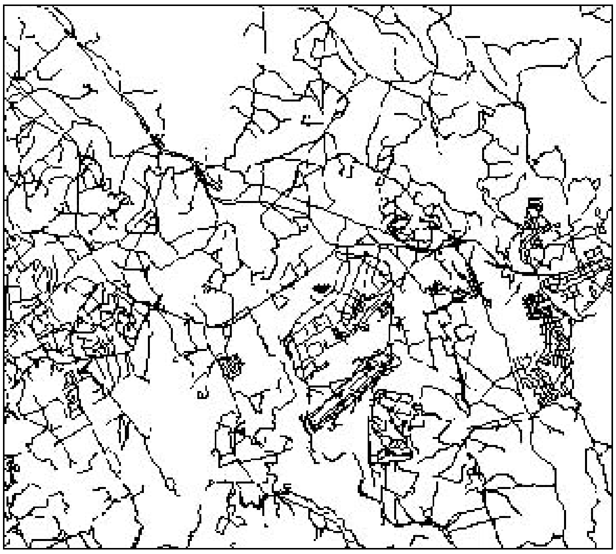


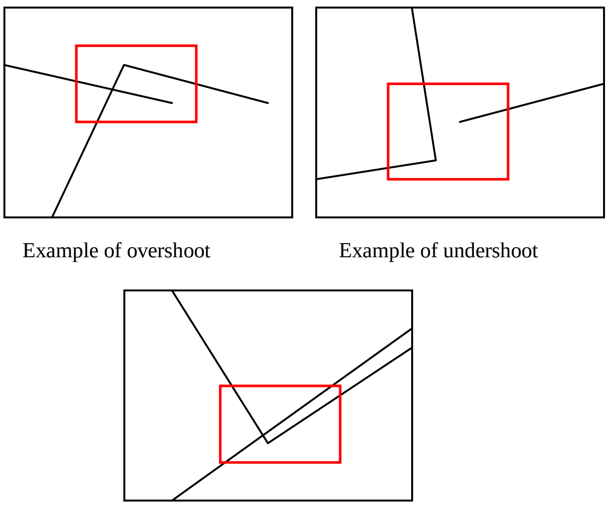
Fig. 4 Road Network Data Configured using Road Data

3.3 Building of Cadastral

The cadastral database under SGD’s control was provided to build the cadastral boundaries as line data and to manage the cadastral attribute data by dBASE, as mentioned previously. The cadastral database was reconfigured to constitute the database to be handled on the GIS, ensuring thus its efficient maintenance. In addition, the transfer of the GIS technology allowed the SGD's staff to update and manage the data in the future. The flow for handling the SGD’s existing cadastral database on the GIS is described as follows.

3.3.1 Correction of cadastral data errors

In order to process the existing cadastral data on the GIS, the cadastral boundary data configured as line data were converted into polygon data. To this end, the lines configuring each cadastral area were formed as a firmly enclosed figure. However, three types of errors (overshoot, undershoot, and line overlap) appeared in most cases during the practice. These errors were corrected with the cooperation of SGD to build the cadastral GIS database.(Fig.5)



Example of overshoot

Example of undershoot

Example of line overlap

Fig. 5 Types of Errors

3.3.2 Cadastral data structuralization

Following the correction of cadastral boundaries as indicated in 3.3.1 above, all the cadastral data were structuralized to ensure their operation on the GIS.

For each cadastral area, the Percel Identity (PID) was provided and attached to each polygon in the data structuralization. By clicking each polygon on the GIS, its PID, area, and circumference could be recognized. Fig. 6 shows an example of polygon data.

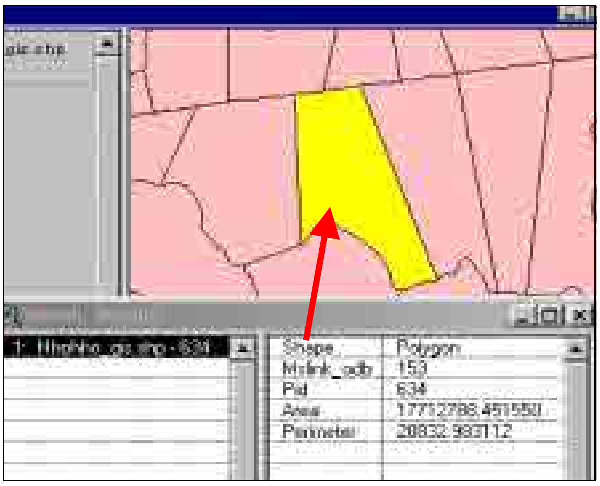


Fig. 6 Example of Cadastral Polygon Data

3.3.3 Building of the national cadastral GIS database

The cadastral attribute data consist of 22 items of information including the PID. The structuralized cadastral data as described in 3.3.2 above are also provided with their PID.

This PID was used as a key code to process the combination of the cadastral data with the cadastral attribute data when building the cadastral GIS database for the whole territory of Swaziland. This cadastral database could be easily edited on the GIS (for addition, correction, and deletion of information). Fig. 7 shows the national cadastral GIS database that has been built.

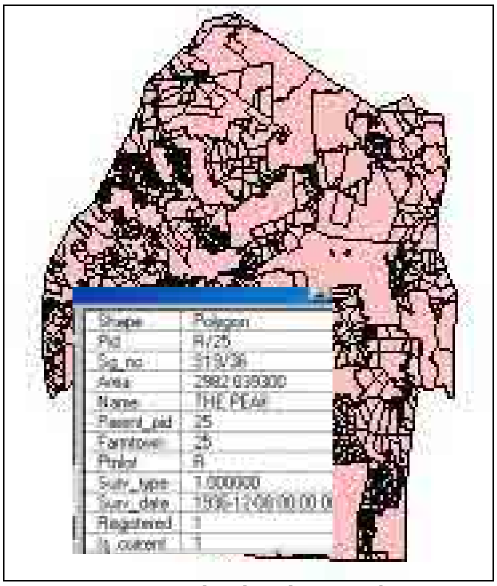


Fig. 7 National Cadastral GIS Database

4. Examples of Cadastral Database Applications

In this Study, (1) the National digital orthophoto database, (2) the National topographic map (line map) database, and (3) the National cadastral GIS database were built to be operated on the GIS. Some applications of these databases are described below.

4.1 Three-dimensional Imaging of Information

(1) Digital orthophoto data, (2) DTM data created from contour data, (3) Road data, (4) River data produced from topographic map data, and (5) cadastral database were represented as three-dimensional images, ensuring the visual monitoring of the distribution of cadastral areas and the topographic conditions.(Fig. 8)

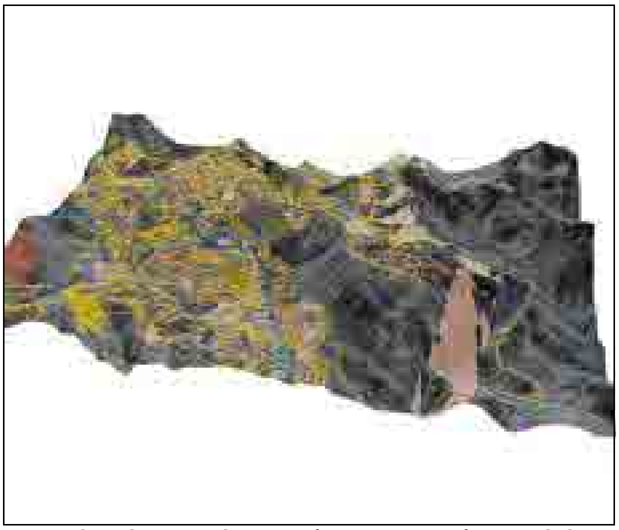


Fig. 8 Three-dimensional Images of Various Types of Data with the GIS

4.2 Flood Disaster

Frequent flood disasters occur in Swaziland due to concentrated heavy rains in the adjacent country. An attempt to extract a cadastral area damaged by floods was undertaken using (1) the Digital orthophoto data, (2) the DTM data obtained from the contour data, (3) the slope data obtained from the DTMs, (4) the River data obtained from the topographic map data, and (5) the Cadastral database.

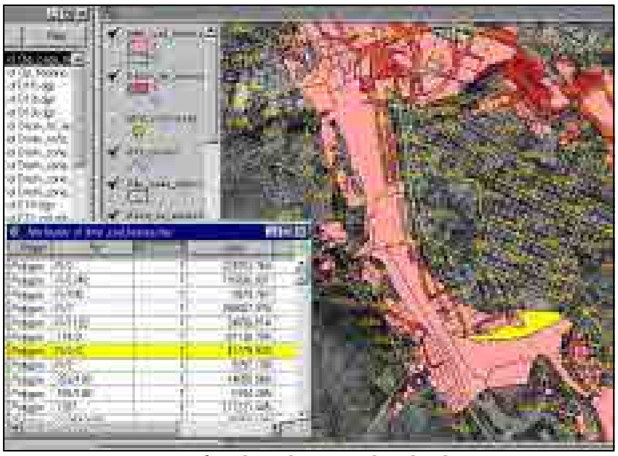


Fig. 9 Image of Cadastral Area under Flood Disaster

From this image, the cadastral area where the flood disaster takes place can be monitored. Since each cadastral area is linked with several cadastral data on the GIS, the owner of the cadastral area and the damaged area value could also be monitored at a glance.

4.3 Agricultural Development

For the agricultural development, it is important to understand the types of candidate lands. In Swaziland, there are the lands of the Kingdom, the lands of governmental agencies, and those privately owned. An example of display of suitable lands for the agricultural development is shown in Fig. 10. An adequate agricultural land can be selected from various types of database on the GIS, on which the cadastral database is overlaid to monitor the type of cadastral features of the candidate land.

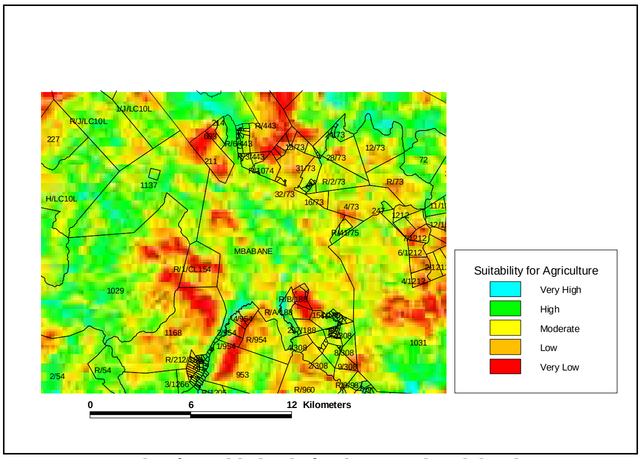


Fig. 10 Example of suitable lands for the agricultural development

5. Conclusion

The orthophoto, topographic map, and cadastral databases of the whole territory of Swaziland were built so that all of them could be used on the GIS. Further, the technology transfer seminar on the GIS was held for the counterpart in this Study, SGD, and other related agencies at the final stage of this Study, to ensure a better understanding of the GIS by the Swaziland side.

It would be preferable in the future that these databases be used widely and effectively for planning various development plans (in the agricultural, sylvicultural, environmental, urban planning, disaster prevention, medical, and educational fields), contributing thus to the development of Swaziland.

Finally, we would like to express our sincere appreciation for the enthusiastic cooperation and support given to us by the Government of Swaziland, its related agencies, Japan International Cooperation Agency, the Ministry of Foreign Affairs, the Ministry of Construction, Japanese Embassy in South Africa, and the JICA Office in South Africa.

Standardization of Geographic Information

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Abstract

The geographic data has been utilized worldwide with the advance of GIS technology now. In order to prepare interoperable datasets, geographic information is started to standardize in the technical committee 211 (TC211) of the International Organization for Standard (ISO). Therefore each country starts to make the profile of the Standards. In this chapter, basic concept and present condition of Standardization are discussed.

1. Necessity of the Standard

The most important problem to build GIS is prepared geographic dataset to be operated in GIS. The cost to acquire geographic dataset is estimated at 60 or 80 percents. A problem to be solved is to acquire low-cost and high-quality geographic data, however a cost to acquire geographic dataset is high. If dataset acquired once is used many times, the cost per an usage becomes relatively cheaper. Therefore, interoperable geographic dataset with common format is desired to prepare. The table 1 represents some formats of geographic dataset that were prepared by the recent developing studies in Japan International Cooperation Agency (JICA). Various kinds of format are used in GIS of many countries. The format of geographic dataset depends on the GIS applied in the system. We understand that datasets with the same format is needed, because many sets of GIS are already introduced in many countries.

Table 1 List of format to be prepared in the project of JICA

Nation	Format used	GIS applied
Angola	Coverage	ArcInfo, ArcView
Mali	DGN	Micro Station
Mozambique	DGN	Micro Station
Burkina Faso	DGN	Micro Station
Laos	Coverage	ArcInfo, ArcView
El Salvador	Coverage、SHP	ArcInfo, ArcView
Swaziland	DGN	Micro Station
Madagascar	DGN	Micro Station
Azerbaidian	DXF	ArcInfo, ArcView
East Timor	SHP	ArcView
Guatemala	RVC	TNTmips
Gambia	SHP	ArcView
Kazakhstan	TAB	MapInfo
Senegal	GCM、SHP、MIF	GeoConcept
Cambodia	Coverage	ArcInfo, ArcView

Of course, dataset acquired by each system is able to be converted to text files such as DXF by the system and is able to be imported by another system. But, the final datasets on CD-ROM represented by Table 1 may not be read directly and applied by user's GIS. It has to be confirmed in brochures of each GIS that these datasets can be imported in the GIS.

2. The trend of Standardization

In order to acquire interoperable geographic dataset, each country has planned to prepare the common format. The Digital Mapping Format (DM-format) was prepared in Japan for the purpose of making the common format. The SDTS in the United States of America, and the GDF in the United Kingdom were also prepared by the same reason. The SDTS was adopted in Australia, New Zealand and Republic of Korea at a later time. With advancing to apply GIS worldwide, it is difficult to analyze various data with these common formats developed by each country. And the standardization of geographic information to manage interoperable data has come to be required, in order to apply the distributed data management system, which system manages operations to query, relate to, classify, analyze and represent by using dataset stored in different systems separately, instead of using own dataset.

The discussion to make the standard for interoperable data, has started by government, academic and industrial experts in the Technical Committee of ISO.

3. ISO/TC211 Technical Committee: Geographic Information/Geomatics

The technical committee to examine the standardization of geographic information was established in 1994. Now, the Drafts of International Standard is examined by experts of 54 countries represented in Table 2.

The International Standard classified 20 work items, is discussed in 5 working groups. The work items increased 5 items or more later. After discussion and ballot by member's countries, these are coming to be enforced as the International Standard. The summery of work items are expressed as follow.

When we want to use existing geographic dataset to build GIS, we have to judge whether each dataset is usable or not. And we also want to know whether required geographic features are included in the dataset. We can confirm them in the Feature Catalogue (discussed in WI:10 Feature cataloguing methodology) which type of geographic features are included. The dataset should be composed of both data and Metadata (See Table 1). Information of Date of production (WI:8 Temporal schema), location of geographic features (WI:7 Spatial schema), quality of products (WI:13 Quality principles and WI:14 Quality Evaluation Procedures) and data structure of geographic features (WI:9 Rules for application schema) are included in Metadata(WI:15 Metadata).

In addition above information, the definition of location (WI:11 Spatial referencing by coordinates and WI:12 Spatial referencing by geographic identifiers), concepts and elements using in this standard (WI:1 Reference Model), language for definition of concepts(WI:3 Conceptual schema language) and definition of interface to another system which include definition of position exchange (WI:16 Positioning Services), procedures to describe maps (WI:17 Portrayal), Coding for data exchange (WI:18 Encoding) and other services (WI:19 Services).

And terminology for standardization (WI:4 Terminology), procedures and examination to conform to the Standard (WI:5 Conformance and Testing) and overview of overall standard items (WI:2 Overview). Description relating to exchange specifications between many countries (WI:20 Functional standards) and reference to International Standard to make the domestic Standard newly are also discussed in this committee.

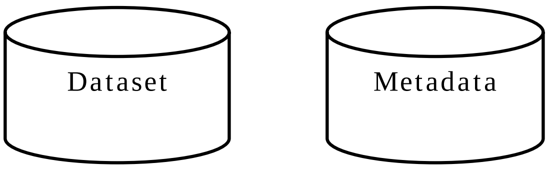

Fig. 1 Configuration of geographic data

We can understand these details of standard items, in order to exchange geographic dataset. The details of 409 items are defined in the Draft of Metadata, International Standard, and these are classified into Mandatory, Option and Conditional.

The international standard prepared in the ISO/TC211 is not unique specifications, that is the rules to make standard in each country and organization. If dataset is acquired based on the profile of the International standard, this dataset is interoperable.

4. Acquisition of geographic dataset up to the Standard

If the interoperable geographic dataset is acquired, the specifications to make interoperable dataset should be specified and the metadata specified details of the dataset should be prepared. During preparation of the geographic dataset, we have to pay attention following issues at least.

1) To use correct terminology.
2) To acquire dataset and a metadata which represent the summery of dataset.
3) To define surveying elements clearly.

Table 2 Examples of Surveying elements

Elements	Examples
Reference ellipsoid	Clarke1880
Plane origin	The origin of Adindan
Vertical origin	The origin of Dakar
Map projection	Universal Transverse Mercator
Size of map	15′ X 15′

Table 3 Sample of Metadata (part)

Items in metadata		Example	Condition
General information	Title	The national topographic mapping in Kita Area.	Mandatory
	Date of preparation	31.10.2001	Mandatory
	Country	Republic of Mali	Mandatory
	Language	French	Option
	Summary of project	1/50,000national base map	Mandatory
	Area of project	N12 ° ～14 ° 、 W9 ° ～11 °	Mandatory
	Contact point	Geographic Institute in Mali	Option
Lineage	Source of data	Photogrammetry using space images	Option
Information for data	Purpose	General map	Mandatory
	Scale	1/50,000	Mandatory
	Data items	Application rule for map symbols in Mali *1	Mandatory
	Data structure	Application rule for map symbols in Mali. *2	Mandatory
	Quality	Surveying specifications of 1/50,000 map in Mali. *3	Mandatory
	Encoding	Micro/Station DGN file	Mandatory
Specific information	Survey elements	Separate sheet (ref. Table 4)	Mandatory
	Additional inform.	Separated in sheet *4	Option
Distribution	Distributor	Open to the public Geographic Institute in Mali	Mandatory

*1 Geographic feature catalogue has not been prepared.

*2 Application schemata have not been prepared.

*3 The procedure for quality evaluation has not been prepared.

*4 Rules for numbering system of map have not been represented here.

Recent Trend of Web-Based GIS and Case Examples

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Abstract

GIS is initially recognized as important because of its capability to integrate, analyze and visualize geographic information on different themes. Recently, especially in some western countries such as United States , geographic database become rich in types and volume, and more accessible, because these geographic information systems become interconnected with Internet. This unique combination of GIS and Internet will bring us a whole new vision for sharing of data, knowledge, and cooperation of people.

1. Characteristics of GIS and Internet

GIS was initially recognized as an important technology mainly because of its capability to integrate, analyze and visualize various geographic data. In order to serve various purposes such as planning e.g. urban planning, natural resource management, etc., various geographic databases have been developed and used in GIS. Whereas development of the geographic database has been advanced, the Internet becomes more and more accessible and different kinds of GIS have become connected with each other through the Internet. Consequently a new capability of multiple GIS has come to the fore. A unique basic function of GIS, i.e. being able to integrate different types of data, has been interconnected by networks, and as a result, people who previously worked in different fields and different organizations are beginning to communicate with each other on the Internet. This trend is further accelerated by the increase of communication speed of the Internet, improvement of protocol, wider availability of metadata service and dispersed functions of software. Now, GIS is expected to play a further important role in our social life.

In an economical sense, networking of GIS has a dramatic impact. In order to carry out their duties, the central and local governments produced various maps, which were intended to be used only in their respective sections. This occasionally resulted in producing redundant data. Offering geographic data in digital form via Internet connecting different sites plays a significant role in avoiding redundancies.

2. Case Examples of the United States

San Diego County in California has an area of approximately 4,200 square miles with population about 2.5 million. There are 18 cities including San Diego City, which is the sixth largest city in the United States. The County has been witnessing phenomena that surpass administrative units such as expansion of urban function, development of infrastructure and migration of daytime population. Under these circumstances, data production, data application and system development can be more economically carried out by cooperation of the local governments concerned, rather than by respective bodies. Therefore, they agreed on teaming up in a partnership, forming an association and carrying out common tasks such as GIS construction, regional planning, etc. SanGIS and SANDAG (San Diego Association of Governments) are some of these examples.

SanGIS and SANDAG

San Diego County has, so far, developed more than 200 layers of geographic data and been offering various services. Some of these data are available to the people via Internet. SanGIS and SANDAG are two of these sites and their URLs are:
http://www.sangis.org/index.html
http://www.sandag.cog.ca.us/data_services/gis/, respectively.

The services include data provision with or without charge and interactive mapping. For example, in the case of REDI (Regional Development Information System), which was developed to support regional development, data such as railroad, traffic network and traffic volume can be overlaid on the land use, land ownership information or aerial photographs. Conditional retrieval can be also performed. Services that are available in the Web are, in addition to mapping of demographic and economic statistics, Community Services that provide information about police stations, fire departments, schools, local service centers and parks, Disaster Hazard Map that shows inundated districts and geological characteristics, Natural Feature Map that shows vegetation and Utility Map that covers all of the social infrastructure such as water purification plants, water supply and sewerage systems, drainages and roads.

Other sites of San Diego County are ARJIS (http://www.arjis.org/mapping/help/disclaimer.html), which offers the information about crimes and (http://www.bandwidthbay.org/main.htm), which offers the information about the status of optical fiber laying.

These examples show that GIS has been firmly rooted as an information infrastructure in a local society and closely connected with daily life of people.

Besides San Diego County, many other local governments also have Web-based GIS service sites such as http://www.ci.portland.or.us/maps.htm of Portland City in Oregon and http://204.182.239.30/honolulu/ of Honolulu City in Hawaii. Anyone can freely access these sites from any place in the world, retrieve what one wishes from wide rage of geographic data including land use planning, land ownership, disasters, crimes, water supply and sewerage systems, parks, and so on, and produce a map in an interactive manner. As seen in these cases, GIS database that was initially created by local governments to carry out their administrative work including regional development, facility management, preservation of nature is open to the people. Now people can use it in such a way that they can manipulate the geographic data in the GIS database and produce maps in an interactive manner. The maps that people obtain are not those of the static images that have been prepared beforehand and stored in the database.

Figure 1 REDI, the local information system of SANDAG

Figure 2 Community Services of SanGIS

Figure 3 Utility of SanGIS

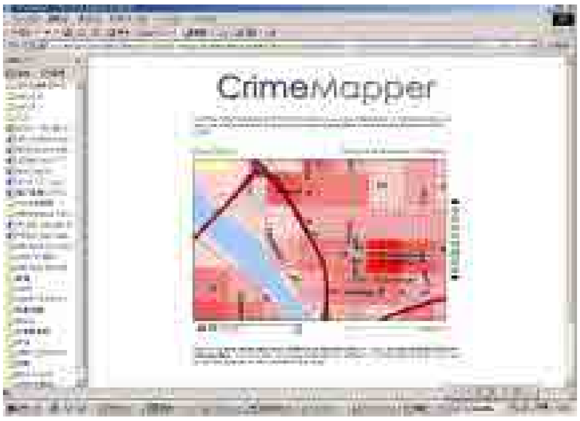

Figure 4 Crime Mapper of City of Portland

3. iPasCAL (Integrated GIS Web System for Supporting Public Administration)

Integrated GIS is an application that was developed with a view that the system should extensively cover map related fields in public administration such as property tax, water supply and sewage systems, roads, urban planning and so on, and the information that has been accumulated in each section should be shared by the entire organization. Its segments, which were designed on the basis of a unified concept, include users and data management, sharing system, and a system that supports individual office work. PasCAL is one of the examples. iPasCAL is a system which accommodates an integrated GIS that allows users to access and retrieve data centrally managed by the public administration supporting package system (PasCAL) by Web browsers in an environment connected with LAN.

The geographic data that iPasCAL deals with has been already stored in the organization, and the users access it via Web server and Map server. Therefore, iPasCAL doesn't need to have its own database. It is not wedded to particular clients' OS and accessible from PCs with small capacity or even from mobile PCs. By designating the data as open or closed, not only the staff of the organization but general public can have access to the data. In this way, the system can be used as a mean of opening of information to the public.

3.1 Outline of System Functions

(1) Screen Controlling Functions

- Addition and deletion of layers, setting of mapping scales, and displaying of legends
- Screen control (Magnification/Reduction), shifting, and displaying the whole area

(2) Editing Functions

- Drawing of a figure (broken lines, polygons, circles and characters) selected by a user
- Editing of a figure (copy, shift and deletion)

(3) Measurement

- Distance measurements and area measurements

(4) Retrieval

Retrieval of positions, figures and attributes

3.2 System Operation Environment

Following table shows operation environment of the system.

WWW Server

OS	Microsoft Windows NT 4.0 (Server/Workstation)
WWW server application	Microsoft Internet Information Server (NT Server)
	Microsoft Personal Web Server (NT Workstation)
Map cut out software	ESRI MO/IMS2.0

MAP Server

OS	Microsoft windows NT 4.0 (Server/Workstation)
GIS Engine	ESRI MapObjects2.0a
Map Management Software	Pasco PMMO.DLL

Data Base server

OS	Microsoft Windows NT 4.0 (Server/Workstation)
RDBMS	Microsoft SQL Server 7.0 SP1

3.3 Screen Image

The following figures show Screen images.(Fig.5,6)

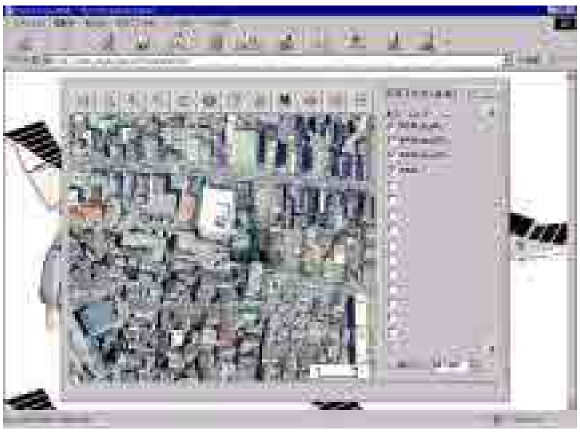

Fig. 5 Overlaying of an aerial photo and topographic map

Figure 6 Overlaying of land use map and topographic map

4. "River Information System" of the Ministry of Land, Infrastructure and Transport

This site (http://www.river.go.jp/) was created by the River Bureau of the Ministry of Land, Infrastructure and Transport. Objectives of the site are to minimize flood-related damages and to prevent drowning by providing real-time information about precipitation and water levels of Class A Rivers (109 rivers) across Japan on the Internet. Pasco Corporation took part in the site construction and was in charge of developing a program for producing map images used in GIS, provision of map data (Pasco Digital Map 25000) and designing of maps.

4.1 Outline of System Functions

The information provided on this site is as follows. The data offered to the people are classified into two categories, i.e. those that are "displayed overlaid on a map" and those that are "retrieved from a map and displayed on a new window."

(1) Those that are displayed overlaid on a map

- Radar precipitation (most up-to-date)
- Radar precipitation (record)

(2) Those that are displayed on a new window

- Information on water level
- Information on precipitation
- Information on water quality
- Information on snowfall
- Levee protection warning
- Flood prediction
- Notice of dam discharge

Four kinds of scales (whole Japan, 1:5,000,000, 1:1,000,000, and 1:300,000) are available to the users for displaying a map on a screen. First, a user selects the area from the initial screen of whole Japan. Then, a user selects the information that he/she wants to see. "MapObjects/Internet Map Server (MO/IMS)" of ESRI of the United States controls the displaying of maps and processes overlaying of various information.

4.2 System Composition

The followings are hardware compositions of operation system. As this site is "offering information on disaster prevention," a large number of simultaneous accesses were anticipated at the time of, for instance, typhoons. In order to cope with such a problem, server machines were multiplexed to enhance their processing capability.

(1) Load Balancer (Load Dispersing System)
This system is able to automatically allocate the processing load to an appropriate WWW server in response to the volume of requests from the Internet.

(2) WWW Server
This is a substantial gate to a WWW site. Unix machine (Solaris7) is used for this system.

(3) Map Server
This is a system to produce a map image in response to a request from WWW server.
A program developed by MO/IMS, Web-based GIS software of ESRI, runs here.

(4) DB (Data Base) Server
This is a file server to store all the data used in the system including map data, water level data and precipitation data.

(5) Image Producing Server
This is a server that receives the “on-line observation data” such as precipitation and water levels, and produces precipitation grids and water level graphs.

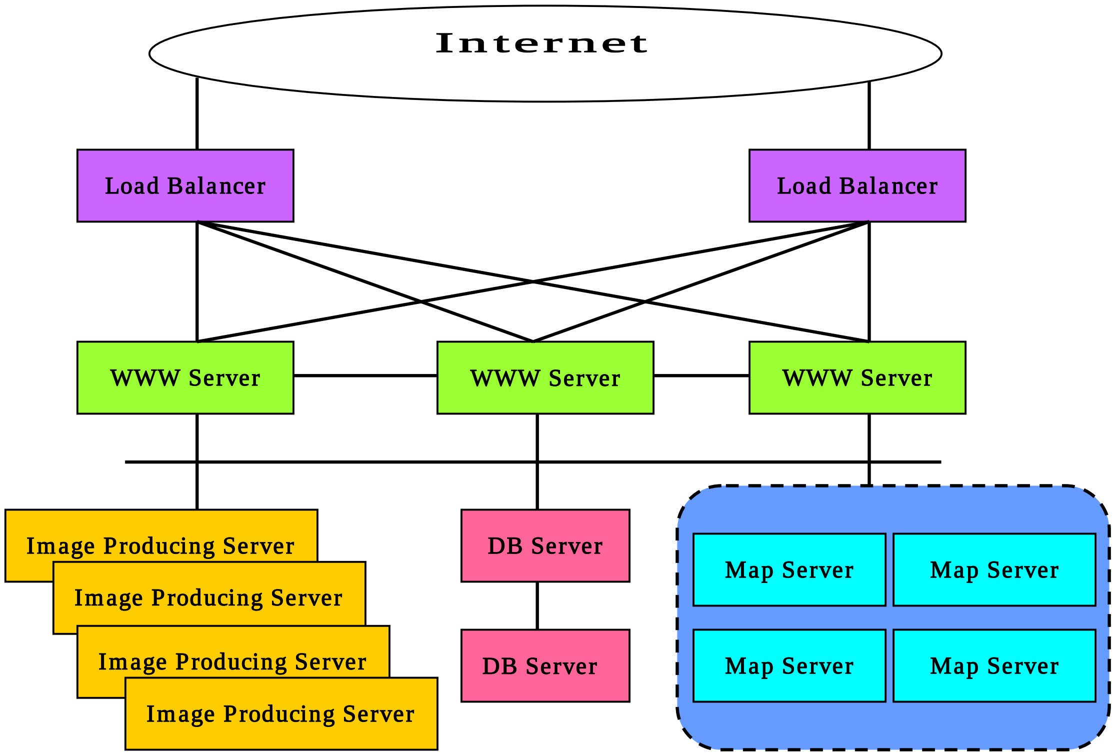

Figure 7 System composition
MO/IMS program within the dotted area

4.3 Operation Status of the Site

The site drew a huge number of accesses on June 1st, 2001, the day when the site opened. It was temporarily closed for adjusting the system and was reassumed on June 20th. As a result, the system could successfully accommodate the accesses with more than 60,000 page views per hour at the time of Typhoon No.15 in September 2001. The following are samples from the web site of the River Bureau, the Ministry of Land, Infrastructure and Transport. The graph below shows the status of access, which was release in the web page.
(http://www.mlit.go.jp/river/saigai/access/index.html)

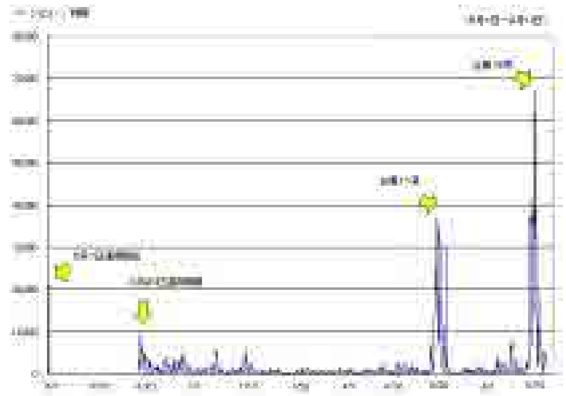

Figure 8. Access status to the site, which was released on the web site of River Bureau, the Ministry of Land, Infrastructure and Transport

Figure 9. Initial Screen for Retrieval

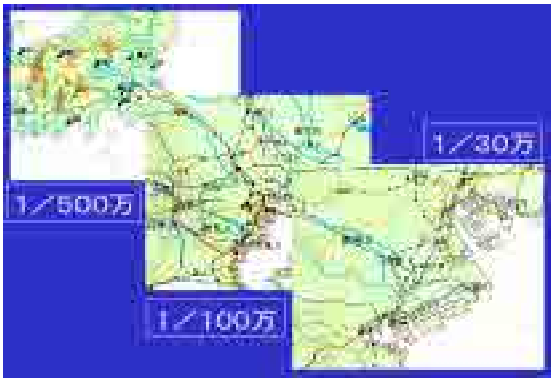

Figure 10 Zooming in

Figure 11. Radar precipitation Map (record) -past 4 hours

Figure 12 Telemeter Information (Precipitation Graph, Water Quality List, Water Level Graph, Dam Discharge Information)

5. Conclusion

Due to the recent development of Web-based GIS, we are now able to distribute maps in the form of vector data through the Web. Moreover, Web-based GIS also enables each GIS site, which is connected each other with the Internet, to exchange data and provide services on equal and independent basis. This system is quite significant for developing countries mainly because that: 1) it can provide a technical basis to avoid redundant investments if these countries can firmly establish designing of geographic database and a system of operation. The fact that developing countries often do not have a system of map notation based on paper map system would be profitable rather than disadvantageous to them; 2) it can create a framework which allows organizations in developing countries, which often lacks human resources, to share data and knowledge and cooperates with other organizations in the policy making process such as regional development planning

Advent of the Web-based GIS ages is regarded as a dawn of a new era for developing countries that can expect much from an integrated GIS database and the management of human resources, albeit communication infrastructure poses a challenge to them. From a global point of view, we have entered a new age when all the people can share various data in the form of GIS via Web-based GIS as a social infrastructure in a true sense. (g.net:http://www.esri.com/news/arcnews/spring01articles/gnet.html).

Image Information Sources
ー Optical Sensors, SAR and other Instruments ー

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Summary

Remote sensing is a very effective method to quickly obtain spatial data on features and topography in a broad range of area. It uses images that are taken from an aircraft or satellite. In resent years, remarkable development has been witnessed in resolving power of satellite-mounted optical sensors. Also recent technical development in active sensors, which use laser and microwaves, is expected to contribute to acquiring high accuracy spatial data in near future. When selecting a method for acquiring spatial data or selecting proper images among various kinds of image information, characteristics of each method or means must be well considered along with the purposes and budgets of an operation.

1. Acquisition Technique of Spatial Data

Suppose you were assigned to investigate an unknown place and file a report on it. Since you've never been there, you have, at the start, no idea about where it is located, how to get there, how it looks like, etc. You may visit a library to check into books and maps to collect information about the place. However, if you are far away from the place, the information you collected may not be so detailed. You may call someone living there and ask about the place in detail. But if the place is located in a foreign country, you may face a language problem. In addition, you may feel uneasy about telephone bill. Thanks to a modern technology, the Internet may help you lead proper sites that give you necessary information. After taking pains with collecting information, you may visit the place to realize that you have missed much information. This analogy shows how collecting spatial data is for GIS.

In the following sections, methods to acquire spatial data are roughly classified into 3 categories for the sake of explanation.

1.1 Data Collection from Existing Maps

Collecting data from existing maps means using the information that our forerunners collected. Map may be used as it is, or whole or part of it may be processed for use. It is analogous to photocopying of literature in a library to use. For example, having a piece of map means having much more information than no map. Using a map, which has been converted into digital images after scanning, as simply a background map for GIS is often quite useful. When map is used in more sophisticated way, coordinates of every feature on a map have to be obtained so that a computer can identify positional information. They can be obtained through digitization process, which is called "map digitizing".

1.2 Data Collection from Images

"Images" here refer not only to aerial photographs taken from an aircraft or photographs taken from a satellite from several hundreds kilometers above, but also to the visualized reflection of microwaves such as radio waves, laser, etc., which are emitted from platform and reflected on the earth surface. This kind of method is analogous to collecting information by telephone as illustrated above. That is, whereas considerable amount of information can be obtained without actually visiting the place, certain degree of technical training is required to interpret and analyze the information on a photograph. Also cost required for interpretation and analysis must be taken into account.
Since image utilization is one of the themes in this paper, it will be explained in detail later along with the trends in new technology.

1.3 On-Site Data Collection

Spatial data dealt in GIS can be regarded as a huge collection of information, each piece of which consists of a pair of data, i.e. positional data and attribute data. In order to ensure high accuracy in obtaining spatial data, field investigation is the most powerful tool. Though it depends on the required accuracy, GPS receivers and other similar equipments make it possible, without much difficulty, to obtain positional data in the field. Much of attribute information, on the other hand, needs to be verified on the site. For example, names (such as geographic names) commonly used by local people often differ from those recorded in official documents. The fact that geographic names and administrative boundaries do not appear on a photograph is so obvious that it is often taken for granted and dropped out of one's mind. Field verification on these items must not be forgotten.

In general, field verification is costly. Furthermore, security measures, especially when verification is conducted in some quarters in foreign countries must be taken into consideration.

Thus, among various methods available, the one most suitable to the objectives of the operation should be selected. In an actual operation, therefore, advantages and disadvantages of each method should be carefully considered without adhering to a particular method.

2. Characteristics of Remote Sensing

A method to acquire information by means of images is generally called remote sensing, which literally means "to acquire information about objects while being away from them and without touching them".

In remote sensing photographs or images of a target area are taken from high above the sky, and the data is received and analyzed at a different place. In general, except for special cases such as disaster measures and military strategies in which data is processed in real time, data is recorded in some media for post processing, thus permitting some degree of freedom in time for analysis.

A device to take photographs or images is called sensor in a broad sense. A flight vehicle that mounts a sensor is called a platform, which is either an aircraft or satellite. An aircraft can be either a rotary-wing aircraft (helicopter) or a fixed wing aircraft. When selecting a sensor for an operation, the objectives of the operation and characteristics of each vehicle should be carefully considered since these platforms vary in flying speed and flight altitude. For example, an aircraft is operated in the atmosphere, i.e. generally several hundred or several thousand meters above the earth, whereas a satellite works in outer space of several hundred kilometers from the earth.

An aircraft has advantages of being very adaptable and therefore can easily accommodate the objectives of a planning agency. In case of an emergency such as disaster, its high mobility permits quick acquisition of the bearings of situation. On the other hand, it can be operated only in the atmospheric sphere and is, therefore, vulnerable to climatic conditions. Particularly clouds in an aerial photograph would pose a fatal obstacle in interpretation of the photographs. Scheduling of aerial photographing is the most bothersome part in the operation due to the vulnerability of aircrafts to the weather conditions. Moreover, in case of an incidence of a natural disaster such as volcanic eruption, data needed for analysis may not be always obtained because of risk involved in low-altitude flight.

The advantages of a satellite for acquiring image information are: 1. a satellite can cover a wide rage of area; 2. it can quickly cover a target area; and 3. it allows repeated observations. Since a platform exists in outer space and automatically operated, photographing of a disaster-hit area does not pose safety problems.

Whereas some satellites take a geosynchronous orbit (stationary orbit), as in the case of a meteorological satellite such as "Himawari" of Japan, a large number of earth observation satellites take a polar orbit, which is orthogonal to the axis of earth rotation. Therefore, photographic cycle of such satellites is fixed and, as a result, mobility is limited, which may result in delays in photographing at a time of disaster. Some commercial satellites is, in response to the requests of the customers, operated so as to quickly acquire images of a target area. Before making such a request, however, due consideration is necessary because an extra request charge is added.

3. Types of Sensors

A sensor that is mounted on a platform functions as "eyes in the air" and takes a view of the surface of the earth. A wide variety of sensors have been developed to serve various purposes. The following are general information about sensors that are commonly used.

3.1 Airborne Sensors

3.1.1 Optical Sensors

Among optical sensors a typical one is an optical camera, which is usually called an aerial camera. It is mounted on an aircraft, which flies along the planned course, and takes sequential photographs in such a way that one photograph overlaps with the next photograph in some degree. These two adjacent photographs can produce a three-dimensional image, when they are placed in a stereoplotter, and give positional information of geographic features or topography of an area in a photograph. When a digital plotter is used in this process, positional information can be obtained in a digital form and the data thus obtained is called spatial data. When an image that was taken by an aerial camera is used as a background image in GIS, distortion of an aerial photograph should be rectified through orthographic projection.

In recent years, a compact CCD camera is mounted on an aircraft to directly obtain images in digital form. At present, however, such a method still remains to be a complementary way of acquiring information because a CCD camera has not been proved accurate enough for surveying purposes. A "three-line scanner", a kind of a digital camera, has been developed and several kinds of them are available in the market. They are now under examination for their practical use.

3.1.2 Airborne Laser Scanner

An airborne laser scanner is a distance-measuring instrument. It emits weak laser beams and measures the time from their emission till their returning to the aircraft after reflecting on the objects on the earth surface. Using this time, distance between the aircraft and an object can be calculated. Laser beams are emitted several thousand to several ten thousand per second. Certain width of earth's surface can be scanned by swinging laser beams perpendicular to the traveling direction of a platform (refer to the figure). GPS and IMU (an advanced gyrocompass system) are used to monitor a posture of an aircraft, i.e. its position and inclination. Analyzing data of both the aircraft and the reflection laser permits quick and precise measurement of configuration of the earth's surface. Since information about the ground (topography) can be isolated from that of objects, which spread out on the ground such as vegetation, buildings and so on, they can be analyzed independently. Positional accuracy thus obtained is, in optimal conditions, reported to be 30 to 50 cm in horizontal direction and 15 cm in vertical direction, though it is affected by the conditions of topography and vegetation in a target area. It is not so hampered by the weather conditions as in the case of aerial photographing, but observations are not possible in rainy weather because raindrops cause absorption and scattering of laser beams.

In Japan, major aerial surveying companies started adopting this technique around 1997.

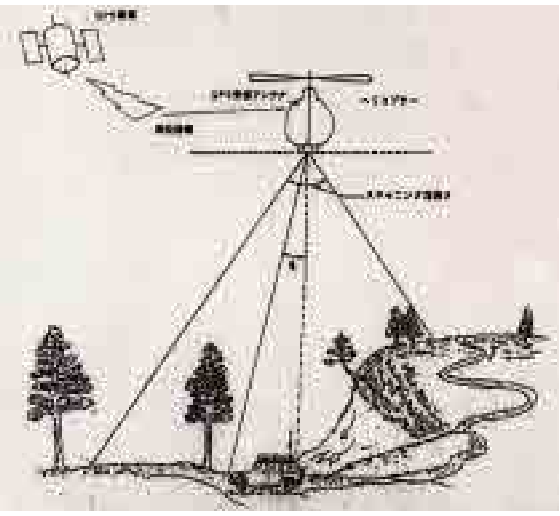

Figure 1. Schematic Illustration of Airborne Laser-mapping System
Geographical Survey Institute "Research Report on Application Technology of Laser Profiler to Topographic Surveying" (1999)

Though several technological issues such as whether accuracy can be constantly secured or not, etc. have to be solved, the technique is now beginning to be applied to topographical surveys under severe natural conditions such as erosion control sites in steep mountains or the investigations of volcanic eruptions.

3.1.3 Synthetic Aperture Radar (SAR)

In synthetic aperture radar (SAR) the condition of ground surface is grasped by analyzing reflection microwaves, which were emitted from an aircraft and returned to it after hitting the objects on the ground. Microwaves refer to the electromagnetic waves with wavelength of 1 to 1,000 mm. SAR has property of being able to acquire data under cloudy weather or even at night, so long as an aircraft is operated, because it uses not a visible light but electromagnetic waves that belong to a radio wave range. According to their wavelengths, microwaves are classified into several bands such as L, C, X, etc. A suitable band should be selected in consideration of the purposes of an operation because reflection property of objects on the ground, such as topography, vegetation and so on, show differences in wavelength.

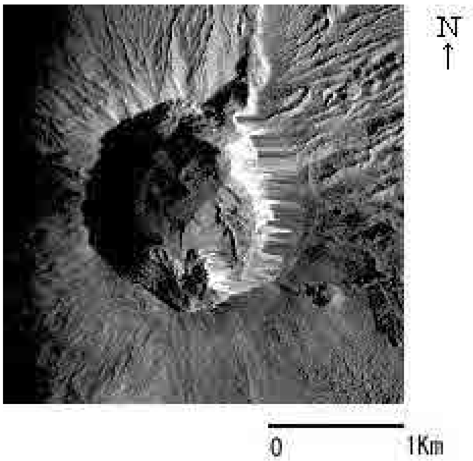

Figure 2. Orthophoto of Miyakejima by Airborne SAR (Geographic Survey Institute)
(Resolution: 10 meters, photographed in Sep. 2000)

For example, in case of analyzing forests by SAR, whereas X-band (wavelength about 30 mm) is more likely to be reflected on tree crowns (top of a forest), L-band (wavelength about 200 mm) prone to be reflected on tree trunks as well as the surface of earth. Accuracy of SAR in acquisition of topographic data is generally regarded to be around 10 to 20 meters, however, it is reported that its accuracy can be theoretically improved, if its power is raised, to scores of cm in both horizontal and vertical directions.

In Japan the Geographic Survey Institute (Ministry of Land, Infrastructure and Transport), Communication Research Laboratory, etc. own SAR and are presently carrying out various experimental data acquisitions (refer to the figure).

3.2 Satellite-mounted Sensors

3.2.1 Optical Sensors

Since the launch of LANDSAT-1 of the United States in 1970s, a number of optical sensors have been mounted on satellites and put into practical use for observation of earth surface. Still many new types are scheduled to be deployed. Present trends

Table 1. Principal Satellites Presently in Operation

Satellite Name (Country Name)	Type of a Sensor	Resolution	Observation Width	Altitude	Days for recurrence	Year of Launch
ERS-2 (European Space Agency)	SAR	30 m	80 km	785 km	35 days	1995
RADARSAT (Canada)	SAR	10-100 m	50-500 km	800 km	24 days	1995
IRS-1C (India)	Optical	5.8 m ~	70 km ~	900 km	5 days	1995
SPOT-4 (France)	Optical	10, 20 m	60 km	820 km	26 days	1998
LANDSAT-7 (USA)	Optical	15 m~	185 km	700 km	16 days	1999
IKONOS (USA)	Optical	0.8 m	11-110 km	680 km	3 days	1999
Terra (USA)	ASTER (Optical, Thermal Infrared, etc.)	15-90 m	60 km	700 km	16 days	1999
EROS-A1 (USA and Israel)	Optical	1.8 m	12.5 km	500 km	7 days	2000
QuickBird (USA)	Optical	0.6 m~	20 km ~	600 km	1.5 days	2001
(For reference) ALOS (Japan)	Optical SAR	2.5 m~ 10-100 m	35 km ~ 70-360 km	700 km	45 days	Scheduled in 2004

include: 1. higher resolution of sensors; 2. multi-national operation of a satellite; and 3. emergence of commercial satellites operated by a private sector.

French satellite, SPOT 1, launched in 1986 had panchromatic resolution of 10 meters, the highest resolution of the time for optical sensors for civilian use. As of 2001, some satellite-on-board sensors have resolution higher than 1 meter. High-resolution satellites in operation include India's IRS-1C (5.8 meters of maximum resolution), EROS-A1 co-developed by the USA and Israel (1.8 meters of maximum resolution), IKONOS of the USA (0.82 meter of maximum resolution) and so on. Further, QuickBird of the USA was successfully launched in October 2001, whose performance is now under examination. It is announced that, if things go well, QuickBird starts acquiring of images of 0.61-meter resolution by the beginning of 2002. The above-mentioned EROS-A1, IKONOS and QuickBird are all operated by private companies in the USA, which implies that acquiring and rendering of satellite images have become business targets. Japan, too, plans to launch a land-observation satellite, ALOS, with a 2.5 meter-resolution sensor in 2004.

Past performance proved that SPOT images of 10-meter class resolution were capable of providing information equivalent to 1:100,000 scale topographic map and actually its data has been already utilized for quick production of topographic maps in some developing countries in Africa. Furthermore, it is expected that high-resolution satellite images be utilized for acquiring even more precise spatial data, which will, in turn, permit producing larger scale topographic maps. However, questions about accuracy and cost remains. Yet, since a number of high-resolution satellites will be available in the future, benefits from completive market for the images obtained by these satellites may be expected. This is one of the fields that we should keep eye on.

3.2.2 SAR

SAR sensors explained in the former section are mounted not only on aircrafts but also on satellites, which keep transmitting data about earth surface. Satellite-on-board SAR has an advantage of easily permitting interference analysis based on the regular recurrence of a satellite. This means that micro-deformation of earth crust can be detected by analyzing phase difference, which can be obtained by interfering the data of the two different times at the same point. This kind of research is carried out at various agencies including the Geographical Survey Institute (GSI) of Japan. For example, GSI has successfully detected crustal deformation accompanied by Hyogoken- Nanbu Earthquake in Kobe city and Awajishima Island.

Shuttle Radar Topographic Mission (SRTM) can be regarded as a special example of satellite-on-board SAR. In 2000, the USA launched "Endeavor", a Space Shuttle, with instruments to emit radio waves. An objective of SRTM was to acquire digital data of topography of the whole earth. (Analysis of the data is still underway but the resolution of the final results would be 30 meters in horizontal direction and 16 meters in vertical direction.) SAR-mounting satellites presently in operation include RADASAT of Canada and ERS-2 of ESA (European Space Agency), both of which use C-band. Japan's JERS-1, which is no longer in operation, mounted SAR of L-band and the 1992-1998 observation data on the whole earth has been archived and is available whenever necessary. ALOS, which Japan will launch as mentioned before, will be equipped with a SAR sensor.

3.3 Other Sensors

Sensors for visible near-infrared region (wavelength around 0.7 μm), short-wavelength near-infrared region (wavelength around 2 μm) and thermal infrared region (wavelength around 10 μm) are sometimes used in exploration of underground resources. As in the case of SAR, a platform can be either an aircraft or a satellite.

4. Distribution Organizations

The following are the major organizations that distribute aerial photographs or satellite images. Note that aerial photographs and satellite images are also available at other organizations that are not listed here. For more detailed information such as price, forms of distribution, etc, please contact at each organization listed below.

- Aerial Photographs (which covers only Japan)
  - Aerial Photograph Department, Japan Map Center
    Kasuga 3-1-8, Tsukuba-shi, Ibaraki-ken, 305-0821
    Phone: 0298-51-6657
    http://www.jmc.or.jp

- Satellite Images (which include satellite SAR)
  - Earth Observation Research Center, National Space Development Agency of Japan
    Harumi 1-8-10, Chuo-ku, Tokyo, 104-6023
    Phone: 03-6221-9000
    http://www.eorc.nasda.go.jp/index_j.html
  - Remote Sensing Technology Center of Japan
    Roppongi 1-9-9, Minato-ku, Tokyo, 106-0032
    Phone: 03-5561-9771
    http://www.restec.or.jp
  - Earth Remote Sensing Data Analysis Center
    Kachidoki 3-12-1, Chuo-ku, Tokyo, 104-0054
    Phone: 03-3533-9310
    http://www.ersdac.or.jp
  - Japan Space Imaging Corporation. (IKONOS images)
    Yaesu 2-8-1, Chuo-ku, Tokyo, 104-0028
    Phone: 03-5204-2734
    http://www.spaceimaging.co.jp
  - Hitachi Software Engineering Co., Ltd. (QuickBird Images)
    Onoe-cho 6-81, Naka-ku, Yokohama-shi, Kanagawa-ken, 231-0015
    Phone: 045-681-2111
    http://www.hitachi-sk.co.jp/Products/Remosen/

Notes

The objective of the manual is to make guidelines for technical transfer concerning GIS. The method of use and functions of GIS technologies depend on the software and purpose of use. There are so many manuals and textbooks on GIS for experts.

Users of GIS for individual applications know well how it will benefit their work. However, without survey on the benefits of GIS applications, it is extremely difficult to know how beneficial GIS will be as a whole in a developing country. Before introducing a GIS in a developing country, an allocation of budget and/or personnel is required and the benefits of the GIS are need to be explained. One appropriate way is a survey on the benefits of GIS applications in other developing countries with similar condition.

As stated, the objective was to create a manual that concentrated on the fact that GIS is very useful in developing countries. Fortunately, the many authors understood and accepted the concept. In each section, technical words on GIS were explained as simply as possible to make the manual understandable for laymen. This was a difficult task but thanks to the great efforts of the authors and other related persons, the objectives of the manual was achieved.

Most of the application examples in the manual are taken from projects of JICA who implement technical cooperation of Japan. Applications of GIS are expanding and recently medical GIS applications are being implemented in assistance projects. Many GIS projects were not included in the manual because they are not finished yet. Because editing schedule was tight, GIS applications were not surveyed sufficiently. Please note that there would be many appropriate examples of GIS applications that have not been included here.

Finally, on behalf of authors, I express special thanks to kind allowance to the concerned departments of JICA, such as Social Development Study Department and Agriculture, Forestry and Fisheries Development Study Department, for kindly allowing JICA studies to be used in the manual.

Editor
Yoshikazu Fukushima
IDI