No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
NATIONAL GEOGRAPHIC AND HYDROGRAPHIC INSTITUTE

# THE ESTABLISHMENT OF A DATABASE FOR GEOGRAPHIC INFORMATION SYSTEMS OF THE CAPITAL AREA IN THE REPUBLIC OF MADAGASCAR

## FINAL REPORT
## (Main)

November 1999

KOKUSAI KOGYO CO., LTD.

SSF
JR
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**Seminar (handing over of the results)**

**Seminar (explanation of the project outline)**


**Workshop (database construction)**


**Workshop (geographic information system)**


Signing of the Inception Report MM
(November 12, 1998)


Explanation and discussions on the Inception
Report (November 9, 1998)

**Signing of the Interim Report MM (June 25, 1999)**

**Explanation and discussions on the Interim Report (June 21, 1999)**


**Signing of the Draft Final Report MM (September 14, 1999)**


**Explanation and discussions on the Draft Final Report (September 13, 1999)**

# PREFACE

In response to a request from the Government of the Republic of Madagascar, the Government of Japan decided to conduct the study on the Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Isao Ikeshima of Kokusai Kogyo Co., Ltd. to Madagascar, four times between October 1998 and September 1999.

The team held discussions with the officials concerned of the Government of the Republic of Madagascar, and conducted field surveys, such as aerial photography and control point survey, at the study area. Upon returning to Japan, the team conducted further studies, such as aerial triangulation, digital plotting and compilation and database macro programming, and prepared the database for Geographic Information Systems, together with this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to all the officials concerned of the Government of Madagascar for their close cooperation extended to the team.

November 1999

Kimio Fujita
President
Japan International Cooperation Agency

## LETTER OF TRANSMITTAL

Kimio Fujita
Director
Japan International Cooperation Agency

Dear Sir,

It is a great honor to submit herewith the final report of the Study on the "Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar".

The study team, led by me, implemented the study from October 1998 to November 1999 in accordance with the contract established with the Japan International Cooperation Agency (JICA).

The study team carried out discussions with the concerned officials of the Government of the Republic of Madagascar and field surveys, e.g. aerial photography, control point survey, etc. at the site. In Japan, aerial triangulation, digital plotting and compilation, and facility management system macro-programming were carried out to construct the GIS database system. This report summarizes the details of the database construction work and the proposals for the utilization of the database in the future.

On behalf of the team, I wish to express my heartfelt appreciation to the concerned officials of the Government of Madagascar and the concerned agencies for the warm friendship and cooperation they have extended to us during our stay in Madagascar.

I also wish to express my sincere gratitude to JICA, the Ministry of Foreign Affairs, the Ministry of Construction, and the Embassy of Japan in Madagascar, as well as the government authorities concerned for the valuable advice and cooperation they have provided us in the course of the site surveys and preparation of the final report.

Yours Sincerely,

November 1999

Isao Ikeshima
Study Team Leader
Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AGETIPA | Executive Agency for Public Infrastructure Works of Antananarivo |
| BDU | Urban Development Bureau |
| DF/R | Draft Final Report |
| F/R | Final Report |
| FTM | Foiben-Taosarintanin'i Madagasikara (National Geographic and Hydrographic Institute) |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| IC/R | Inception Report |
| IMS | Infrastructure Management System |
| IT/R | Interim Report |
| JICA | Japan International Cooperation Agency |
| JIRAMA | Electricity and Water Company of Madagascar |
| M/M | Minutes of Meeting |
| S/W | Scope of Work |
| TELMA | Telecom Malagasy |
| TOR | Terms of Reference |
| UNDP | United Nations Development Program |
| WGS84 | World Geodetic System 84 |

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# CHAPTER 1 OBJECTIVES OF THE STUDY

The objectives of this study are: (1) to construct a geographic information system (GIS) database (urban base map (topographic map) data, land condition data, and land use data; 1:10,000 scale level) for the preparation of an urban infrastructure development plan and urban plan for Antananarivo City and its surrounding areas, and (2) to construct urban facility databases (roads, waterworks, sewerage, and electricity and communications facilities) for the pilot area (15km$^2$ of the study area).

The study also aimed to transfer techniques to the counterparts through the conduct of the work and workshops.

The scope of the study is shown in *Fig. 1.1 Study Area Location Map.*

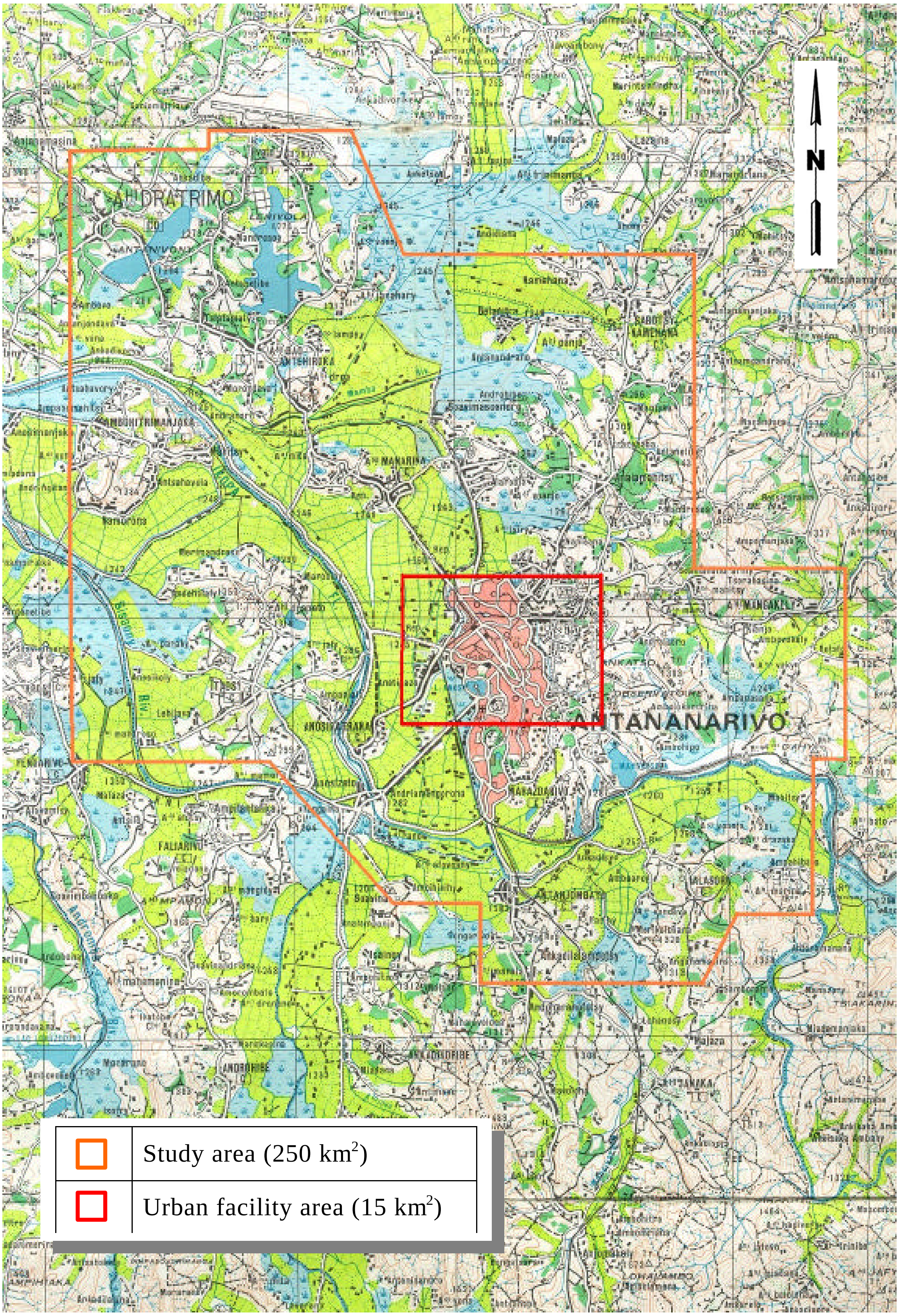



**Fig. 1.1 Study Area Location Map**

# CHAPTER 2 CONTENT OF THE STUDY

## 2.1 Background of the Study

Antananarivo City, the capital of the Republic of Madagascar, is the largest city in the country with a population of 1.6 million (1994 estimate). As in other developing nations, urban and rural standards of living significantly differ, resulting in the huge influx of rural migrants to the urban area. Accordingly, the drastic increase in the city's population is feared to result in the further deterioration of the living environment as urban infrastructures become incapable of coping with the situation.

Given this condition, the preparation of an urban development plan for the city is urgently required. Although an urban development plan was created in 1974 with the help of the French government, the plan has only been revised once, in 1982.

The French government also extended assistance in the production of topographic maps essential to planning. Topographic maps at a scale of 1:50,000 to 1:100,000 were produced around 1930, and another at a scale of 1:100,000 was produced 60 years ago and revised in 1975.

In 1985, the basic policy for urban planning in Antananarivo was formulated through the United Nations Development Program (UNDP). However, concrete plans could not be made due to the absence of basic information, e.g. latest topographic maps, making the provision of geographic data for the improvement of urban facilities an urgent concern. Madagascar also lacks the technology and experience in large scale topographic mapping, digitizing, and the construction of geographic information systems, which are needed for urban planning.

Given this background, the Government of Madagascar requested assistance from the Japanese government in August 1996 for the production of a large scale map and the construction of GIS databases in order to formulate an urban development plan and urban infrastructure improvement plan.

In response to the request, the Japanese government dispatched a preparatory study team to Madagascar, 10 to 28 February 1998, and then a preliminary study team from 27 June to 6 July 1998. During this period, the preliminary study team held discussions with relevant government agencies in Madagascar and concluded the Scope of Work. The study commenced in October 1998 and was completed in November 1999.

## 2.2 Study Specifications

This study constructed the urban base map database, land condition database, land use database, and urban facility databases according to the following specifications.

① Urban base map database

- The survey standards adopted for urban base map production are as follows.
  Reference ellipsoid: Hayford International (1924 ellipsoid）
  Projection Method: Laborde Madagascar Projection
- Aerial photography was carried out in black and white, at a scale of 1:20,000
- For ground control point survey, GPS was carried out for horizontal positioning and direct leveling for height.
  The observation accuracy adopted for direct leveling was the accuracy for ordinary leveling (within 50mm $\sqrt{S}$ error of closure from one known point to another, with S representing observation distance; a discrepancy of within 20mm $\sqrt{S}$ for double running observation; with S for observation distance) stipulated in the Base Mapping Regulations of JICA.
- The bundle method and block adjustment were adopted for aerial triangulation.
- Digital plotting was carried out at a scale of 1:10,000, with an interval of 5m between intermediate contours and 2.5m between supplementary contours.
- The map symbols used were the symbols for digital mapping concluded through discussions with the FTM.
- A unified code system and layer configuration for topographic and planimetric features were established in accordance with the map symbols.
- Data in each topographic database were classified into points, lines, and surface data.
- Topographic map characteristics were allocated to each data whenever necessary.

② Land Condition Database and Land Use Database

- The land condition map was divided into 19 categories, largely classifying the study area into 3 sections (hills, plain, others) and further subdividing these sections.
- The land use map was divided into 14 categories using the symbols of the urban base map as a basis.
- Each data was made into a polygon data.

③ Urban Facility Databases

- Each facility database is made up of feature data representing the physical components (pipes, manholes, overhead wiring, cables, etc.) of each facility and attribute data for secular information.
- Data on map features consist of point, line and surface data, each allocated a symbol showing the characteristics of the facility involved whenever necessary.
- Attribute data consists of secular information (pipe diameter, length, height, date of construction, etc.).
- The map feature data and attribute data were linked using ID numbers.

## 2.3 Study Plan by Year & Implementation

*Table 2.1 Study Plan by Year and Implementation* below shows the study work by fiscal year (FY) and their implementation.

### Table 2.1 Study Plan by Year and Implementation

| FY | Work Item | Outline | Volume |
|---|---|---|---|
| First Fiscal Year | **(1) Preparatory Work** | | |
| | 1. Collection of relevant data | Collection of data and materials relevant to the study | |
| | 2. Preparation of the Inception Report (IC/R) | Study of implementation policies and preparation of the IC/R | 15 sets in English<br>20 sets in French |
| | **(2) First Study Work in Madagascar** | | |
| | 1. Explanation & discussion of the IC/R | The IC/R was explained and discussed with the Madagascar side for approval | |
| | 2. Collection of relevant data | Confirmation of the contents of the databases to be constructed and collection of data | |
| | 3. Database design | The design of the databases was established after discussions were held on the classification of geographic information, data structure, and representation of codes. | |
| | 4. Air photo signal installation | Installation of air photo signals prior to aerial photography. | Approx. 20 points<br>**(21 points installed)** |
| | 5. Aerial photography | Aerial photography (black & white photos at a scale of 1:20,000) | Approx. 250 $km^2$ |
| | 6. Aerial photo processing | Processing of aerial photographs | |
| | 7. Control point survey | To be carried out during the GPS survey; leveling carried out as well. | Approx. 8 points; 55 km<br>**(17 points surveyed)** |
| | 8. Compression & correction of topographic map (1:2,000) | The existing map was compressed to a scale level of 1:10,000, and revised. | Approx. 30 $km^2$<br>**(34 $km^2$ covered)** |
| | **(3) First Work in Japan** | | |
| | 1. IMS macro-programming 0 | Macro-programming of the software for the data-bases to be constructed according to the design established during the first study work in Madagascar. | |
| | 2. Aerial triangulation | Aerial triangulation was carried out based on the results of the control point survey | Approx. 56 models<br>**(98 models obtained)** |
| | 3. Compression & correction of topographic map data (1:500) | The existing map data were compressed to a scale level of 1:10,000, and revised. | Approx. 50 $km^2$<br>**(52 $km^2$ covered)** |
| | 4. Topographic map data (1:500) revision and digital plotting of contour lines | Contour lines in the compressed and edited map were plotted, and revisions were carried out as to changes in topographic and planimetric features | Approx. 50 $km^2$<br>**(52 $km^2$ covered)** |
| | 5. Digital plotting of the urban base map | Areas not covered by existing maps were plotted. | Approx. 170 $km^2$<br>**(164 $km^2$ plotted)** |
| | 6. Digital compilation of the urban base map | Digital compilation of data plotted in item 5. | Approx. 170 $km^2$<br>**(164 $km^2$ compiled)** |
| | 7. Photo-interpretation & compilation of land use and land condition data | Based on the aerial photos and existing data, land use (about 10 categories added to those in the urban base map) and land condition were classified and indicated in the drawing bearing the data obtained under item 8 of (2), and 3 and 5 of (3). | Approx. 250 $km^2$ |
| | **(4) Second Work in Madagascar** | | |
| | 1. Collection and formulation of urban facility data | Collection and formulation of data on 4 types of urban facilities (i.e., sewerage, waterworks, utility poles, road structure) in the pilot area. | Approx. 15 $km^2$ |
| | **(5) Second Work in Japan** | | |
| | 1. Preparation of the Interim Report (IT/R) | The IT/R was formulated, summarizing the work carried out in the first study year. | 15 sets in English<br>20 sets in French |

| FY | Work Item | Outline | Volume |
|---|---|---|---|
| Second Fiscal Year | **(6) Third Work in Japan (1)** | | |
| | 1. DBMS macro-programming 1 | Macro-programming of the software for the database to be constructed according to the design to be established during the first study work in Madagascar. | |
| | **(7) Third Work in Madagascar** | | |
| | 1. Explanation and discussion of the IT/R | The IT/R was explained and discussed with the Madagascar side for approval. | |
| | 2. IMS macro-programming 2 | The program constructed during the third work in Japan was discussed with the Madagascar side to determine items that have to be revised. | |
| | 3. Field survey for the urban base map | A field survey was carried out to confirm planimetric features, administrative boundaries and place names undecipherable in aerial photos and existing maps. | Approx. 250 $km^2$ |
| | 4. Digitizing of urban facility data | Data on urban facility were digitized using the digital compilation manuscript of the urban base map as reference. | Approx. 15 $km^2$ |
| | 5. Field survey on land use and land condition | A field survey was carried out to confirm land use and land condition undecipherable in aerial photos and existing maps. | Approx. 250 $km^2$ |
| | **(8) Third Work in Japan (2)** | | |
| | 1. Preparation of the Draft Final Report (DF/R) | The DF/R was formulated, summarizing all the work carried out prior to this period. | Main:<br>15 in English<br>20 in French<br>Summary:<br>15 in English<br>20 in French<br>10 in Japanese |
| | 2. Recommendations | Recommendations were made on how to improve all aspects of work involved in the construction of a database, and with regards to database operation and maintenance. | |
| | 3. IMS macro-programming 3 | The program corrected during the third work in Madagascar was revised. | |
| | 4. Supplementary compilation for the urban base map | Supplementary compilation for the urban base map was carried out based on the results of the field survey during the third work in Madagascar. | Approx. 250 $km^2$ |
| | 5. Structuring of urban base map data | The digital data formulated during the supplementary compilation of the urban base map was structured. | |
| | 6. Official approval | The urban base map was presented to the Japan Association of Surveyors for approval. | |
| | 7. Digitizing land use and land condition data | Land use and land condition data were digitized based on the results of the field survey carried out in the third work in Madagascar. | Approx. 250 $km^2$ |
| | 8. Structuring of land use and land condition data | The digital data on land use and land condition wereconverted into polygons and granted attributes. | |
| | **(9) Fourth Work in Madagascar** | | |
| | 1. Explanation and discussion of the DF/R | The DF/R was explained and discussed with the Madagascar side. | |
| | 2. Workshop | A workshop on the formulation, maintenance, and utilization of geographic information was held for the users and the engineers who will be directly involved with the operation of the geographic database in Madagascar. | |
| | 3. Database system and IMS installation | The urban base map database, land use database, land condition database, and urban facility databases were integrated and arranged under the software program (IMS) which was corrected during the third work in Japan (2). | |

| FY | Work Item | Outline | Volume |
|---|---|---|---|
| | **(10) Fourth Work in Japan** | | |
| | 1. Preparation of the Final Report (F/R) | The F/R was formulated, incorporating the comments of the Madagascar side on the DF/R. | Main:<br>15 in English<br>20 in French<br>Summary:<br>15 in English<br>20 in French<br>10 in Japanese |
| | 2. Formulation of the IMS User's Manual | A user and operation manual for the IMS interface was prepared | 20 sets in English<br>30 sets in French |
| | 3. Creation of a CD-ROM | The database constructed during the third work in Japan was stored in a CD-ROM. | 53 |
| | 4. Outputs | The maps in the databases constructed during the third work in Japan were printed out. | 23 copies each |

The major differences in the plan prior to the commencement of the study and the results of the study were the quantity of the established new ground control points and the number of models used for aerial triangulation.

The increase in the new ground control points is attributed to the unintentional failure to establish the control points initially planned.

The increase in the number of models for aerial triangulation is attributed to setting an overlap much higher than necessary in an effort to prevent gaps in the flight coverage which was a possibility due to restrictions in shooting.

*Table 2.2 Work Progress* below shows the progress of the work from October 1998 to November 1999.

## Table 2.2 Work Progress

| Work Item | 1998 | | | 1999 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Collection of relevant data | ■ | | | | | | | | | | | | | |
| Explanation & discussion of the Inception Report | | ■ | | | | | | | | | | | | |
| Air photo signal installation | | ■ | | | | | | | | | | | | |
| Aerial photography and photo processing | | ■ | | | | | | | | | | | | |
| Control point survey | | ■ | ■ | | | | | | | | | | | |
| IMS macro-programming | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Optimization & use of existing digital data | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Aerial triangulation | | | ■ | | | | | | | | | | | |
| Digital plotting of urban base map | | | | ■ | ■ | ■ | ■ | | | | | | | |
| Digital compilation of urban base map | | | | | ■ | ■ | ■ | ■ | | | | | | |
| Interpretation & compilation of land use & land condition data | | | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Collection & creation of urban facility data | | | | ■ | ■ | ■ | ■ | | | | | | | |
| Field survey for the urban base map | | | | | | | | | ■ | ■ | | | | |
| Digitizing of urban facility data | | | | | | | | ■ | ■ | ■ | | | | |
| Field survey on land use & land condition | | | | | | | | | ■ | ■ | | | | |
| Supplementary compilation for the urban base map | | | | | | | | | | | ■ | | | |
| Structuring of urban base map data | | | | | | | | | | | ■ | | | |
| Digitizing of land use & land condition data | | | | | | | | | | | ■ | | | |
| Structuring of land use & land condition data | | | | | | | | | | | ■ | ■ | | |
| Workshop | | | | | | | | | | | | ■ | | |
| Database and IMS installation | | | | | | | | | | | | ■ | | |
| Formulation of IMS User's Manual | | | | | | | | | | | | | ■ | ■ |
| Creation of CD-ROM, outputs | | | | | | | | | | | | | ■ | ■ |

## 2.4 Study Team Members and Counterparts

The JICA Study Team members and the FTM counterparts in the first fiscal year are as shown in the following table.

| JICA | Function | FTM |
|---|---|---|
| Mr. Isao IKESHIMA | Team leader | Mr. NARY Herilalao Iarivo |
| Mr. Mamoru TAKAHASHI | Database | Mr. RAKOTOVAO Manarivo |
| Mr. James WILKINSON | Infrastructure management system | Mr. RAHAINGOALISON Narizo |
| Mr. Akira NISHIMURA | Infrastructure management system | |
| Mr. Morten STRAND | Supervision of aerial photography and control point survey | Mr. RABEMALAZAMANANA |
| Mr. Satoru NISHIO | Urban facilities | Mr. RANDRIAMANANA Fidèle |
| Mr. Ken-ichi SHIBATA | Land use and land conditions | Ms. RATOVOARISON Nivo<br>Mr. LI HAN TING |
| Ms. Marie-Line CHARLES | Interpreter | |
| Ms. Odile GAYON | Coordinator | Mr. RAVELOMANANTSOA Josoa |

The JICA Study Team members and the FTM counterparts in the second fiscal year are as shown in the table below.

| JICA | Function | FTM |
|---|---|---|
| Mr. Isao IKESHIMA | Team leader | Mr. NARY Herilalao Iarivo |
| Mr. Mamoru TAKAHASHI | Database | Ms NARY Herinirina Iarivo |
| Mr. James WILKINSON | Infrastructure management system | Mr. RAHAINGOALISON Narizo<br>Mr. RAJAONARISON J. Désiré |
| Mr. Satoru NISHIO | Urban facilities | Mr. RAJEMISON Michel |
| Mr. Ken-ichi SHIBATA | Land use and land conditions | Ms. RATOVOARISON Nivo<br>Mr. LI HAN TING |
| Ms. Marie-Line CHARLES | Interpreter | |
| Ms. Odile GAYON | Coordinator | Mr. RAVELOMANANTSOA Josoa |

## 2.5 Background for GIS Introduction

### (1) Problems of Antananarivo City

Antananarivo City is faced with the following problems.

- Historically, villages make up the hilly regions where soil erosion potential is high.
- Flat and low-lying grounds make up the plain where inefficient drainage conditions result in constant flooding.
- Inefficient infrastructure due to the continuous influx of a large number of rural migrants into the city.
- Absence of an urban development plan to counteract the various problems above-mentioned.

### (2) Necessary Countermeasures

- Planning and implementation of suitable land use and soil erosion control measures through erosion control projects.
- Suitable land use planning, etc., through the formulation and implementation of flood control measures.
- Formulation of appropriate urban development plan and urban facility plan to cope with extremely fast urbanization.
- Collection of all types of basic information, including their unified management, essential to the implementation of the various countermeasures above-mentioned.

### (3) Necessary Tools

- For soil erosion, a tool that would enable the forecast of soil erosion potential is required.
- For flooding, a tool that would determine the nature of flooding occurrences and forecast inundation is required.
- For urban infrastructure, a tool that would enable infrastructure maintenance and the preparation of a new development plan is required.
- The digitization of information to enable unified data management is necessary as a first step to the realization of the tools above-mentioned.

### (4) Database

Data digitization and structuring were carried out to enable the effective use of the database in the future.

### (5) Establishment of GIS

GIS is equipped with various functions, and its establishment is indispensable for the effective use of the database constructed.

### (6) Advantages of GIS and Digital Databases

Aside from the usage previously mentioned, the constructed databases and GIS further provide invaluable information as they hold, analyze, and calculate various data.

Here are some concrete examples of GIS and digital database applications:

- Urban planning
- Installation of facilities
- Prevision of flood and disaster
- Systematic land use

# CHAPTER 3 DATABASE OUTLINE

## 3.1 Urban Base Map

### 3.1.1 Collection of Relevant Data

The materials required for the construction of the urban base map database were collected and are shown in the table below.

**Table 3.1 Collected Data**

| Classification | Data | Responsible Body | Remarks |
|---|---|---|---|
| Control points | Control point survey results<br>Levelling results | FTM | |
| Existing aerial photos | 1:10,000 aerial photos | FTM | Taken in 1997 |
| Existing topographic maps | 1:10,000 topographic map<br>1:20,000 topographic map<br>1:50,000 topographic map<br>1:100,000 topographic map<br>1:500,000 topographic map<br>1:2,000,000 road map<br>1:10,000 tourist map | FTM | Only for the study area |
| Existing digital data | 1:500 digital data | AOC | Vicinity of Antananarivo (for fixed property/assets) |
| | 1:2,000 digital data | BDU | The above was compiled by reduction |
| | 1:2,000 digital data | FTM | For fixed property assets |
| Map symbols | 1:10,000 analog map symbols (existing maps)<br>1:10,000 marginal information (existing maps)<br>1:50,000 analog symbols (existing maps)<br>1:10,000 tourist map (existing maps)<br>1:2,000 digital symbols (output maps)<br>BD200 data – explanatory leaflet | FTM | Absence of regulations, e.g., map symbol regulations, acquisition standards, etc. |
| Place names/ administrative boundaries | Names of towns, villages and districts, administrative boundaries, and other place names, etc. | Ministry of Home Affairs | Digitized by FTM based on materials and field studies |

Discussions were held with the Madagascar side on the collected data, and the following were decided.

① Survey Standards and Work Regulations

Work regulations adopted for general survey work, e.g. ground control point survey, etc., were basically in accordance with those established by JICA. Discussions were held with the FTM whenever deemed necessary.

② Use of Control Points Survey Results

The known points as of previous FTM survey results were used for air signal installation, ground control point survey, and bench mark survey. The existing 1:10,000 aerial photos were also used for leveling.

③ Selection of Digital Map Symbols

New digital map symbols were created from the present analog map symbols and the digital map symbols currently in use in Madagascar (refer to *3.1.2 Map Symbol Classification*).

As much as possible, the map symbols for control points and for topographic representation were made in accordance with the old symbols. For roads, the symbols reveal the standard representation of true road widths, paths for light vehicles, and crosswalks, and distinguish paved roads from the unpaved. For buildings, a number of symbols have been added to represent public buildings, e.g. municipal and city halls, thereby enhancing the usefulness of topographic maps. For administrative boundaries, new administrative divisions were established and in consideration of this change, the representative symbols were reconsidered.

The annotations of place names were also determined in accordance with existing survey maps (refer to *3.1.3 Annotation Standards*)

The classification codes for each symbol are made up of 4 digits and are serially arranged in numbers by item category.

As a result of modifications in the map symbols, discussions were carried out regarding changes in the marginal design of the map. Fundamentally, the changes were in accordance with former topographic map marginal designs, and the legend was revised. The discussion also concluded the inclusion in the map of the annotation below.

> *This data was prepared jointly by Japan International Cooperation Agency(JICA) under the Japanese Government Technical Cooperation Program and the Government of Madagascar.*

Note: This will be annotated in French in the map.

④ Collection of Existing Digital Data (1:500, 1:2,000)

A study was carried out to determine the type of digital data available in the country. The results of the study clearly indicate the existence of the following three types of digital data.

| | |
|---|---|
| 1/500 digital data: | Digital data (Central Antananarivo and its vicinity) produced by AOC |
| 1/2000 digital data: | Compressed and edited (by BDU) version of the above data. |
| 1/2000 digital data: | Digital data (Eastern Antananarivo) produced by FTM |

The usage of the existing digital data was studied under section *3.1.4 Urban Base Map Production Method* subheading *4) Optimization and use of existing digital data*.

⑤ Collection of data on place names and administrative divisions

For the construction of the urban base map database, FTM conducted a study on new administrative divisions and place names, and the administrative annotations and data on administrative boundaries were digitized. The study team received and edited the data after entering it into the base map database.

## 3.1.2 Map Symbol Classification

# Table 3.2 Map Symbol Classification (1)

| SEQ NO. | Feature Class | Feature Code | Description French | Description English | Description Japanese | Symbols | Data type Color | Area | Line | Circle | Arc | Point | Direc-tion | Descri-ption | Const-ruction | Attri-bute | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Points** | 1001 | Point géodésique | Triangulation point | 三角点 | △1438 | Black | | | | | ● | | | | ● | ・Elevation value is annotated.<br>・Values with one decimal will be rounded off.<br>・Real point position = center of the symbol. |
| 2 | | 1002 | Point géodésique (église) | Control point (church) | 基準点（教会） | ⊙1366 | Black | | | | | ● | | | | ● | ・Elevation value is annotated.<br>・Values with one decimal will be rounded off.<br>・Real point position = center of the symbol. |
| 3 | | 1003 | Point géodésique (château d'eau) | Control point (water tank) | 基準点（給水塔） | Blue<br>Black<br>Light blue ⊙1366 | | | | | | ● | | | | ● | ・Elevation value is annotated.<br>・Values with one decimal will be rounded off.<br>・Real point position = center of the symbol. |
| 4 | | 1004 | Repère de nivellement | Bench mark | 水準点 | ⊙1366 | Black | | | | | ● | | | | ● | ・Elevation value is annotated.<br>・Values with 2 decimals will be rounded off.<br>・Real point position = center of the circle. |
| 5 | | 1005 | Point coté | Elevation point | 標高点 | ・1261 | Black | | | | | ● | | | | ● | ・Elevation value is annotated.<br>・Values with one decimal will be rounded off. |
| 6 | **Terrain Shape** | 1101 | Courbe normale | Intermediate contour line | 主曲線 | | Brown | | ● | | | | | | | ● | ・Interval: 5m ・Elevation = attribute<br>・Continuous line ・Hidden line (buildings, roads, rivers, cliffs, elevations) |
| 7 | *Configuration du terrain* | 1102 | Courbe maîtresse | Index contour line | 計曲線 | | Brown | | ● | | | | | | | ● | ・Interval: 25m ・Elevation = attribute<br>・Continuous line ・Hidden line (buildings, roads, rivers, cliffs, elevations) |
| 8 | | 1103 | Courbe intercalaire | Supplementary contour line | 補助曲線 | | Brown | | ● | | | | | | | ● | ・Interval: 2.5m ・Elevation = attribute<br>・Continuous line ・Hidden line (buildings, roads, rivers, cliffs, elevations) ・Hyphen: 2mm; hyphen interval : 0.5mm |
| 9 | | 1114 | Cuvette | Depression | 凹地記号 | Contour | Brown | | | | | ● | | | | | ・Correspond to natural depressions of the relief.<br>・Arrow only (the contour is not part of the symbol). |
| 10 | | 1201 | Routes, voies ferrées: en remblai | Fill road symbol | 盛り土の道路・鉄道 | | Black | | ● | | | | | | | | ・Earth embankments and cuts along roads and railway tracks. Slope: ≧1/2. Difference in elevation: ≧ 2m; length: ≧ 50m. ・Represented symbol: hachure interval = 1.0mm; hachure length = 0.5mm<br>・Acquired data: upper line only<br>・Orientation (hachures oriented to the right). |
| 11 | | 1202 | Routes, voies ferrées: en déblai | Cut road symbol | 切土の道路・鉄道 | | Black | | ● | | | | | | | | |
| 12 | | 1203 | Talus | Earth cliff | 土崖 | | Brown | | ● | | | | | | | | ・Applicable to steep slopes (earth cliffs), except fills and cuts for roads and railway tracks. |
| 13 | | 1204 | Escarpement rocheux | Rocky cliff | 岩崖（小） | | Black | | ● | | | | | | | | ・Applicable to steep slopes (rocky cliffs), except fills and cuts for roads and railway tracks. |
| 14 | | 1205 | Rochers | Rocks | 岩崖（大） | | Black | | ● | | | | | | | | ・Applicable to rocky cliffs ≧ 15 m.<br>・Symbol: hachure interval = 1.0mm; hachure length = 1.5mm. ・Acquired data: upper line<br>・Orientation (hachures oriented to the right). |
| 15 | | 1206 | Levée de terre | Embankment | 土堤 | | Brown | | ● | | | | | | | | ・Width of embankment top: less than 2 m; Height: ≧1.5 m; length: ≧ 50m. ・Symbol: hachure interval = 1.0mm; hachure length = 1.0mm）<br>・Acquired data: center line. |
| 16 | | 1207 | Grotte | Cave | 洞口 | | Black | | | | | ● | | | | | ・Entrance of natural excavation. |
| 17 | | 1208 | Dômes granitiques | Scattered rocks | 岩 （円頂丘） | | Black | | | | | ● | | | | | ・Applicable to rock outcrops.<br>・Circle diameter: 0.5mm, hachure length: 0.5mm. |
| 18 | | 1209 | Etendue de sable | Sand, beach | 砂地（砂丘） | S | Black | | | | | ● | | | | | ・Land covered with sand. Symbol placed in the middle of the sand area.<br>・Delimited by land use boundary. |
| 19 | | 1210 | Mur de soutènement | Retaining wall | 擁壁 | | Black | | ● | | | | | | | | ・Concrete or masonry construction which protects slopes. Symbol applicable to height ≧ 3m and length ≧ 50m .<br>・Acquired data: upper line only<br>・Orientation (half-circles oriented to the right). |
| 20 | | 1211 | Barrage | Dam | 堰 | | Black | | ● | | | | | | | | ・Built on river to control the flow, or water intake.<br>・Big dams: shown by surface.<br>・Real dam position at center of symbol.<br>・Acquired data: from left to right bank. |
| 21 | **Transport** | 2001 | Route revêtue: principale | Paved road: main | 舗装道路：真幅道路 | | Black | | ● | | | | | | | | ・Large paved road, ≧ 3m (unit: metre).<br>・Roadway only (sidewalks excluded).<br>・Symbol applies also to paved roads. |
| 22 | | 2002 | Route revêtue: très étroite | Paved road: very narrow | 舗装道路：軽車道 | | Black | | ● | | | | | | | | ・Paved roads from 1.5m ~ less than 3m.<br>・Width on the map = 0.3mm. |
| 23 | | 2003 | Route revêtue: chemin, sentier | Paved road footpath | 舗装道路：徒歩道 | | Black | | ● | | | | | | | | ・Paved roads less than 1.5m.<br>・Acquired data: road center line. |
| 24 | | 2011 | Route non revêtue praticable toute l'année: principale | Unpaved road passable all-year-round: main | 未舗装道路：真幅道路 | | Black | | ● | | | | | | | | ・Unpaved roads, width ≧ 3m (unit: meter). |
| 25 | | 2012 | Route non revêtue praticable toute l'année: très étroite | Unpaved road passable all-year-round: very narrow | 未舗装道路：軽車道 | | Black | | ● | | | | | | | | ・Unpaved roads from 1.5m ~ less than 3m.<br>・Width on the map = 0.3mm. |
| 26 | | 2013 | Route non revêtue: chemin, sentier | Unpaved road: footpath | 未舗装道路：徒歩道 | | Black | | ● | | | | | | | | ・Unpaved roads less than 1.5m.<br>・Acquired data: road center line. |
| 27 | | 2014 | Route praticable une partie de l'année | Road passable part of the year | 一時期通行不能道路 | | Black | | ● | | | | | | | | ・Impassable road during a certain period (flood, etc.). Interpreted data, confirmed during completion.<br>・Roads represented in accordance with existing map symbols. |

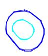
# Table 3.2 Map Symbol Classification (2)

| SEQ NO. | Feature Class | Feature Code | Description French | Description English | Description Japanese | Symbols | Color | Area | Line | Circle | Arc | Point | Direc-tion | Descri-ption | Const-ruction | Attri-bute | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | | 2021 | Zone de séparation, rond-point | Separation zone, rotary | 分離帯・ロータリー | | Black | | ● | | | | | | | | ・Central separations and rotaries less than 3m: represented by one line. 3m and over: represented by real shape. |
| 29 | | 2022 | Escalier | Stairs | 石段 | | Black | | ● | | | | | | | | ・Applicable to stairs: Length ≧10m, width ≧ 1,5m. ・Width on the map: 0.3m. ・Acquired data: central line. |
| 30 | | 2023 | Chemin d'exploitation | Farm road | 庭園路、農路 | | Black | | ● | | | | | | | | ・Applicable to roads inside parks, factories and residential areas. ・Data interpreted and confirmed during completion. ・Representation specifications in accordance with existing maps. |
| 31 | | 2024 | Pont | Bridge | 橋梁 | | Black | | ● | | | | | | | | ・Data interpreted and confirmed during completion. ・Bridge lines thicker than road lines. ・Road edges: unmasked lines. |
| 32 | | 2025 | Tunnel routier | Road Tunnel | 道路のトンネル | | Black | | ● | | | | | | | | ・Same symbol as one side of bridge symbol. ・Roads inside tunnels are masked. |
| 33 | | 2031 | Gare routière | Bus terminal | バスターミナル | | Black | | | | | ● | | | | | ・Representation of stations where bus lines begin and end. ・Applicable to long distance bus stations only. |
| 34 | | 2101 | Chemin de fer (voie principale) | Railway track | 鉄道（本線） | | Black | | ● | | | | | | | | ・Important railway tracks for passengers and cargo. ・Representation in accordance with existing maps. |
| 35 | | 2102 | Voie de garage | Side track | 鉄道（側線） | | Black | | ● | | | | | | | | ・Railway tracks other than main tracks. ・Representation in accordance with existing maps. |
| 36 | | 2111 | Gare | Train station | 駅 | Railway | Red | ● | | | | | | | | | ・Same representation as public or administrative buildings. ・Name of the station as annotation. |
| 37 | | 2112 | Station | Train stop | 小駅(ﾌﾟﾗｯﾄﾌｫｰﾑ) | Railway | Black | | ● | | | | | | | | ・Acquired data: station (platform) outline. ・White symbol. ・Applicable to stations without building. |
| 38 | | 2121 | Tunnel ferroviaire | Train tunnel | 鉄道のトンネル | | Black | | ● | | | | | | | | ・Same symbol as road tunnel (No. 32). ・Railway track inside the tunnel will be masked. |
| 39 | | 2122 | Passage à niveau | Level crossing | 平面交差 | | Black | | | | | ● | | | | | ・Acquired data: Central point of level crossing. ・Will not be represented on the map. |
| 40 | | 2201 | Câble transporteur d'énergie électrique | Power line | 送電線 | | Black | | ● | | | | | | | | ・Applicable to overhead power lines with pylons. ・Symbol in accordance with existing maps. ・Pylon coordinates determined by photo-interpretation. ・Pylons not represented. |
| 41 | | 2202 | Ligne téléphonique | Telephone line | 電話線 | | Black | | ● | | | | | | | | ・Symbol used inside pilot area only. ・Symbol listed in legend. |
| 42 | **Buildings** | 3001 | Construction | Building | 普通家屋 | | Red | ● | | | | | | | | | ・Plotting of individual buildings ≧ 5m x 5m = 25m$^2$. ・Smaller buildings with interval less than 5m will be linked. |
| 43 | *Constructions* | 3002 | Bâtiment administratif ou public | Public or administrative building | 公共建物 | | Blue | ● | | | | | | | | | ・Same criteria as for constructions (No. 41). ・Public buildings identified on site and based on collected documents. |
| 44 | | 4001 | Réservoir (carburant) | Tank (fuel) | 燃料タンク | | Black | ● | ● | | | × | | | | | ・Petrol/gas tank with diameter ≧ 0.5mm on the map. ・Black dot. |
| 45 | | 4002 | Château d'eau | Tank (water) | 貯水タンク | Blue Light blue | | | | | | ● | | | | | ・Water tank with diameter ≧ 0.5mm on the map. ・Symbol diameter: 2mm; color: blue. |
| 46 | | 4003 | Calvaire | Roadside cross | 十字架像 | | Black | | | | | ● | | | | | ・Applicable to roadside crosses which are famous or used as landmarks (the black dot is smaller than the church symbol). |
| 47 | | 4004 | Tombeau | Tombstone | 墓碑 | | Vermil-lion | | | | | ● | | | | | ・Applicable to individual tombstones or small groups of tombs. ・Symbol of existing maps used. |
| 48 | | 4005 | Monument commémoratif / statue | Monument | 記念碑及び立像 | | Black | | | | | ● | | | | | ・Monuments or statues which are famous or used as landmarks. ・Symbol of existing tourist maps used. |
| 49 | | 4006 | Tour hertzienne | Radio tower | 電波塔 | | Black | | | | | ● | | | | | ・Transmitter-receiver radio towers used as landmarks. |
| 50 | | 5001 | Province | Provincial seat | 州庁 | | Black | | | | | ● | | | | | ・Central government office of the province. |
| 51 | | 5002 | Commune | Town hall | 市町村役場 | | Black | | | | | ● | | | | | ・Location of city hall, town office or branch. |
| 52 | | 5003 | Arrondissement | Ward office | 区役所 | | Black | | | | | ● | | | | | ・Location of ward office for special districts, designated towns. |
| 53 | | 5004 | Police | Police station | 警察署 | | Black | | | | | ● | | | | | ・Police station. |
| 54 | | 5005 | Poste ordinaire | Post office | 郵便局 | | Black | | | | | ● | | | | | ・Applicable to post and telecommunication offices. ・Existing 1:50,000 map symbol used. |
| 55 | | 5006 | Téléphone et télécommunication | Telecommuni-cation office | 電話局及び通信 | | Black | | | | | ● | | | | | ・Applicable to telephone or telegraph offices (whether private or public). ・Existing 1:50,000 map symbol used. |
| 56 | | 5007 | Caserne de sapeurs-pompiers | Fire department | 消防署 | | Black | | | | | ● | | | | | ・Applicable to main and local fire departments. |

# Table 3.2 Map Symbol Classification (3)

| SEQ NO. | Feature Class | Feature Code | Description French | Description English | Description Japanese | Symbols | Data type Color | Area | Line | Circle | Arc | Point | Direc-tion | Descri-ption | Const-ruction | Attri-bute | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 | | 5008 | Ecole: primaire / secondaire | Elementary / Junior high school | 小学校 | | Black | | | | | ● | | | | | • Applicable to public, religious and private elementary schools (existing for more than 10 years or ≧ 5mm x 5mm on the map). • Circle at the bottom of the symbol: White circle. |
| 58 | | 5009 | Ecole: lycée | High school | 中・高校 | | Black | | | | | ● | | | | | • Applicable to public, religious and private high schools (existing for more than 10 years or ≧ 5mm x 5mm on the map). • Cross within the circle at the bottom of the symbol. |
| 59 | | 5010 | Ecole: enseignement supérieur | University | 大学・上級技術学校 | | Black | | | | | ● | | | | | • Applicable to public, religious and private universities (existing for more than 10 years or ≧ 5mm x 5mm on the map). • Circle at the bottom of the symbol: Black. |
| 60 | | 5011 | Hôpital | Hospital | 病院 | | Black | | | | | ● | | | | | • 1:50,000 map symbol used. • Applicable to all main medical facilities. |
| 61 | | 5012 | Banque | Bank | 銀行 | | Black | | | | | ● | | | | | • Applicable to individual buildings only. |
| 62 | | 5013 | Marché | Market | 市場 | | Black | | | | | ● | | | | | • At least 3cm x 3cm on the map. • 1:50,000 map symbol used. |
| 63 | | 5014 | Usine | Factory | 工場 | | Black | | | | | ● | | | | | • At least 1cm x 1cm on the map. • Existing tourist map symbol used. |
| 64 | | 5015 | Eglise | Catholic Church | カソリック教会 | | Black | | | | | ● | | | | | • Catholic churches. • Color inside the circle: Black. |
| 65 | | 5016 | Temple | Protestant church | プロテスタント教会 | | Black | | | | | ● | | | | | • Protestant churches. • Color inside the circle: White. |
| 66 | | 5017 | Mosquée | Mosque | イスラム教寺院(モスク) | | Black | | | | | ● | | | | | • Muslim mosque. • Moon crescent above the circle. |
| 67 | | 6001 | Cimetière chrétien | Christian cemetery | 墓地（キリスト教） | | Vermil-lion | | | | | ● | | | | | • Applicable to Christian cemeteries ≧ 3cm x 3cm on the map. • Vertical cross. • Precinct defined by land use boundary. |
| 68 | | 6002 | Cimetière musulman | Muslim cemetery | 墓地（イスラム教） | | Vermil-lion | | | | | ● | | | | | • Applicable to Muslim cemeteries ≧ 3cm x 3cm on the map. • Precinct defined by land use boundary. • Symbol size: same as for Christian cemetery. |
| 69 | | 6003 | Carrière à ciel ouvert | Quarry | 石切場 | Rocky cliff | Black | | | | | ● | | | | | • Applicable to quarries ≧ 3cm x 3cm on the map. • Symbol shape: same as for rocky cliff (No. 13). |
| 70 | | 6004 | Terrain de sport | Stadium | 運動競技場 | | Black | | ● | | | × | | | | | • This symbol will not appear in the legend (but the codes will not be adjusted). |
| 71 | | 6005 | Aérodrome | Air field | 飛行場 | | Black | | | | | ● | | | | | • Symbol for air fields. • Existing map symbol used. |
| 72 | | 6006 | Terrain de camping | Camp site | キャンプ地 | | Black | | | | | ● | | | | | • Applicable to camp sites ≧ 3cm x 3cm on the map. • Existing 1:50,000 map symbol used. |
| 73 | | 6007 | Ruine | Ruins | 遺跡 | | Black | | | | | ● | | | | | • Applicable to ruins ≧ 3cm x 3cm on the map. • Existing 1:50,000 map symbol used. |
| 74 | **Land Classification** | 6101 | Limite d'usage du sol | Land use boundary | 土地利用界 | | Dark Green | | ● | | | | | | | | • Represents land use boundaries. • Not represented if superimposed on roads, rivers, fences or surface symbols. |
| 75 | *Classification du terrain* | 6102 | Limite de terres cultivées | Cultivation boundary | 耕地界 | | Dark Green | | ● | | | | | | | | • Represent cultivation boundary, such as rice paddies. • Not represented if less than 6mm x 6mm on the map. |
| 76 | | 6103 | Haie vive | Hedge | 生け垣 | | Black | | ● | | | | | | | | • Hedges at least 1cm on the map. • Existing map symbol used. • Not represented if superimposed on roads, or in dense residential areas. |
| 77 | | 6104 | Clôture | Fence | 柵 | | Black | | ● | | | | | | | | • Fences at least 1cm on the map. • Existing map symbol used. • Not represented if superimposed on roads, or in dense residential areas. |
| 78 | | 6105 | Mur | Wall | へい | | Vermillion | | ● | | | | | | | | • Walls at least 1cm on the map. • Existing map symbol used. • Not represented if superimposed on roads, or in dense residential areas. |
| 79 | | 7001 | Rizière | Paddy | 水田 | | Green | | | | | ● | | | | | • Applicable to cultivation such as paddies. • Symbol placed in the middle. |
| 80 | | 7002 | Culture | Cutivated land | 耕作地 | | Green | | | | | ● | | | | | • Applicable to market gardens and pasture land. • Symbol placed in the middle. |
| 81 | | 7003 | Verger | Orchard | 果樹園 | | Green | | | | | ● | | | | | • Applicable to land cultivated as orchards. |
| 82 | | 7004 | Plantation forestière | Forest plantation | 樹木畑 | | Green | | | | | ● | | | | | • Cultivation of ornamental trees an other tree plantations. |

# Table 3.2 Map Symbol Classification (4)

| SEQ NO. | Feature Class | Feature Code | Description | | | Symbols | Data type | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | French | English | Japanese | | Color | Area | Line | Circle | Arc | Point | Direc-tion | Descri-ption | Const-ruction | Attri-bute | |
| 83 | | 7005 | Jardin | Garden | 庭 |  | Green | | | | | ● | | | | | • Bush in gardens, parks or uninhabited areas. |
| 84 | | 7006 | Forêt | Forest | 森林 |  | Green | | | | | ● | | | | | • Applicable to dense tree populations of various varieties. • Symbols distributed evenly within the concerned area. |
| 85 | | 7007 | Terrain vague | Barren land | 荒地 |  | Green | | | | | ● | | | | | • Unfarmed natural land, or abandoned land. |
| 86 | | 7100 | Cotonnier | Cotton | 綿（木綿） |  | Green | | | | | ● | | | | | • Symbol adopted but not listed in the legend. • Field identification. |
| 87 | | 7101 | Mimosa | Mimoza | ミモザ |  | Green | | | | | ● | | | | | • Idem |
| 88 | | 7102 | Canne à sucre | Sugar cane | サトウキビ |  | Green | | | | | ● | | | | | • Idem |
| 89 | | 7103 | Cocotier | Coconut palm | ココヤシ |  | Green | | | | | ● | | | | | • Idem |
| 90 | | 7104 | Bananier | Banana tree | バナナの木 |  | Green | | | | | ● | | | | | • Idem |
| 91 | | 7105 | Manioc | Manioc | キャッサバ |  | Green | | | | | ● | | | | | • Idem |
| 92 | | 7106 | Sisal | Sisal | サイザル（麻） |  | Green | | | | | ● | | | | | • Idem |
| 93 | | 7107 | Oranger | Orange tree | オレンジの木 |  | Green | | | | | ● | | | | | • Idem |
| 94 | | 7108 | Vanillier | Vanilla tree | バニラの木 |  | Green | | | | | ● | | | | | • Idem |
| 95 | | 7109 | Caféier | Coffee tree | コーヒー木 |  | Green | | | | | ● | | | | | • Idem |
| 96 | | 7110 | Giroflier | Clove | チョージ（グローブ） |  | Green | | | | | ● | | | | | • Idem |
| 97 | | 7111 | Ravinala | Ravinala | ラビナラ |  | Green | | | | | ● | | | | | • Idem |
| 98 | | 7112 | Vigne | Vineyard | ブドウ園 |  | Green | | | | | ● | | | | | • Idem |
| 99 | | 7113 | Baobab | Baobab | バオバブ |  | Green | | | | | ● | | | | | • Idem |
| 100 | | 7114 | Eucalyptus | Eucalyptus | ユーカリ樹 |  | Green | | | | | ● | | | | | • Idem |
| 101 | | 7115 | Bambou | Bamboo | 竹 |  | Green | | | | | ● | | | | | • Idem |
| 102 | | 7116 | Epineux | Thornbush | 刺のある木 |  | Green | | | | | ● | | | | | • Idem |
| 103 | | 7117 | Cactus | Cactus | サボテン |  | Green | | | | | ● | | | | | • Idem |
| 104 | | 7118 | Mangrove | Mangrove | マングローブ |  | Green | | | | | ● | | | | | • Idem |
| 105 | | 7119 | Arbre isolé | Independent tree | 独立樹 |  | Green | | | | | ● | | | | | • Idem |
| 106 | | 7120 | Pin | Pine | 松 |  | Green | | | | | ● | | | | | • Idem |
| 107 | **Water** | 7501 | Cours d'eau permanent, canal | Permanent river, canal | 永続的な河川及び用水路等 | Blue<br>Light blue<br> | | ● | ● | | | | | | | | • Applicable to rivers and canals: Width ≧2m Length ≧100m. • Outline acquired by continuous segment (under bridges: masked lines). • Water surface in blue on the map. |
| 108 | *Hydrographie* | 7502 | Cours d'eau, canal (trait simple) | Canal (one line) | 一条河川等 | | Blue | | ● | | | | | | | | • Applicable to canals: Width less than 2m. • Acquired data: Canal center line. |
| 109 | | 7503 | Cours d'eau périodique | Intermittent river | 涸れ川 |  | Blue | | ● | | | | | | | | • Acquired data: River center line. • Identification in the field. |
| 110 | | 7504 | Lac, étang | Lake and pond | 湖・池 | Blue<br>Light blue<br> | | ● | ● | | | | | | | | • Applicable to lakes and ponds ≧ 1mm x 1mm on the map. • Outline acquired by continuous segment. • Water surface in blue on the map. |
| 111 | | 7505 | Mare périodique | Intermittent pond | 涸れ池 | Blue<br>Cyan<br> | | ● | ● | | | | | | | | • Highest water level: Estimated and indicated by broken line. • Lowest water level: Indicated by lake symbol. • Identification in the field. |

# Table 3.2 Map Symbol Classification (5)

| SEQ NO. | Feature Class | Feature Code | Description French | Description English | Description Japanese | Symbols | Color | Area | Line | Circle | Arc | Point | Direc-tion | Descri-ption | Const-ruction | Attri-bute | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 112 | | 7506 | Source | Spring | 泉 | | Blue | | | | | ● | | | | | |
| 113 | | 7507 | Chute | Waterfall | 滝 | | Blue | | ● | | | | | | | | ・Applicable to waterfalls over 3m high. |
| 114 | | 7508 | Marais | Swamp | 湿地 | Blue Cyan | Blue | ● | ● | | | ● | | | | | ・Applicable to ground which is always soft and humid; Swamp vegetation. Also applicable to mud fields. |
| 115 | | 7509 | Sens du courant | Flow direction | 流水方向 | | Blue | | | | | | ● | | | | |
| 116 | Admin. Boundary<br>*Limites adminis-tratives* | 8001 | Chef lieu: commune urbaine | Urban commune | 市庁所在地 | CU | | | | | | ● | | | | | ・Symbol placed and centered under urban commune name. |
| 117 | | 8002 | Chef lieu: commune rurale | Rural commune | 村庁所在地 | CR | | | | | | ● | | | | | ・Symbol placed and centered under rural commune name. |
| 118 | | 8003 | Chef lieu: arrondissement administratif | Ward | 区庁所在地 | AR | | | | | | ● | | | | | ・Symbol placed and centered under ward name. |
| 119 | | 8101 | Limite de province | Provincial boundary | 州界 | | | | | | | ● | | | | | ・Boundaries placed on real positions.<br>・Will be slightly moved when overlapping other map symbols.<br>・Boundary hierarchical order = boundary code classification order. When several boundaries overlap, the one with the highest hierarchical order will be represented. |
| 120 | | 8102 | Limite de commune urbaine | Urban commune boundary | 市界 | | | | | | | ● | | | | | |
| 121 | | 8103 | Limite de commune rurale | Rural commune boundary | 村界 | | | | ● | | | | | | | | |
| 122 | | 8104 | Limite d'arrondissement administratif | Ward boundary | 区界 | | | | ● | | | | | | | | |

### 3.1.3 Annotation Standards

#### (1) General Rules

♦ **Annotations**

Annotations refer to characters used to represent local names of areas, artificial and natural structures, elevation and contour lines, and/or explain the name, type and state of objects without a specified symbol.

♦ **General Rules for Annotations**

The general rules for annotations are as follows.

1. Depending on the type of the object, the area and shape to be covered on the map, annotations shall be classified into: small objects, areas, and lines.
   a. **Small objects** are used for objects that stand alone, e.g. single buildings
   b. **Areas** represent collective housing conditions as well as expansive districts.
   c. **Lines** represent objects with more length than width, e.g. rivers.
2. For the annotation of local names, official names currently in use shall be adopted. In the absence of an official name, the most commonly used name shall be adopted.
3. As a rule, abbreviations shall not be indicated. However, in the case of commonly used abbreviated forms (including those starting with letters) and non-abbreviated forms that cannot be properly annotated because they contain too many characters, abbreviations shall be used but in a manner that would not incur any interpretation problems.
4. The annotations shall accurately represent the relative position of the objects and shall be made in a manner that would prevent the erasure of essential topographic and planimetric features.
5. Annotations shall be made in a manner that would prevent crossovers in the characters to facilitate the reading of the map.

♦ **Selection of Annotations**

Annotations were selected according to the following:

1. Names of administrative divisions (hereinafter referred to as "administrative names"), e.g. urban cities/towns, rural villages, wards in urban cities, etc. shall all be represented.

2. As a rule, names of all residential and non-residential areas, railways, and stations shall be indicated on the map.
3. Only names of famous rivers, lakes, sea, bays, mountains, islands, roads, and other topographic features, or those considered essential on the map shall be annotated.

♦ **Characters to Use**

The letters and type, and applicable limits are as shown in the appendix.

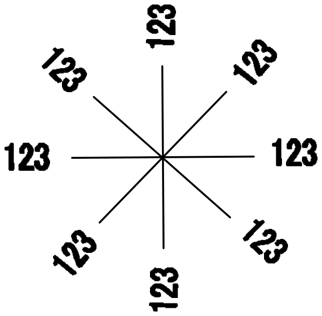
- *Character Size*
  Character size refers to the height of a character.

- *Spacing*
  The characters in an annotation shall be evenly spaced.

- *Arrangement of Characters*
  The characters in an annotation shall be arranged horizontally or in a sloping manner.

1. Horizontally arranged characters refers to characters written from left to right below and parallel to the margin.
2. Characters arranged in a sloping manner are written along linear objects either in a straight or a curve line.
   a. Characters are arranged along the linear object in a straight line.
   b. Characters are arranged along the linear object in a curve line.

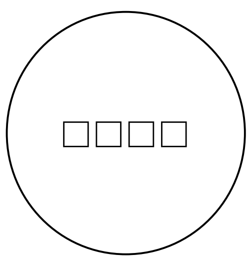
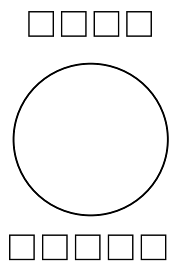
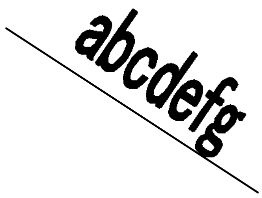
- *Annotation Direction*
  As deemed appropriate, the annotations, i.e. letters, numerals, shall be written in either of the directions shown below.



### ♦ Arrangement of the Annotations

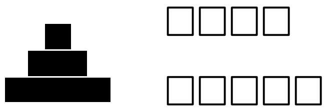
The table below shows the arrangement of annotations.

**Table 3.3 Arrangement of Annotations**

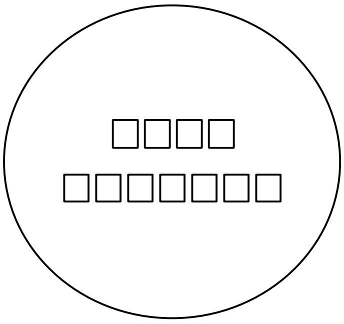
| Classification | Alignment | Position and Priority Ranking of Annotations | Remarks |
|---|---|---|---|
| Small Objects | Horizontal | The standard space between the object and the annotation shall be 1.0mm.<br>⑤□□□□<br>②□□□□ ①□□□□<br>■<br>④□□□□ ③□□□□<br>⑥□□□□<br>※ The location of the annotation may be changed if features are in disarray, making annotations difficult to carry out as above-mentioned. If this makes the instructions of the annotations unclear, an instruction point shall be indicated at the center of the object concerned. | ①, ②, … are the priority ranking for representation |
| Area | Horizontal | Area I Indicated within the object  Area II Indicated outside the object  | The space between the annotation and object in area II shall be equivalent to 1 character size. |
| Linear objects | Sloping Straight line |   | When annotations are indicated outside the object, the space between the object and the annotation shall be equivalent to half the size of a character.<br>If linear objects are thick and wide, annotations shall be placed within the object. |
| | Sloping Curve line |   | |

When two lines of characters are split into 2 rows, the space between the lines of characters shall be one character, and annotation shall be carried out as follows.

1. For small objects, the characters shall be left justified and the center line shall correspond to the center of the object.



2. For annotations of areas, the middle of each line shall be made to coincide with the center of the object.



## (2) Bylaws

♦ **Administrative Divisions**

1. With the exclusion of prefectures and districts, all administrative names shall be indicated.
2. If the adoption of the specified character size is difficult due to lack of space on the map, the size shall be reduced as deemed appropriate.

♦ **Residential Areas**

Names of residential areas shall be indicated according to 5 types of inhabited areas and 3 types of uninhabited areas.

♦ **Roads**

1. As a rule, the names of expressways, freeways, and toll roads shall be indicated. For highways, thoroughfares, and private roads, annotation shall be limited to generally well known names.
2. Common national roads shall be indicated as [RN 4a]. The annotations of famous road names shall be in accordance with the method specified for linear objects. However, the annotation characters for national roads shall be vertically aligned with the road symbol.

3. Names of slopes, roads over a mountain pass, bridges, etc., shall be annotated only when deemed famous and essential on the map.

4. Names of road and railway tunnels shall be annotated at the entrance/exit of the tunnel, in accordance with the methods specified for small objects. However, if it is distinguishable at a glance that the entrance/exit concerned is of the same tunnel, only one annotation shall be made.

5. The interchange of expressways shall be annotated using the following abbreviations:

| | | | |
|---|---|---|---|
| (ex.) | ○○ Interchange | → | ○○ IC |
| | △△ Junction | → | △△ JCT |
| | □□ Service Area | → | □□ SA |
| | ▽▽ Parking Area | → | ▽▽ PA |

♦ **Railways**

1. Local railway names shall be adopted for annotation which shall be carried out as: 「○○ Railway」「○○ Railway ○○ Line」.

2. All station names shall be indicated. Passenger stations shall be annotated as「○○ Station」 in accordance with the annotation methods for small objects. Freight depots, marshalling yards, and signal stations shall be annotated in accordance with their conditions and the annotation methods for small objects and areas.

♦ **Buildings**

1. Depending on the object to be represented, the annotations of building names shall be in accordance with the methods specified for small objects or areas.

2. As a rule, local building names shall be adopted for annotation. However, abbreviations may be used for names that are particularly too long.

3. Except for factories, e.g. ironworks, oil factories, etc., that are distinguishable for what they are, annotations shall be made alongside the company name and a factory number shall be indicated.

♦ **Miscellaneous Objects**

Names (local name and type) of miscellaneous objects shall be annotated as long as they are famous or considered essential on the map, in accordance with the annotation methods for small objects.

♦ **Water Bodies**

1. The names of rivers – rivers and single line stream – shall be annotated in accordance with the methods specified for linear objects.
2. For rivers that cannot be represented as linear objects in marginal areas, annotation shall be carried out according to the methods specified for small objects and areas.
3. Names of lakes, ponds and marshes shall be annotated in accordance with the methods specified for small objects and areas, depending on their shape and width.
4. The gulfs to be named shall be limited to inland bays that comparatively cover a narrow extent, and annotations shall be in accordance with the methods specified for small objects or areas, depending on the shape and width of the inland bay.
5. Names of islands shall be in accordance with the methods specified for small objects or areas, depending on the shape and size. If the island and its sole residential area have the same name, and if the symbols used to represent the two are adjacently located due to the shape and size of the island, one name shall be used to represent both.

♦ **Structures in Water Bodies**

Names of dams, sluices, gates, ferry docking areas, etc., shall be annotated in accordance with the methods specified for small objects or linear objects, depending on their scale.

♦ **Open Spaces**

The names of open spaces (stadiums, parks, airfields, etc.) shall be annotated in accordance with the methods specified for areas. However, in case of limitations in map space, the methods specified for small objects or linear objects shall be adopted if deemed necessary.

♦ **Mountains**

1. Names of mountains, hills, sharp ridges, etc., that are famous or considered essential on the map shall be annotated on their peaks according to the methods specified for small objects and areas.
2. Names of valleys and mountain streams shall be annotated based on methods specified for linear objects with the center of the annotation atop the line of the valley. If streams exist, standards (1) and (2) for *Water Bodies* shall apply.

♦ **Control Point Elevations**

The elevation of triangulation points, bench marks, etc., shall be annotated to the right of the symbols or somewhere suitable if they overlap with other essential features.

♦ **Values of Contour Lines**

1. The values to be annotated shall be those mainly of index contour, supplementary contour, and curve lines indicating depressions. For flat areas that need to be interpreted on the map, however, intermediate contour lines shall be adopted.
2. The annotation of values shall be carried out without blocking features represented on the map. The values shall not be indicated for ridges with large curvatures and on lines of valleys.
3. The values shall interrupt contour lines; the middle of the annotation shall be made to coincide with the contour line.
4. In principle, the representation density, including control points, shall be 10 annotations for 10cm x 10cm on the map.

Based on the conclusions reached in discussions with the FTM, the annotation classification is as shown in *Table 3.4 Table of Annotations* shown next page.

# Table 3.4 Table of Annotations

| Code | Type | Description | Length on the map | Area on the map | Level | Color | Upper/ Lower case | Normal/ Italics | Char. size | Char. space | Annotation type | | | Example |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | Point | Area | Line | |
| 9001 | Control points | Triangulation point | | | | | | Normal | 2.0 | 0.0 | ○ | | | 1258 |
| 9002 | | Bench mark | | | | | | Normal | 2.0 | 0.0 | ○ | | | 1254.3 |
| 9003 | | Spot height | | | | | | Normal | 2.0 | 0.0 | ○ | | | 1251 |
| 9004 | | Contour value | | | | Brown | | Italics | 1.0 | 0.0 | | | ○ | 1234 |
| 9101 | Mountains | Mountain, hill | | < 15cm×15cm | | | Upper | Italics | 2.0 | 2.0 | | ○ | | (Not in residential areas) |
| 9102 | | | | ≥15cm×15cm | | | Upper | Italics | 3.0 | 2.0 | | ○ | | (Annotation takes the shape of the topography.) |
| 9201 | Roads, railways | National road number | | | | | Upper | Italics | 2.0 | 2.0 | | | ○ | RN 4a |
| 9202 | | Highway, toll road | | | | | Lower | Italics | 2.0 | 1.0 | | | ○ | |
| 9203 | | Slope, bridge, interchange, tunnel, etc. | | | | | Lower | Italics | 2.0 | 1.0 | ○ | ○ | ○ | |
| 9204 | | Railway line name | | | | | Lower | Italics | 2.0 | 1.0 | | | ○ | |
| 9205 | | Station, bridge, railway facilities | | | | | Lower | Italics | 2.0 | 1.0 | ○ | ○ | ○ | |
| 9301 | Constructions | Individual building or block | | < 5cm×5cm | | | Lower | Normal | 2.0 | 0.0 | ○ | ○ | | Hôpital Principal |
| 9302 | | | | < 15cm×15cm | | | Lower | Normal | 2.5 | 0.0 | ○ | ○ | | Hôpital Principal |
| 9303 | | | | ≥15cm×15cm | | | Lower | Normal | 3.0 | 0.0 | ○ | ○ | | Hôpital Principal |
| 9401 | Miscellaneous objects | Roadside cross, monument, etc. | | < 5cm×5cm | | | Lower | Normal | 2.0 | 0.0 | ○ | ○ | | Monument |
| 9402 | | | | < 15cm×15cm | | | Lower | Normal | 2.5 | 0.0 | ○ | ○ | | Monument |
| 9403 | | | | ≥15cm×15cm | | | Lower | Normal | 3.0 | 0.0 | ○ | ○ | | Monument |
| 9501 | Land use | Park, stadium, grazing ground, air field, golf club, quarry, etc. | | < 5cm×5cm | | | Lower | Normal | 2.0 | 0.0 | ○ | ○ | | Aérodrome |
| 9502 | | | | < 15cm×15cm | | | Lower | Normal | 2.5 | 0.0 | ○ | ○ | | Aérodrome |
| 9503 | | | | ≥15cm×15cm | | | Lower | Normal | 3.0 | 0.0 | ○ | ○ | | Aérodrome |
| 9601 | Others | Island, waterfall, pass, ruin | | < 5cm×5cm | | | Lower | Normal | 2.0 | 0.0 | ○ | ○ | | Lycée |
| 9602 | | | | < 15cm×15cm | | | Lower | Normal | 2.5 | 0.0 | ○ | ○ | | Lycée |
| 9603 | | | | ≥15cm×15cm | | | Lower | Normal | 3.0 | 0.0 | ○ | ○ | | Lycée |
| 9701 | Water bodies | River, canal, valley, torrent | < 5cm | Width < 2mm | | Blue | Lower | Italics | 2.0 | 0.0 | ○ | | ○ | Ankady |
| 9702 | | | | Width ≥2mm | | Blue | Lower | Italics | 2.5 | 0.0 | ○ | | ○ | Ikopa |
| 9703 | | | < 30cm | Width < 2mm | | Blue | Lower | Italics | 3.0 | 0.0 | ○ | | ○ | Ankady |
| 9704 | | | | Width ≥2mm | | Blue | Lower | Italics | 3.5 | 0.0 | ○ | | ○ | Ikopa |
| 9705 | | | ≥30cm | Width < 2mm | | Blue | Lower | Italics | 3.5 | 3.5 | ○ | | ○ | Ankady |
| 9706 | | | | Width ≥2mm | | Blue | Lower | Italics | 4.0 | 4.0 | ○ | | ○ | Ikopa |
| 9707 | | Lake, pond, swamp | | < 5cm×5cm | | Blue | Lower | Italics | 2.0 | 0.0 | | ○ | | Lac Mahazoarivo |
| 9708 | | Bay, harbor | | < 15cm×15cm | | Blue | Lower | Italics | 2.5 | 0.0 | | ○ | | Lac Mahazoarivo |
| 9709 | | | | ≥15cm×15cm | | Blue | Lower | Italics | 3.0 | 0.0 | | ○ | | Lac Mahazoarivo |
| 9801 | Administrative divisions | Urban Commune (CU) | | | | | Upper | Normal | 4.5 | 0.0 | | ○ | | AMPANDRANA |
| 9802 | | Rural Commune (CR) | | | | | Upper | Normal | 4.0 | 0.0 | | ○ | | ANALAKELY |
| 9803 | | Ward (AR) | | | | | Upper | Normal | 4.0 | 0.0 | | ○ | | ANALAKELY |
| 9811 | | Administrative entity | | Generic name: Lower Geographic name: Upper | | | | Normal | 2.0 | 0.0 | | ○ | ○ | Commune d'ALASORA |
| 9901 | Residential areas, etc. | Inhabited area (very big) | | | | | Lower | Normal | 4.0 | 0.0 | | | | Ankadivato |
| 9902 | | Inhabited area (big) | | | | | Lower | Normal | 3.5 | 0.0 | | ○ | | Ankadivato |
| 9903 | | Inhabited area (average) | | | | | Lower | Normal | 2.5 | 0.0 | | ○ | | Antsakaviro |
| 9904 | | Inhabited area (small) | | | | | Lower | Normal | 2.0 | 0.0 | | ○ | | Antsakaviro |
| 9905 | | Inhabited area (very small) | | | | | Lower | Normal | 1.5 | 0.0 | | ○ | | Antsakaviro |
| 9906 | | Uninhabited area (big) | | | | | Upper | Italics | 3.5 | 3.5 | | ○ | | BETSIMITATATRA |
| 9907 | | Uninhabited area (average) | | | | | Upper | Italics | 2.5 | 0.0 | | ○ | | BEVOLANA |
| 9908 | | Uninhabited area (small) | | | | | Upper | Italics | 2.0 | 0.0 | | ○ | | AMBODIHADY |

### 3.1.4 Urban Base Map Production Method

#### (1) Air Signal Installation

Air signal installation was implemented by FTM.

Prior to the installation, the following were discussed and concluded by JICA and FTM:

① Location and number of signals
A total of 21 signals (4 existing points and 17 new points) were installed based on the results of the field reconnaissance survey on existing points.

② Shape and quality of air signals
As a rule, the air signals should be highly visible and made of limestone. The signals are Y-shaped, each wing measuring 90cm x 50cm, and installed under the sun.

③ Preservation of Ground Control Points
In order to effectively protect the new ground control points for long term use, a 40cm reinforcing bar was installed underground at the center of the location of the point.

#### (2) Air Photography and Processing

An aircraft of Madagascar Flying Service was chartered and aerial photography was carried out by FTM, using the agency's aerial camera.

Aerial photography covered 250 km2 and was carried out in black and white. The flight direction was from east to west of the study area in view of the costs involved.

The main specifications for aerial photography are as follows:

| | | | |
|---|---|---|---|
| ① | Aerial camera | : | RMK TOP15 |
| ② | Focal distance | : | f=153.15mm |
| ③ | Image size | : | 23×23cm |
| ④ | Overlap | : | 60% |
| ⑤ | Sidelap | : | 30% |
| ⑥ | Scale | : | 1:20,000 |
| ⑦ | Datum level | : | 1,300m |
| ⑧ | Flight altitude | : | 3,000m |

Owing to favorable weather conditions, aerial photography was completed in one day on 27 November 1998.

The Japanese side provided the films, chloride paper, and the developing solution, and the photos were developed in the FTM laboratory.

After the shooting, the quality of the shots was checked to ensure accuracy. The overlap in every flight strip widely exceeded the target overlap (60%), as shown below.

| Strip No. | (Photo No.) | (Overlap) |
|---|---|---|
| C-1 | (1～17) | 78～85% |
| C-2 | (1～17) | 73～76% |
| C-3 | (1～15) | 72～76% |
| C-4 | (1～18) | 72～77% |
| C-5 | (1～21) | 75～80% |
| C-6 | (1～19) | 72～76% |
| C-7 | (1～16) | 74～75% |

This is mainly attributed to the navigating skills of the technicians and wind conditions. The number of photos taken was 1.7 times what was intended.

The sidelap was 10-45%.

In consideration of subsequent work and weather conditions, the sidelap was adopted assuming that it will not hamper the plotting work.

The negatives were annotated with the following, in accordance with the agreement reached during discussions carried out with the FTM.

Center of Photo Margin: 98 JICA-FTM-244/200
Corner of Photo Margin: C-1.01

### (3) Ground Control Point Survey

Ground control point survey is carried out to determine the horizontal position and height necessary for the aerial triangulation and digital plotting work that ensues thereafter. This project covered GPS surveys and ordinary leveling, both of which were carried out by FTM.

① GPS Survey

Using the existing 7 triangular points established by FTM, GPS was carried out to establish 17 new points. Three Leica GPS SR-399 were used; these equipment are owned by FTM.

The increase in the number of new points established (originally set at 8) is mainly attributed to the damaged condition and loss of some of the triangular points in Madagascar which were earmarked for use in GPS.

Observations entailed 25 sessions and 59 baselines, each session lasting over 60 minutes. The type of observation carried out was static observation (15 second data acquisition interval).

Using the WGS84 ellipsoid, calculations were carried out by first doing a baseline analysis on all data acquired using the SKI software. The data were converted to the ellipsoid and coordinate system adopted in Madagascar after the quality of the data and the changes in established control points were checked.

② Ordinary Leveling

Ordinary leveling covered 55 km and was carried out using WILD NA2 and KERN GK1A.

As a rule, the network was made of closed loops. Where this was not possible, double running observation was carried out.

The height of existing national bench marks was used as the base for the calculation.

Ordinary leveling was not only carried out to measure the elevation for aerial triangulation and digital plotting. It was also carried out to simultaneously measure the height of the control points this study established under GPS, and enhance the accuracy of the elevation of these points.

The points subjected to adjustment calculation were pricked on the aerial photos at intervals of about 400m, and the elevation values were annotated.

### (4) Optimization and Use of Existing Digital Data

① Data Creation

The creation of data for this study was based on the following policies established after discussion with the FTM.

a) The database layer division was in accordance with the decisions concluded in the discussion on the digital map symbols.
b) The existing digital data were analyzed and assessed to determine their effective use for the production of the urban base map.
c) The data was arranged as a MicroStation design file in consideration of the editing conditions of FTM.

② Evaluation and Optimization of Existing Digital Data

The existing data collected were analyzed, and the method of optimization was determined based on the following evaluation.

a) The 1:500 digital data produced by AOC, is configured in over 200 files. As inferred from the size of each file, these are data files of plotting manuscripts by models that have not been digitally compiled. The files cannot be used in the database as the division of the layer for topographic and planimetric features is obscure and because the layer configuration between files is not unified.

b) Although each file of the 1:2000 digital data compiled by BDU from the 1:500 digital data above mentioned is layered by topographic and planimetric features, the layer configuration of the files is not unified. Further, since the division of layers does not match the map symbol codes decided this time, data used was limited to the basic ones, i.e. buildings and roads. Accordingly, only data on buildings and roads were extracted from all files (about 170), and compilation was carried out to unify the coding and layering configuration.

   The consistency of the position of the data with the digital plotting data was verified, and the data was confirmed to meet the accuracy stipulated in the work regulations.

   In addition, the data format was converted from the mapping file to the design file format.

c) The 1:2000 digital data of FTM were produced through MicroStation. Although there are no problems in the format, as in the above mentioned digital data, the layering of the topographic and planimetric features is not in accordance with the digital map symbols discussed and was, therefore, recompiled. As for the classification of buildings and roads that require more than the compilation work to complete, field identification was carried out to confirm the features, and revisions were carried out in the form of supplementary compilation.

   The extent of existing data in relation to the study area is shown in *Fig. 3.1 Existing Data Coverage.*

③ Compression and Revision of Existing Digital Data (Compilation by Reduction)

Since the optimized existing digital data have to be in accordance with the digital map symbols established in the discussions, editing, i.e. extracting data from the items and altering the layer configuration, was carried out. For roads, the most minute shapes were maintained and roads less than 3m were allocated symbols. For buildings, the compilation of small buildings with a side length of less than 5m was generalized for convenience. For secular changes, the data was revised, i.e. proofread, during digital plotting and digital compilation.

④ Use of Existing Digital Data

The 1:10,000 level data produced in the work above mentioned were subject to format conversion. With the superimpose function of the analytical plotter, the accuracy and compatibility of the data were checked and areas affected by secular changes were extracted.

### (5) Aerial Triangulation

The aerial photos taken and the results of the ground control survey and leveling were used for aerial triangulation. Calculations were carried out based on the bundle method.

The volume of work that aerial triangulation entailed was as follows:

No. of flight strips: 7 strips

No. of models: 98 models

| | |
|---|---|
| C-1 | 8 models |
| C-2 | 15 models |
| C-3 | 14 models |
| C-4 | 17 models |
| C-5 | 18 models |
| C-6 | 15 models |
| C-7 | 11 models |
| Total | 98 models |

In accordance with the results of the ground control survey, the control points used in the adjustment calculations for aerial triangulation were 23 points for the adjustment of horizontal positions and 114 points for height adjustments.

The adjustment calculation results showed the following standard deviations: 17cm (41cm: maximum) in horizontal position, and 32cm (117cm: maximum) in height. These findings are favorable due to the highly accurate positions of the ground control points and the highly visible air signals installed on the control point locations.

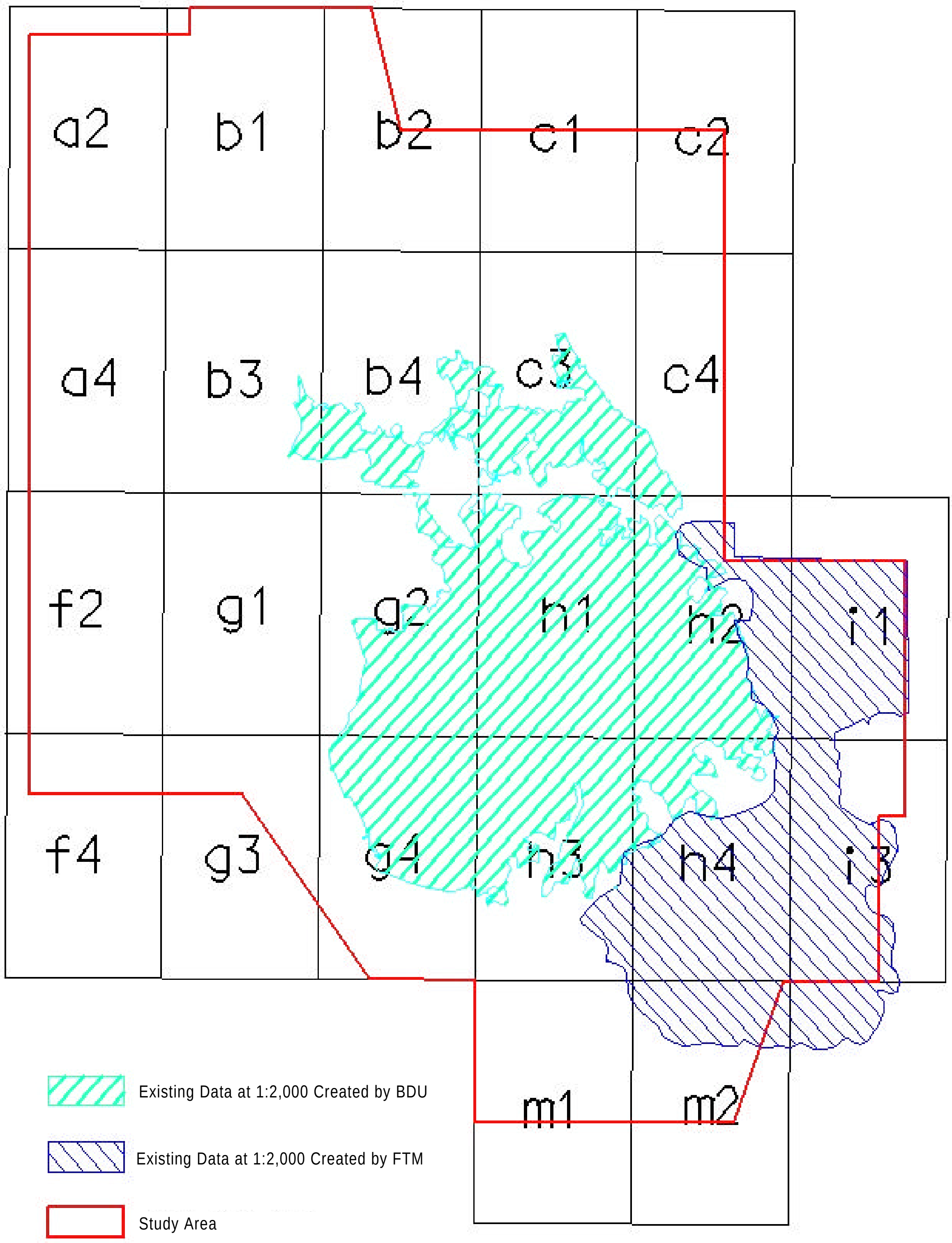



**Fig. 3.1 Existing Data Coverage**

### (6) Digital Plotting

Using the aerial photos and the aerial triangulation results, digital plotting was carried out using an analytical plotter to measure the coordinates of topographic and planimetric features. Plotting was also carried out in accordance with the map symbol classification decided after discussions with the FTM and the data acquisition standards. The absence of field identification data made the classification of tree species difficult, and consequently aerial photos were used to identify the extent of the vegetation, tree density and patterns for classification. The detailed classification of tree species will be entrusted to FTM in the future. For roads, the average width of roadways (by 1m units) was adopted, while roads with a width of 3m or over were, as much as possible, indicated using their true shape. Roads with a width of under 3m and over 1.5m were represented on the map using symbols for roads with a width of 0.3mm. Roads with a width of less than 1.5m, i.e., pathways, field identification was carried out to confirm shapes and width in areas in cities and towns that are undecipherable.

In areas with existing digital data, all data items, except for data to be used, were partially subject to digital plotting, and this involved plotting revisions regarding secular changes in the existing data.

In areas without existing digital data, all data items were digitally plotted.

① Partial Digital Plotting

- As for the 1:2,000 digital data (52 $km^2$ within the 250 $km^2$ study area) compiled by reduction by BDU, only digital data on buildings and roads were used while additional plotting was carried out on the rest. As for buildings and roads, existing digital data were entered into the analytical plotter and superimposed with the model aerial photos to decipher secular changes and to carry out digital plotting for revision. Data revision was carried out, however, during the digital compilation work.

- The contour line interval of the 1:2,000 digital data compressed by FTM and the one established this time around for the map symbols differed: 2m and 5m, respectively. Initially, the interpolation of a 5m contour line from the existing contour line data was considered. However, in view of difficulties in the detailed representation of changes in flat areas (paddy fields) and artificial topographic structures, the collection of contour line data was postponed and plotting was carried out anew.

② New Digital Plotting

In areas without existing digital data, all data items were digitally plotted and matched with the existing data. Field identification was carried out after digital plotting. However, areas that were undecipherable in aerial photos (road pavement division and width, concealed vegetation and small features, e.g. trees, etc.) were first confirmed at the site prior to plotting, which was done as supplementary work.

### (7) Digital Compilation

Digitally plotted data were entered into the compilor for the addition, deletion or revision of topographic and planimetric features, in accordance with the map symbol specifications. The legend of existing topographic maps of covered areas was used as reference in the classification of map symbols. Compilation to match the digitally plotted data with existing digital data involved correction in some of the existing data pertaining to secular changes. Simultaneously, errors in existing digital data (errors in shape, deletion of data overlaps and irrelevant data, etc.) were corrected. Because the quality of the existing digital data is not as good as expected, digital compilation entailed more work than initially envisaged.

After the digital compilation work, the data was printed out to mark areas that were considered questionable during digital plotting and digital compilation, to confirm their authenticity at the site.

### (8) Field Identification

The printout (field completion manuscript) where areas considered questionable in digital plotting and digital compilation are marked was taken to the site for the conduct of a supplementary survey. Errors in the map (errors in map symbol classification, shapes of topographic and planimetric features, etc.) confirmed by the field identification work were marked on the manuscript for corrections during the supplementary compilation work. The main considerations of the field identification work were as follows:

① Since aerial photography in water areas was carried out at the start of the rainy season, the water table was comparatively high and the digital plotting indicates the shoreline position at that time. In contrast, field identification was carried out in the dry season, hence a slight variation in shoreline position can be seen. As for water level, the representation of average annual water table is desired. Discussions with the FTM, however, concluded not to carry out a supplementary survey to revise the shoreline position in view of the fact that the water table at the time of shooting was close to the average water table.

② Because existing data on road pavements are not categorized, the division of all roads by pavement in the area covered was studied for classification.

③ Some errors were observed in the digital plotting of graveyards, small buildings, and ovens for brick-baking in Madagascar, which are of similar shape and materials. In view of the voluminous work load, only items confirmed during field identification were revised, and the rest of the revisions were entrusted over to FTM.

For place names, annotations, and administrative boundaries, existing data were collected, field confirmation was carried out, an administrative boundary and annotation map was prepared. Further, the data was digitized using MicroStation, and the supplementary compilation of data was carried out. These were all carried out under the direction of the Study Team and the cooperation of FTM.

### (9) Supplementary Compilation

The results of the field identification work were used in the supplementary compilation, whereby additions, deletions, or revisions were carried out on the digitally compiled data. After this was completed a file containing the data that has been subjected to supplementary compilation was created. Data on topographic features were revised In accordance with the field completion manuscript. Digital data on administrative names and boundaries, and place names, etc., were entered into the compilation instrument and linked with the digitized topographic data. Afterwards the data were matched with the background representation and the location of annotations was revised to prevent overlaps with the symbols and the annotations themselves.

### (10) Urban Base Map Data Structuring

In accordance with the specifications established through discussions with the Madagascar side, the digital data subjected to supplementary compilation were structured for use in the database system. The digital data was divided into 4-digit codes for each map symbol item. Each data was classified as point, line, or surface data types.

For contour lines, shadowed lines were used to represent the intersecting sections of roads and distorted surface areas. This data of continuous lines was attributed with height to enhance the possibility of adopting a 3 dimensional topographic usage (Bird's Eye View, Slope Classification Map, etc.). To enable the construction of a database on houses in the future, compilation was carried out for buildings by forming polygons. To facilitate the use of the data on the water system (rivers, canals, ponds, lakes, wetlands, etc.), revisions were also carried out by forming polygons.

A neatline data file type was decided based on discussions with the FTM, taking the final volume of the data into account, and based on the practicality of managing revisions, additions, etc. The matching of data between neatlines was carried out by node matching, in order to facilitate data structuring by GIS, i.e. ArcInfo.

#### (11) Official Approval

The digital data that has undergone supplementary digital compilation was converted into the digital mapping format of the regulations established by the National Geodetic Institute of the Ministry of Construction for public survey work, and was approved by the Japanese Surveyor's Association.

Data verification was carried out by checking the output map, aerial photos, and supplementary survey paper, as well as the logical inspection of the data file.

#### (12) Production of Results

After obtaining the official approval, the data file was printed out in color (1:10,000) using the ink jet plotter and stored in a CD-ROM.

*Fig. 3-2 Urban Base Map Production Flowchart* shows the overall work progress.

### 3.1.5 Database Structure

The urban base map data were produced using MicroStation and in accordance with the structuring specifications. Further, the data were converted into the ARC/INFO3 format adopted in this study, to enable the incorporation of the data into the database.

Each data item was configured based on the table on map symbol classification.

*Fig. 3.3 Urban Base Map at 1:10,000* shows a sample of the urban base map at a scale of 1:10,000. In comparison with the usual 1:10,000 topographic map, this map is more detailed with houses delineated separately and 5m intermediate contours.

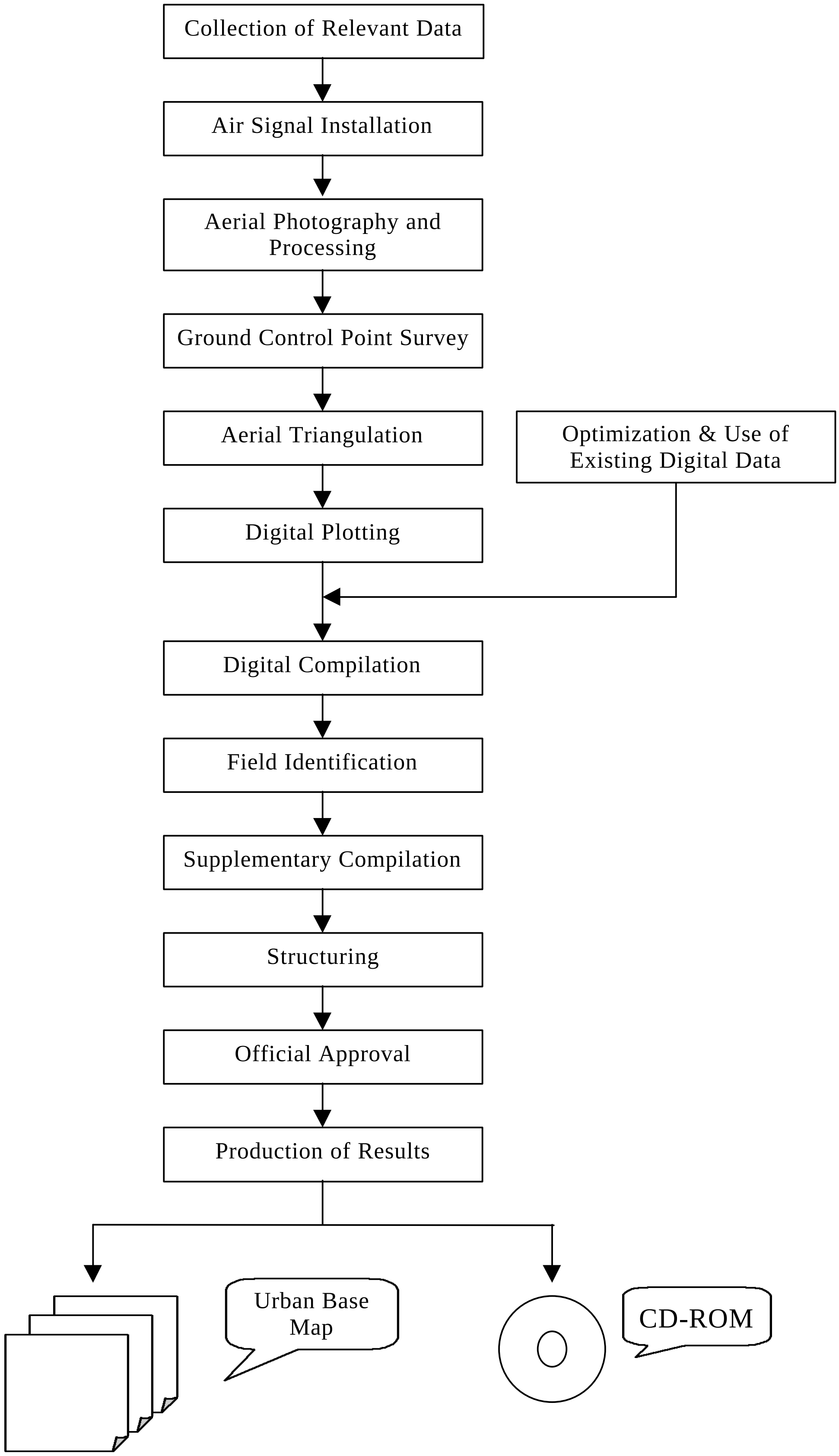



**Fig. 3.2 Urban Base Map Production Flowchart**

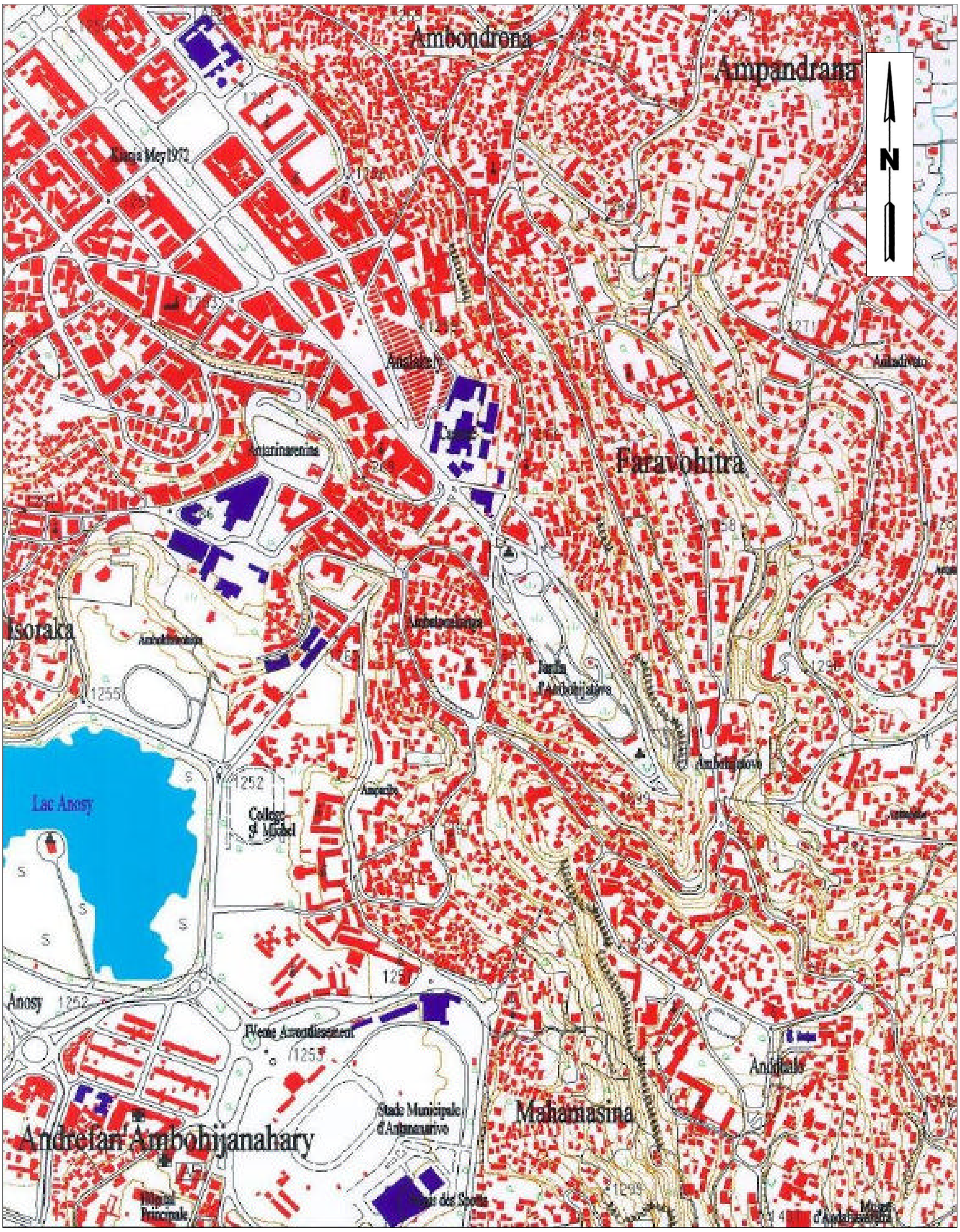



Fig. 3.3 Urban Base Map at 1:10,000

## 3.2 Land Condition Map

### 3.2.1 Objectives in Creating the Land Condition Map

#### (1) Basic Concept

The land condition map, as it is called by the Geographical Survey Institute under the Ministry of Construction of Japan is a type of thematic map created in accordance with the basic concepts of knowledge and analysis of the following:

- evolution of land condition and topography,
- altitude,
- land chronology in relation to human activities, such as banking,

in order to show to a large extent land characteristics and behavior in case of natural disaster such as flood.

This map is planned not only for use in the formulation of flood prevention measures but also to forecast land movements due to earthquakes and ascertain the danger of mountainous slopes. It can also be used as basic data for the management of land conservation, regional development and land use.

The Japanese land use map shows three main features:

- Geomorphological classification in order to give a qualitative grasp of regional characteristics,
- Ground elevations represented as contours in 1m steps for the plain area, for a quantitative evaluation of the land,
- Various organizations and facilities such as:
    - Governmental and public offices that issue warnings and evacuation orders in time of disaster,
    - organizations concerned with the relief and rescue of victims,
    - Various facilities such as embankments, water intake and drainage and other water utilization facilities.

Thus, the land condition map is mainly used to monitor the total situation of a specific region for land development or disaster prevention.

#### (2) Policy for the Creation of the Land Condition Map

Geographical conditions in the Antananarivo area are too different from conditions in Japan that adopting a similar basic concept for the creation of the land condition map would not be advisable. Therefore, the following policy was adopted:

① Formation of the plain and its topographic features

The Antananarivo area is roughly divided from the topographic point of view into two domains: a hilly area and a plain area. The difference in elevation between the hilly area and the plain area is approximately 200m. The flat area, corresponding to the Antananarivo Plain, and is a collapsed plain formed as a result of a large ground cave-in that took place in the geological structure. A large lake formed after the cave-in, as shown by a wide distribution of lake-bottom sediment. The water level of this lake has fallen twice, creating two stages of terrace in the hilly area. While the water level in this lake is at present being gradually lowered due to man-made drainage works, the river bottom slope is very gentle in the plain area because of the sediment and debris flowing into it from the upper reaches. The difference in elevation between the lower and upper reaches is less than 2m. As a result of this minute elevation difference and also due to the clay layer covering the area, rainfall in the rainy season remains standing in the plain area for a long time.

② Causes of flooding

The land condition map created in Japan lays emphasis mainly on flood disaster prevention. In the Antananarivo Plain, however, flood disaster is seen in a different way. As this area is a collapsed terrain district where lake deposits remain even at present and although flowing water is artificially controlled by a dam in the upper reaches and by drainage works in the lower reaches, water remains standing due to the rainfall that reaches nearly 300mm per month in the rainy season, in addition to which water flowing from the upper reaches also stand in the plain area, so that flooding continues for a large part of the year. Thus, inundation in the Antananarivo Plain is not a total flood disaster caused by abrupt flooding, but the repeated results of these two causes.

③ Identification of flood areas

The land condition maps created in Japan lay emphasis mainly on forecasting the danger of flooding and on reducing the damage and injury resulting from the floods. In the study area, however, emphasis was placed on identifying to some extent the districts where flooding occurs every year, and using the data received from a satellite the extent of flooding in each observation period is shown on the map. It would normally be necessary to measure the water depth in the flooded districts during each period and to investigate the inundation frequency.

④ Main organizations for river management

The land condition maps in Japan show the facilities of the main organizations that manage the rivers and the shelters in time of flooding, so that they can be used as hazard maps to provide important information. It was decided that as inundation continues for long periods of time the main facilities to be represented in the land condition map of the Antananarivo area should include only the governmental offices, the main organization for river management and the weather information disseminating organizations. When a large flood disaster occurs, it is usual in this area for a temporary committee for countermeasures against flood disaster to be convened to take actions based on the information provided by the organizations concerned. There is no public organization that is engaged in flood disaster management at all times.

⑤ Soil erosion in the hilly area

This hilly area was formed as a peneplain covered with a basic bed of granite and gneiss. At present, however, only the tops of the hilly land remain outstanding in the Antananarivo Plain because the area sank below the lake. The surface layer of the hilly area is covered with laterite and soil erosion occurs in many places. The urban areas in the center of Antananarivo are paved with concrete, and may be considered protected from danger of soil erosion. However, it is thought that there is probably a high danger of soil erosion because of the slope conditions of the original terrain and the fragile soil and geological features of the ground. Therefore, it was decided that the terrain features of the hilly area be classified in more detail for the creation of the land condition map.

The biggest problem in the hilly area lies in assessing the degree of danger due to soil erosion. By classifying slopes from the elevation data prepared at the time of the topographic mapping work and carrying out a detailed survey of the state of devastation (crumbling, landslides, other erosion conditions), the degree of danger can be evaluated using GIS. The land condition map forms part of the thematic maps for evaluation, and classification was done giving consideration to the gradients and form of the slopes in the hilly area.

### 3.2.2 Land Condition Map Production Method

#### (1) Collection of relevant data

The existing documents, various thematic maps, aerial photographs and satellite data were collected prior to implementation of the study, in order to grasp the conditions of the study areas including the geographical, geological and topographical features, and the vegetation. These documents were used as the basic data for the creation of the land condition map. In this Study, satellite data (for three seasons), existing aerial photographs and 1:25,000-scale land use maps were obtained with the cooperation of FTM and put to use in the creation of the land condition map.

#### (2) General field classification

The general field classification to gain a rough grasp of the geographical and topographical features of the entire study area was made in Madagascar in parallel with the general study for the creation of the land condition map. The general field classification concentrated on topographic features for consideration of categories for topographic classification.

#### (3) Discussion of the classification category draft

The classification category draft was prepared using the collected data such as the results of the general field classification, aerial photographs and documents. The terrain features of the study area were first classified into the categories of hills, plain and other, and these were further classified into more detailed categories.

It was decided that the items to be represented in the land condition map would be: 1) geomorphological classification; 2) seasonal flooded districts based on satellite data rather than ground elevation; and 3) facilities and organizations of importance in time of disaster.

#### (4) Creation of land condition map manuscript using topographic map data and photo-interpretation

The land condition map manuscript was prepared by categorizing the topographic maps with reference to the topographic map data, especially the elevation data, unclear places being filled in through aerial photograph interpretation. At the land condition map manuscript stage, topographic classification was only carried out prior to discussions with the FTM and the general field classification. For the creation of the land condition map, Mrs.

RAHARIJAONA Raharison Léa Jacqueline, geologist, Geology Dept., Faculty of Science and Engineering, University of Antananarivo, gave the Study Team instructions and supervised in particular the categorization of land conditions and confirmation through general field classification.

### (5) Discussions with the FTM

Discussions with the FTM were held with the objectives of creating the land condition map and checking classified categories, the method of using satellite data and facilities and organizations to be deemed important in time of disaster. In addition, how the land condition map was to be put to use was also discussed.

### (6) Confirmation through photo-interpretation and field reconnaissance

The land condition map manuscript was corrected by perusal of the topographic maps and photo-interpretation through discussions with the FTM, and outcrop observation and soil sampling were carried out at main points in the field reconnaissance. In the outcrop observation, the remarkable depositional and folded forms of the hilly area could be observed. The soil sampling survey, on the other hand, was made on the boundary between the plain area and the hilly area, using hand augers. In this season, there were many excavated sites in the plain area for brickmaking, and these sites were very useful for the observation of soil profiles.

### (7) Correction of land condition map and digitization

On the basis of the results of the study described above, the land use map was corrected on the drawings and digital data were created using a digitizer. In digitization, the same coordinate system as that of the topographic map data was used, to enable overlay on the topographic map data.

### (8) Map output and archiving on CD-ROM

The final land condition map was output by a plotter at a scale of 1:10,000, with every outline the same as in the topographic map, and was archived on a CD-ROM so that it can be handled by Arc/View.

*Fig. 3.4 Land Condition Map Production Flowchart* shows the overall work progress.

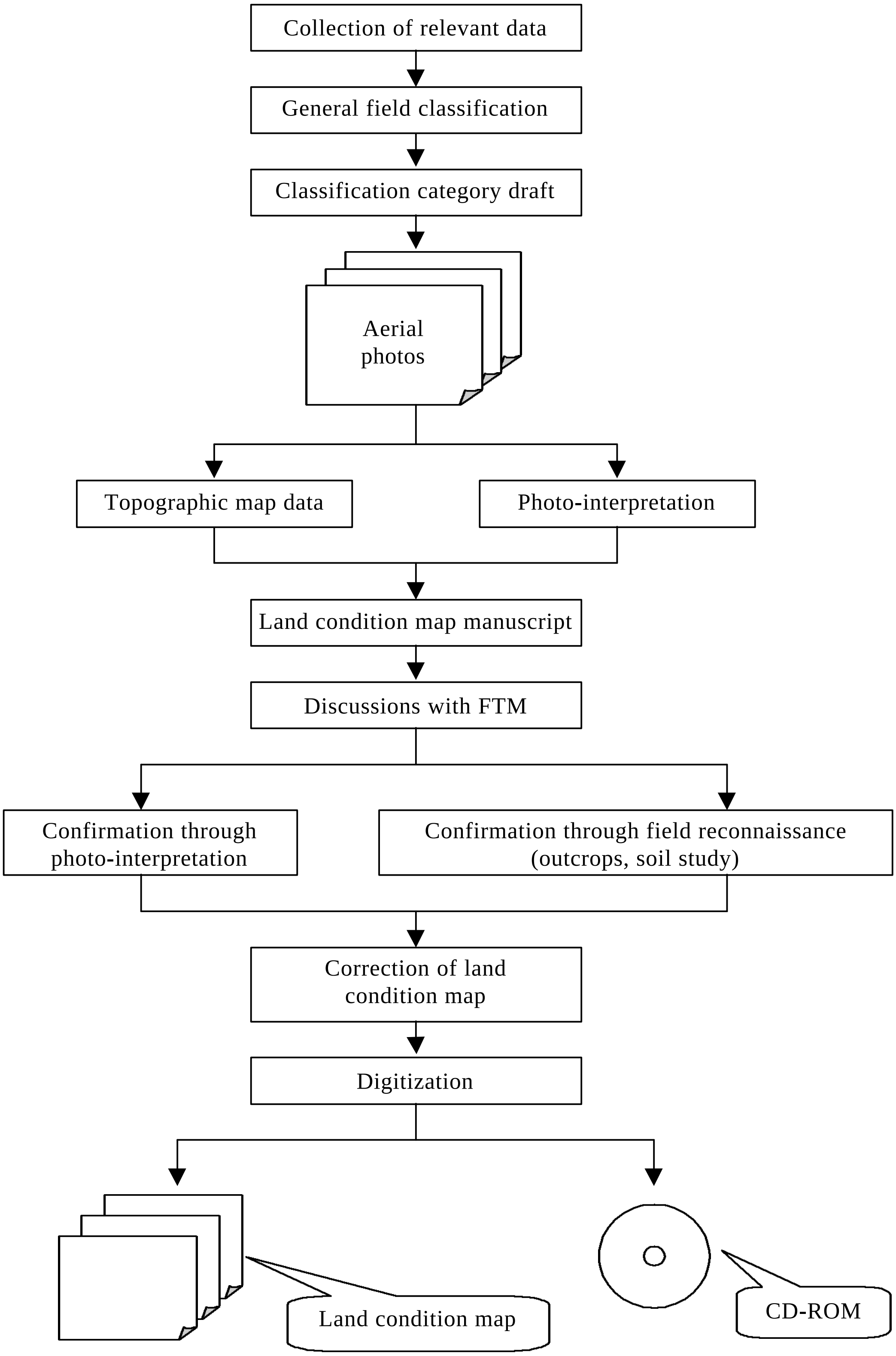



**Fig. 3.4 Land Condition Map Production Flowchart**

### 3.2.3 Land Condition Map and Regional Characteristics

As described above, the land condition map contains three category items: ① geomorphological classification; ② ground elevations; and ③ various facilities and organizations. The geomorphological classification is shown in *Table 3.5 Land Condition Map Categories.*

Tendencies in the land condition map of the study area are summarized below:

- The study area is roughly divided into two parts: the hilly area in the eastern and northwestern parts, and the plain area in the western part. Some isolated hills of bedrock (monadnocks) remain also in the plain area in the western part.

- The hilly area is classified into 7 main categories based on topographic status, including mainly sloping areas from the top to the foot of the hills, and also includes denuded land, gullies, cliffs and artificial flat areas. The plain area on the other hand is flat overall, and was divided roughly into 5 categories to show the delicate differences in elevation. The last classification labeled “Others” includes artificial banking for residential and industrial areas in the lowlands, embankment/road banking and water bodies.

- The bedrock of the hilly area consists mainly of granite and gneiss, and a large folded stratum can be seen in the western part; most of it is covered with a deep layer of laterite soil. The hill slopes include gentle slopes from the hilltop, hillside slopes (concave, convex, balanced and mixed types), steep slopes, terraces, talus slopes and colluvial slopes. Below the hill slopes are also valley bottom plains bordering on the plain area. As for the terraces, some are distinct, and others are indistinct.

- In the plain area, the greatest concern given is for those districts which are flooded almost every year, and in these areas therefore, the dates of observation of satellite data were indicated instead of ground elevations.

## Table 3.5 Land Condition Map Categories

| No | Classi-fication | Symbols | Categories | Content |
|---|---|---|---|---|
| 1 | Hilly area | Hm | Residual hill | Circular topography and irregular weathered hill mass. |
| 2 | | Hg | Gentle hill slope | Gentle slope around a hill top |
| 3 | | Hs | Hillside slope | Concave, convex, balanced and mixed types of hillside slope |
| 4 | | Hh | Steep hill slope | The hill slope topography differs in the northern part, the northwestern part, the central part and the southern part.<br>• The slopes in the northern part and in the southern part are gentle overall.<br>• One district in the city area of the central part is located on a steep and narrow ridge.<br>• There are island-type hills in the northwestern part, some of which are used as terrace fields up to the hill tops. |
| 5 | | T | Terrace | Terrace fields formed by a water-level change in 2 steps. |
| 6 | | Ht | Talus slope/Colluvial slope | Talus-type depositions exist on the lower part of the semi-circular slopes at the valley head.<br>Talus slopes exist at the foot of the hilly ground where steep slopes change to gentle slopes.<br>The semi-circular slopes at the valley head show an erosive topography peculiar to granite strata. |
| 7 | | Hv | Valley bottom plain | There are two types of plains: shallow valley on hill slope (talus-depositional topography) and V-type valley bottom on a steep slope. These two types are different in deposition and erosion, but show valley bottom shapes and so are included in the same category. |
| 8 | | N | Denuded land | Districts under development work, soil and rock pits and quarries with no vegetation, from which debris easily flows out. |
| 9 | | → | Gully | There are several gully districts in the suburbs of the southern part. It seems that there are a number of very small gullies in the hill slopes, but they cannot be made out on aerial photographs. |
| 10 | | C | Cliff | A steep cliff that exists on the boundary between the hilly area and the plain area. |
| 11 | | Af | Artificial flat land | Land artificially leveled through land development. |

| No | Classi-fication | Symbols | Categories | Content |
|---|---|---|---|---|
| 12 | **Plain area** | F | Flood plain | A plain area formed by river flooding and deposition of lacustrine sediment. |
| 13 | | Fh | Micro-high relief on the flood plain | A residual part of a weathered island-type hill, irregular in shape, that is used as agricultural land, but which cannot be considered reclaimed land.<br>Artificial micro-high relief is included in the category of banking. |
| 14 | | Fl | Micro-low relief on the flood plain | A district of poor drainage that is slightly lower relative to the flood plain.<br>An area in which water stands for a long time after the rainy season ends. In such areas of poor drainage, there are many districts in which water stands for a long time because the lower reaches are blocked by embankments and roads. These districts lie in the plain area, but they are not used as agricultural land. When the water level is low, the water is drained from such districts. This category was determined with reference to aerial photograph interpretation and the water levels indicated in the existing topographic maps. |
| 15 | | Fr | Ancient flow path | An ancient flow path is what remains of a meander scar after river modification. The flow path is intermittently continuous, forming a channel-shaped lowland.<br>The reclaimed, flat districts are used as agricultural fields, which look dark because the soil has a higher water content than the surrounding districts.<br>There are many ancient flow paths in the plain in the northwestern part. The ancient flow paths show as long, narrow winding patterns and semi-circular patterns in aerial photo-graphs and existing topographical maps, but some of them have been levelled flat for use as agricultural fields, so that the topographic elevations are unclear. There are also similar patterns in the surrounding districts, and these are thought to indicate ancient flow paths constantly shifting as the wet lands silt up. |
| 16 | | Fs | Valley bottom plain | This is a long and narrow valley bottom plain penetrating the hills. There is a sloping part and a belt-shaped part that slopes very slightly toward the plain along the edge of the hills.<br>The valley bottom plain is proof that this area was a lake. The valley is wide, and it is thought that the original valley was widened due to water erosion and debris deposition. |
| 17 | **Others** | Ab | Artificial banking | Artificially banked land, not including embankments and roads |
| 18 | | B | Embankment/road banking | Banking for roads or embankments along a river or by a dammed lake. |
| 19 | | W | Water body | An area covered by water, such as a lake or river. |

A sample of the land condition map at the scale of 1:10,000 is shown in *Fig. 3.5 Land Condition Map at 1:10,000*. This map represents various topographic elements in color, classified into 19 categories based on the 1:10,000-level urban base map.

Because the map is stored in the form of digital data, it can be readily output to any scale. This sample was output at a scale of 1:10,000.

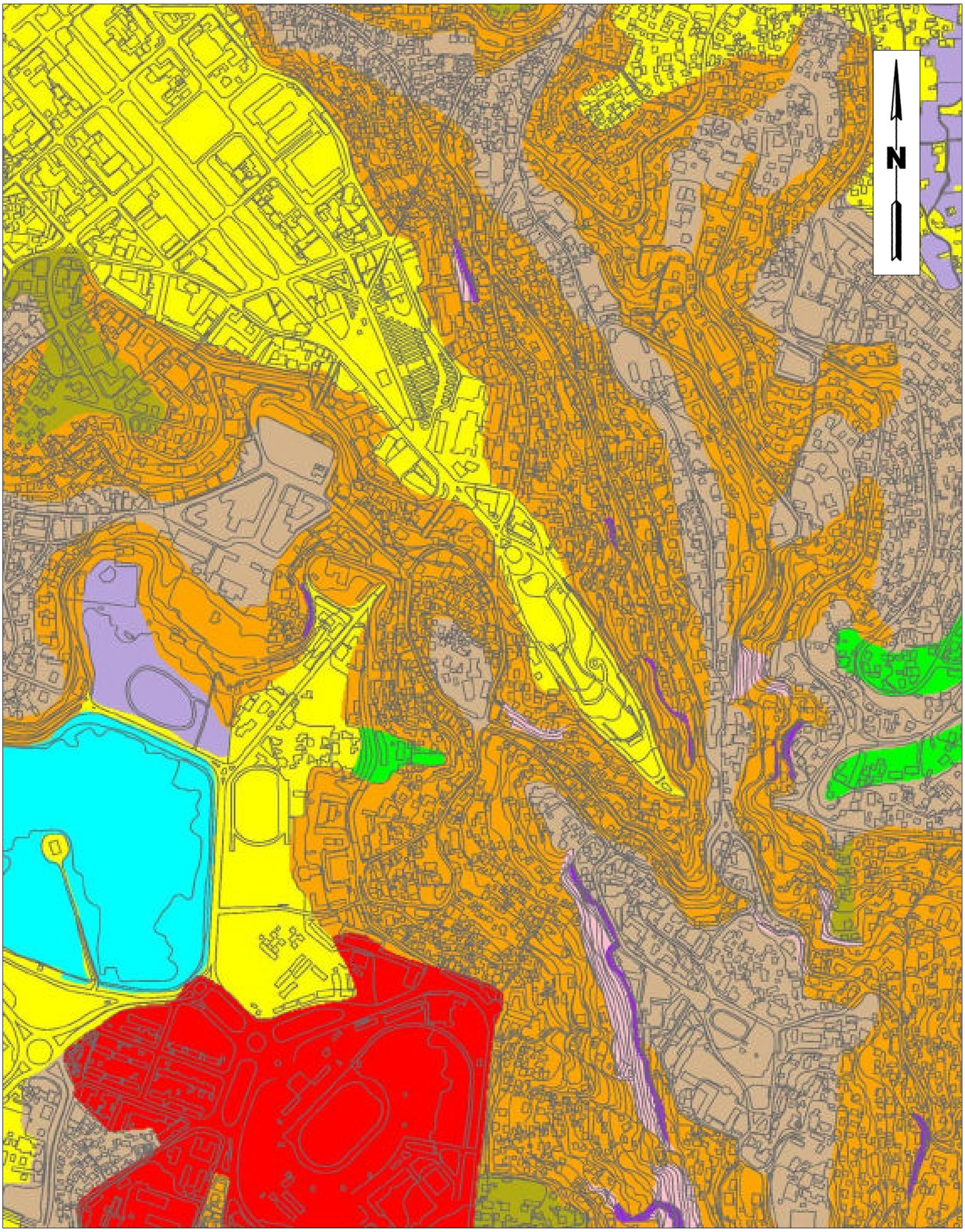



**Fig. 3.5 Land Condition Map at 1:10,000**

## 3.3 Land Use Map

### 3.3.1 Objectives in Creating the Land Use Map

The land use map is the most basic material for understanding present land use conditions in the study area, and it is indispensable in the drawing up of various plans such as city planning and agricultural development programs. The land use map can be created by interpreting and classifying land use conditions using aerial photography and satellite data, and showing the findings on topographic maps.

Although some land use maps of the study area had been created on a scale of 1:25,000 using satellite data, it was thought that a more detailed understanding of land use conditions would be effective when considering future city planning. Therefore, it was decided to create an up-to-date land use map of the study area at a scale of 1:10,000, based on the aerial photographs taken in this Study.

The Antananarivo Metropolitan Area is roughly made up of two topographic areas, a hilly area and a plain area. Characteristically the city area has been developed in the hilly area, while paddy fields are widely distributed in the plain area.

The City of Antananarivo is the product of its historical background. The Imerina Dynasty built the Antananarivo Kingdom on the hill of Andohalo because of its excellent geopolitical location. Then, the European powers were attracted by the geopolitical advantages in this location of the kingdom and helped the kingdom expand. As a result, the Metropolis grew rapidly. In short, the present city area of Antananarivo expanded as a castle town around the Queen’s Palace on the hill. At the same time, one of the main reasons why the city area is still centered on the hill is that poor drainage causes standing water in the plain area all year round.

The plain area was in ancient times a large lake formed by drastic changes in the geological structure, the area then being covered with debris sediments carried by the river running through the area. The water level in the lake has fallen twice in the past for some reason, and artificial drainage works have also been carried out in the lake area, resulting in the present state. The flow paths of the Ikopa River and the Mamba River which run through the study area were formed after the lake had dried up. In the plain area, there are still vestiges left of the lake; rainfall during the rainy season and debris and water flowing down from the upper reaches cause poor drainage, resulting in large parts of the plain area being under standing water. Most of the plain area is used as paddy fields, but there are some abandoned paddy fields in areas that have not been properly irrigated, that have turned into swampland, waste land and grassland.

In this Study, a 1:10,000-scale land use map was created through photographic interpretation and general field classification, using the topographic map data prepared in the course of the study. The study method and the results are described below.

## 3.3.2 Land Use Map Production Method

### (1) Collection of data

Data such as existing land use maps, documents, aerial photographs and satellite data were collected prior to the study, as basic data for the creation of the land use map. In particular, the FTM cooperated in this survey by providing satellite data (for three seasons), existing aerial photographs and existing 1:25,000-scale land use maps, and these were put to use in the creation of the land use map.

### (2) General field classification

A general field classification was carried out in order to grasp an outline of the land use conditions over the entire study area, in parallel with the general field classification for the creation of the land use map. An understanding was obtained of the relationship between land use conditions and the topographic features, and the characteristics of land use in the study area.

### (3) Classification category draft

The draft of the classification categories of land use in the study area for the purpose of creating the land use map was prepared using data collected, such as the results of the general field classification, aerial photographs and documents. The classification categories were determined by classifying the types of land use broadly into forest, grassland, cultivated land and others, each of which were then broken down in more detail.

### (4) Creation of the land use map manuscript through the use of topographic map data and photo-interpretation

The land use map manuscript was prepared using the topographic map data and filling in unclear places through interpretation of aerial photographs. The topographic map data was utilized for deciding the classification categories of land use. The land use map manuscript was prepared by coloring in on the topographic map.

### (5) Discussions with the FTM

Discussions were held with the FTM on the subject of the classification categories and the results of classification, based on the land use map manuscript prepared in the study in Japan, and on the method of representation in the final land use map.

### (6) Revision of the land use map by confirmation through photo-interpretation and field reconnaissance

The land use manuscript was revised and corrected through the interpretation of aerial photographs, hearings and field reconnaissance, on the basis of the results of discussions with the FTM and with the cooperation of the FTM.

### (7) Digitization of the land use map

The data from the land use map were digitized from the land use map manuscript on the same coordinate system as the topographic map data, mainly by using a digitizer. All the digital data were created as polygon data.

### (8) Output of the land use map

The land use map that has been converted into digital data can be output at any scale, but through discussions with the FTM it was decided that it would be output at the scale of 1/10.000.

### (9) Storage of the land use map on CD-ROM

The digital data of the land use map was stored as polygon data on a CD-ROM.

*Fig. 3.6 Land Use Map Production Flowchart* shows the overall work progress.

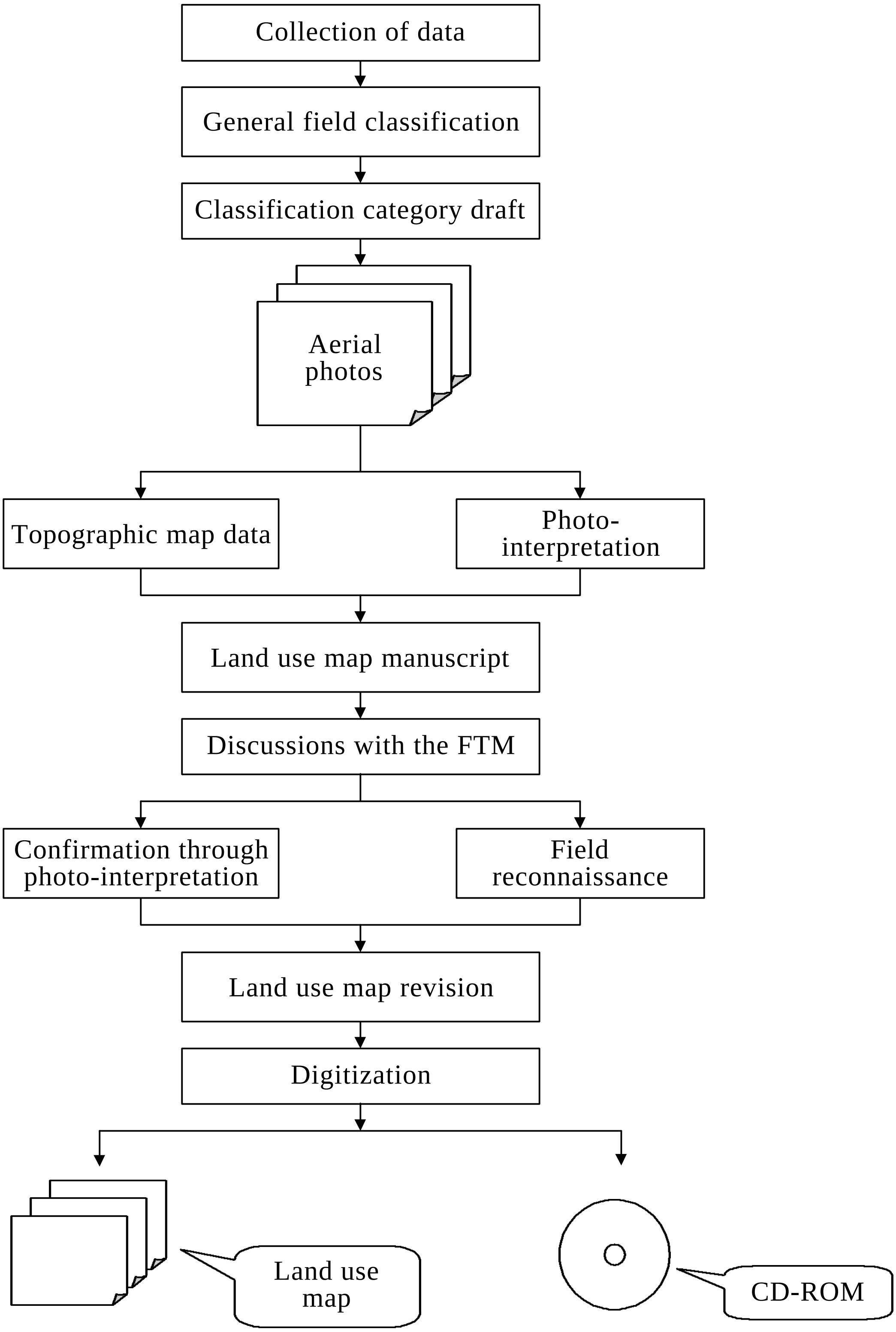



**Fig 3.6　Land Use Map Production Flowchart**

### 3.3.3 Land Use Map and Regional Characteristics

The land use map was drawn up to a scale of 1:10,000 in accordance with the classification categories shown in *Table 3.6 Land Use Map Categories.*

① The study area is roughly divided into the hilly area and the plain area as described in the section on the land condition map, and it may fairly be said that land over almost the entire area is utilized. The hilly area is occupied by the cities, towns, villages, fields and grasslands, and the greater part of the plain area by paddies and other fields.

② Towns and villages are crowded closely together on the hills. In particular, the center of the capital where the Queen’s Palace stands is located on an eminence overlooking the western part of the hill, and it was developed as a castle town for its topographical advantages. Therefore, towns and villages are thickly distributed all over the hilly area.

③ A recent trend is for people to have gathered in the Metropolitan Area in order to flee the poverty of the agricultural villages. The marked tendency toward overpopulation is also seen here. Many of the people gathering in the Metropolitan Area have come to take up residence in the lowlands which are poorly drained and where there is a high risk of inundation or flooding all year round. Those in charge of administration in the Metropolitan Area have been making efforts to improve the local environment in the lowlands by land reclamation and the construction of drainage channels. As a result, towns and villages have also spread out onto the lowlands surrounding the hilly area.

④ Most of the plain area is used as paddy fields, but the general field classification found a decreasing tendency in the availability of land for use as paddy fields except in those places provided with well-planned irrigation channels. One of the reasons for this is that there are many places where excavation for brick-making, which is widely carried out in the lowlands, exposes the clay layer, leaving only soil that is too poor for use as paddy fields. Another reason is that the rice crop production does not make use of well-provided irrigation facilities, but uses only rain water or flood water in the paddy fields. These districts would appear to have an abundance of irrigated paddy land, but it is presumed that abandoned paddy fields occupy a large part of the area.

⑤ There are also paddies and other fields in the valley bottom plains that spread their fingers into the hilly area, but these fields have an adequate, stable supply of water from spring water from the upper reaches, providing natural irrigation. In some places good use is made of the spring water to cultivate fields up to the upper parts of the hills.

⑥ There is little forest land, and almost no natural forest exists in the Metropolitan Area, except for the area around the zoological gardens on the hill in the central southern area. Other forests are artificially planted districts. Few forests are seen on the hills in the suburbs because these districts are used to provide cattle pasture and wood for firewood and charcoal.

⑦ Other categories such as artificially developed land, graveyards, quarries, uncultivated land, waste land and swampland, found scattered throughout the area, were also represented on the land use map.

## Table 3.6 Land Use Map Categories

| No. | Categories | Sub-categories | Remarks |
|---|---|---|---|
| **1** | **Forest** | | Natural forests on the hilltops and in the lowlands, including trees in parks. |
| **2** | **Reforestation** | | Economic woods planted with such varieties as eucalypti and pine trees. |
| **3** | **Grassland** | | Grasslands on the hilltops and in the lowlands and include shrubbery. |
| **4** | **Cultivated land** | Paddy field | Paddy fields exist in the lowlands and valley bottom districts in the hilly area, where double cropping and 2-crop systems are prevalent. |
| **5** | | Field | Fields are distributed on the outskirts of the hilly area; cereals and vegetables such as cassava and potatoes are cultivated. |
| **6** | | Orchard | Fields cultivated with fruit trees. |
| **7** | | Tree plantation | Fields in which trees and saplings for gardens are cultivated. |
| **8** | **Urban area** | Cities, towns and villages | Include residential districts as well as roads and embankments. |
| **9** | **Others** | Artificially developed land | Large reclaimed districts in lowlands and housing plots developed by ground cutting in the hilly area. |
| **10** | | Graveyard | Large graveyards on the top of hills. |
| **11** | | Quarry (stone, soil) | Rock pits in the hilly area and soil pits in the lowlands. |
| **12** | | Uncultivated land and waste land | Sandy land in river courses and abandoned paddy fields. |
| **13** | | Swampland | A district that is swampy during the greater part of every year and cannot be readily used for any purpose. |
| **14** | **Water body** | River, lake and marsh | Bodies of water such as rivers, lakes and marshes. |

*Fig. 3.7 Land Use Map at 1:10,000* is a sample of the land use map at a scale of 1:10,000. The land use conditions on the urban base map at the 1:10,000 level were classified into 14 categories and represented in color.

Because the map is stored in the form of digital data, it can be readily outputted to any scale. This sample was outputted to a scale of 1:10,000.

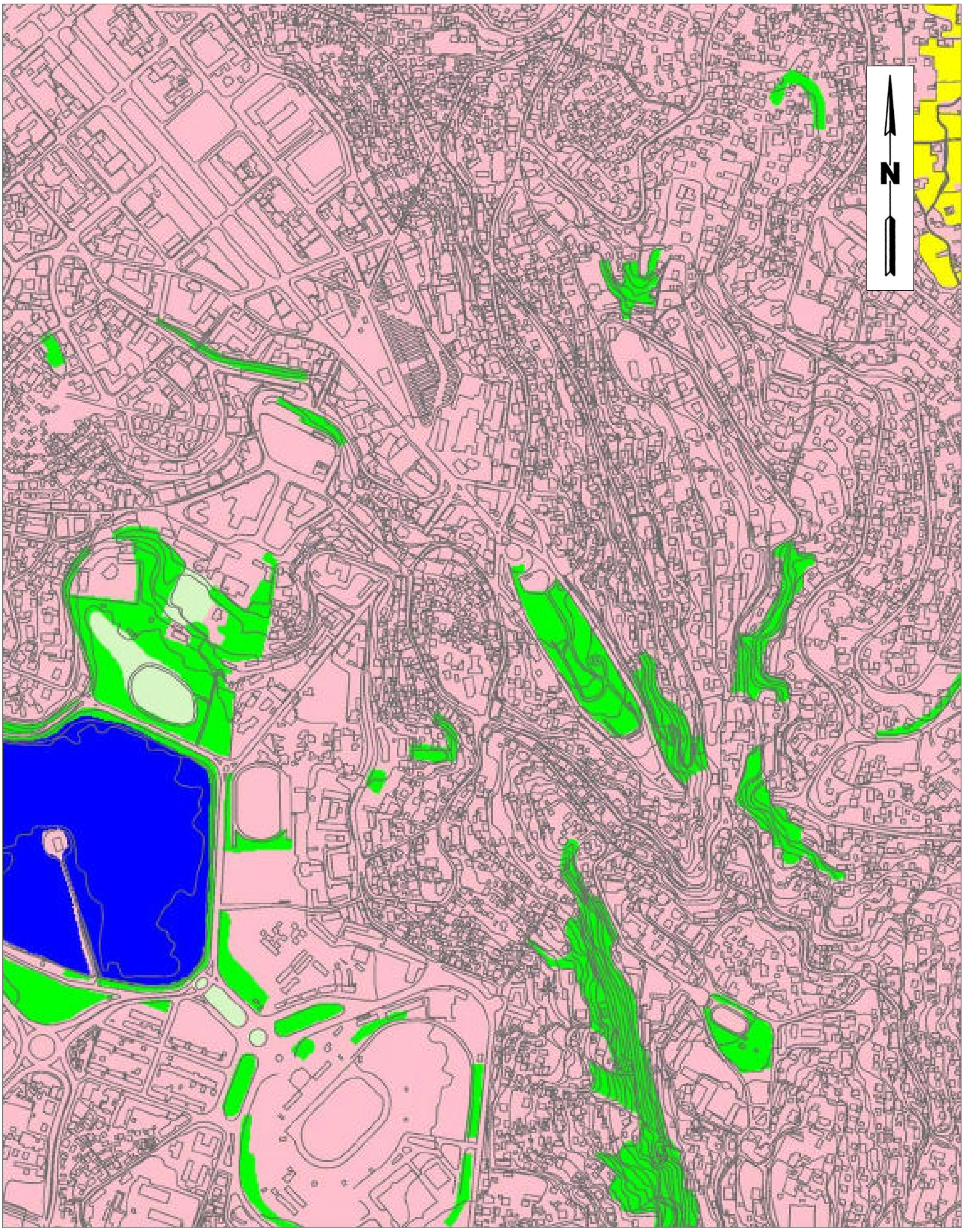



**Fig. 3.7 Land Use Map at 1:10,000**

# CHAPTER 4 GEOGRAPHIC INFORMATION SYSTEM (GIS)

## 4.1 System Components

The hardware and software for use with the introduction of GIS were examined.

### (1) Hardware Considerations

When examining which hardware to choose, the following points were taken into consideration:

- It must be the latest possible hardware, able to withstand further upgrades.
- Maintenance can be easily performed in Madagascar.
- It must be compatible with existing hardware.

### (2) Software Considerations

When examining which software to choose, the following points were taken into consideration:

- The software must offer upgrades and a support system.
- It must have functions which are compatible with future GIS needs.
- Data must be usable with other software currently in use.

After examining all the above considerations, a latest Gateway desktop personal computer was selected for its compatibility with existing hardware and its facility of maintenance.

For software, ArcView was selected for its compatibility with existing software and its capacity to be used with future GIS applications.

### 4.1.1 Hardware

Based on the GIS system to be used, the primary hardware components of the GIS system consist of:

- Gateway desktop computer; E-5250 450 Xeon dual processor
- Gateway VX1100 21" color monitor
- Calcomp 34480 Drawing Board III (A0) digitizing tablet
- HP Designjet 750C plus (A0) printer

The computer and monitor are used for storing, viewing, editing, and analyzing the infrastructure data. The digitizing tablet is used for input and correction of the infrastructure data. The printer is used for creating printed maps of various infrastructure themes.

### 4.1.2 Software

Based on the GIS system to be used, the primary software components of the GIS system consist of:

#### (1) GIS Software

**a) ArcView GIS**

ArcView GIS, a desktop GIS software, is used to visualize, explore, query, and analyze geographic data. ArcView GIS was used to create the IMS (Infrastructure Management System) interface.

**b) Network Analyst**

This is an optional software module for ArcView GIS. It provides additional analysis functions to solve network and routing problems.

**c) Spatial Analyst**

This is an optional software module for ArcView GIS. It provides additional analysis functions to model, analyze, and create spatial data and grids, and solve spatial problems.

#### (2) Other Software

**a) Windows NT4 Operating System (service pack 4)**

Windows NT4 provides a professional workstation environment that is both reliable and secure. As with other versions of Windows, the user interface is familiar and easy to use.

**b) Microsoft Office 97 Professional**

A full featured professional office suite featuring a word processor, spreadsheet, database, presentation graphics, and image editing. These tools are used to add and modify infrastructure data attributes, create reports, and manipulate graphics and images.

### 4.1.3 Data

#### (1) Electricity Database

The electricity database consists of both graphical and attribute data supplied by JIRAMA. The graphical data includes points, lines, and polygons that were digitized from maps using MicroStation software. The attribute data were entered into a spreadsheet and converted to dBase format to be linked to the graphical data in the GIS. Attribute data includes descriptive information about the local boundaries, cables, utility poles, and transformers.

#### (2) Telecommunication Database

The telecommunication database consists of both graphical and attribute data supplied by Telecom Malagasy. The graphical data includes points, lines, and polygons that were digitized from maps using MicroStation software. The attribute data were entered into a spreadsheet and converted to dBase format to be linked to the graphical data in the GIS. Attribute data includes descriptive information about the Telecom zones, cables, utility poles, manholes, exchanges, distributors, and connectors.

#### (3) Water Database

The water database consists of both graphical and attribute data supplied by JIRAMA. The graphical data includes points, lines, and polygons that were digitized from maps using MicroStation software. The attribute data were entered into a spreadsheet and converted to dBase format to be linked to the graphical data in the GIS. Attribute data includes descriptive information about the pipelines, manholes, and valves.

#### (4) Drainage/Sewer Database

The drainage/sewer database consists of both graphical and attribute data supplied by AGETIPA. The graphical data includes points, lines, and polygons that were digitized from maps using MicroStation software. The attribute data were entered into a spreadsheet and converted to dBase format to be linked to the graphical data in the GIS. Attribute data includes descriptive information about the local boundaries, pipelines, drains, manholes, and inlets.

### (5) Road Database

The road database consists of both graphical and attribute data extracted from the newly created topographic maps. The graphical data consists of centerlines which were digitized from maps using MicroStation software. The attribute data were entered into a spreadsheet and converted to dBase format to be linked to the graphical data in the GIS. Attribute data includes descriptive information about the roads such as dimensions and construction details.

### (6) Topography Database

The topography database consists of graphical data from the newly created topographic maps. These data include all of the line features and are used as a reference background for the main infrastructure themes.

### (7) Land Use Database

The land use database consists of graphical and attribute data from the newly created land use maps. The graphical data consists of polygons which were digitized from the new maps using Arc/Info software. The attribute data were entered into the Arc/Info database. The Arc/Info data were exported and subsequently imported with ArcView GIS software.

### (8) Geomorphology Database

The geomorphology database consists of graphical and attribute data from the newly created geomorphology maps. The graphical data consists of polygons which were digitized from the new maps using Arc/Info software. The attribute data were entered into the Arc/Info database. The Arc/Info data were exported and subsequently imported with ArcView GIS software.

## 4.2 GIS System Structure

### 4.2.1 GIS System Design

The GIS system was designed to provide two main functions, an interface which focuses on the infrastructure data, and a general desktop GIS. This was accomplished by a dual installation of the ArcView GIS software and optional modules. One installation was used to develop and create the IMS interface to the GIS functions, and the other version is a standard installation of ArcView GIS. The diagram illustrates the relation of the design.

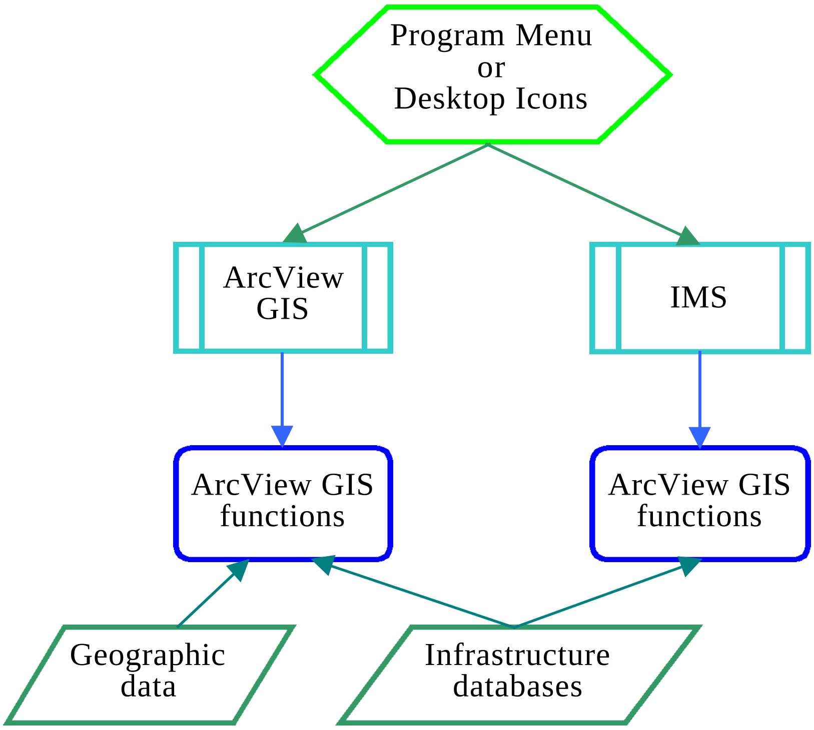



**Fig. 4.1 Hardware Configuration**

### 4.2.2 Database Integration

A key element of GIS is the ability to link or join descriptive attributes to the graphical data based on direct or proximal conditions. In most cases there is a common item such as an unique ID which can be used to link the graphical and attribute data. Where there is no direct link, a spatial link can be established based on proximity of features to each other. Linking attribute data to graphical data provides increased flexibility and analytical options for both the graphical and attribute data.

## 4.3 Macro-Programming

A series of macro programs were created to establish and control the IMS interface, and provide a series of preset views of the infrastructure data.

### 4.3.1 IMS Interface

The IMS interface establishes a direct link to the graphical and attribute data in the infrastructure databases. It is intended to be an introduction to Facilities Management. The opening screen proudly displays the FTM logo and credits for the data. A series of preset views has been established which correspond to the individual map sheets. There is a view for each infrastructure theme. From any of these views, features can be selected and analyzed, updated, or output to a printer or file. All of these functions correspond to the ArcView GIS functions so that there is no need to learn a new commands and functions if the user is already familiar with ArcView GIS.

### 4.3.2 IMS Functions

#### (1) Input

Data input of graphical and/or attribute data will occur when there is a need to add to, modify, or maintain the infrastructure data. Graphical and attribute data can be input through any of several methods which include digitizing, on-screen digitizing, ascii coordinate input (interactive or from a file), and data conversion from other formats.

Typically, graphical data is digitized from a manuscript such as a map. Subsequently the graphical data are checked and edited if necessary. Alternatively, the data may be digitized with a different software and the resulting file converted to a format compatible with ArcView GIS. Attribute data is typically entered using a spreadsheet software such as Excel or a database software such as Access, or directly into dBase. If not in dBase format, the attribute data are converted into dBase format to be used with the graphical data in ArcView GIS.

### (2) Analysis

GIS is a tool that is especially useful to visualize, explore, query, and analyze data geographically. It can be used to solve problems, identify hidden trends and relationships, and understand geographic relationships. ArcView GIS has many methods to analyze the graphical and attribute data using spatial, surface, statistical, and network functions. Particularly useful are the spatial and network functions for analysis of infrastructure data. Spatial statistics and analysis can be used to determine quantities, volumes, and zones of proximal distance. Network functions are used for routing and planning service areas. Additionally, the attributes can be statistically analyzed to quantify data and identify trends. Combining data from 2 or more sources can be very useful for planning of new facilities. This is one of the strongest features of GIS and geographical analysis.

### (3) Output

ArcView GIS provides a flexible and intuitive method for producing printed maps of the infrastructure data. There are many standard map layouts that can be used or modified at any scale and popular size. For special cases a custom map layout can be created. Map layouts, graphical data, and attributes can also be exported to other popular formats, enabling these data to be used directly in reports, spreadsheets, and other software. The final map layouts can also be saved to a file for printing later or at another location.

## 4.4 Urban Facility Database

Urbanization of Antananarivo City in recent years have led to a huge influx of migrants from the rural areas, resulting in drastic population increase and the gradual incapacitation of the city's infrastructure. As pressures to devise an urban development plan and calamity prevention plan surmount in view of the situation, the Government of the Republic of Madagascar and the Antananarivo City government acknowledged the urgent need for the construction of an urban facility database.

### 4.4.1 Data Collection and Urban Facility Database Construction (Production of Input Base Map)

The basic policies behind the construction of the urban facility database were: ① acquisition of various information to clearly confirm the current state of the infrastructure in the city and its surrounding area, ② construction of a database system that can be effectively utilized for urban development planning and calamity prevention planning, ③ a data structure that allows simple and quick data construction and update.

*Fig. 4.2 Data Collection and Urban Facility Database Construction Flow Chart* shows an outline of the work. Data collection and database construction were carried out by urban facility.

#### (1) Interviews With Urban Facility Managers

Relevant agencies (e.g. JIRAMA for waterworks, the Urban Planning Division of the Ministry of Territorial and Urban Management, AGETIPA, BDU, TECSULT for sewerage, JIRAMA for electricity, TELMA for communications) were interviewed on the various services offered by the urban facilities for analysis.

The interviews covered a variety of issues mainly on the current concerns and problems of relevant agencies, relationship with other companies (joint construction and rehabilitation work, joint use of management diagrams, etc.), use of existing diagrams, opinions on the effective use of the digital data, and the establishment of specifications for a database.

### (2) Collection of Urban Facility Data

Urban facility data collected were all types of mapping information in every type of map and diagram used for the management of urban facilities, and information on attribute data in statistical data, registers, and ledgers. Information on urban facilities was collected from the relevant agencies aforementioned through the FTM.

The condition of the collected data and information (see items below) and the results were used as reference in the interviews.

① All data in topographic maps and diagrams in use

Names and data items, condition of data (paper, polyester based, microfilm, etc.), storage conditions, section/division in charge of data storage, usage.

② Statistical registers and materials

Data names and items, sources, year produced, usage, condition of data (book, ledger, floppy disk, etc.)

### (3) Discussions and Establishment of Urban Facility Database Specifications

A draft was made containing the usage of and the items in the collected information and data, for discussion with the FTM. The discussion conclude the following data items important to the construction of the urban facility database.

① Graphic data

- Roads: centerline, width line, section cuts
- Waterworks: boundaries, conduits, type of valves (air valves, hydrants, etc.) other facilities (relay areas [pumps], supply towers, tanks [fire prevention])
- Sewerage: manholes, conduits
- Electricity: various installations (substations, transformers, switches), cables, electric posts
- Communications: manholes, electric posts, armored cables, distributors, connectors, switchboards, exchangers

② Character Data

- Roads: digitized road width, classification of divisions and road number, classification and width numbering of installations

- Waterworks: names of boundaries, conduit numbers, valve types and numbers, numbers of other facilities, numbers of the valve register.
- Sewerage: basin names, manhole numbers, conduit numbers, etc.
- Electricity: district numbers of boundaries (district boundaries), electric post numbers, numbers of various installations, numbers of electric cables
- Communications: names of divisions in exchange management, names of sectors, manhole numbers, armored cable numbers, distributor and connector numbers, switchboard numbers, electric post numbers.

### (4) Design of Map Features and Attribute Data

The following were taken into consideration in the design of the map features and attribute files.

① Design of map features, e.g. coordinates, points, lines, polygon
② Design of characters, e.g. data type, size of data for representation, number of characters, etc.
③ Design of a handling file for the establishment of key functions that would enable the simultaneous use of multiple data files.
④ Design of the screen interface necessary for the presentation of map features and attributes.

Graphic and attribute data was arranged by sheet units in accordance with the neatline for a 1:2,000 map scale. Also, three files were made for every sheet of data on map features (points, lines, and polygon files).

The graphic data was in the DGN format at the time of input and converted to ArcView during the database structuring stage. The attribute data format was MS-EXCEL at the time of input and converted to ArcView during database structuring.

*Table 4.1 Graphic Data Format* and *Table 4.2 Attribute Data Format* show samples of the data format of the coordinates of graphic data and attribute data.

## Table 4.1 Graphic Data Format

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project | Establishment of a database for geographic information system in Antananarivo area | # | Date of creation | . . | | Operator | |
| Operation | | # | Dates of correction | . . | Comments | | |
| Program | Graphic data format | # | | . . | | | |

| A2 Type | ID number AT Sheet number | I1 | I3 | F11.2 X coordinate | F11.2 Y coordinate | |
|---|---|---|---|---|---|---|
| | | Installation number | Sequential number | | | |

# Table 4.2 Attribute Data Format

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Project | Establishment of a database for geographic information system in Antananarivo area | # | | Date of creation | . . | | | Operator |
| Operation | Attribute data for pipes | # | | Dates of correction | . . | Comments | | |
| Program | List of water supply data | # | | | . . | | | |

| Sheet number (1–7) | *1 (8) | Sequential number (9–11) | Sector (12–13) | Sub-Sector (14–15) | *2 (16) | Material (17–18) | Diameter (mm) (19–22) | Length (m) (23–29) | Date of construction (y/m/d) (30–37) | *3 (38–40) | 45 50 55 60 65 70 72 73 75 | 80 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | . | | | | 0 1 0 |
| | | | | | | | | . | | | | 0 2 0 |
| | | | | | | | | . | | | | 0 3 0 |
| | | | | | | | | . | | | | 0 4 0 |
| | | | | | | | | . | | | | 0 5 0 |
| | | | | | | | | . | | | | 0 6 0 |
| | | | | | | | | . | | | | 0 7 0 |
| | | | | | | | | . | | | | 0 8 0 |
| | | | | | | | | . | | | | 0 9 0 |
| | | | | | | | | . | | | | 1 0 0 |
| | | | | | | | | . | | | | 1 1 0 |
| | | | | | | | | . | | | | 1 2 0 |
| | | | | | | | | . | | | | 1 3 0 |
| | | | | | | | | . | | | | 1 4 0 |
| | | | | | | | | . | | | | 1 5 0 |
| | | | | | | | | . | | | | |
| | | | | | | | | . | | | | |
| | | | | | | | | . | | | | |
| | | | | | | | | . | | | | |
| | | | | | | | | . | | | | |

*1 Installation number *2 Pipe function *3 Sheet number of JIRAMA

### (5) Input Base Map Production

The input base map was produced in accordance with the specifications established for map features and attribute data of every urban facility. Necessary items of the database were noted on the input base map.

To facilitate the entry of map features and character data, the input base map was produced using a base map (film base) around a scale of 1:2,000. Simultaneously, data sheets were prepared to enter attribute data.

In addition, to convey to FTM the importance of producing an input base map, a manual was made and the techniques involved were transferred to the counterpart.

### (6) Data Confirmation and Revision by Field Identification

The consistency of all items pertaining to urban facilities noted down in the input base map, topographic map, ledgers, registers, etc., to actual conditions were confirmed at the site. For road width, about 300 places were actually surveyed to ensure accuracy. The work was carried out by FTM under the direction of a study team member.

Any incompatible data detected after the field identification were revised and checked for accuracy, and the input base map was completed.

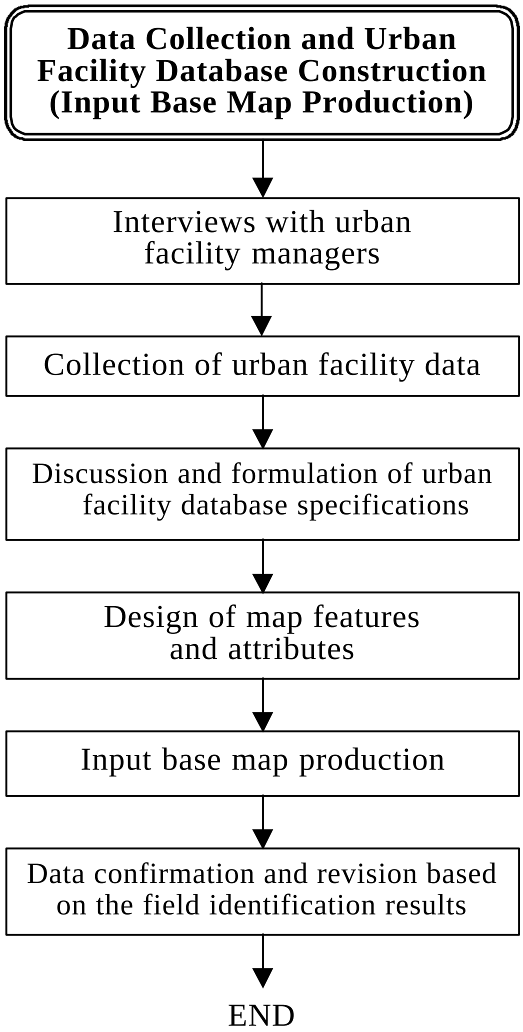



**Fig. 4.2 Data Collection and Urban Facility Database Construction Flowchart**

### 4.4.2 Digitization of Urban Facility Data

Using the input base map and a digitizer, the databases of every urban facility were constructed.

#### (1) Planning and Preparation

The detailed work plan (schedule, required manpower, etc.), attribute data sheets, and the above-mentioned input map were prepared.

#### (2) Base Map Digitization

A digitizer was used to digitize the input base map in accordance with the file design. The attribute data were entered into the data file (Excel format) from the data sheet so it can be incorporated into the system. Base map input was carried out by FTM.

#### (3) Base Map Output

The digitized base map data was printed out in the specified format to produce the map for inspection.

#### (4) Inspection

Using the base map printout, inspection was carried out to determine mistakes in the entry of key codes and errors in the cutting of sections of map features.

#### (5) Database Structuring

Map feature data in the DGN file format and the attribute data in the MS-Excel file format were converted into the ArcView format to enable operations under ArcView. Database structuring was carried out using ArcView.

#### (6) Storage of Urban Facility Database

After the inspection and revisions are completed, the urban facility database was stored in a CD-ROM.

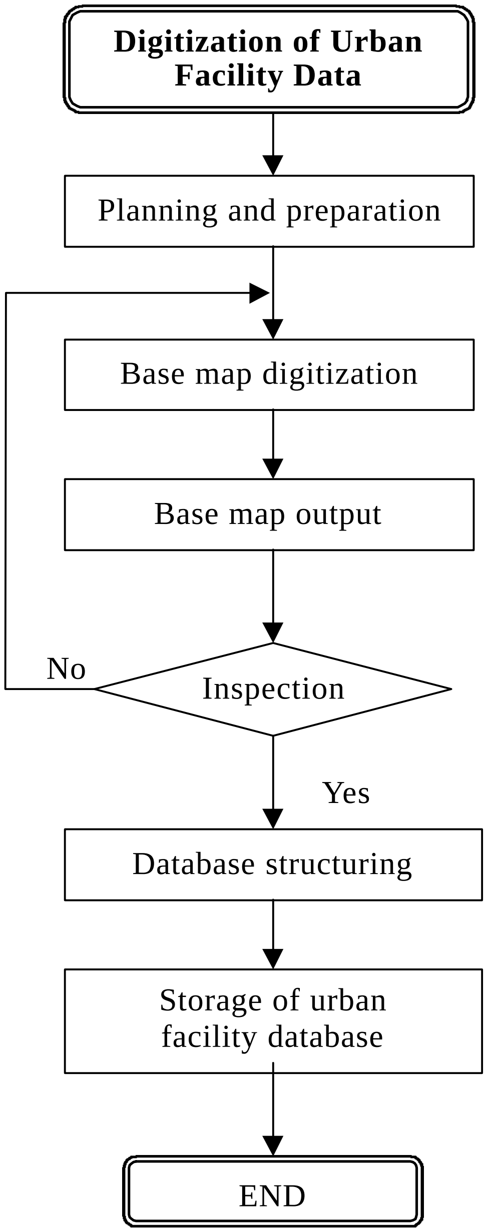



**Fig. 4.3 Urban Facility Data Digitization Flowchart**

### 4.4.3 Infrastructure Management System (IMS) Structure and Functions

IMS (Infrastructure Management System) was constructed using the ArcView software. This section details the basic structure and functions of IMS. IMS structure is as shown below.

#### (1) IMS Structure

① Entry System

- Map feature entry system
- Attribute data entry system

② Management System

| | |
|---|---|
| • Urban base map IMS | (Inactive D.B.). |
| • Road IMS | (Active D.B.) |
| • Waterworks IMS | ( " ) |
| • Sewerage IMS | ( " ) |
| • Electricity IMS | ( " ) |
| • Communications IMS | ( " ) |

The main IMS functions in each management system are as follows.

#### (2) IMS Functions

① Functions regarding map features: scroll, zoom in/out, presentation of specific items (division of layers), color setting

② Search functions: search by function keys, location/position, or other search conditions

③ Statistical functions: data calculation

④ Representation (output) functions: representation and output of calculation results, representation and output of map sections, representation of special items.

## 4.5 GIS Created During This Study

### 4.5.1 GIS Introduction

The ultimate function of the GIS is to provide a powerful tool for the unified management of various information and for policy formulation and implementation as stipulated in section 2-2. As a first step toward the attainment of this level of usage, this study aimed to introduce a feasible GIS.

Studies were carried out on problems the city of Antananarivo is currently facing, especially those related to social infrastructure, i.e. waterworks and sewerage, flood countermeasures (land condition map), and urban planning (land use map).

Studies were also carried out to determine the quality of the information currently being managed by the city of Antananarivo, and the relevant items for the production of a 1:10,000 scale digital map. Based on the results of the studies, the GIS established covered the following facilities and thematic maps:

① 1:10,000 digital topographic map
② Land use map
③ Land condition map
④ Urban facilities
- Roads
- Waterworks
- Sewerage
- Electricity
- Communications

To cover these items, a basic database and rudimentary analytical functions were provided.

### 4.5.2 Database Construction

The type of database constructed under this study is detailed hereunder.

#### (1) 1/10,000 Digital Topographic Map (Urban Base Map)

This map was designed to be used also as a data input base map. The map symbols for the 1:10,000 digital map were digitized, with each item assigned a topographic classification code. The data contained in each item were classified into points, lines, and polygons to cope with highly advanced usage, and will be displayed on screen for use in GIS.

### (2) Land Condition Map

The land condition map database was constructed based on the urban base map (topographic map) database, aerial photos, and satellite images. The database contains geomorphological classification, areas prone to flooding, and information on main facilities established to cope with calamities. This database is constructed to forecast flooding and soil erosion.

### (3) Land Use Map

The land use map database is constructed based on the urban base map (topographic map) database and aerial photos, to understand present land conditions and for land use planning in the future.

### (4) Urban Facilities

The following five urban facility databases were constructed under this project.

① Roads (see sample in *Fig. 4.4 Road Facility Map*)

Construction of a road database containing information on road pavement, road shoulder, location and quantity of road accessories (e.g. paths, bridges, tunnels) for use in future maintenance and traffic planning activities.

② Waterworks (see sample in *Fig. 4.5 Waterworks Facility Map*)

Focusing on the management of supply facilities, i.e. pipelines and valves, a database on valve location and type, type and dimensions of pipelines was constructed for use in times of repairs due to accidents and regular maintenance.

③ Sewerage (see sample in *Fig. 4.6 Sewerage Facility Map*)

Construction of a sewerage database containing information on the location, type, dimensions of manholes, pipelines, and valves for future use in the formulation of new plans and periodical maintenance plans, and for future simulation.

④ Electricity (see sample in *Fig. 4.7 Electrical Facility Map*)

Construction of a database on electrical facilities mainly containing information on electricity posts (location, material, cable type and diameter, voltage, etc.) for use in electrical supply planning, facility maintenance, and rehabilitation planning as a result of calamities and accidents.

⑤ Communications (see sample in *Fig. 4.8 Communications Facility Map*)

Construction of a database on communications facilities mainly containing information on the location of wired communications facilities, i.e. telephone posts (type and dimensions of cables) for use in planning new facilities, formulating rehabilitation plans as a result of calamities and accidents, and for periodical maintenance.


**Fig. 4.4 Road Facility Map**


**Fig. 4.5 Waterworks Facility Map**


**Fig. 4.6 Sewerage Facility Map**


**Fig. 4.7 Electrical Facility Map**


**Fig. 4.8 Communications Facility Map**

## 4.6 Future Applications of Constructed Databases

This project only constructed basic databases and because the collected materials did not contain all data required, revisions should be carried out.

### (1) 1/10,000 Digital Topographic Map (Urban Base Map)

Digital mapping was set at a scale that corresponds to a 1:10,000 topographic map scale. Accordingly, the database contains all topographic mapping items for a 1:10,000 scale topographic map. However, the application of these mapping information, e.g. roads, rivers, houses, etc., is not limited to the map scale and can be widely used therefore.

### (2) Land Condition Map

This database provides free access to information regarding countermeasures, i.e. flood countermeasures, soil erosion countermeasures, adopted as a consequence of flood calamities that have hit the nation in recent years.

### (3) Land Use Map

This database provides the urban planner with all relevant information that can be accessed whenever one deems necessary.

### (4) Urban Facilities

Many of the attribute information required were missing in the collected materials, thereby only enabling the construction of a database for rudimentary analysis.

① Roads

This database provides those in charge of roads with statistics pertaining to road length, route length, road pavement, etc.

② Waterworks

This database provides those in charge of waterworks with statistical information, e.g. number of facilities by type, pipe length by type, necessary for waterworks facility operation and maintenance, as well as information on the location of the facilities.

③ Sewerage

As in the waterworks database, this database provides those in charge of sewerage with information regarding the statistics and location of the facilities.

④ Electricity

As in the waterworks and sewerage databases, this database provides those in charge of electricity with information regarding the statistics and location of the facilities. By using the housing information shown in the background diagram, the use of this database also enables the creation of a user’s map.

⑤ Communications

As in the electricity database, this database provides those in charge of communications with information regarding the statistics and location of the facilities.

# CHAPTER 5 EXPANSIVE APPLICATIONS OF GIS

## 5.1 Future Use

The study work this time around involved surveys concerning the construction of databases for urban facilities (waterworks, sewerage, electricity, communications facilities) land use map, and land condition map. Various relevant data (graphic data, attribute data) were collected and digitized, although for the construction of the urban facility database, only one section of Antananarivo City was covered. Because of this, the study work this time around can be considered as a part of the IMS pilot project. In this regard, some issues have to be considered in view of the future application of IMS.

The application of IMS would require learning the smooth operations involved, to understand the concept behind the IMS operation and study the operational methods that would enable local workers who are unskilled in computer usage to carry out the objectives of IMS.

The complete application of IMS, however, would necessitate the analysis of the services it provides (e.g. facility operation and maintenance, etc.), in order to clearly determine the functions required by the sectors that would adopt IMS and the database structure and items that would enable its complete application. The aim here is not to realize the complete application of IMS directly after the pilot study is completed, but to gradually upgrade the level of application until full application is eventually achieved.

With regard to the data for database construction, a standard criteria should be established for data creation to ensure data consistency. In particular, the unification of map symbols to be used in every facility database is a significant issue. For data input, it is also very important that the data are of the same format.

As a component of GIS, therefore, a thorough investigation of how these various materials are applied by every facility administrator for facility operation, maintenance and expansion is indispensable to the operation of this system.

## 5.2 Expansion of GIS Functions

### 5.2.1 Study Implementation

The extremely restricted IMS functions were actualized in this study using Arc/View. These functions, however, were very fundamental in nature and do not, therefore, enable the full use of IMS.

When considering improvements in the IMS functions, it is very important to know the kind of services carried out by the facility administrator and how the data (graphic data, attribute data) collected in this study are used. Accordingly, there is a need to confirm these conditions at the site and to compile the results for the formulation of the IMS design and the database design.

### 5.2.2 Expansion of IMS Functions

In accordance with the results of the studies above-mentioned, a plan to expand the GIS functions should be prepared and implemented with due consideration of the additional database items required and the difficulties, the urgency and the financial restrictions involved in the development of the functions.

## 5.3 Database Construction

### 5.3.1 Construction of Facility Databases

The facility databases were constructed using the collected data and in accordance with the procedures mentioned in Chapter 3. This phase entails the construction of a database only for the pilot area, and the experience gained should be used in the construction of a full scale database.

- Standardization of the Format of New Facility Data

  The data that will be created shall be in accordance with the base map produced by FTM, and in terms of positioning accuracy, the neatline division established by FTM will be used as a guideline. Each facility administrator will be provided with the base map, and the map symbols that they have used to date shall be digitized and unified.

- Improvement of the Base Map and Attribute Data Production Manual

  Based on conditions met during the actual work, the manual for the constructed database shall be revised so that even beginners can understand the procedures and considerations involved, and to raise the usefulness and value of the manual.

- Database Construction Tools

  Unlike a manually constructed database, the construction of a full scale database requires the adoption of a large production system taking economic influences into account. This, however, necessitates the division of labor, e.g. arrangement of collected data by sheet, base map construction, attribute data upgrade, digitization of base map attribute information, inspection, etc. The digitization of the base map will not only adopt the old practice of using the digitizer, but also the use of a scanner to improve data entry efficiency. The digitization of attribute information was carried out using a personal computer and a software (e.g. Excel) for graphic formats, to produce this data in large amounts. These considerations and experiences should be referred to, therefore, in determining the tool to be produced for database construction.

- Database Quality Control

  For the quality control of the constructed database, inspections were carried out using the output map to check whether the data (graphic and attribute data) were compatible. However, if the database contains huge amount of data, other quality control measures may be taken. For graphic data, this would entail inspections to determine whether the coordinates of the nodes and tie points are completely matched, as well as checking the adjoining of a section of adjacent sheets. For attribute data, logical inspections will be carried out to determine missing codes in the attribute items, inconceivable construction dates, and unlikely matching of attribute data. Accordingly, there is a need to develop such methods of inspection to maintain and improve the database quality.

Although the above are the concerns to be addressed when constructing a full scale database, the schedule involved in the selection of the area to be covered by database construction is an equally important concern as well. It is, therefore, important to formulate and implement a rational database improvement plan that fully takes into account the urgency of database construction as a social issue and the financial restrictions that are likely to entail.

### 5.3.2 Land Condition Map Database Construction

The land condition map shows how the study area topography has developed. Constructing this database is a new endeavor for FTM. The items delineated on the map are ① geomorphological classification, ② flood prone areas determined from satellite data, ③ main facilities provided in times of calamity.

#### (1) Geomorphological Classification

The topographic features in the study area were classified into hilly area, plain area, and others, based on discussions with the FTM and professors of prestigious universities. The classification was carried out in detail particularly with regard to issues of flooding and soil erosion.

To be specific, the hilly area is divided in terms of location or origin, from the top to the foot of the hill. The division of the plain started from the gentle slopes of the hilly area all the way to the slightly elevated area or the depression.

After fully studying the appropriateness of these classifications in view of the purposes for the use of the database and changes in surrounding areas, database update to prevent inconsistencies in the classification and the development of surrounding areas should be seriously considered.

#### (2) Identification of Flood-prone Areas by Satellite Images

The land condition map was produced under the assumption that it will be useful in forecasting calamities, particularly flooding and soil erosion, and the formulation of future land use plans.

The production of a land condition map showing the minute features of the plain area is considered extremely useful in the formulation of various plans for the development of the area, especially since annual flooding in this area significantly affects the villages and the farmlands. Although there is only a 2m difference in ground elevation in the upstream and downstream sections of the study area, the acquisition of detailed data on ground elevation would be necessary in the formulation of various land use plans. Ground elevation data refer to the elevation in the plain. In terms of accuracy, however, it was difficult to create data on 1m ground elevation using the aerial photos taken during this study. Accordingly, the flood prone areas identified from satellite images were inscribed with the observation date, was divided into 3 periods and indicated on the land condition map. Originally, noting down the water depth and flooding probability in flood prone areas was advisable. Scarcity in data, however, made this impossible this time around. It is, therefore, advisable to accumulate such data.

### (3) Main Facilities Provided in Times of Calamity

Interviews with the FTM, particularly with regards to government flooding countermeasures, indicated that the following methods are being implemented at the moment.

In times of large floods, the government office concerned summons an emergency committee, and upon studying the various data obtained from the meteorological and hydrological observation stations, issues appropriate directives to the relevant public enterprises. The water level or river flow observation station, which is located on a bridge along a huge river, provides water level and river flow data.

Since floodwater stays longer in the surrounding floodplain it is very important to determine the facilities that would help understand conditions of standing water and the land condition map data to be revised including calamity countermeasures.

## 5.3.3 Land Use Map Database Construction

The land use map produced accurately represents the land use conditions during the time of the study based on aerial photos. After the map was produced, the land use map database was constructed.

### ♦ Basic Data for Land Use Map Production

Aerial photos were taken of the entire study area to produce a basic topographic map. Although the aerial photos were very effective in understanding land use conditions in a vast area, their use was by no means economical.

Lands in the hilly area are fully used, especially in the plain or the city outskirts where villages continue to expand. Future land use data update expenses will be curtailed, however, as aerial photos to be taken will only cover newly developed village areas.

Land use maps can also be produced using SPOT images and especially with the expected development of a satellite with high resolving power. The use of satellite images would not only entail the computerized processing of the images but also the interpretation of the processed images to produce a detailed land use map. Nonetheless, a balance between the need for efficiency and the need to economize should be established.

## 5.4 Database Update

Once the database is constructed its update would be a significant operational concern. In particular, the update of data on facilities is very important due to significant secular changes. The sections hereafter mainly detail facility data update, while details on land condition and land use data are summarized in *5.4.3 Database Update*.

### 5.4.1 Database Update Cycle

The databases in the IMS are very important considering that the system is used on a daily basis. Ideally, these databases should be constantly in sync with each other. This is impossible to establish, however, especially due to the inevitable lapse in time between the rehabilitation of the facilities and the production and relay of information on these facilities. Even if the production and relay of information are smoothly carried out, there is still a need to study the rehabilitation period and the economics involved.

- Production of Information for Facility Rehabilitation
  The rehabilitation of facilities is influenced by the financial expenditures of the facility administrator. Rehabilitation is also considered to take several months. Given these considerations, it is surmised that data update should be carried out at the most twice per fiscal year.

If the above rehabilitation data production cycle is taken into consideration, the database could be updated once or twice a year.

However, measures, i.e. temporary data update or database update upon receipt of data on facility rehabilitation, that would filter any adverse influence that may be brought upon by the rehabilitation cycle can be also introduced, in view of the synchronous nature of the databases and for quality control.

It is, therefore, advisable to study the way IMS is operated in order to conduct regular database update.

## 5.4.2 Data Collection for Database Update

If database update is decided based on the cycle stipulated in *5.4.1 Database Update Cycle*, every facility administrator would require every type of material on facility rehabilitation services and database update. The data required for database update shall be produced based on the newly constructed database and the base map produced by FTM, and in accordance with the map symbols adopted by every facility administrator. It is, therefore, necessary to establish a system for the regular collection of these data and materials.

## 5.4.3 Database Update

### (1) Land Condition Database Update

As long as there are no significant geomorphological changes, there is no need to update the land condition map database. However, data on ground elevation and the main facilities provided in cases of calamities should be updated appropriately for use in emergencies.

### (2) Land Use Map Database Update

The land use map database is considered to significantly change with time. In particular, there is a need to update data on principal cities at least every 5 years especially in view of the continuous expansion of the capital – the city is radiating out from the central area due to the huge influx of the rural population. The use of aerial photos or satellite images for data update will be inevitable.

### (3) Facility Database Update

Facility database construction did not involve the rehabilitation of any existing database, but only the construction of new databases. The database construction work volume also entailed the formulation of relevant methods and manual. Even with regard to data update, the formulation of methods and a manual is also necessary. The following are necessary in the formulation of a manual for database update.

- Use the existing facility map as base map, and clearly indicate details to be updated on the map.
- The sections updated and not updated should be matched.
- Consider the type of data (points, lines, surface) in the updated section and save the data type after the update is completed.

The proper handling of old data is, however, of importance as well. Old data should not be considered irrelevant and eliminated, but rather saved as historical records.

The system should be set up with a function that would enable the storage of such historical data.

## 5.5 Recommendations to FTM on IMS

Sections 5.1 to 5.4 detail the future operation of GIS mainly for IMS. There is a need to determine the type of implementation body for database improvement and the design of functions which will provide the basic data for the operations.

### 5.5.1 IMS Services

The previous sections detail the database construction and functions for IMS.

IMS is a powerful tool for the rational operation, management, maintenance and expansion of various urban facilities. The operation of IMS through the established GIS will be carried out by the various urban facility administrators.

FTM's role in the operation of the IMS is to construct and update the databases, and stabilize and upgrade database functions, to enable the facility administrators to smoothly operate IMS.

Accordingly, FTM is expected to actively carry out the following:

- Study and analysis of the services with every urban facility administrator
- Design and implementation of IMS upgrade based on the results of the study and analysis of the services
- Database construction following the upgrade of the IMS and the expansion of the areas where it can be applied.

The above services directly relate to IMS and significantly differs from FTM's previous activities.

Aside from this, a digital topographic map at a scale of 1:10,000 was used as the background map for GIS.

If the use of IMS becomes highly improved in the near future, there is a need to investigate the production of a digital topographic map – for use as background map – at a much bigger scale. This particular activity can be incorporated as one of the common services to be provided by FTM.

Nonetheless, there is a need to carry out a full discussion with the facility administrators concerning the topographic features that have to be delineated in the background map.

Previous sections detail the services related to the use of IMS mainly for urban facility management. It is also clear that even the system for the management of fixed properties (including those based on taxes) that is based on cadastral survey results is also another form of GIS that is useful to the government. FTM is expected to be fully capable of coping with the fixed property management system using the technical experience it has gained from the use of IMS for facility management.

In the past, FTM's responsibilities mainly involved the production of various topographic maps. Now, involvement in this project has provided FTM with the opportunity to advance into the field of GIS. This field, particularly database construction, covers a lot of services and is therefore seen to attract numerous potential clients, i.e. urban facility administrators. Considering this as a part of the IMS services will clearly create a huge market for FTM in the future.

### 5.5.2 IMS Research and Development

Aerial photo survey techniques alone would not suffice for the implementation of the various services outlined in section *5.5.1 IMS Services*. The training of human resources and research and development activities outlined below is, therefore, a matter of significant concern to FTM.

- Training of personnel in the study and analysis of services applicable to IMS (GIS)
- Training of personnel in GIS operations (system design, database design, programming)
- Training of personnel in database construction (base map production, entry of graphic data, attribute data production and entry)
- Research and development of effective database construction tools
- Research and development of tools for extracting database errors

These above-mentioned issues should be seriously considered by FTM in its development of the IMS (GIS) services.

## 5.6 GIS Software Utilization

### 5.6.1 GIS Software Utilized by FTM

In recent years, the use of GIS by FTM and other administrative organization has extended over different sectors. *Table 5.1 GIS Software Used by FTM* summarizes the GIS software that are currently used by FTM and their applications.

**Table 5.1 GIS Software Used by FTM**

| GIS Software | Section | Application |
|---|---|---|
| Arc/Info | DIB/DpGO | • Automatic marginal design<br>• Simple calculation of DTM |
| | DpRD/DMC | • Database structuring (BD500)<br>• Forest database<br>• Land use |
| | DIG | • Geographic information database<br>• Digital plotting (thematic map, base map) |
| ArcView | DIB/DpGO | • Orthophoto processing/marginal design |
| | DpRD/DMC | • Database and orthophoto demonstration |
| | DIG | • Digital plotting (thematic maps) |
| MapInfo | DpRD/DMC | • Integration of total station data<br>• Use of BD500 database |
| | DIG | • Format conversion (for users) |

Note): DIB/DpGO : Direction de l'Information de base/Département de Géomatique
DpRD/DMC : Direction Marketing Commercial/Département Recherche et Développement
DIG : Direction de l'Information Géographique

### 5.6.2 GIS Features and Database Utilization

The main GIS functions are: ① database, ② search functions, ③ superimpose functions, ④ analysis of topographic features, ⑤ 3-dimensional representation. With these functions, GIS can be used as a tool in various analysis work, the results of which can be provided as valuable information to relevant agencies. This particular feature is considered significant in GIS.

In this study, these GIS functions were used to enable various analysis and to serve as the most fundamental data; the following databases were constructed: ① topographic information, ② information on every facility, ③ information on land conditions, ④ information on land use condition. As shown in *Table 5.2 Data Applications in GIS*, GIS was put into application using the various data produced.

**Table 5.2 Data Applications in GIS**

| Data Type | | Usage |
|---|---|---|
| General Data | | • Background map of each GIS |
| Topographic Map Data | Contour lines | • Classification of elevation<br>• Slope classification<br>• Slope direction classification |
| | Water system | • Classification of water systems<br>• Production of river profile map |
| | Vegetation | • Classification of vegetation |
| | Villages | • Land use classification |
| | Farmlands | |
| Urban Facility Data | Roads | • Unified management of basic data on every facility; provision of data for facility expansion and preservation planning, appropriate assessment of the location of new facilities through superimposition with other data (land use and land condition data) |
| | Waterworks | |
| | Sewerage | |
| | Electrical facilities | |
| | Communications facilities | |
| Land Condition Data | Geomorphological classification | • Land classification（danger of collapse, land use potential） |
| | Classification of inundation prone areas | • Land classification（danger of flooding, land use potential） |
| | Related facilities | • Suitable land classification |
| Land Use data | Land use classification | • Land classification（superimposition with land condition data） |
| | Classification of the use of buildings | • Classification of building use, classification by number of levels |

Not all data shown in the table above can be analyzed separately. To analyze such data, additional information would be necessary. For example, the analysis of land condition data would require data on elevation, rainfall, and discharge.

### 5.6.3 Advantages of GIS

As mentioned in section *2.1 Background of the Study*, the formulation of an urban development plan for the city of Antananarivo is urgently required due to various reasons. To do so, however, all relevant data on the city should be collected; such data would cover the following:

- Data on population, including population distribution
- Data on public facilities (city hall, hospitals, police stations, post offices, schools, health centers, fire department, sewerage company, waterworks company, telephone company, etc.)
- Data on road network within the city
- Data on land use conditions (public land, residential area, commercial area, industrial area, parks, etc.)
- Building conditions
- Data to verify land ownership rights

It is presumed that the data above-mentioned are acquired in analog form from the city hall and other relevant agencies. From these data, basic information, such as those shown below, may be created to assist in the formulation of countermeasures against the various urban problems:

- Data on population will enable the representation of population density and increase and decrease in population in every administrative unit on the map, making it possible to determine the rate of concentration of population in a specified area and consequently the preparation of countermeasures.
- Preparation of materials that would determine the average location of various public facilities for the benefit of the users. Preparation of materials to decide a suitable location for new facilities.
- Preparation of materials to determine current condition of lifelines, i.e. waterworks, electricity, communications. Preparation of materials to estimate storage and processing capacity, and extent of use in case expansion of lifeline is considered, as well as preparation of materials for the formulation of an expansion plan.
- Preparation of materials for the formulation of a lifeline rehabilitation plan.
- Preparation of materials for the appropriate development of residential areas, industrial areas, and commercial areas in the urban area.
- Preparation of materials for the formulation of road network development plan and road improvement plan in the urban area.

These materials can be produced either directly from the collected data, an integrated format of multiple data, or as a result of calculations based on a combination of data.

The manual (analog-based) implementation of the work would require a lot of manpower and be time consuming. Accordingly, digitizing these information, linking them to the positioning data on the map, and their unified management by GIS would enable the extraction of unprocessed data and simple data calculations, and the acquisition of processed information essential to urban development planning and urban policy formulation.

For the moment, the following usage of the data which can be accessed from the databases constructed, should be seriously considered.

- In addition to data from the land condition, land use, and urban base map databases, past flooding records should be used to forecast future flooding occurrences in the area, and help the formulation of plans (rearrangement of land use conditions, resettlement, expansion of drainage installations, reinforcement of dykes/levees) to minimize damage.
- Data from the lifeline database should be managed uniformly and used to formulate future maintenance and expansion plans.
- Data from the road database should be managed uniformly and used to formulate maintenance plans.

To realize the effective and advantageous utilization of GIS, as above-mentioned, and as stipulated in section *5.5.1 IMS Services*, FTM should expand the constructed databases in response to the demands of the users. Using the experiences accumulated from this project and from FTM's previous activities, there is a need to prepare the basic data to counter-act various urban problems, and promote how useful the application of GIS is to the agency responsible for formulating urban policies, as well as agencies responsible for urban planning. To do so, however, it is necessary to specifically explain how GIS can be a powerful tool for urban policy formulation and urban development planning. The training of GIS experts for urban policy formulation and urban development planning, and devising the powerful tools required are concerns that ensue those underscored in section *5.5 Recommendations to FMT on IMS*.

# CHAPTER 6 TECHNICAL TRANSFER

This project was implemented making use of various technologies, from aerial photography to GIS database construction. Some of these technologies were transferred to the FTM.

## 6.1 On-the-job Training

### (1) Air Signal Installation

This was carried out with the cooperation of FTM, and the agency staff were trained on the following in the course of the work: manner of allotting points/marks, deciding the air signal size and material.

### (2) Aerial Photography and Processing

This was carried out with the cooperation of FTM, and the agency staff learned the techniques involved in aerial photography planning, etc., during the course of the work.

### (3) Ground Control Survey

This was carried out with the cooperation of FTM, and the agency staff learned the techniques involved in the calculation of measured data, effective calculation methods, and concluding re-surveys.

### (4) Production of and Input Base Map

Initially, this was not included in the scope for technology transfer. However, as a part of the database construction work, it’s inclusion was inevitable. Transfer of technology relevant to this work was fully discussed with the FTM and carried out.

### (5) Digitization of Urban Facility Data

This was carried out with the cooperation of FTM, and the agency staff were trained in the detailed processes and simple data inspection methods during the course of the work.

### (6) Others

Due to the strong interest shown in the planning, management, and quality control methods of the above survey work, the technologies involved were covered in the technology transfer operations after thorough discussions with the FTM. In addition, questions in the standard work volume led to explanations of the empirical figures of Japan.

## 6.2 Seminar

The project outline presentation and the handing over of the results ceremony were held at a seminar as per the following schedule:

1. Date and time — 15 September 1999, 09:30—12:00
2. Venue — Hilton Hotel
3. Participants — Ministère de I'Aménagement du Territoire et de la Ville (9 persons), JIRAMA (4 persons), TELMA (2 persons), BPPA (2 persons), Japanese Embassy in Madagascar (3 persons), JICA (6 persons), Sumitomo Corporation (1 person), FTM (16 persons), press (11 persons), total (54 persons)
4. Time schedule

| | |
|---|---|
| 09:30-10:00 | Opening Address by FTM |
| 10:00-10:30 | Explanation of the Project Outline |
| 10:30-10:45 | Coffee Break |
| 10:45-11:00 | Explanation of the GIS System |
| 11:00-11:15 | GIS Use and Applications |
| 11:15-11:30 | Greetings by the Japanese Government Side |
| 11:30-11:45 | Handing Over of the Results Ceremony |
| 11:45-12:00 | Greetings by His Excellency Mr. Minister of Ministère de l'Aménagement du Territoire et de la Ville |
| 12:00 | Closing Address by FTM |

## 6.3 Workshop

A workshop was held on database construction for FTM technicians, and on SIG for FTM executives/technicians and related organizations as per the following schedule:

1. Date and Time 16 to 27 September 1999, 08:45-15:30
2. Venue FTM
3. Participants FTM, JIRAMA, TELMA, AGETIPA

### (1) Database construction

Participants: FTM technicians (6 persons)
Period: From 16 to 17 September 1999
Content:
- Graphic data input method
- Database structure (graphic data, attribute data, etc.)
- Data input method using MicroStation
- Production of input base map and application

### (2) GIS

Participants: FTM technicians (6 persons)
Period: From 16 to 27 September 1999
Content:
- Introduction of each database
- GIS software
- ArcExplorer
- IMS
- Spatial Analyst
- PowerPoint

Participants: FTM executives (6 persons)
Period: From 22 to 27 September 1999
Content:
- Introduction and applications of each database, analysis using GIS
- Introduction of ArcExplorer, utilization on Internet
- Copyrights
- Introduction to PowerPoint, creation of a presentation

Participants: Related organizations (8 persons)
Period: From 20 to 24 September 1999
Content:
- Introduction of ArcExplorer
- Q&A session on ArcExplorer and databases

# CHAPTER 7 RESULTS

The results to be handed over to FTM by JICA are as outlined below:

| | | |
|---|---|---|
| 1. | Inception Report | |
| | English | 5 copies |
| | French | 10 copies |
| 2. | Interim Report | |
| | English | 5 copies |
| | French | 10 copies |
| 3. | Draft Final Report | |
| | English | 5 copies |
| | French | 10 copies |
| 4. | Final Report | |
| | English | 5 copies |
| | French | 10 copies |
| 5. | Digital Map databases | |
| | CD-ROM | 50 copies |
| 6. | IMS User's Manual | |
| | English | 10 copies |
| | French | 20 copies |
| 7. | Plotted Maps | |
| | 1:10,000 topographic map | 20 copies |
| | 1:10,000 land use map | 20 copies |
| | 1:10,000 land condition map | 20 copies |
| | 1:10,000 urban facility map | 20 copies |
| 8. | Aerial Photographs | |
| | 1:20,000 negatives | 1 set |
| | 1:20,000 contact prints | 3 sets |

The reproduction of the survey results produced and the CD-ROM to be created for the handling of these results for academic research and socio-economic development, and not for profiteering, will be allowed under the authority of JICA and FTM.

# APPENDIX

| | |
|---|---|
| **Scope of Work (S/W)** | **3 July 1998** |
| **Minutes of Meeting (M/M)** | **3 July 1998** |
| **Minutes of Meeting (M/M)** | **12 November 1998** |
| **Minutes of Meeting (M/M)** | **25 June 1999** |
| **Minutes of Meeting (M/M)** | **14 September 1999** |

SCOPE OF WORK

ON

THE ESTABLISHMENT OF A DATABASE
FOR GEOGRAPHIC INFORMATION SYSTEMS
OF THE CAPITAL AREA

IN

THE REPUBLIC OF MADAGASCAR

AGREED UPON BETWEEN
MINISTRY OF TERRITORIAL AND URBAN MANAGEMENT
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
*in Antananarivo, Madagascar, on 3, July 1998*

Mr. Andriamboavonjy Amédée
Director of Cabinet of Minister
Ministry of Territorial and
Urban Management
President of Council of
Administration
National Geographic and
Hydrographic Institute

Mr. Akira Yaguchi
Leader,
Preliminary Study Team
Japan International Cooperation
Agency

A. INTRODUCTION

In response to the request of the Government of the Republic of Madagascar (hereinafter referred to as "Madagascar") , the Government of Japan (hereinafter referred to as "Japan") decided to implement the Establishment of a Database for Geographic Information Systems of the Capital Area (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of Japan, will undertake the Study, in close cooperation with the authorities concerned of Madagascar.

The present document sets forth the Scope of Work with regard to the Study.

B. OBJECTIVE OF THE STUDY

The objective of the Study is to prepare a digital map database at the scale level of 1/10,000 as the base for Geographic Information Systems. The database shall consist of digital urban topographic base map data, digital land use data, digital land condition data and digital urban facility data. Existing map data shall be utilized as much as possible.

C. STUDY AREA

The Study area is the Antananarivo Metropolitan Area of approximately 250km$^2$ defined in the Appendix.

D. SCOPE OF THE STUDY

In order to achieve the above mentioned objective, the Study shall cover the following items:

1. Collection of basic information:
   (1) exiting map data and aerial photographs,
   (2) existing control point data,
   (3) existing geographic information,
   (4) existing facility data and
   (5) information on expected Geographic Information System applications.

2. Control point survey:

Existing control point data shall be utilized as much as possible, while supplementary control point survey shall be carried out.

3. Aerial photography:

Aerial photographs shall be taken at the scale of approximately 1/20,000. Aerial photo signals shall be set if necessary, prior to the commencement of the aerial photography.

4. Database Design:

Reconnaissance survey shall be conducted in the Study area to determine the classification of data items. Design of the digital map database to be prepared in the Study shall be conducted.

Q.Y

5. Aerial triangulation:
Aerial triangulation shall be carried out by the block adjustment method.

6. Digital topographic and land use data acquisition:
Digital stereo plotting shall be carried out at the scale level of 1/10,000.

7. Field identification:
Information on topography, land use and land condition shall be identified in the field.

8. Land condition mapping:
Manuscript maps of land condition shall be prepared based on the aerial photo interpretation and the field identification..

9. Database compilation:
The digital stereo plotting data, the result of the field identification and the land condition mapping, and the existing map data shall be compiled into a digital map database.

10. Field completion:
Supplementary information on topography, land use and land condition shall be identified in the field. Administrative boundaries and geographical names shall be verified. The collected information shall be added to the digital map database.

11. Database installation:
The digital map database prepared in the Study shall be installed into a database management system.

E. STUDY SCHEDULE
The Study shall be conducted in accordance with the attached tentative schedule.

F. REPORTS AND FINAL PRODUCTS
JICA shall prepare the followings and submit them to Madagascar. In case any doubt arises in their interpretation, English text shall prevail.

1. Inception Report:
Inception Report shall be submitted at the commencement of the Study. Five (5) copies in English and ten (10) copies in French shall be submitted.

2. Interim Report:
Interim Report shall be submitted within 8 months after the beginning of the Study. Five (5) copies in English and ten (10) copies in French shall be submitted.

3. Draft Final Report:
Draft Final Report shall be submitted within 11 months after the beginning of the Study. Five (5) copies in English and ten (10) copies in

French shall be submitted.

4. Final Report:
   Final Report shall be submitted at the end of the whole Study. Five (5) copies in English and ten (10) copies in French shall be submitted.

5. Digital Map Database:
   The digital map database described in the "B. Objective of the Study" shall be submitted at the end of the whole Study. Fifty (50) copies shall be submitted in the form of CD-ROM.

6. Handling Manual for database:
   The handling manual for the digital map database shall be submitted at the end of the whole Study. Ten (10) copies in English and twenty (20) copies in French shall be submitted.

7. Plotted Maps:
   The digital urban topographic base map data, digital land use data, digital land condition data and digital urban facility data shall be plotted at the scale of 1/10,000. Twenty (20) copies for each data shall be submitted at the end of the whole Study.

8. Aerial Photographs:
   One (1) set of negative film and three (3) copies of aerial photographs at the scale of approximately 1/20,000 taken in the Study shall be submitted at the end of the whole Study.

G. UNDERTAKINGS OF MADAGASCAR

1. To facilitate the smooth implementation of the Study, Madagascar shall take the following necessary measures;
   (1) to secure the safety of the Japanese Study Team (hereinafter referred to as "the Team"),
   (2) to permit the members of the Team to enter, leave and sojourn in Madagascar for the duration of their assignment therein, and exempt them from alien registration requirements and consular fees,
   (3) to exempt the members of the Team from taxes, duties, fees and any other charges on equipment, machinery and other materials brought into Madagascar for the conduct of the Study,
   (4) to exempt the members of the Team from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with the implementation of the Study,
   (5) to provide necessary facilities to the Team for the remittance as well as utilization of the funds introduced into Madagascar from Japan in connection with the implementation of the Study,
   (6) to secure permission for entry into private properties or restricted areas for the implementation of the Study,
   (7) to secure permission for the Team to take all data and documents (including photographs) related to the Study out of Madagascar to Japan,

(8) to provide the medical services as needed. Its expenses will be chargeable on members of the Team.

2. The Government of Madagascar shall bear claims, if any arises against the members of the Team resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Team.

3. The National Geographic and Hydrographic Institute (hereinafter referred to as "FTM") shall act as counterpart agency to the Team and also as coordinating body in relation with other relevant organizations concerned for the smooth implementation of the Study.

4. FTM shall, at its own expenses, provide the Team with the followings in cooperation with other organizations concerned;
(1) available data (including map data) and information related to the Study,
(2) counterpart personnel,
(3) suitable air-conditioned office space with office equipment and furniture in Antananarivo,
(4) credentials or identification cards,
(5) vehicles with drivers.

H. UNDERTAKINGS OF JICA

For the implementation of the Study, JICA shall take the following measures;
1. to dispatch, at its own expenses, the Team to Madagascar,
2. to pursue technology transfer to Madagascar counterpart personnel in the course of the Study.

I. OTHERS

1. JICA and FTM shall consult with each other in respect of any matter that may arise from or in connection with the Study.
2. The Scope of Work and the Minutes of Meeting on the Scope of Work are prepared both in English and French. When any doubt arises in their interpretation, English text shall prevail.
3. When any doubt arises in the interpretation of the documents concerned with the Study, the English text shall prevail.

Attachment

# TENTATIVE SCHEDULE

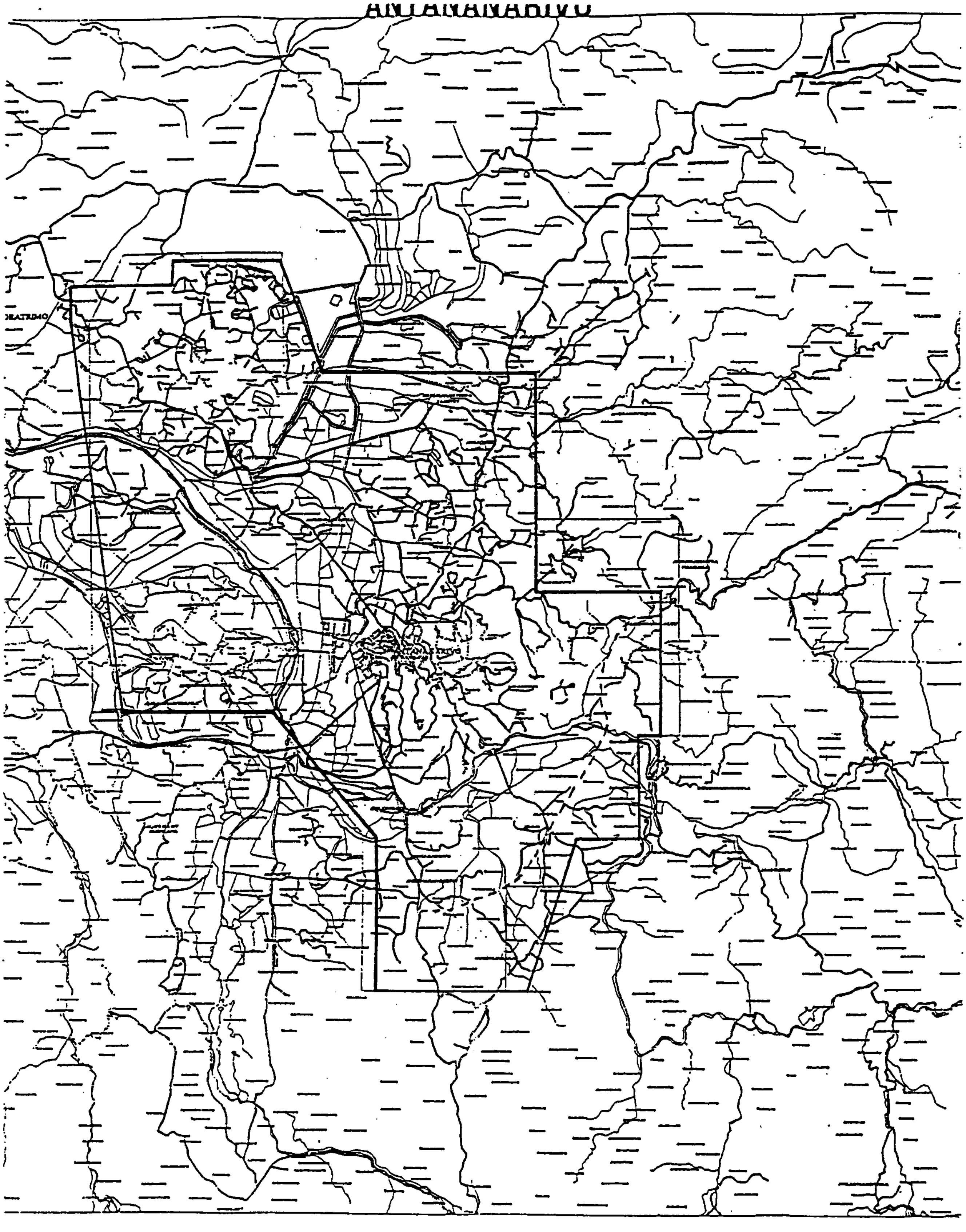
## (STUDY TEAM)

## The Establishment of a Database for Geographic Information Systems of the Capital Area in The Republic of Madagascar

| Month | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th | 12th | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Field Work | ■ | ■ | ■ | | | | | ■ | ■ | ■ | | ■ | | |
| Work in Japan | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Reports | ▲ IC/R | | | | | | | ▲ IT/R | | | ▲ DR/F | | ▲ F/R | F/P |

Note : IC/R : Inception Report
IT/R : Interim Report
DF/R : Draft Final Report
F/R : Final Report
F/P : Final Product

ANTANANARIVO



Route principale
Route en projet
Reseau hydrographique
Limite contractuelle

Echelle 1/100.000

MINUTES OF MEETING
UPON
THE PRELIMINARY STUDY

FOR

THE ESTABLISHMENT OF A DATABASE
FOR GEOGRAPHIC INFORMATION SYSTEMS
OF THE CAPITAL AREA
IN
THE REPUBLIC OF MADAGASCAR

AGREED UPON BETWEEN

MINISTRY OF TERRITORIAL AND URBAN MANAGEMENT
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

*In Antananarivo, Madagascar, on 3, July 1998*

Mr. Andriamboavonjy Amédée
Director of Cabinet of Minister
Ministry of Territorial and
Urban Management
President of Council of
Administration
National Geographic and
Hydrographic Institute

Mr. Akira Yaguchi
Leader,
Preliminary Study Team
Japan International Cooperation
Agency

The Japanese Preliminary Study Team (hereinafter referred to as the "Team") organized by the Japan International Cooperation Agency (hereinafter referred to as "JICA") headed by Mr. Akira YAGUCHI visited the Republic of Madagascar from the 28th of June to the 5th of July, 1998 to study preliminarily for "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" (hereinafter referred to as "the Study") in response to the request from the Government of the Republic of Madagascar.

The Team had a series of discussions and exchanged views with the representatives of the National Geographic and Hydrographic Institute (hereinafter referred to as "FTM") and other organizations concerned. (See Appendix for the attendants.)

Through the discussions, both sides have completed the Scope of Work and confirmed the following points;

1. Objective of the Study

The objective of the Study was agreed to be the preparation of a digital map database at the scale level of 1/10,000 as the base for Geographic Information Systems. It was also agreed that the database shall consist of digital urban topographic base map data, digital land use data, digital land condition data and digital urban facility data, and that existing map data shall be utilized as much as possible.

2. Study Area

The Study Area was agreed to cover the Antananarivo Metropolitan Area of approximately 250km².

3. Provision of the FTM personnel

FTM promised to provide FTM engineers and technicians in order to implement the Study.

4. Use of the existing map data

Both sides agreed that the existing map data such as those for the taxation inventory planning of the Department of Topographic Service, for instance, shall be utilized as much as possible if their accuracy was verified. It was also agreed that FTM shall guarantee the use of those map data.

5. Administrative boundaries and geographical names

Administrative boundaries and geographical names shall be verified by the FTM.

6. Study Equipment

FTM requested the Team that the Study equipment indispensable to maintain and to improve the technology to be transferred to FTM in the course of implementing the Study shall be provided to FTM. The Team promised to convey the request to the JICA headquarters.

A.Y.

7. Alternation of schedule in aerial photography

Both sides agreed that if the aerial photography failed to be completed in one year after the commencement of the Study, other measures alternative to the new aerial photography shall be discussed by both sides.

8. Vehicles

FTM explained the difficulty in providing the vehicles, and the Team promised to convey the situation to the JICA headquarters.

9. Training

FTM requested that Madagascar counterpart personnel take advantage of training in Japan related to the Study to promote an effective technology transfer. The Team promised to convey the request to the JICA Headquarters.

10. Steering Committee or Working Group

Both sides agreed that a Steering Committee or a Working Group consisting of the governmental organizations concerned with the Geographic Information System, shall be established in order that the digital map database prepared in the Study shall be fully utilized by those organizations.

11. Information Disclosure

Both sides agreed that the digital map data prepared in the Study shall be widely disclosed to the public. Both sides further confirmed the importance continuously to discuss the consolidation of the distribution system of digital data in cooperation with the Steering Committee.

12. Others

Both sides agreed that daily allowances and accommodation fees arising from assignments of FTM personnel in the course of implementing the Study shall be borne by FTM.

The Minutes of Meeting are prepared both in English and French. When any doubt arises in their interpretation, English text shall prevail.

APPENDIX

## List of attendants to the discussions

### Madagascar side :

National Geographic and Hydrographic Institute (FTM)

| | |
|---|---|
| Mr. RAZAFINAKANGA Andrianjafimbelo | Director General |
| Mrs. RANDRIANANDRAINA Noëlle | Director General Adjoin |
| Mr ANDRIAMPARANY Naina | Technical Counselor of Director General |
| Mr NARY Henlalao Ianvo | Director of Basic Geographic Information |
| Mrs RAZANAMALALA Vacarivary Angelinette | Director of Edition Works |
| Mr. RAKOTOZAFY Robert | Director Marketing and Commercial |
| Mr. RAKOTOARISON Max Simon | Chef de Department Geodesy and Hydrographic |
| Ms. NARY Herimirma Sarivo | Chief of Division of Digital Mapping |
| Mr. Nicolas LAMBERT | Technical Assistant |

Office of Vice Primer Minister charged of Finances and Economy
Direction General of Economy and Plan

| | |
|---|---|
| Mrs. RASOAVOLOLONA Jeanne | Director of Public Investments |

Ministry of Foreign Affairs

| | |
|---|---|
| Mr. FENO Jeannet | Director of Bilateral Cooperation |
| Mr. RATEFINANAHDRY Jean de Dieu | Chief of Division of Technical, Economical, and Financial Cooperation |

Ministry of Territorial and Urban Management

| | |
|---|---|
| Mr RAMANANTSOA Herivelona | Minister of Territorial and Urban Management |
| Mr. ANDRIAMBOAVONJY Amédée M. | Director of Cabinet of Minister<br>President of Council of Administration of FTM |

Ministry of Territorial and Urban Management
Department of Topographic Service, Office of Landed Pilot Operations

| | |
|---|---|
| Mr. RAMAMONJISOA Aimé | Chef of Project |
| Mr RAZAFINDRAICAVO Henry | Chef Provincial Topographic |
| Mr. David CAILLEAU | Assistant Engineer, CPF |

Antananarivo City

| | |
|---|---|
| Mr. RAZANAMASY Guy Willy | Mayor of Antananarivo City |

### Japanese side :

Preliminary study Team

| | |
|---|---|
| Mr. YAGUCHI Akira | Chef de mission |
| Mr NARAWA Mutsumi | Planning of studies |
| Mr. EGAWA Yoshitake | Planning of basic mapping and of transfer of technology |
| Mr. MORITA Toshiyuki | Interpret |

Embassy of Japan at Antananarivo

| | |
|---|---|
| Mr. TSUKAHARA Shigeru | Second Secretary |

A.Y.

# MINUTES OF MEETING
# FOR

# THE ESTABLISHMENT OF A DATABASE FOR GEOGRAPHIC INFORMATION SYSTEMS OF THE CAPITAL AREA IN THE REPUBLIC OF MADAGASCAR

**AGREED UPON BETWEEN**

**NATIONAL GEOGRAPHIC AND HYDROGRAPHIC INSTITUTE, MINISTRY OF TERRITORIAL AND URBAN MANAGEMENT**
**AND**
**JAPAN INTERNATIONAL COOPERATION AGENCY**

**ANTANANARIVO, 12 NOVEMBER 1998**

| | |
|---|---|
| RAZAFINAKANGA Andrianjafimbelo | Isao IKESHIMA |
| Director General | Leader |
| National Geographic and Hydrographic Institute | JICA Study Team |
| | Japan International Cooperation Agency |

Japan International Cooperation Agency Study Team for the "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" (hereinafter referred to as "JICA Study Team"), and the National Geographic and Hydrographic Institute (hereinafter referred to as "FTM") held a meeting concerning the Inception Report on "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" on the 9th day of November 1998, from 9:00 a.m. to 4:00 p.m. The meeting took place at "FTM" office in a friendly atmosphere. The members who attended the meeting are listed in Appendix-1. The conclusions of the discussions were as follows:

1. "FTM" agreed on the Inception Report prepared by "JICA Study Team".
2. "FTM" side requested the following to the Team:

   (1) Since the Presidential residence is situated in the southernmost part of the study area, aerial photography and plotting works cannot be conducted in a zone extending on 18 $km^2$. Accordingly, this zone shall be cut from the study area.

   On the other hand, it was requested to include in the study area a 18 $km^2$ area located north-east of Soavina City in the south-west area of the capital Antananarivo City, where urbanisation is growing fast.

   (2) FTM personnel expressed a strong desire to have training opportunity in Japan.

"JICA Study Team" promised to convey these requests to the JICA headquarter.

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APPENDIX-1

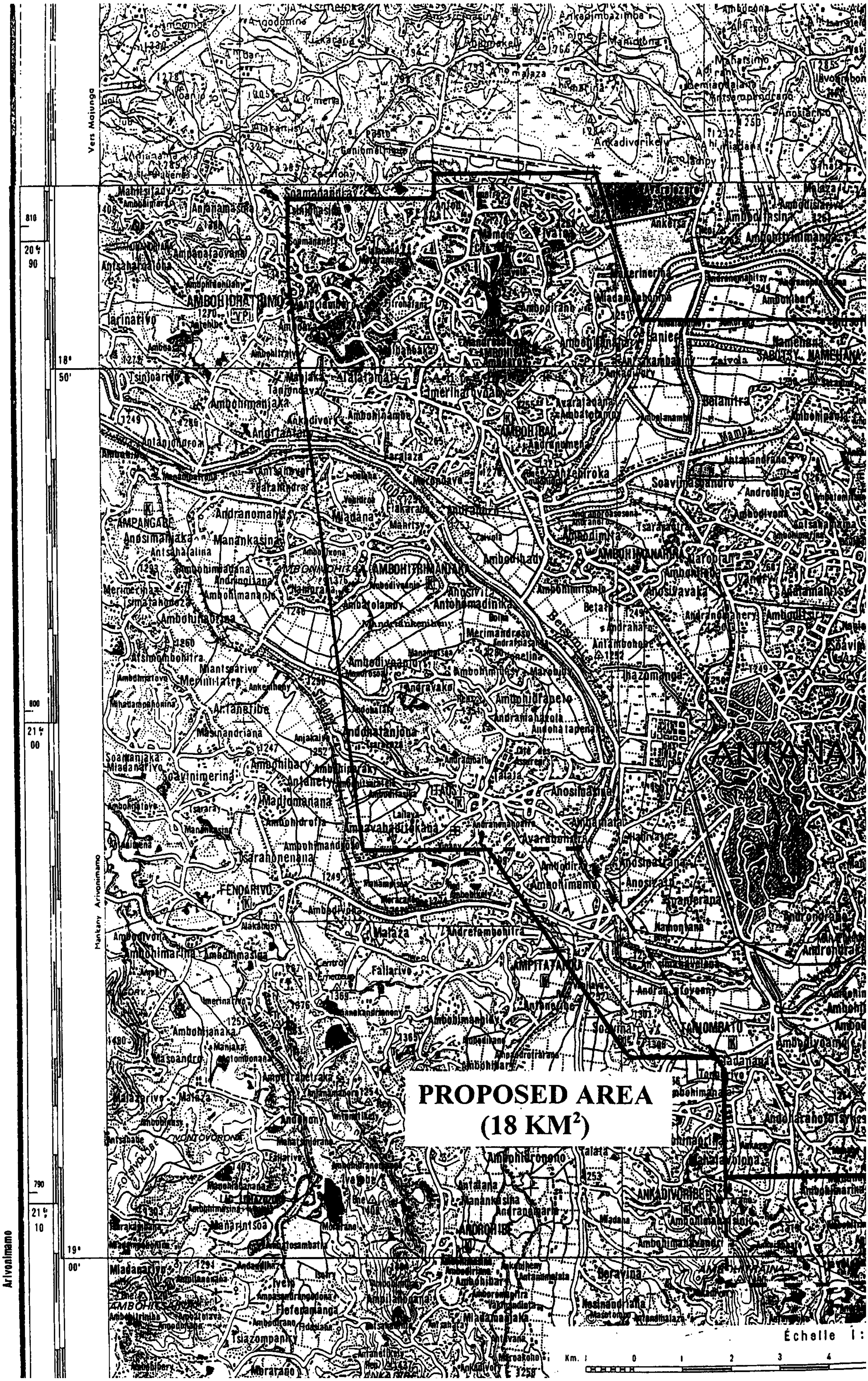
## LIST OF ATTENDANTS

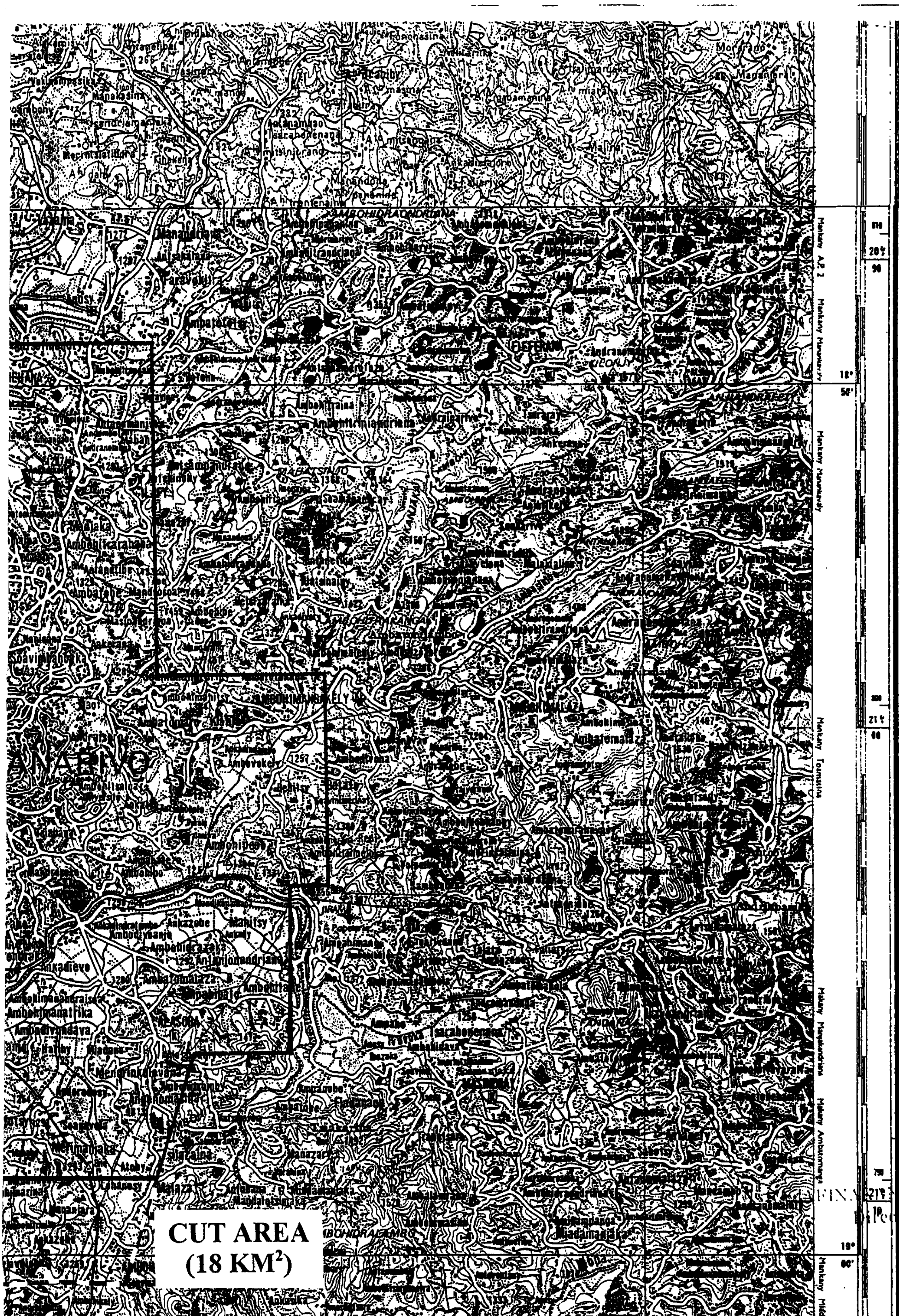
Malagasy Side:

| | |
|---|---|
| Mr. RAZAFINAKANGA Andrianjafimbelo | Director General<br>FTM |
| Mr. RAKOTOZAFY Robert | Director of Marketing and Sales<br>FTM |
| Mr. RAVELOMANANTSOA Josoa | Business Engineer<br>Marketing and Sales Division<br>FTM |
| Mr. NARY Herilalao Iarivo | Director of Basic Geographic Information<br>FTM |
| Mr. RAHAINGOALISON Narizo | Director of Geographic Information<br>FTM |
| Ms. RATOVOARISON Nivo | Chief of Hydrography Division<br>FTM |
| Mr. RAKOTOVAO Manarivo | Chief of Research Department<br>FTM |
| Mr. LI Han Ting | Chief of Remote Sensing Division<br>FTM |

Japanese Side:

| | |
|---|---|
| Mr. Isao IKESHIMA | Leader of JICA Study Team |
| Mr. Mamoru TAKAHASHI | Database Engineer |
| Mr. Ken-ichi SHIBATA | Land Use and Land Condition Engineer |
| Mr. Morten STRAND | Surveyor |
| Ms. Marie-Line CHARLES | Interpreter |
| Ms. Odile GAYON | Coordinator |
| Mr. Katsuo TANAKA | JICA |
| Mr. Yoshitake EGAWA | Technical Advisor, JICA |


PROPOSED AREA
(18 KM²)
Échelle
Arivonimamo
Vers Majunga

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**MINUTES OF MEETING**

**FOR**

**THE ESTABLISHMENT OF A DATABASE
FOR GEOGRAPHIC INFORMATION SYSTEMS
OF THE CAPITAL AREA IN THE
REPUBLIC OF MADAGASCAR**

**AGREED UPON BETWEEN**

**NATIONAL GEOGRAPHIC AND HYDROGRAPHIC INSTITUTE,
MINISTRY OF TERRITORIAL AND URBAN MANAGEMENT
AND
JAPAN INTERNATIONAL COOPERATION AGENCY**

**ANTANANARIVO, THE 25TH OF JUNE, 1999**

RAZAFINAKANGA Andrianjafimbelo
Director General
National Geographic and Hydrographic Institute

Isao IKESHIMA
Leader
JICA Study Team
Japan International Cooperation Agency

The Japan International Cooperation Agency Study Team for "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" (hereafter referred to as "JICA Study Team"), and the National Geographic and Hydrographic Institute (hereinafter referred to as "FTM") held a meeting concerning the Interim report on "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" on the 21st day of June, 1999, from 9:30 a.m. to 3:30 p.m. The meeting took place at the FTM office in a friendly atmosphere. The attendants of the meeting are listed in Appendix-1.

The conclusions of the discussions were as follows:

1. FTM agreed on the Interim report prepared by JICA Study Team.

2. The JICA Study Team handed over the following final results to the FTM:

-Interim Report:

| | |
|---|---|
| English | 5 copies |
| French | 10 copies |

-Aerial Photographs:

| | |
|---|---|
| negative films ( approximately 1/20,000 ) | 1 set |

3. FTM requested to the JICA Study Team that the following equipment that JICA has provided for the Study, be donated to FTM:

| | |
|---|---|
| - Personal Computer and accessories<br>Gateway E-5250 450 | 1 unit |
| - Inkjet Printer and accessories<br>HP 750 Plus (A0) | 1 unit |
| - Digitizer and accessories<br>Digitizer board (NS Calcomp 34480)<br>Digitizer stand (NS Calcomp 34480) | 1 unit |
| - GIS Software ESRI Arc View 3.1 | 1 set |
| - Application Softwares: | |
| . Software ESRI Network Analyst | 1 set |
| . Software ESRI Spatial Analyst | 1 set |
| . Software MS Office 97 Pro | 1 set |
| - Projector EPSON ELP 7200 | 1 unit |
| - Uninterruptable Power Supply APC SU 1400I<br>(and UPS software APC AP9007) | 1 unit |
| - Transformer TOYODEN TK-3 | 1 unit |

The JICA Study Team promised to convey this request to the JICA headquarter.

APPENDIX-1

## LIST OF ATTENDANTS

Malagasy Side:

| | |
|---|---|
| Mr. RAZAFINAKANGA Andrianjafimbelo | Director General, FTM |
| Mr. RAKOTOZAFY Robert | Director of Marketing and Sales Division, FTM |
| Mr. NARY Herilalao Iarivo | Director of Basic Geographic Information, FTM |
| Mr. RAHAINGOALISON Narizo | Director of Geographic Information, FTM |
| Mr. RANJALAHY Marc | Business Engineer 2, FTM |
| Mr. RAKOTOVAO Manarivo | Chief of R & D Department, FTM |
| Mr. RAJAONARISON J. Désiré | Chief of Database Department, FTM |
| Mr. RABEMALAZAMANANA | Chief of Geomatic Division, FTM |
| Mr. ANDRIATSIMIANGY J. Robson | Chief of Laboratory, FTM |
| Mr. RAKOTO Rahetindralambo | Chief of Photogrammetry Division, FTM |
| Mr. LI Han Ting | Chief of Remote Sensing Division, FTM |
| Ms. RAKOTOVOARISON Nivoharimanga | Chief of Hydrography Division, FTM |

Japanese Side:

| | |
|---|---|
| Mr. Isao IKESHIMA | Leader of the JICA Study Team |
| Mr. Mamoru TAKAHASHI | Database design Engineer |
| Mr. James WILKINSON | Database management system design Engineer |
| Mr. Satoru NISHIO | Survey on urban facility data Engineer |
| Mr. Ken-ichi SHIBATA | Land Use and Land Condition Engineer |
| Miss Marie-Line CHARLES | Interpreter |
| Miss Odile GAYON | Coordinator |
| Mr. Akira SAITO | Japanese Embassy |

**MINUTES OF MEETING**

**FOR**

**THE ESTABLISHMENT OF A DATABASE
FOR GEOGRAPHIC INFORMATION SYSTEMS
OF THE CAPITAL AREA IN THE
REPUBLIC OF MADAGASCAR**

**AGREED UPON BETWEEN**

**NATIONAL GEOGRAPHIC AND HYDROGRAPHIC INSTITUTE,
MINISTRY OF TERRITORIAL AND URBAN MANAGEMENT
AND
JAPAN INTERNATIONAL COOPERATION AGENCY**

**ANTANANARIVO, THE 14TH OF SEPTEMBER 1999**

RAZAFINAKANGA ~~Andrianjafimbelo~~
Director ~~General~~
National Geographic and Hydrographic Institute

Isao IKESHIMA
Leader
JICA Study Team
Japan International Cooperation Agency

The Japan International Cooperation Agency Study Team for "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" (hereafter referred to as "JICA Study Team"), and the National Geographic and Hydrographic Institute (hereinafter referred to as "FTM") held a meeting concerning the Draft Final Report on "The Establishment of a Database for Geographic Information Systems of the Capital Area in the Republic of Madagascar" on the 13th day of September, 1999, from 9:30 a.m. to 12:00 a.m. The meeting took place at the FTM office in a friendly atmosphere. The attendants of the meeting are listed in Appendix-1.

The conclusions of the discussions were as follows:

1. FTM agreed on the Draft final report prepared by JICA Study Team.

2. The JICA Study Team handed over the following final results to the FTM:

-Draft Final Report:

| | |
|---|---|
| English | 5 copies |
| French | 10 copies |

-Aerial Photographs:

| | |
|---|---|
| Aerial photographs ( approximately 1/20,000 ) | 3 copies |

3. As mentioned in the Minutes of Meeting signed on June 25th, 1999, the JICA Study Team conveyed to the JICA Headquarter the FTM request for the donation of equipment provided for the Study. The JICA Headquarter agreed to donate the following equipment to FTM.

| | |
|---|---|
| - Personal Computer and accessories<br>Gateway E-5250 450 | 1 unit |
| - Inkjet Printer and accessories<br>HP 750 Plus (A0) | 1 unit |
| - Digitizer and accessories<br>Digitizer board (NS Calcomp 34480)<br>Digitizer stand (NS Calcomp 34480) | 1 unit |
| - GIS Software ESRI Arc View 3.1 | 1 set |
| - Application Softwares: | |
| . Software ESRI Network Analyst | 1 set |
| . Software ESRI Spatial Analyst | 1 set |
| . Software MS Office 97 Pro | 1 set |
| - Projector EPSON ELP 7200 | 1 unit |
| - Uninterruptable Power Supply APC SU 1400I<br>(and UPS software APC AP9007) | 1 unit |
| - Transformer TOYODEN TK-3 | 1 unit |

## LIST OF ATTENDANTS

Malagasy Side:

| | |
|---|---|
| Mr. RAZAFINAKANGA Andrianjafimbelo | Director General, FTM |
| Mr. RAKOTOZAFY Robert | Director of Marketing and Sales Division, FTM |
| Mr. NARY Herilalao Iarivo | Director of Basic Geographic Information, FTM |
| Mr. RAHAINGOALISON Narizo | Director of Geographic Information, FTM |
| Mr. RAVELOMAMANTSOA Josoa | Business Engineer, Marketing & Sales Division, FTM |
| Mr. RAKOTOVAO Manarivo | Chief of R & D Department, FTM |
| Mr. ANDRIANTSIMIANGY J. Robson | Chief of Laboratory, FTM |
| Mr. ANDRIAMANANA Malala | Chief of Aerial Flight Department, FTM |
| Mr. RAKOTONANDRASANA Velosoa | Database Operator, FTM |
| Ms. RAKOTOVOARISON Nivoharimanga | Chief of Hydrography Division, FTM |
| Ms. NARY Herinirina | Chief of Mapping Department, FTM |
| Ms. RANDRIAMANANA Lydia | Chief of Database Division, FTM |
| Mr. RAKOTOARISON Max | Follow-up and Planning, FTM |
| Mr. RABOKOSON Julien Astina | Management Control, General Direction, FTM |
| Mr. RAMINOHARIZAKA Paul | Chief of Topographic Division, FTM |
| Mr. RANDRIANAIVO Eugène | Chief of Control and Photo-interpretation Division, FTM |
| Mr. RAJEMISON Michel | Chief of Geodetic Surveying Division, FTM |

Japanese Side:

| | |
|---|---|
| Mr. Isao IKESHIMA | Leader of the JICA Study Team |
| Mr. Mamoru TAKAHASHI | Database design Engineer |
| Mr. James WILKINSON | Database management system design Engineer |
| Miss Marie-Line CHARLES | Interpreter |
| Miss Odile GAYON | Coordinator |
| Mr. Akira SAITO | Japanese Embassy |
| Mr. Hisashi MORI | Technical Advisor, JICA |