No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE NATIONAL GEOGRAPHIC DEPARTMENT (NGD)
THE PRIME MINISTER'S OFFICE OF LAO P.D.R.

THE STUDY FOR THE ESTABLISHMENT OF GIS BASE MAP DATA FOR THE MEKONG RIVER BASIN IN LAO PEOPLE'S DEMOCRATIC REPUBLIC

SUMMARY OF FINAL REPORT

February 2003

PASCO CORPORATION
AERO ASAHI CORPORATION

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1. CONCLUSIONS

NGD of the Prime Minister's Office prepared GIS base map data for the Mekong River Basin in Laos under the guidance of the Study Team during the Study and through this work the NGD counterparts acquired technology of data generating and updating, and database management. As a result, establishment of the base map data was completed as was expected and it is judged that the database will make a great contribution to planning of land development and conservation and other various purposes in the area. Technology transfer was successfully done as to fundamental techniques for data generating, updating and management. But, it is necessary for the NGD counterparts to acquire application techniques for meeting the demands for higher level of data services.

2. RECOMMENDATIONS

2.1. Improvement of the Survey Law

For the new activities, NGD needs new national funds and cooperation of a variety of organizations in data updating, facility maintenance and so on. To fulfill theses requirements, the activities need to be authorized by law. Therefore, it is suggested that the terms, digital mapping data and GIS data, should be added in the decree.

2.2. Budget for Data Maintenance

The GIS data should be open to the public. It will be hard to consider allotting a new fund for data service because of the financial difficulties. Therefore, the data should be released at a reasonable price that enables NGD to balance the budget that covers reproducing materials, reproducing labor, facility maintenance, and surveying and updating. In addition, other new products with added value should be developed and published.

The following recommendations are what should be done in the early stage of data service.

2.3. Public Relation of the Mekong GIS Database

It is important for NGD to announce the publication to promote its utilization. In the early stage of service at least, NGD should publicize the database service as frequently as possible. Therefore, effective measures should be taken for publicizing. Distribution of pamphlets and announcement by mass media are indispensable in general. Exhibition and demonstration on the GIS are also advisable as effective measures

2.4. Data Distribution

It is important to accumulate many and various cases of data utilization for advertising the usefulness of the database and encouraging further utilization. Therefore, it is advisable for NGD to provide the data at a rather low price to the power users engaged in some governmental or public projects. It is also suggested that NGD should hold occasional seminars to inform some cases of data utilization to the public.

2.5. Pricing

NGD should price the data at a level that covers reproducing materials, labor, updating cost, and facility maintenance and depreciation expenses.

NGD should categorize the data into several ready-made products. The digital data also should be compiled into areas by province or quadrangle of 1:100,000 topographic map, etc.

2.6. Information of Data Quality

It is recommended that NGD should inform data quality and surveying date to the users before providing. The Data Usage Manual should be utilized for informing users of how to use the data.

2.7. Demand for Hard Copy of Map

It is foreseen that an user would want hard copies of the new data in the form of an analogue map initially, with the goal being to evaluate the usefulness of the data before a decision is made to utilize it. It is also foreseen that many people would want hard copies instead of the existing 1:100,000 topographic maps only because the data are updated. It is recommended that NGD should prepare its working system for quick and exact printing on demand.

2.8. Data Correction

New data are not necessarily perfect in general. It is recommended that, when a data error is found, NGD should correct it as quickly as possible.

The following recommendations are what should be done in any stage of data service.

2.9. Maintenance of Technology

It is essential that the transferred technologies should be kept at a sustainable maintenance and for the improvement of the Mekong GIS Database into the future. Therefore, it is recommended that NGD should establish a basic plan for technical training. NGD also should search various ways of training, including OJT. The Data Generation Manual should be utilized for instructing new technicians and it should be improved when necessary in the future.

2.10. Data Updating

Data updating is very important for GIS database with regard to sustainable utilization of the data by end-users. Data updating is especially important for roads and built-up areas due to rapid change by year. Updating every year or every two years will be essential for satisfying the demands for accuracy.

Administrative boundaries, tentatively stored in the database, should be updated in the future.

2.11. Data Quality Improvement

It is recommended that NGD should unremittingly improve data quality. There are several data layers that need special explanation to the users because they have not been finalized yet in data quality. For instance, administrative boundaries are tentative at many places. They should be updated soon after determination in the future. Village name (point) does not necessarily meet the built-up area (polygon). Field surveys are indispensable for quality improvement in the near future.

Land use data is not necessarily continuous between two areas because of difference of data acquisition methods, differences of classification systems and differences in surveying date. This discontinuity can only be solved by future updating with a definite classification system and method.

Visualized contour data for steep slope areas look unnatural. The main purpose of contour data in this Study was to generate DEM. For digital map revision in the future, however, it is worthwhile improving the contour data by digitizing the original contour lines again.

In spite of unavailability of new aerial photos, topographic features in the southern region should be updated as soon as possible by other means such as field check.

2.12. Data Adding

Necessary data for a use should be prepared by the end-user. It is, however, suggested that, when requested, NGD should undertake the data preparation.

In addition, NGD should prepare the basic data layers when many users recognize they are essential to be added to the database.

2.13. Data Protection

Copyright of the data must be protected for maintaining the data service. Data protection is technically possible for the moment, but any protection will not be durable. At present, there is no complete way to solve this issue. It can be said that frequent data updating would avoid the infringement of copyright.

2.14. Archive Reservation

NGD should preserve all the GIS data even after becoming out-of-date through data updating, because these data will be precious records for analyzing the past conditions of the country and their changes.

The followings are suggestions regarding digital map compilation in the future.

2.15. Digital Map Compilation

Hard copy service will satisfy everyone's minimum requirement for updated maps. These hard copies are superior to the existing topographic maps because of updated information, but it is suggested that this service should be provisional.

The hard copies outputted from the GIS base map data are based on a design formulated after repeated trial and error, but they are far inferior to the existing topographic maps in visual expression. In general, it is unavoidable that a hard copy outputted from GIS data is inferior in visual expression to a conventional map, because the GIS data is not created for the purpose of paper map compilation from the first. A good map is produced through compilation process based on a proper cartographic design in order that every user can reach geographic facts easily and correctly.

Conventional method for map compilation requires high cost. But, modern method including digital map compilation has been rapidly developed and spreading today. It is more efficient and economical than the conventional method. Therefore, if digital base map data are available, a digital method should be applied to the compilation. Since the Mekong GIS base map data are available now, NGD has had the advantage for digital map compilation as well as digital map updating. Therefore, it is recommended that NGD should acquire this ability as soon as possible for the future.

2.16. Demand for Added Value

It is foreseen that many people would want the data with an added value. If their demands are technically acceptable, NGD should meet these user needs as well as possible. Therefore, it is advisable that NGD should acquire a minimum ability to add value to the data on demand, and should become a GIS data processing center for the country.

It is advisable that NGD should publish some new maps that will be a promising source of revenue. For example, a series of road maps will meet the needs of tourist enterprises and foreign travelers. Also tourist maps of historical sites and scenic places will be promising. It is also suggested that the existing tourist maps of cities should be revised. If the digital map compilation method is available, all these maps can be compiled by utilizing the base map data.

3. BACKGROUND OF THE STUDY

The Mekong River is the largest international river in Indochina, flowing over six countries and forming a drainage basin of approximately 800,000 square kilometers, which is called "the Mekong River Basin." Laos is one of six riparian countries and it alone is landlocked, covering 237,000 square kilometers. About 90% of the country, 214,000 square kilometers, is within the Mekong River Basin.

Several traditional industries, especially agriculture and forestry, have been developed in Laos. Recently, modern industries such as hydropower have been developed and they are going to make further progress. From the geographic characteristics it can be said that there is a high potential for further development in agriculture, forestry, hydropower and water transport.

A minimum level of construction and rehabilitation of principal roads has almost been attained and various projects of production and land development are on going. And many new projects are in the research or planning stages. But, problems of environmental deterioration would likely be a result of land development. In order to refrain from possible deterioration and keep sustainable economic activities, development planners and decision makers are required to evaluate the broader concept of land development, taking a variety of factors into consideration. In addition, it is important to monitor the environmental changes together with the rapid social and economic changes and to make various analyses for finding the problems and solutions. Geographic Information System (GIS) is a tool to monitor chronological environmental changes and help the planners and decision makers to make more rational and efficient analyses and discussions.

From this point of view, the necessity of establishing a GIS database for the Mekong River Basin, a so-called "National Spatial Data Infrastructure (NSDI)," was identified. This database provides a basic spatial framework, with which user organizations can construct their database not only for monitoring environmental changes but also for analyzing data, making plans, making decisions, implementing programs and managing projects as well.

In 1996, the Government of Laos (hereinafter referred to as "Laos") requested the Government of Japan to establish a GIS database for the Mekong River Basin in Laos and to transfer the technology to utilize and updating the digital data. In response to the request, the Government of Japan decided to conduct "The Study for the Establishment of GIS Base Map Data for the Mekong River Basin" (hereinafter referred to as "the Study").

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the Preparatory Study Mission to Laos in May 1998 to discuss the Scope of Work (hereinafter

referred to as “S/W”) with the Laotian side. S/W was agreed upon between the Prime Minister’s Office of Laos and the Mission on 29 May 1998.

Based on S/W, the five-year work plan was settled on and the JICA Study Team was organized as the implementing body. The National Geographic Department of the Prime Minister’s Office (hereinafter referred to as “NGD”) was assigned as the counterpart agency to the Team.

The Study started in November 1998 and ended in January 2003.

4. OBJECTIVES OF THE STUDY

Major objectives of the Study are as follows;

(1) To generate GIS base map data for the Mekong River Basin in Laos and to create “the Mekong GIS Database”.

(2) To transfer the technology of GIS base map data generating, updating and database management to NGD.

5. STUDY AREA

Seventeen (17) administrative units within the Mekong River Basin, namely, Vientiane Municipality, Xaisomboun Special Region and fifteen (15) Provinces excluding Houaphan and parts of Phongsali and Xiangkhouang. The size is 214,000 square kilometers, making up 90% of the country.

Figure 1: Study Area

6. PECULIARITY OF THE STUDY

The whole data were generated and updated in Laos entirely by the NGD counterparts under the guidance of the Team. Through this work, OJT was carried out for technology transfer.

7. INPUT

7.1. Input from the Laotian Side

7.1.1. Organizations of the Study

(1) The Steering Committee

The Government of Laos organized the Steering Committee for the Study as the coordinating body. The members were selected from the following orgatizations.

1. Prime Minister's Office
2. National Geographic Department
3. Lao National Mekong Committee
4. National Office of Forest Inventory Planning
5. Department of Geology and Mines

(2) The National Geographic Department (NGD)

In accordance with S/W, NGD took necessary measures and made provisions such as operation space and the counterpart personnel to the Team. The counterparts totaled twenty-three (23). The total man-month was about 900. Many of them were from Cartography Division and Photogrammetry Division. The structure of NGD is shown below.

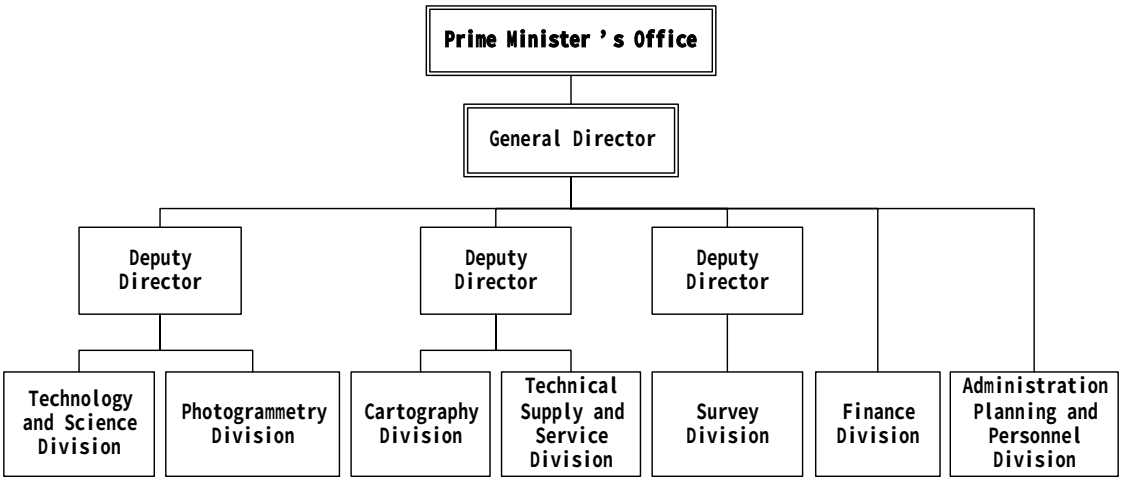

Figure 2: The Organization chart of NGD

7.2. Input from the JICA Side

7.2.1. Organizations of the Study

(1) The JICA Study Team

The JICA Study Team (hereinafter referred to as "the Team") was sent to Laos every year. There were a total of thirteen (13) members during the five years.

Table 1: Study Team

Team Leader	Kiyoo SAZAMANI
Deputy Team Leader	Eisaku TSURUMI
Supervisor of Aerial Photography	Hideto HOSODA
Supervisor of GPS Survey 1	Yutaka NAKATA
Supervisor of GPS Survey 2	Kiyofumi TAMARI
Supervisor of System Design	Hideaki UMEDA
Supervisor of Photo Interpretation 1	Minori ONAKA
Supervisor of Photo Interpretation 2	Akihiro YAMADA, Kentaro USUDA
Supervisor of Photo Interpretation 3	Akihiro SUGITA
Supervisor of Digital Map 1	Yunshan BAI, Jorge Cecilio
Supervisor of Digital Map 2	Jorge Cecilio, Akihiro SUGITA
Environment Analysis	Yukio SATO

(2) The Technical Committee

The Technical Committee composed of the NGD engineers and the Team members was organized for discussing and making important decisions on technical matters during the Study.

Table 2: The Technical Committee

Name	Position
Mr. Khamkhong DETCHANTHACHACK	Deputy Director: NGD
Mr. Thongchanh MANIXAY	Deputy Director: NGD
Mr. Bounkong SOUGNATTI	Deputy Director: NGD
Mr. Bouasoth SOUVANNAKUMMAN	Head of Division: NGD
Mr. Kongkham SOURIGNA	Head of Division: NGD
Mr. Phouangphanh SAYASANE	Head of Division: NGD
Mr. Sangkhane THIANGTHAMMAVONG	Deputy of Division: NGD
Ms. Sikhay S.SIRIBOUNMA	Deputy of Division: NGD
Mr. Eisaku TSURUMI	Deputy Team Leader: JICA Team
Mr. Akihiro SUGITA	Team Member: JICA Team

7.2.2. Equipment

The following equipments were supplied.

SPOT satellite image data	one set
Computer system and equipment	one set
Furniture for operation	one set

Equipment for photo interpretation	one set
Surveying vehicle	three vehicles

7.2.3. Operation Rooms and Computer Net Work System

The existing two rooms of NGD were repaired and remodeled into an operation room and an office room. Then, the Digital Map Editing System was installed in the operation room. The system is composed of about 25 instruments and GIS software.

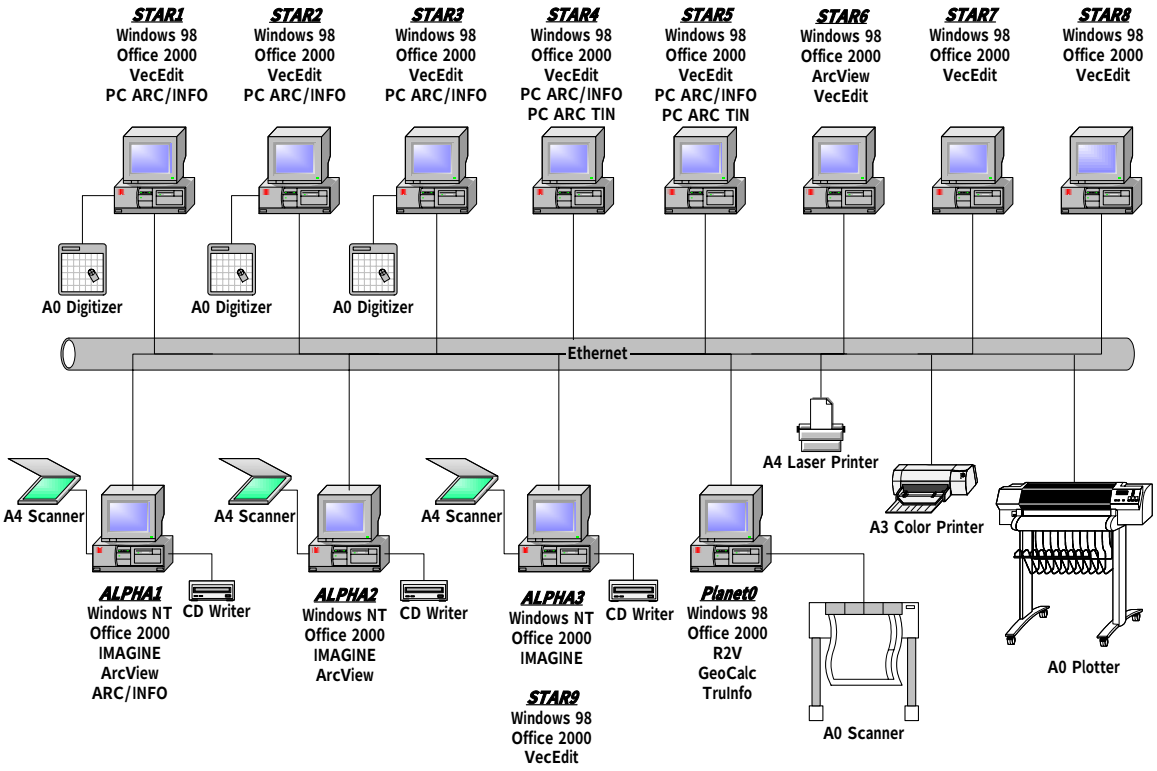

Figure 3: Computer Network

8. RESULTS OF THE STUDY

8.1. Establishment of GIS Base Map Data

GIS base map data were established for the whole Study area. This is comprised of basic data layers, which are shown below. A visualized sample is shown below too.

Table 3: List of the GIS Data

Data Layer	Description
Road	Paved road
	Street road
	Improved unpaved road
	Unpaved road
	Temporary road
	Footpath
River	River and Stream line
	Intermittent River and Stream
	River and Stream line (Center Line)
	Intermittent River and Stream (Center Line)
	Canal
	River name
	River and Stream
	Intermittent river and Stream
	Lake and Pond
	Intermittent Lake and Pond
	Island
Administrative Boundary	Province Name
	District Name
	International boundary
	Provincial boundary
	District boundary
Built-up Area	Urban Area
	Rural Area
Contour	Elevation
	Principal Contour
	Secondary Contour
	Supplementary Contour
	Auxiliary Contour
Elevation Point	Geodetic Point
	Spot Height
	Elevation

Data Layer	Description
Land Use	Dry Evergreen
	Mixed Deciduous
	Dry Dipterocarp
	Gallery Forest
	Coniferous Forest
	Mixed Board Leaved Coniferous
	Forest Plantation
	Bamboo
	Unstocked Forest
	Natural Regeneration
	Ray
	Savannah
	Scrub
	Rice Paddy
	Agricultural Plantation
	Other Agricultural Land
	Barren Land and Rock
	Grass Land
	Swamp
	Urban or Built-up Area
	Other Land
	Cloud / Cloud Effects
	Water
Village	Village Name
	Village Code
	X, Y Coordinate
	Map Number
	Population
	Household
	Big Village
	Small Village
Small Object	School
	Buddhist Monastery
	Bridge (less than 3m)
	Bridge (more than 3m)
	Dam (practicable)
	Dam (non-practicable)
	Airport
	Airfield
	Water Gauge
Ortho Image	10m resolution
DEM	30m resolution

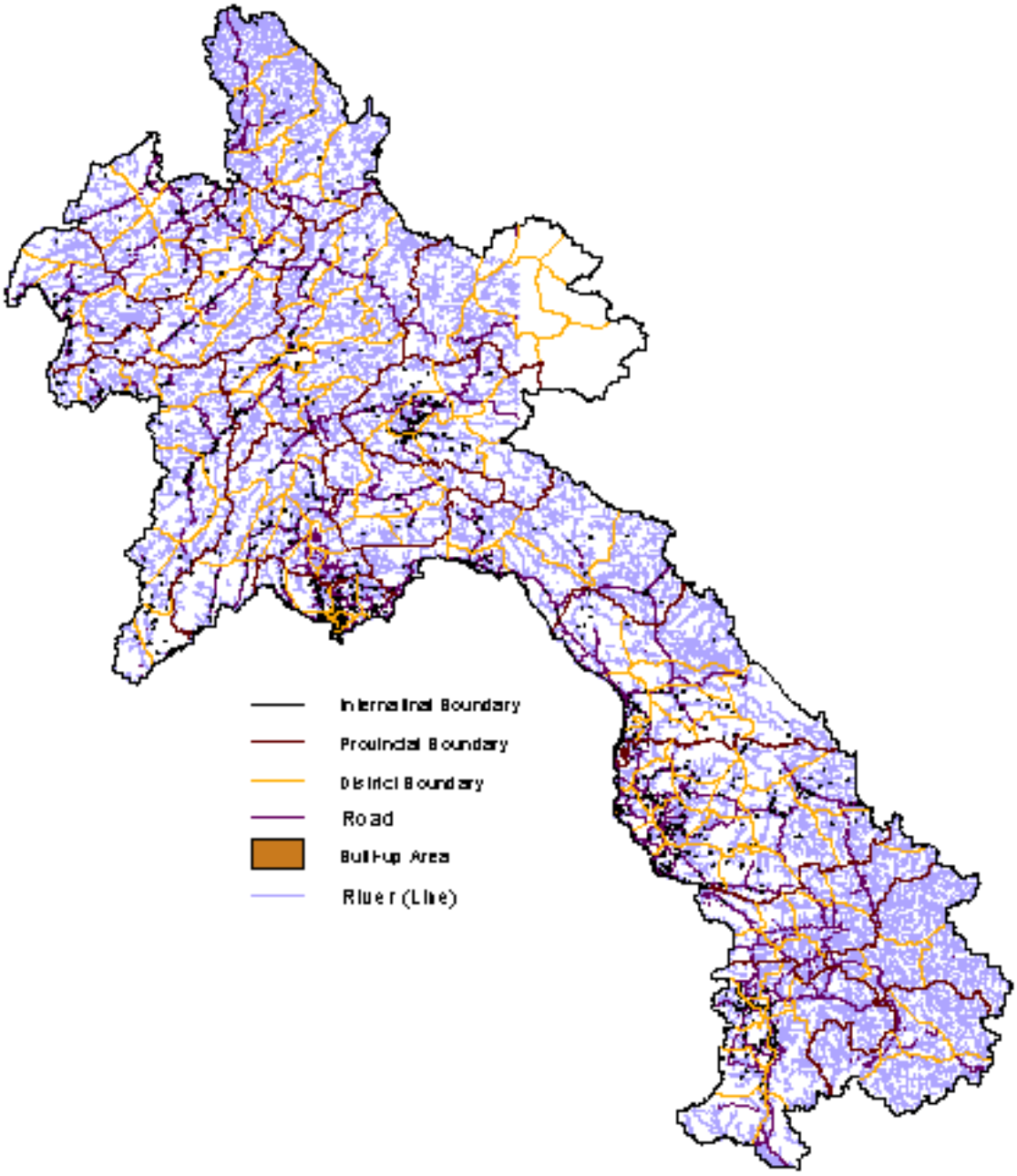

Figure 4: GIS Data

8.2. Aerial Photograph

For acquiring new geographic information, aerial photos were taken at the scale of 1:50,000for the areas where new maps and photos were not available. Index of the new photos and the existing maps and photos is shown below.

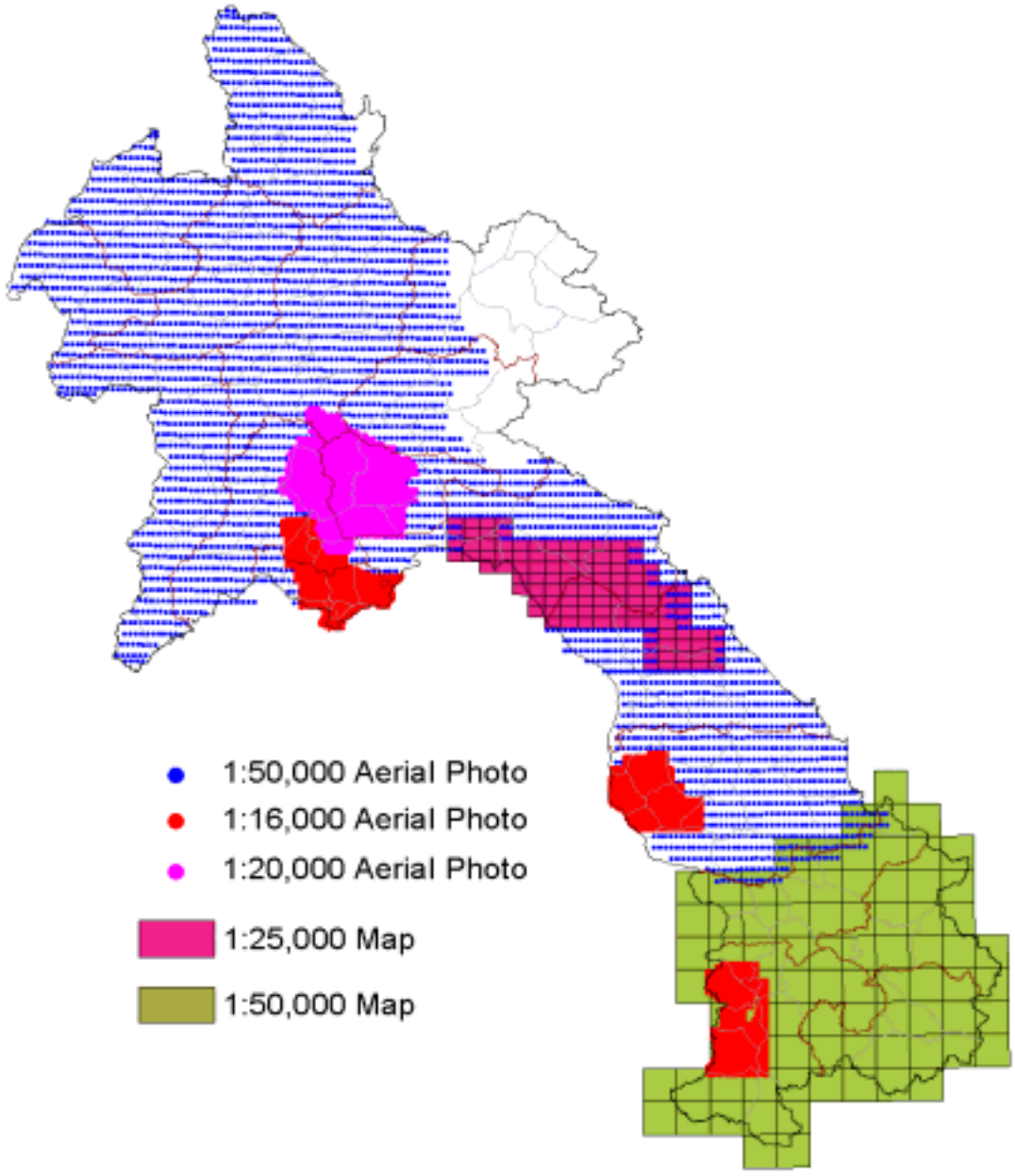

Figure 5: Index of the new photos and the existing maps and photos

8.3. Satellite Image

For acquiring new information and compiling digital data generated from the existing maps, satellite image data for the whole area were obtained. Index is shown below.

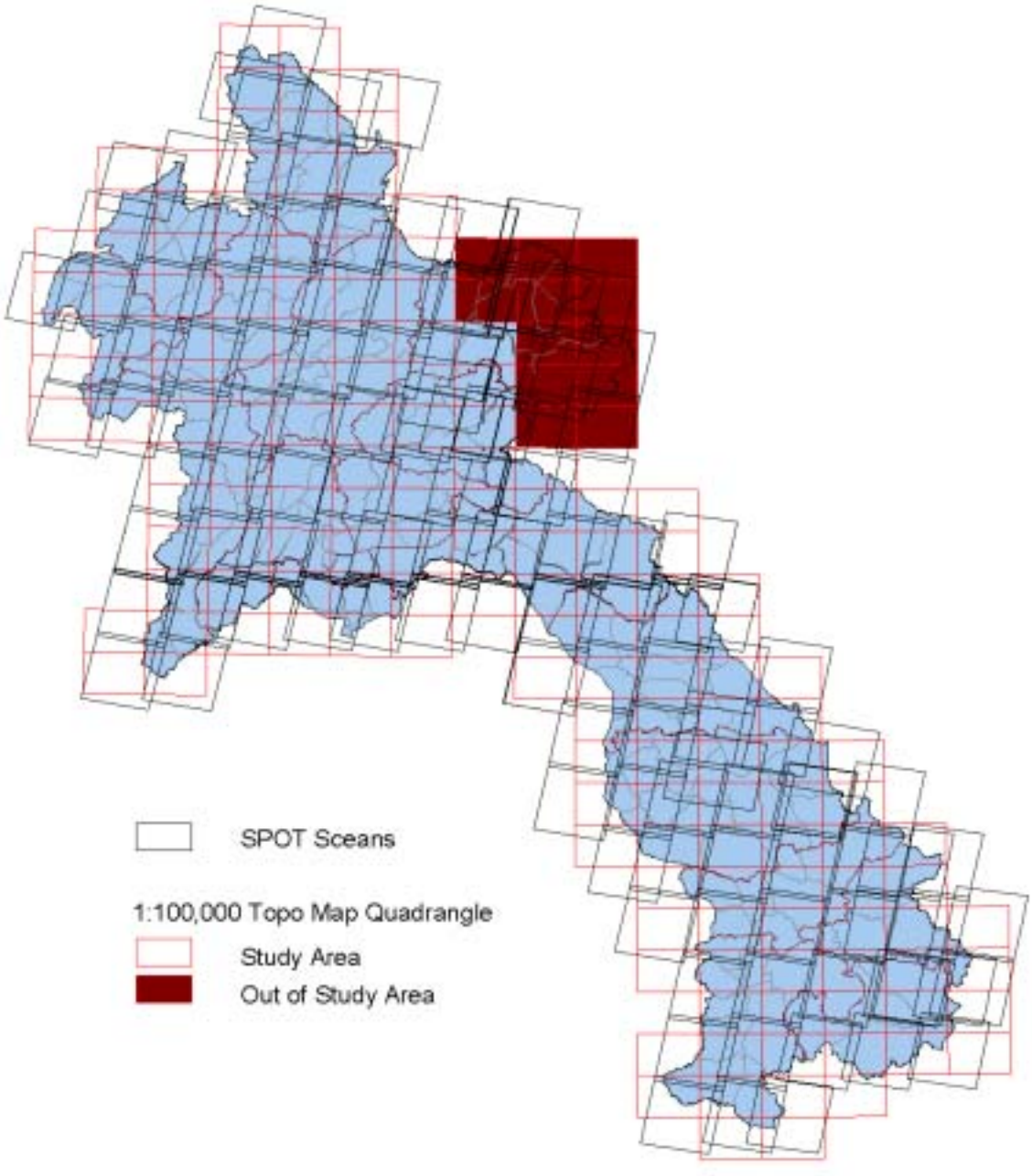

Figure 6: SPOT Image Index

8.4. Geodetic Datum Shift Parameters

There have been several different datums used in Laos. In order to make the Mekong GIS data and those in other datums convertible to/from each other, a net linking of the following datums was carried out by GPS observation.

- Lao National Datum 1997
- Vientiane Datum 1982
- Indian Datum 1975
- Indian Datum 1960

As a result, following datum shift parameters were obtained.

Table 4: Datum Shift Parameters

Local Datum	Dx(m)	Dy(m)	Dz(m)
Lao National Datum 1997	44.585	-131.212	-39.544
Vientiane Datum 1982	42.358	-124.688	-37.366
Indian Datum 1975	201.148	838.024	293.960
Indian Datum 1960	198	881	317

8.5. Manuals

The Study Team prepared GIS Data Generation Manual to help the NGD technical staff in generating and updating the GIS data, and Mekong GIS Data Usage Manual to help the NGD staff and data users.

8.6. Technology Transfer

One of the objectives of the Study was "Technology Transfer" to the NGD counterparts, which enables NGD to generate and update the GIS base map data and to manage the System without assistance in the future. The Team conducted technology transfer with lectures and OJT. Twenty-three (23) counterparts participated in the works. A list of the counterparts is shown below.

Table 5: The Counterparts

Ms. Sisouphanh PHOUMIVONG	Ms. Somkhith KHOUNPHONESAVANH
Mr. Aksone SIMMAVONG	Ms. Imphone CHANNGAKHAM
Mr. Thavisay KHAMPHICHITH	Ms. Noun PHOMMIXAI
Mr. Michith THAVONG	Ms. Sikhay S.SIRIBOUNMA
Mr. Phatnakhone INSISIENGMAI	Mr. Souvanny VONGSOUVATH
Mr. Bounkeuth SINDAVONG	Mr. Samliang PHILAPHA
Mr. Phoukham PHONGMALAYKHAM	Mr. Chanthavy CHOUTDARA
Mr. Bounpheng PHENGKHOUANE	Mr. Vannalath PHIMMAVONG
Ms. Ammala KEONOUCHANH	Mr. Sangkhane THIANGTHAMMAVONG
Ms. Somsanouk MUANGVONG	Mr. Phouangphanh SAYASANE

Ms. Chanthone PIOKEOPASEUT	Mr. Bounnhom KEOVONGSY
Ms. Phothin XAMONTY	

The Team members gave five lectures using the textbook that they had prepared. After then, for starting OJT in practical processing, four lectures were also given. During the work, a series of special lectures were given for full understanding of theory of technology and a wide picture of the project.

During OJT, the counterparts practiced each process under the individual guidance of the Team members. Sometimes, explanations were given to the counterparts as the occasion demanded. Through the OJT, the counterparts made considerable progress in each process.

In connection with the Study, four (4) counterparts were sent to Japan to learn advanced technologies during the Study. Contents of the training are shown below.

Table 6: Contents of the training in Japan

Name	Contents	Duration
Mr.khamphone AMPHAYPHONE	• Introduction to PC • Introduction to GIS • Coordinate Conversion and Map Projection • GIS equipment Installation • Visualization of spatial data	1999/3/10～5/9
Mr.Souvany VONGSOUVATH	• Introduction to GIS • ArcView usage • Data analysis and processing • Analysis of land use change	2000/2/22～4/23
Ms.Noun PHOMMIXAY	• Photogrammetry with satellite image data and Introduction to GIS • Photo Interpretation • Generation of DEM and ortho image • Generation and compilation of GIS data	2000/10/24～12/16
Mr.Bounnhom KEOVONGSY	• Photogrammetry with satellite image data and Introduction to GIS • Vector Data compilation • Remote Sensing • Generation of ortho Image • Digital Photogrammetry	2001/10/15～11/30

The NGD counterparts acquired the technologies as was expected. It is judged that all the participants have attained the level of ability to process standardized works without assistance. Some of them have acquired the ability to improve the process or to develop some new products and services.

In the last stage of the Study, the Study Team prepared GIS Data Generation Manual for the NGD technical staff and Mekong GIS Data Usage Manual for users and technical staff, and also the Team and NGD jointly held a one-day seminar to introduce the GIS base map data for the Mekong River Basin to user organizations in Laos.

The technology transfer through OJT is evaluated as shown below.

Table 7: Evaluation of Technology Transfer

Item	Before the Study	After the Study	Remarks
Geodetic Survey	Experienced in GPS observation	Experienced in calculation of datum shift parameters	New survey is necessary in northern region for improving the accuracy of datum 1960
Aerial Photography	Knowledge of aerial photo. Experienced in checking	-	Technology of digital photogrammetry should be acquired
Ortho Image Generating	Inexperienced	Four counterparts mastered	Further training is necessary for improving accuracy
Aerial Photo Interpretation	Inexperienced	Many counterparts mastered.	New interpreters should be trained.
		A few counterparts attained a minimum level. They are apt to interpret too much in detail.	The counterparts need more knowledge and experience for forest classification.
Transcription	Inexperienced	Many counterparts mastered.	
Topographic Feature Data Generating and Updating	Inexperienced	Many counterparts mastered. They should be very careful in operation.	Essential work in the feature.
Contour Data	Inexperienced	Many counterparts mastered. They should be very careful in operation.	
DEM Generating	Inexperienced	Easily mastered due to automatic process.	
Land Use Data (Polygon)	Inexperienced	A few counterparts mastered. They should be very careful in operation.	Essential work in the feature.
Computer Operation	Inexperienced	All counterparts mastered fundamental operation.	Essential work in the feature. They need further new techniques.

The NGD counterparts, who had not experienced at all in data generating, updating and management in the beginning stage, have acquired fundamental techniques for geographic data processing through OJT. It is judged that they have attained a level of ability for ordinary data service. But, it is necessary for them to acquire further application techniques for meeting the demands for higher level of data services.

9. IMPLEMENTATION

The chronology of the Study is shown on the last page.

9.1. Inception Report

Based on S/W, the Team prepared a detailed working plan of the Study and prepared the Inception Report, which covered the five-year work plan. After the approval of JICA, the Team submitted the Inception Report to NGD for explanation and discussion on the basic policy, study methodology, work processes, work schedule, staffing/equipment/facilities, technology transfer, and NGD's undertaking. The Report was agreed upon between NGD and the Team in November 1998.

9.2. Specifications of the GIS Base Map Data

The GIS base map data created in this Study are fundamentally composed of road, river and its name, village and its name, other small objects, land use, administrative unit, elevation point, contour line, DEM and ortho satellite image. The existing 1:100,000 topographic map was the standard base for digitizing and updating.

As for geodetic datum, the Team and NGD confirmed to adopt the Lao National Datum 1997, which had been defined as a new geodetic datum through the Land Titling Project (LTP). They also confirmed to adopt UTM for the map projection coordinate system.

9.3. Research of the Existing Maps and Aerial Photographs

For updating the basic features on the 1:100,000 topographic maps for the whole Study area, ortho satellite imagery was utilized to provide current information. Its resolution, however, is not high enough to identify the changed artificial features. Therefore, the Team researched the existing topographic maps and aerial photos to choose recent maps and photos that were useful for data updating.

9.4. Geodetic Datum Network Survey and Calculation of Datum Shift Parameters

The NGD counterparts carried out a net linking of intervals among control points of various datums by GPS static observation and calculated the amount of each displacement for obtaining datum shift parameters.

Based on the GPS observation data, the Team calculated the datum shift parameters. The Team and NGD made a determination of datum shift parameters to be used for coordinate conversion to/from each local datum.

9.5. Aerial Photography

For the area where recent aerial photos and topographic maps were not available, monochromatic aerial photography was conducted at a scale of 1:50,000 in the beginning of 1999. The area was 150,000 square kilometers. The photos totaled 3.903.

9.6. Ortho Satellite Image Preparation

The NGD counterparts generated the ortho data from SPOT image data under the guidance of the Team. After data checking, all of 163 sheets of 1:100,000 scale ortho satellite images were output to paper in Japan.

9.7. Aerial Photo Interpretation and Field Check

Photo interpretation played an important part for supplementing the unsatisfactory interpretation of satellite imagery in this Study. Under the guidance of the Team, the NGD counterparts prepared photo interpretation keys in the form of sheets and carried out photo interpretation using the existing aerial photos taken after 1996 and the new photos taken by JICA in 1999. The Bolikhamxai area and Bolaven Plateau in the southern four Provinces were excluded from the photo interpretation area, because these areas were covered by new topographic maps.

9.7.1. Interpretation of Topographic Features

Aerial photo interpretation for updating of artificial topographic features such as urban areas, small objects, roads and water bodies was carried out. During the photo interpretation, field check on the features was carried out in the Vientiane area. After correction, the changed features were marked directly on the photos with colored pencils.

9.7.2. Interpretation of Land Use

The National Office of Forest Inventory and Planning (NOFIP) has conducted “Nationwide Reconnaissance Survey of Land Use and Forest Cover in Lao P.D.R.” With the Steering Committee’s agreement, the Team and the counterparts obtained these data and updated them using recent aerial photos for the northern region of the country.

The southern four provinces were not interpreted because the recent aerial photos were not available. The central three provinces were also not interpreted because updated NOFIP’s data was available. Louangphabang Province was not too because an updating project of NOFIP was ongoing.

During the interpretation work, the counterparts conducted field excursions in the Vientiane area to memorize the landscape of typical forests. The final results of interpretation were marked directly on the photos with colored pencils.

9.7.3. Transcribing

The NGD counterparts transcribed manually the entire interpretation results of topographic features marked on the photos onto the 1:100,000 satellite images with colored ink. The erason for transcribing was to reduce processing time and the propensity for errors in the process of digitization.

9.8. GIS Data Collection, Generating, Updating and Structuring

The Team and the NGD counterparts digitized the 1:100,000 topographic maps covering the Study area for generating GIS data of topographic features, administrative boundaries and so on. In addition, the Team collected some existing data such as village name data, land use data and contour data from other organizations. The Team applied these collected data for establishing the Mekong GIS Database with some necessary updating.

9.8.1. Features in the 1:100,000 Topographic Map

The counterparts digitized the topographic features of the 1:100,000 map and updated the data with new information from recent maps and aerial photos. The following data layers were finalized and stored in the GIS database:

Road (line)
River (line)
River (polygon)
Elevation point (point)
Small objects (point)

(1) Bolikhamxai Area

1:25,000 topographic maps of Bolikhamxai area have more up-to-date information than the 1:100,000 topographic maps. Therefore, instead of aerial photos, these maps were used for updating of road, river, built-up area and small objects in Bolikhamxai area.

These maps were scanned. Afterimage rectification, the features were digitized.

(2) The Southern Four Provinces

1:50,000 topographic maps, which were updated during 1997-1998 for the southern four provinces have recent information. Therefore, they were scanned. After image rectification, road and river were digitized for updating.

(3) Road and River in the Whole Study Area

The existing 1:100,000 topographic maps for the whole Study area were scanned. After image rectification, road data and river data were generated. Then, the data were updated with new data of Bolikhamxai area and southern four provinces and the results of aerial photo interpretation transcribed on ortho satellite images. Final data were stored in the database.

(4) Elevation Point and Small Objects in the Whole Study Area (p.50)

The existing 1:100,000 topographic maps for the whole Study area were scanned. After image rectification, elevation point and small objects were digitized. Then, the small objects data were updated with new data of Bolikhamxai area and the results of photo interpretation transcribed on ortho satellite images. Final data were stored in the database.

(5) Administrative Boundary

There are 18 administrative units of provincial level in Laos. Each is divided into several districts, totaling up to 142 for the whole country. The NGD counterparts generated data of international boundary and provincial boundary from the 1:100,000 topographic map and stored them in the Mekong GIS Database. District boundary data prepared by UXO Lao were combined with the provincial boundaries and stored in the database.

Many of these boundaries of Lao including international boundaries are not fixed at present. Therefore, the data stored in the Mekong GIS Database is tentative.

(6) Place Name

The NGD counterparts extracted place names of rivers and villages from the 1:100,000 topographic map and made a detailed list with each code number by using Excel software. Then, the counterparts checked the village names against those from the UXO Lao database, which is more recent. The entire list was checked and corrected referring to the statistics tables published by the National Statistics Centre. The counterparts also checked the names of rivers. These place name data were stored in the database.

9.8.2. Contour Data and Digital Elevation Model (DEM)

The Team investigated the contour data of "Watershed Classification Project" (WSCP) of the Mekong River Commission (MRC). Based upon the agreement with the Steering Committee,

the Team and the NGD counterparts updated the WSCP contour data and stored in the database from a viewpoint of good use of existing data. After then, they generated a new DEM from the contour data and also stored in the database.

9.8.3. Land Use

After photo interpretation of land use and forest cover for the northern region, the results were manually transcribed to polyester film sheets. Then, the sheets were scanned. After image rectification, the land use and forest cover were digitized and these data were stored in the database.

10. QUALITY OF THE RESULTS

The data quality is not uniform by layer and surveying date. Therefore, NGD is required to inform the quality and surveying date to the users before providing. The following data layers need special explanation.

(1) Administrative boundary data----------	Partially tentative
(2) Contour data----------	Skipped for some lines
(3) Land use and forest cover data----------	Nonconformity by surveying date
(4) Built-up area and village name----------	Nonconformity in some places
(5) Topographic feature data in the southern region--	Small objects are not updated except for Bolaven Plateau

11. GIS DATA PRINTING OUT

After repeated trials for design, 163 sheets of 1:100,000 maps were printed out from the GIS base map data with A0 size colored ink jet plotter.

It is unavoidable that these hard copies are inferior in expression to conventional analogue maps because the GIS data was not prepared for the purpose of map compilation from the first. If a digital map compilation technology is introduced, NGD will be able to compile better analogue maps based on GIS base map data.

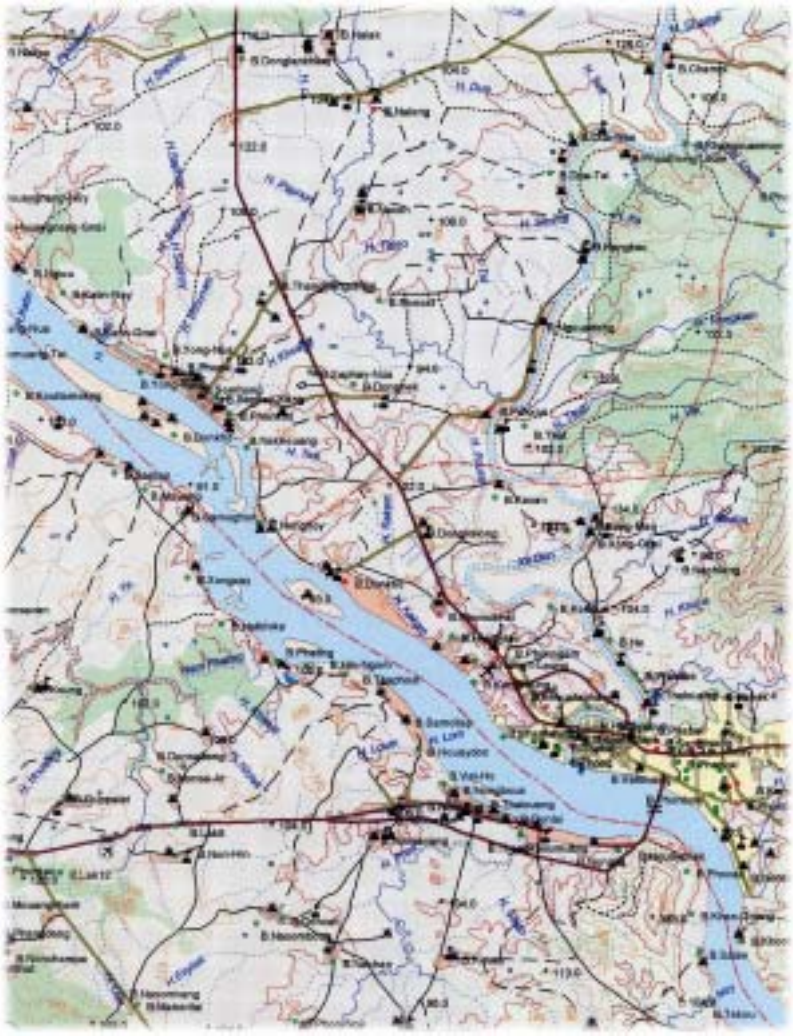

Figure 7: Sample of Printed Out Map

12. ENVIRONMENTAL ANALYSIS

Using land use and forest cover data from the database, the Team analyzed land use change for nine (9) provinces of the northern region. Although definition of classes and surveying date are not even throughout the area, rough information on land use change from 1982 to 2001 were made for each province of nine. Obtained values are not official because the analysis was done on an experimental basis.

As a tool for presentation of environmental analysis and planning, visualization of information is useful. For this purpose, DEM provides various outputs such as shaded relief image and bird's-eye view. The Team made some samples of images to present at the seminar held in the end of the Study.

Using other data than land use data, the Team made some new data such as length of road and river, size of administrative unit, etc.

13. PRESENT SITUATION OF NGD

13.1. The Present Situation of NGD

NGD is the surveying, aerial photography and mapping authority of the Lao PDR. Its responsibility is to control, to inspect and also to plan and to implement if needed, surveying, aerial photography and mapping activities.

13.2. Products and Services

NGD's main products are topographic maps, thematic maps, photomaps and aerial photos. The scales of topographic maps covering the whole country are 1:1,000,000, 1:500,000, 1:200,000, 1:100,000 and 1:50,000. They are now over 20 years old.

As well as selling maps and photos, NGD offers a variety of services, i.e. distribution of geodetic data, dispatching of surveying staff, lending of survey equipment and so on.

13.3. Divisions and Human Resources

Administrative, Planning and Personnel Division	7 persons
Finance Division	6 persons
Cartography Division	15 persons
Photogrammetry Division	20 persons
Survey Division	36 persons
Technology and Science Division	6 persons
Technical Supply and Service Division	15 persons

There are 105 persons. Among these, 80% is in technical jobs and 20% in administrative jobs. Counterparts who participated in technical operation were from Cartography Division, Photogrammetry Division, Survey Division, and Technology and Science Division.

13.4. Facilities

NGD has equipment and processing facilities for most mapping activities such as computers, computer network, GPS equipment, analytical plotters, mapping software and map size plotters. Aerial photography camera and film processing laboratory are missing. Existing map printers do not work.

13.5. Finance

The activities of NGD are first of all financed from the national funds, which primarily cover minimum salaries and materials. NGD generates income through selling maps and surveying

services. All the income generated through selling maps goes to the national treasury. But, according to the provisional agreement with Prime Minister's Office, NGD is presently able to use about 80% of the income generated from surveying services for operational costs and additional salaries to employees.

It is found that fluctuation of annual income is very large and fluctuation of money returned to the national treasury is also large. Consequently, expenditures for operating costs such as surveying, map printing, water and electricity are not constant. But, national funds do not seem to alleviate the fluctuation.

14. USES OF THE GIS DATABASE

The GIS database provides the framework to be used in various fields of usage. Several usages are exemplified below:

(i) Watershed Management

- Topographic analyses for picturing geographical characteristics of watershed
- Planning of allocation and rehabilitation of meteor-hydrological stations

(ii) Water Distribution Planning

- Monitoring and coordinating of water uses for end-users
- Macro-level planning of water distribution

(iii) Hydropower Development

- Finding of suitable topographies for potential dam sites for rough planning
- Approximate estimation of population, properties, forest

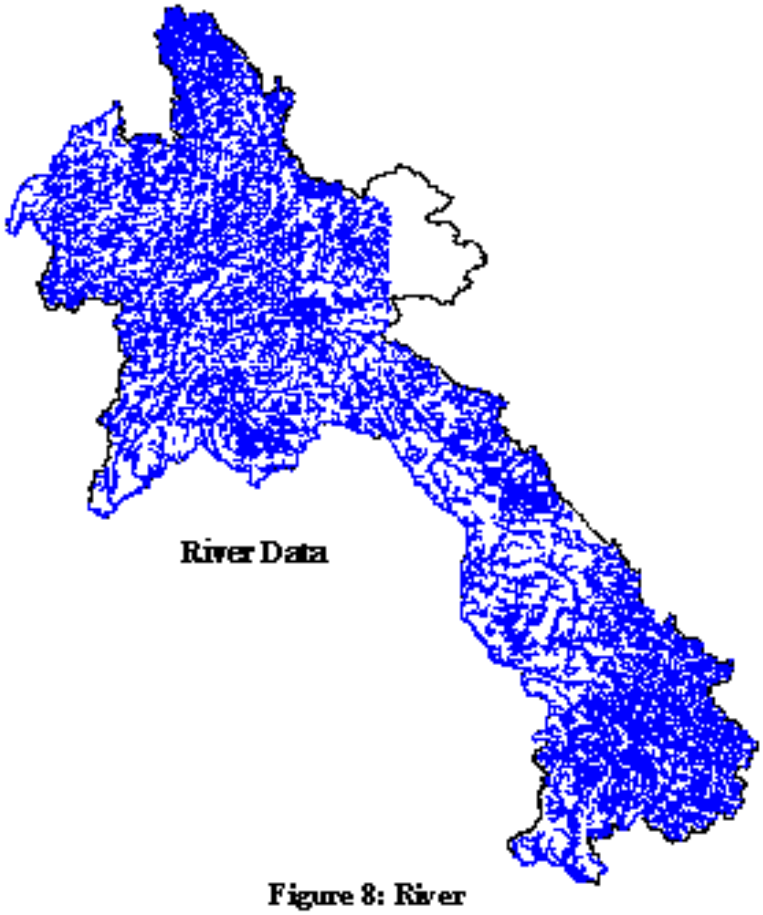

Figure 8: River

cover and land use to be drowned

- Market research for electrification using built-up area data with population and production data
- Prioritization of transmission line network and substation system using contour data and DEM

(iv) Soil Survey and Land Classification

- Soil mapping
- Analyses of soil suitability for agriculture and forestry

(v) Agriculture Planning

- Irrigation planning
- Cropping planning

(vi) Forestry

- Mapping of forest cover and its change
- Monitoring of illegal deforestation
- Mapping of soil and its erosion

(vii) Environment

- Monitoring and analyzing environmental changes
- Formulation of measures for environment conservation and utilization

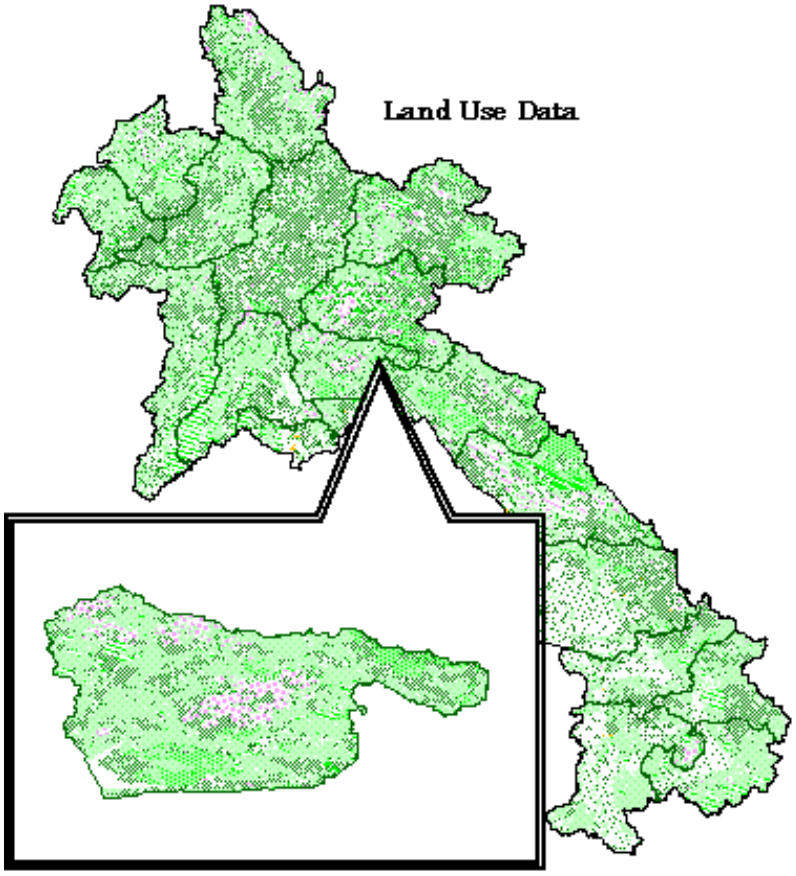

Figure 9: Land Use

(viii) Mining

- Field surveying of geology and mines using digital map of up-to-date information

- Digital compilation of geological map using contour data and DEM
- Preparation of 3D perspectives of geologic structure using DEM

(ix) UXO

- Mapping of unexploded ordnances
- Analysis of population, industry and ground surface condition

(x) Natural Disaster Prevention

- Mapping of past disasters
- Hazard mapping for landslide in mountainous areas using DEM and other thematic data
- Floods in lowlands and riverbank erosions in urbanized areas
- Estimation of damages caused by anticipated disasters

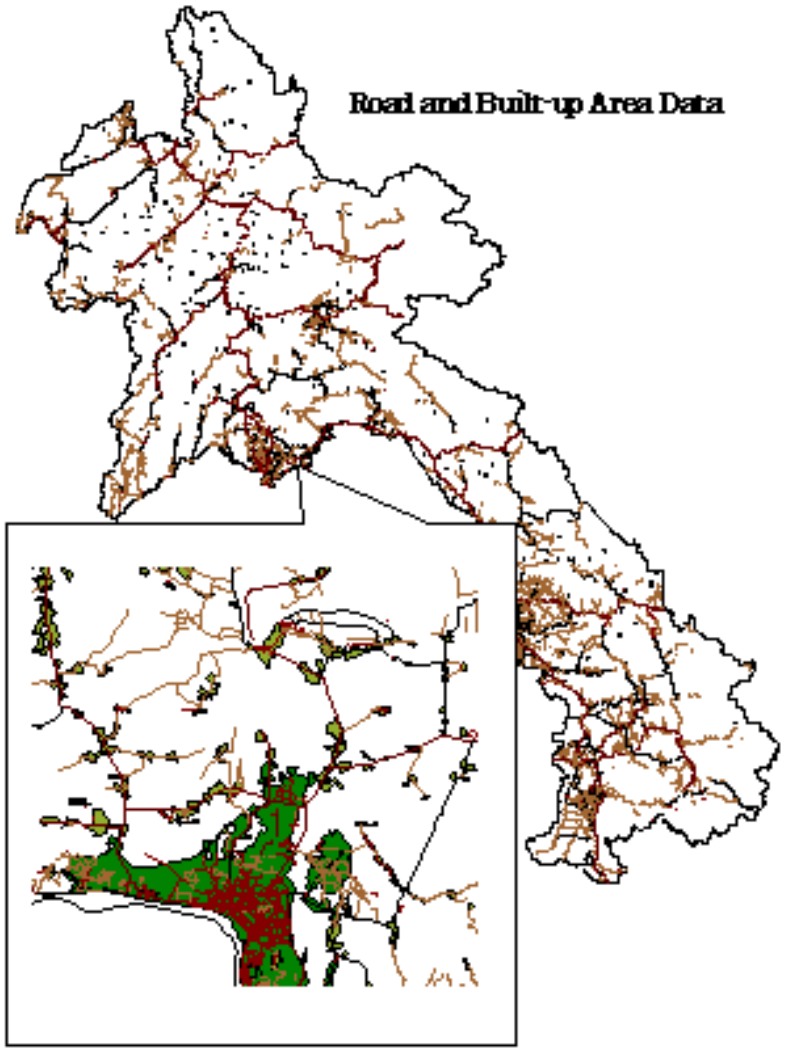

Figure 10: Road, Built-up Area

(xi) Tourism

- Touring route planning
- Estimation of accessibility and cost
- Mapping of traditional culture, historical places and scenic places

(xii) Communications

- Road planning, management and maintenance
- Master planning of telecommunication line
- Estimation of the areas to be benefited by radio wave

(xiii) Health and Medical Service

- Mapping of the districts benefited by primary health care
- Epidemiological analyses
- Drinking water supply planning

(xiv) Education

- Inventory of existing schools
- School allocation planning

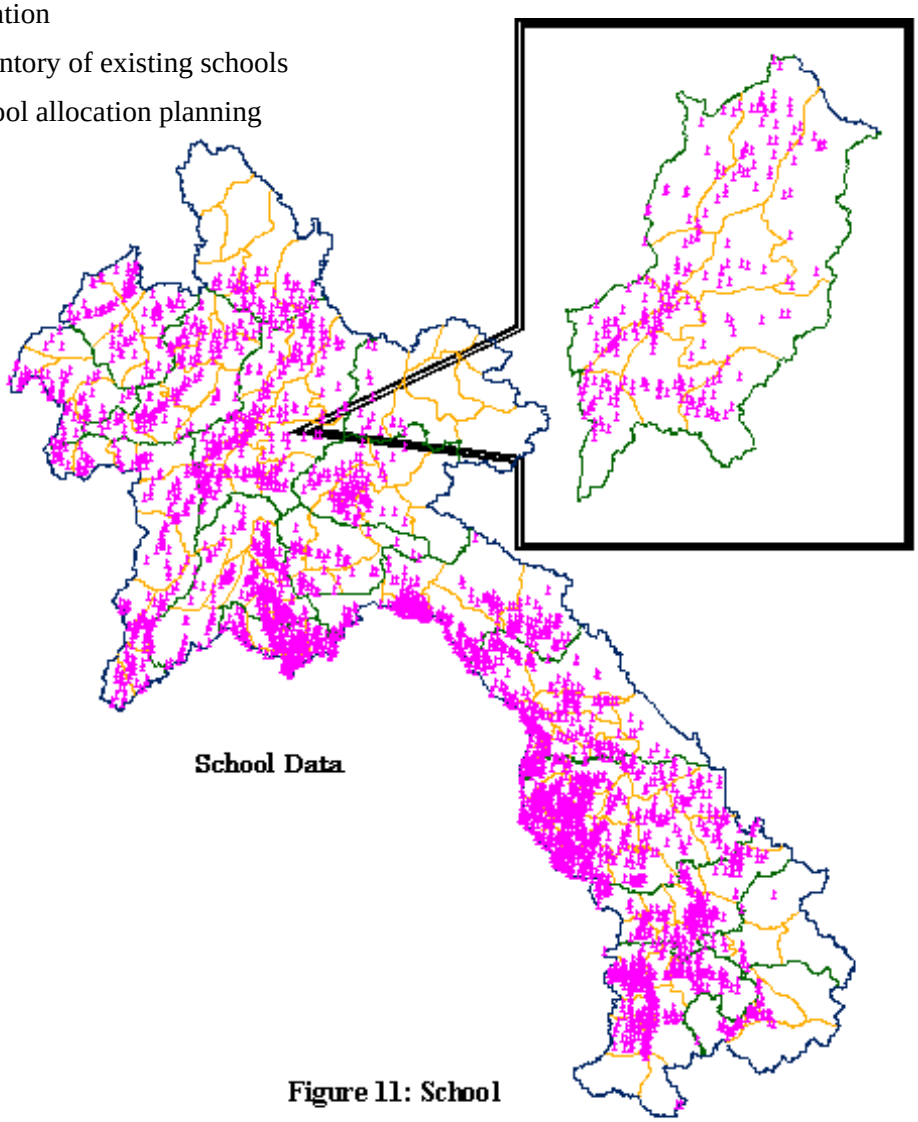

Figure 11: School