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Japan International Cooperation Agency(JICA)

Geographical Institute of Burkina (IGB)
Ministry of Infrastructure, Housing and Urban Planning

# THE STUDY ON THE NATIONAL TOPOGRAPHIC MAPPING OF THE SOUTHWESTERN AREA IN BURKINA FASO

# SUMMARY




MARCH 2001

Aero Asahi Corporation

Taux de change

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Japan International Cooperation Agency(JICA)

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# ON
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# PREFACE

In response to a request from the Government of Burkina Faso, the Government of Japan decided to conduct a development study concerned of the national topographic mapping in the southwestern area of Burukina Faso and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA dispatched a study team headed by Mr. Kokichi Kimura of the Aero Asahi Cooperation four times between November 1998 and February 2001.

The team held discussions with the officials concerned of the Government of Burkina Faso and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of the study for their close cooperation and supporting to the Study.

March 2001

Kunihiko Saito
President
Japan International Cooperation Agency

March 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Saito,

**Letter of Transmittal**

We are pleased to submit to you the Study Report on the National Topographic Mapping of the Southwestern Area in Burkina Faso. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulation of the mentioned project. Also included are comments made by the Geographic Institute of Burkina, Ministry of Infrastructure, Housing and Urban Planning of His Majesty's Government of Burkina Faso during technical discussions on the draft report which were held in Ouagadougou.

This Study had the objectives to develop the 1/50,000-scale national topographic maps covering the southwestern area of 20,600 square kilometers that is important for the economic development of Burkina Faso and to conduct the transfer of the national topographic mapping technology.

To fulfill these objectives, the topographic mapping method was improved from the conventional analog mapping system into a digital mapping system. The technical standards for it were also established and the mapping equipment, the digital topographic mapping data and the national topographic maps were developed. Further, the GIS basic data was produced from the digital topographic data and the presentation of a pilot GIS was made at a seminar.

Based on the results of this Study, we recommend the following points: The extensive use of the GIS using the GIS basic data will contribute to the higher efficiency of services in the policy-making agencies and promotion of the sustainable development policies to cope with the increasing pressure of desertification. It is also expected that the development of the national topographic maps and GIS basic data to cover the entire country will be promoted through operating the developed national digital topographic mapping system.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport. We also wish to express our deep gratitude to the Geographic Institute of Burkina, Ministry of Infrastructure, Housing and Urban Planning of His Majesty's Government of Burkina Faso for the close cooperation and assistance extended to us during study.

Very truly yours,

Kokichi Kimura
Team Leader
Study Team on the Study of the
National Topographic Mapping of the
Southwestern Area in Burkina Faso

# Summary

## 1. Objectives and Background of the Study

Burkina Faso is an inland country of West Africa that is located at the south end of the Sahara. The pressure of desertification had a critical effect on its natural environment and economy. The study area belongs to the Sudan-type tropical climate zone and is rich in water resources, but it is not suited to dwell and has retarded in development because it has suffered from epidemics in the past. However, the campaign against epidemics early in the 1990's succeeded in facilitating the move of the population and the agricultural development in this area, resulting in the boost of the GDP of Burkina Faso. The Government of Burkina Faso has been proceeding with the study of water resource dam construction project and the study of development of low hinterlands (Bas Fonds) that are suitable for rice farming. Based on the necessity of developing the comprehensive geographic spatial information for these projects, the Government of Burkina Faso has made the request to the Government of Japan for the national topographic mapping in the study area of 20,600 square kilometers and the transfer of such technology.

## 2. Items of the Study

In this Study, the following study items were implemented to attain the objectives of the study:

(1) The low-cost, high-efficiency digital mapping system to aim at realizing the information society was systematically developed.

(2) Training of operation personnel was conducted through preparation of manuals and OJT to ensure them to fully operate the developed system in the technical processes newly introduced.

(3) The national topographic maps and GIS basic data necessary for the economic development of the southwest area with urgent necessity were developed for a period of 30 months by making the most of the developed system and OJT personnel.

(4) The pilot GIS to support agricultural development and school construction was developed to promote the business-oriented GIS using the GIS basic data.

## 3. Study Processes

In the 4 study works in Burkina Faso that were carried out from November 1998 to March 2001, the following work processes were implemented:

(1) In the first study work in Burkina Faso, signalization for aerial photos, aerial

photography, ground control point survey including GPS survey, equipment survey, and creation of photo interpretation standards were implemented.

(2) In the second study work in Burkina Faso, establishment of technical specifications and work specifications, improvement of the geographical name decision system, aerial triangulation, digital plotting, field survey and the survey on GIS applications were implemented.

(3) In the third study work in Burkina Faso, digital compilation, digital map symbol structuralization, GIS basic data structuralization, establishment of technical specifications and work specifications, survey on GIS applications, and aerial triangulation with class-1 plotter were implemented.

(4) In the fourth study work in Burkina Faso, the discussions on the final report were made and the seminar was held.

In the study in Japan, the design of the digital mapping system, the design and building of the pilot GIS, aerial triangulation, partial works of digital plotting, digital map symbol structuralization and GIS basic data structuralization, and the map printing process were implemented.

## 4. Recommendations

As the result of the technical cooperation, it is recommended as follows:

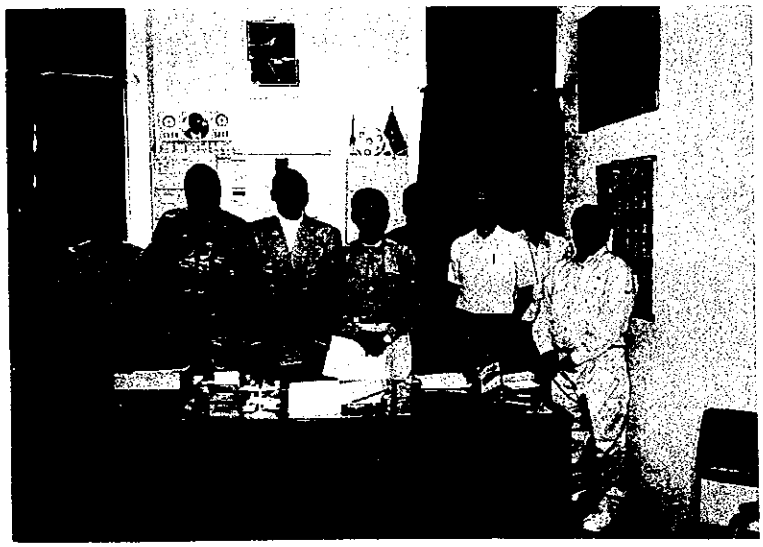
(1) The development programs such as the regional agricultural development support system and the regional environmental simulation system will reinforce the capability of formulating the sustainable development policies to cope with the pressure of desertification.

(2) The extensive use of a simple GIS using the GIS basic data will be easy to introduce and effective to enhance the level and the efficiency of services in the policy-making agencies.

(3) The development of the national base map and the GIS basic data to cover the entire country though operating the developed national digital topographic mapping system will lead to establishment of high level of national land management. The developed system has the capability of developing the national topographic mapping information to cover the entire country for 6 years if it is fully operated.

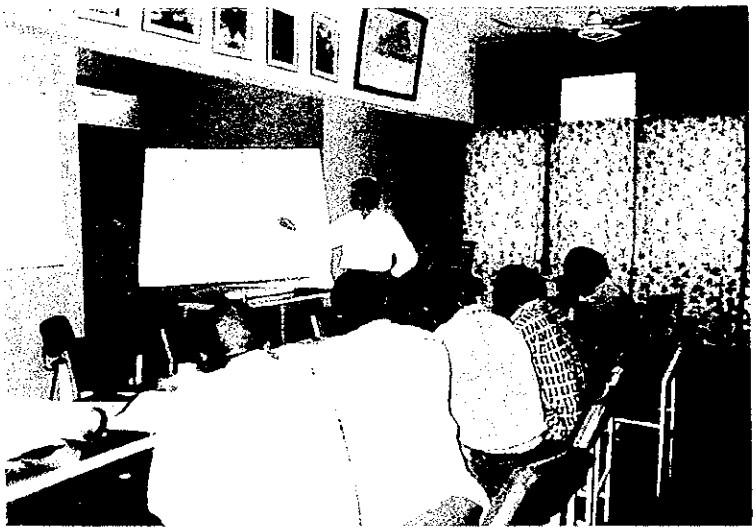
Exchange of the minutes with signature

Management Council in IGB



Management Council in IGB

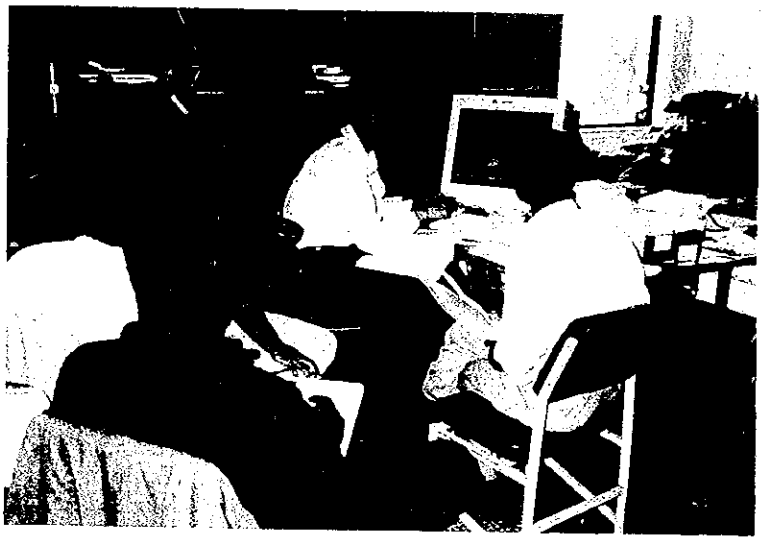
A scenery in the study area



Technological consultation on levelling

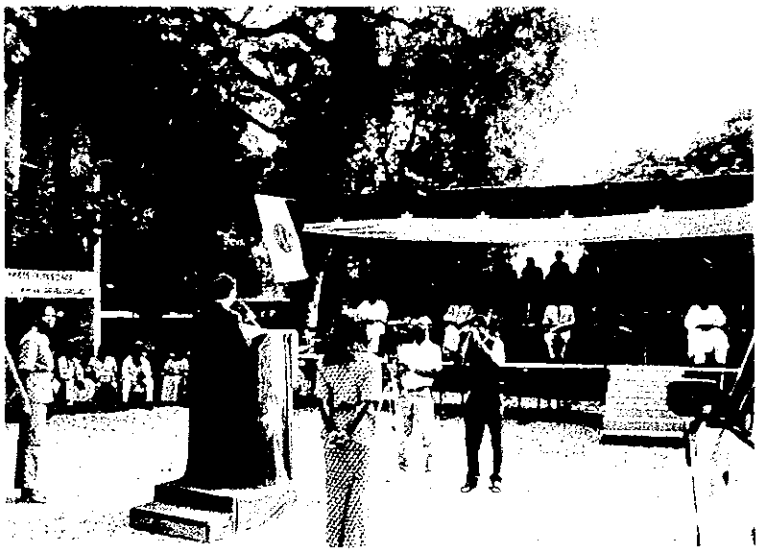
A scenery of levelling observation

Explanation of the established equipment

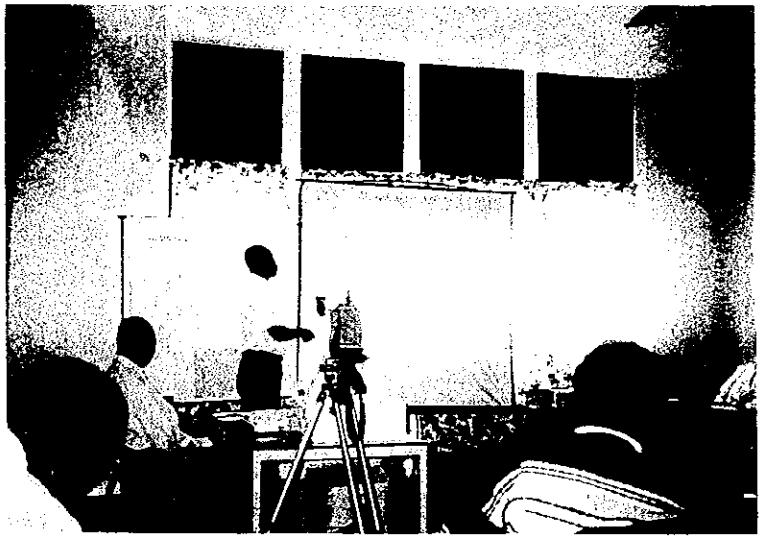


OJT of digital plotting

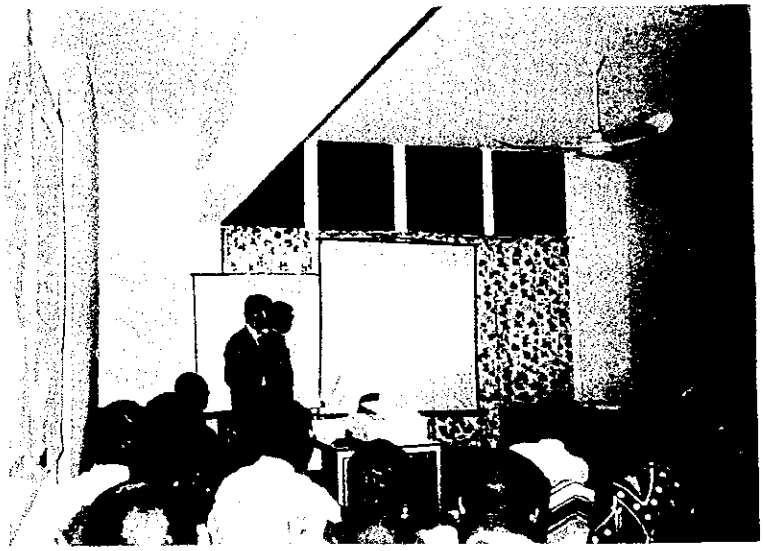
Technological consultation of field identification



Seminar opening ceremony



Technological presentation of a counter personal in the seminar



Technological presentation of a member of the study team in the seminar

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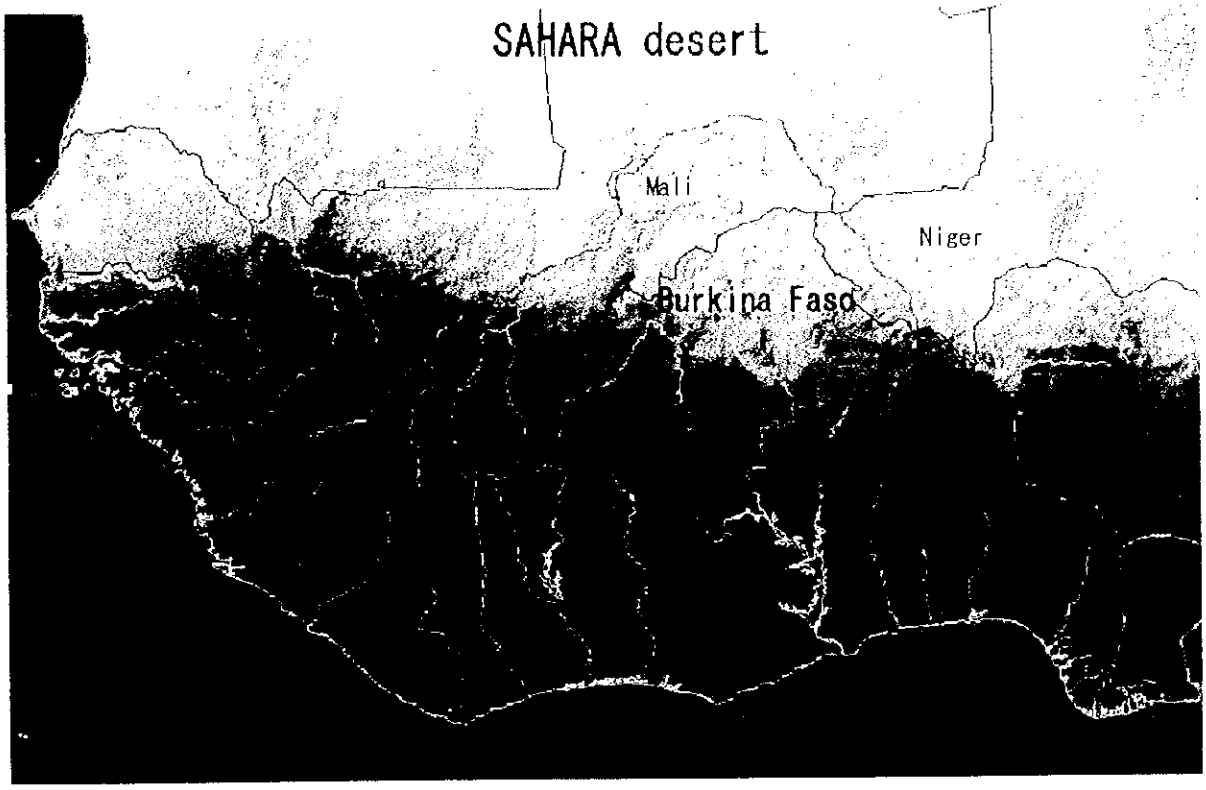



**Figure 1 Study area in Burkina Faso**

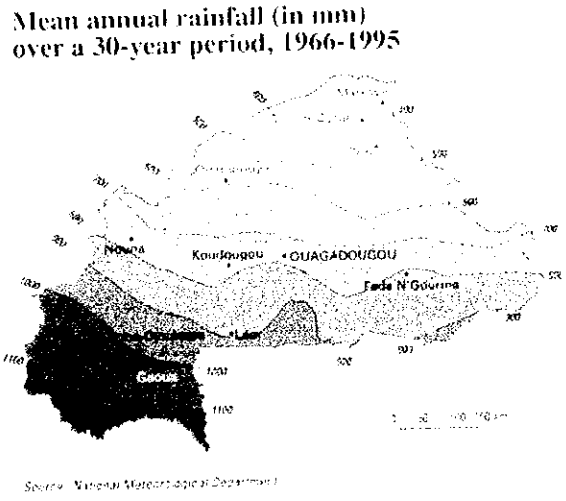



**Figure 2 Rainfall distribution and project area**

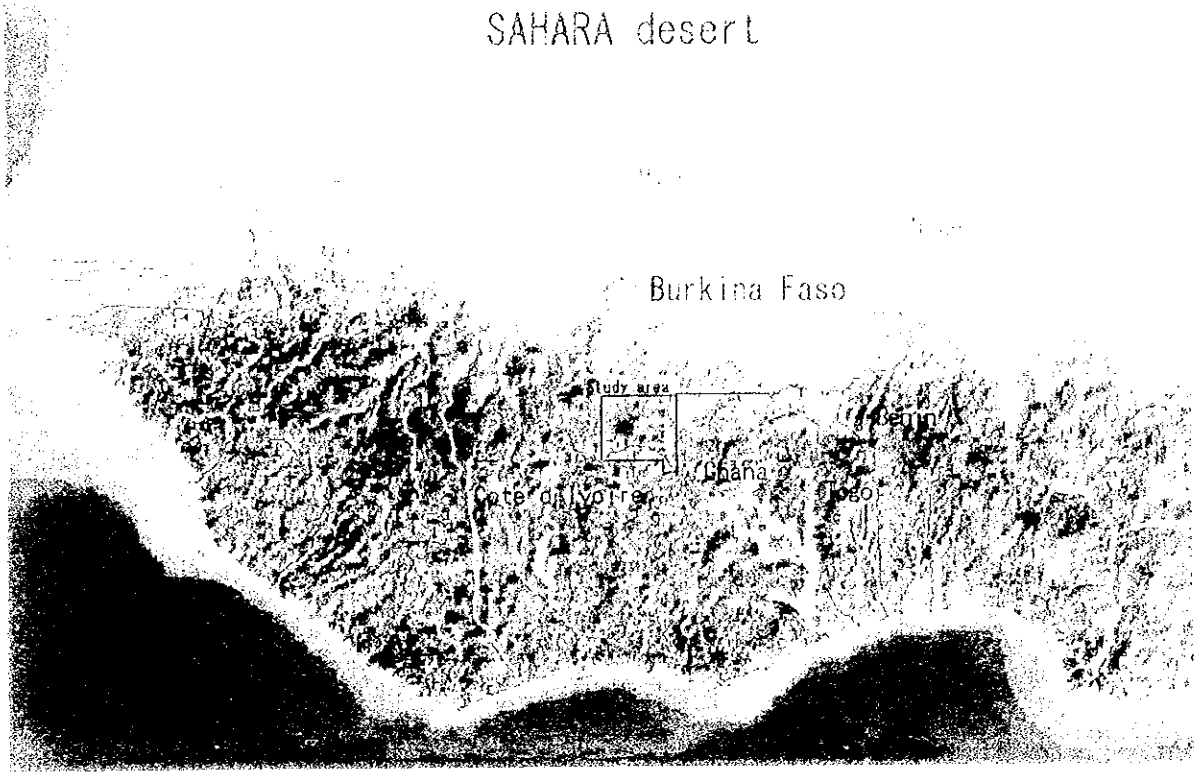



Figure 1 Study area in Burkina Faso

Mean annual rainfall (in mm)
over a 30-year period 1960-1990

Figure 2 Rainfall distribution and project area

# 1. INTRODUCTION

## 1.1 Background of the study

Burkina Faso is an inland country of West Africa that is located at the south end of the Sahara and its natural environment and its agricultural and stock raising industry, an economic core, are seriously affected by the pressure of desertification. (Refer to Figure 1.) The Government of Burkina Faso has been promoting the comprehensive development and maintenance of its national land under "the Second Five-Year National Land Development Plan". However, it has faced the necessity of acquiring the comprehensive information on the national land space in order to promote the sustainable economic development in harmony with the environment. The Government has therefore established the "Schema Directeur de Cartographie et Territoire (SDCT)", which is now being executed.

The study area located in the southwestern part of Burkina Faso belongs to the Sudan-type tropical climate zone and is relatively rich in water resources, but this area has been retarded in development because it is inadequate for residence due to endemics such as Guinea worm, trypanosomiasis and onchocerciasis. The Government of Burkina Faso has promoted the campaign against endemics under the assistance of the United Nations. As a result, this policy has been effectively executed to cause the movement of the population to the southwestern area and propel the agricultural development. The GDP of Burkina Faso has been enhanced in the long term though it has depended upon drought and rainy seasons, and it has been highly evaluated as a brilliant achievement in the Sahel region where the agriculture is generally inactive.

The Government of Burkina Faso continues to promote the studies for the water resources dam construction plan and the development of the low hinterland (Bas Fonds) that is suited for rice and other farming. This means that the Government faces the task to enhance this area up to the sustainable higher development level harmonized with the natural environment. For this purpose, the Government of Burkina Faso has made a request to the Government of Japan for technical cooperation in the national topographic mapping study of this study area.

## 1.2. Objectives of the study

Based on the results of the preliminary study, the Scope of Work agreement was signed and became effective between the preliminary study team and IGB. The study has the following two objectives:

(1) To produce the 1/50,000-scale national topographic maps for the southwestern area of approximately 20,600 km$^2$, Burkina Faso.

(2) To transfer the technology to the counterparts on the Burkina Faso side through this study.

The work processes to be carried out to improve the conventional technology in the practical work are as follows:

(1) Plotting process

In the plotting process, 1/50,000 digital topographic map data is created in the 10m contour line intervals.

(2) Compilation process and structuralization process

The digital topographic data is structuralized in phases.

The total period of the study will be about 30 months.
For the details of the provision of other facilities, refer to the S/W.

## 1.3. Final output configuration of the study

The final output configuration of the study is showed in Figure 3.

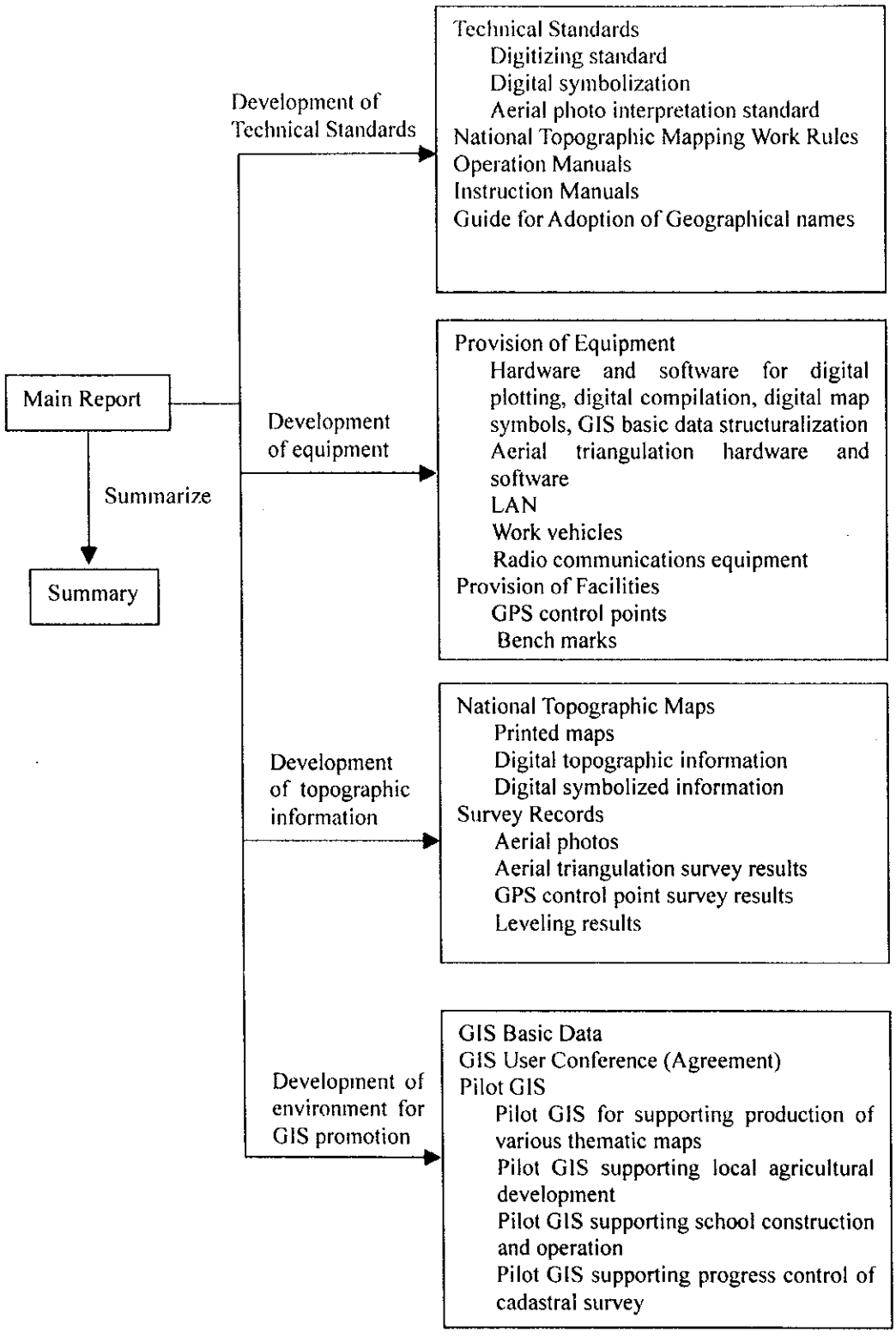



**Figure 3 Final output configuration of the study**

## 2. OUTLINE OF THE STUDY AREA AND TECHNICAL CONDITION

### 2.1. Priority of the national topographic mapping in the southwestern area

#### 2.1.1. Economic trend and role of the southwestern area in Burkina Faso

Burkina Faso is one of the poorest countries that is ranked at the 18th of 160 countries in the world in the evaluation method based on the GDP per capita according to the "World Development Report 1991" issued by the World Bank. As the rank was the 7th in 1989, its situation has been remarkably improving.

In Burkina Faso, about 85% of the total labor population is engaged in agriculture and livestock raising. Agriculture occupies about 30% of the GDP and the export of agricultural products shares over 60% of foreign currency income.

Since the country largely depends upon the self-supporting and self-sufficient rain-fed farming, it suffered a hard hit due to a long drought from 1972 to 1973. After that, the long drought from 1983 to 1984 caused severe damage to the agricultural production of this country.

In the rainy years of 1984 to 1985, the economy recovered remarkably and the GDP recorded a growth of 10.5% in yearly average. However, the start of the rainy season was delayed in 1987 and the GDP growth rate decreased to 7%. In 1989, the agricultural production was sluggish due to drought and the GDP growth rate was minus 0.4%.

However, the long-term GDP growth rate for a period of 1982 to 1990 exceeded 3% of population growth rate. The real growth rate was 3.7% in yearly average. This high growth rate was due to the positive promotion of the campaign against onchocerciasis, the endemic in the southwestern area that the Government of Burkina Faso and the United Nations was coping with. This policy was effectively executed to ensure the cultivation of the fertile southwestern area that is relatively rich in water resources. As a result, the agricultural production in the southwestern area increased and accordingly increased the national agricultural production and GDP. The rainfall characteristics in the southwestern area will be seen from Figure 2.

### 2.1.2. Advanced development stage and necessity of early development

The development plan in Burkina Faso was executed from the first to the fourth phase during the period of 1967 to 1986. For the period of 1986 to 1990, the New First Five-Year National Development Plan was executed with the individual targets:

① Priority investment on agricultural sector and water resource development for self-supply and livelihood improvement (43.8% of total investment);
② Prevention of desertification through forest conservation;
③ Suppression of trade deficit;

The Second Five-Year National Development Plan (1991-1996) is aimed at:

① Increase of agricultural and stock-raising production keeping the environmental and social balance;
② Activation of business activities through improvement of investment environment in the private sector;
③ Reduction and efficiency of the public sector;
④ Activation of human resources through reinforcement of elementary education and insurance service for grassroots.

The development concept and plan for the southwestern area could be seen in the more detailed levels in the request. However it is necessary to grasp that the development level was different in quality from the development stage in which the movement of population has made progress after the epidemics have been stamped out, so that the farmland has been expanded. Although the load of the cultivated farmland on the natural environment is large even at the present stage, the future development plans will be of larger scale through introduction of up-to-date technologies. Therefore, it is necessary to grasp the comprehensive national land space information, and make plans and execute the development from a higher point of view in order to promote sustainable production in harmony with the natural environment.

The southwestern area has not only a yearly rainfall of over 1,000mm but also fortunate topographic conditions in which the alluvial plain formed with fertile soil by the floods from the Mouhoun and the Komoe rivers is extended. It is clear that the development of this area capable of cultivating money-convertible rice has a high priority to Burkina Faso including the Sahel region.

At present, the study of the alluvial plain is in progress under the guidance of the U.N. in order to realize the development concept. As there is no 1/50,000 national topographic map,

the 1/200,000 topographic maps have been developed to the 1/100,000 scale, the alluvial plain has been interpreted from the 1/50,000 aerial photos, and the interpreted maps have been developed to the 1/100,000 scale and digitized. These processes will be simplified in interpretation, plotting and digitization of 1/50,000 national topographic maps in the plotting process. Therefore, it is desired to provide 1/50,000 national topographic maps as soon as possible. (Refer to Figure 4.)

In addition, 1/100,000 soil maps are being prepared for the regional agricultural development plan in a similar method, but 1/50,000 national topographic maps should also be provided for this plan as soon as possible.

Most of on-going development plans are in similar unfavorable conditions because there is no 1/50,000 national topographic map, resulting in lower study accuracy, duplicate costs and delay in the study.

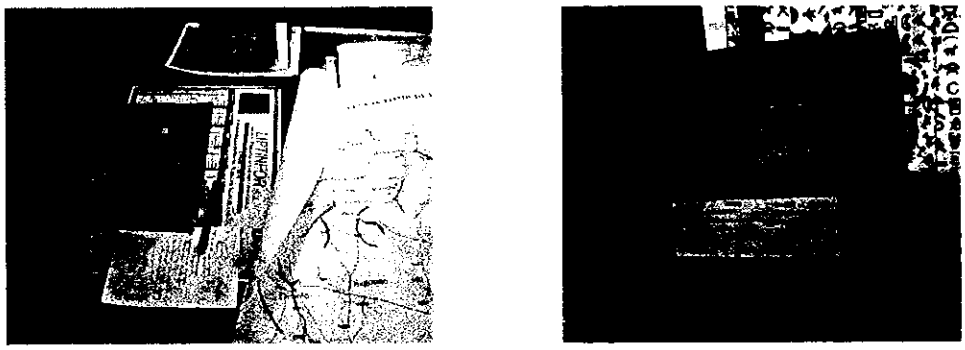


**Figure 4 Alluvial plain study work conditions (a, b)**

## 2.2 National topographic map development plan

The national topographic mapping plan of Burkina Faso has been executed under the National Topographic Map Development Master Plan (SDCT) that was resolved at the Cabinet meeting in 1990 as a high-priority plan in the Second Five-Year National Development Plan. For the resolution at the Cabinet meeting, this plan was put into the priority order and deliberated in detail in accordance with the rules for national topographic map production in African countries adopted by ECA, and based on the questionnaire study covering the organizations using the national topographic maps in Burkina Faso.

The most important plan in SDCT was the 1/50,000 national topographic mapping plan, the detail of which is shown in Figure 5. It shows additionally the map sheets produced in "the Study of the National Topographic Mapping of Southwestern Area in Burkina Faso".

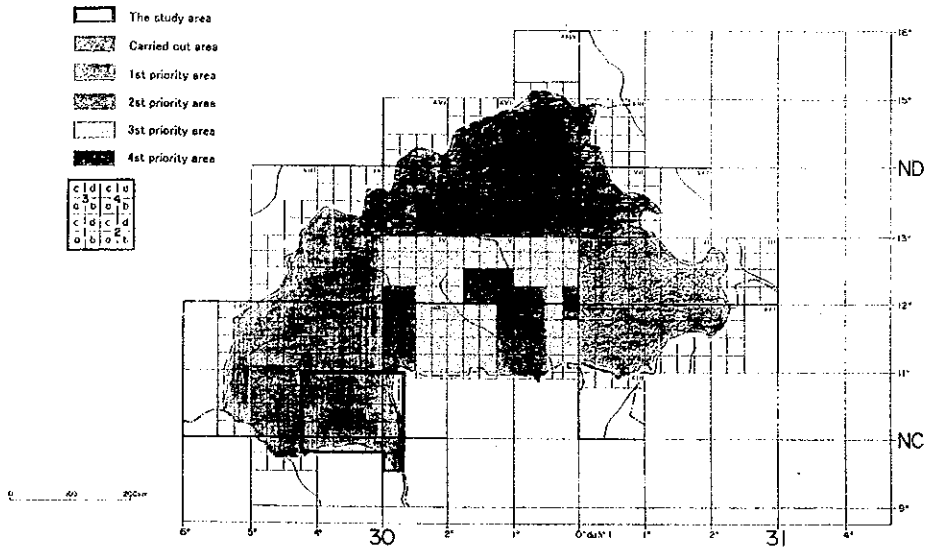



**Figure 5 1/50,000 national topographic mapping plan**

## 2.3 National topographic mapping capacity of Burkina Faso

### 2.3.1. Geodetic survey standards

The standards for horizontal positioning and elevation can be guaranteed by the national control points and the leveling net. In Burkina Faso, the geodetic datum and the original point of leveling are appropriately defined and the horizontal control points and the leveling net are provided. In the study area, it is necessary to increase second-order GPS control points and third-order benchmarks.

### 2.3.2 Technical capability of the engineers

In response to the request for technology transfer, the technical capability of IGB engineers concerned with the development work of the 1/50,000 national topographic maps has been examined in the oral question method. The evaluation method has been made in two levels: level A is the capability requiring only technical advice and accuracy control and level B is the capability requiring technical training because some of IGB staff are inexperienced. The results of examination are shown in Table 1.

**Table 1 Technical capability of technical personnel**

| Work Process | Evaluation | Remarks |
|---|---|---|
| Aerial photo signal installation | A | The work performed by IGB by itself is sufficient. |
| GPS control point survey | A | 2 engineers were trained in Switzerland. The engineers dispatched by Lausanne Polytechnic, a Swiss confederation survey public corporation, trained the IGB engineers. IGB's independent survey was also made with sufficient results. |
| Leveling | A | IGB's independent survey was made with sufficient results. |
| Aerial triangulation | B | One engineer had experience in studying at ITC, the Netherlands. 5 engineers were engaged in this work. IGB had the PATM386 software, but no experience in block adjustment. Photo control point survey was made for each model for orientation because the software version was too old and not installable. |
| Digital plotting | B | One engineer had experience in studying at ITC, the Netherlands and at an educational organization of Ministry of Elementary Education, France. 2 engineers were trained for digital plotting in Canada. 3 other engineers were engaged in this work. They are experienced in many contract works, but it is necessary to train them for the new system customized for national topographic mapping. |
| Field survey | A | IGB had an achievement of joint work with CLIDE LTD., UK. |
| Digital information processing | B | One engineer was trained at a private French company. 4 engineers were trained in Canada. One engineer was trained in Belgium. IGB had great achievements of GIS data digitized from the 1/200,000 national topographic maps and analysis of land use change for 1970 to 1990 using satellite images. However, it is necessary to train them for the new system customized for 1/50,000 national topographic maps. |

### 2.3.3. IGB's own equipment and materials

The survey equipment and materials that IGB possesses are shown in Table 2.

**Table 2 IGB's own survey equipment and materials**

| Survey equipment/material | Quantity | Remarks |
|---|---|---|
| (1) Geodetic and topographic survey equipment | | |
| • Theodolite | 15 units | |
| • Level | 9 units | |
| • RDS (Range detection system) | 2 units | |
| • MICROFIX | 6 sets | |
| • D15 | 1 unit | |
| • GPS receiver (Leica 2000) | 2 units | |
| • GPS receiver (Leica 3000) | 2 units | |
| • Base line analysis software (SAI-Ver.2.1) | 1 set | |
| (2) Photogrammetric equipment | | |
| • Plotter (A10) | 1 unit | Repaired in this work. |
| • Plotter (B8S) | 2 units | With one encoder. |
| • Plotter (B8S) | 1 unit | Modified to analyzing plotter. |
| • Planicarte | 1 unit | Out of order |
| • PUG-4 | 1 | |
| • Microstation Ver.5 (digitizing software-English) | 1 | |
| • 3DD (digitizing software – French) | 1 | |
| • PAT-M386 (aerial triangulation software) | | |
| (3) Photograph process equipment | | |
| • Developer (FE120) | 1 unit | |
| • Printer | 2 units | |
| • Enlarger | 1 unit | |
| • Film dryer (TG-24) | 1 unit | |
| (4) Information processing/digitizing equipment | | |
| • Workstation (SUN) | 3 sets | |
| • Scanner (A0 color: CT-3600) | 1 unit | |
| • Digitizer (A0) | 1 unit | |
| • Plotter (HP755MC) | 1 unit | |
| • Plotter (MH MX) | 1 unit | |
| • PC586 | 5 units | |
| • PC486 | 7 units | |
| • Software (ARCINFO PC) | 3 | |
| • Software (ARCVIEW) | 12 | |
| • Software (Arcview UNIX) | 2 | |
| (1) Map editing equipment | | |
| • Map reproduction camera (KLIMSCH) | 1 unit | |
| • Continuous developer (KLIMSCH) | 1 unit | |
| • KARGL correction projector | 1 unit | |
| • Contact print vacuum printer | 1 unit | |
| (2) Work vehicles | | |
| • Toyota BJ45 | 1 unit | |
| • Toyota BJ60 | 1 unit | |
| • Toyota double-cabin | 1 unit | |
| • Peugeot | 1 unit | |

## 3. PLAN OF THE STUDY

### 3.1. Approaches to the objectives

#### 3.1.1. Development of 1/50,000 national topographic digital mapping system

**(1) Cost-effective system with high-speed processing**

In comparison in the practical technology, the cost of digital mapping is 20% lower than that of analog mapping and the map production period is 40% shorter. Especially, analog mapping requires more experience and continuous mental concentration and higher skills in compilation drafting and scribing and a longer time to train technicians. Therefore, a digital mapping system will be designed and developed from the point of view of mapping cost and speed and training of technicians.

**(2) Information society-oriented system for creating GIS basic data**

As the advanced information technology and the development of infrastructure for it is making progress, the value of digital information has drastically been enhanced also in Burkina Faso. In particular, the digital topographic mapping information on the national basic maps as universal GIS basic data has become the base of the spatial information in relation to all the social activities including administration. This will be the focus of society in the era in which decision-making is speedier, more comprehensive and at a high-level point of view, allowing information to create new values. For this purpose, a digital mapping system that can be directly connected to a system to produce GIS basic data is called for. Digital information would be obsolete and the information operation method would be forgotten if the data is not always used without added or corrected changes of data. Therefore, a system that can not only store the data for future use, but will also be a system that allows the data to readily be used will be developed.

#### 3.1.2. Training of engineers for 1/50,000 national topographic mapping system

It is called for by IGB to educate its technical personnel for operation and management of the 1/50,000 national topographic mapping system and its technical leaders for future improvement of the system after the completion of development under the study.

### 3.1.3.Development of 1/50,000 national topographic maps and digital mapping information of the southwestern area

The large-scale development study of the 1/50,000 printed national topographic maps, digital topographic mapping information and GIS basic data covering the southwestern area of 20,600km$^2$ is now in progress and it is desired to complete the development as early as possible (within about 29 months).

### 3.1.4. Development of Pilot GIS using the GIS basic data

The measures in which the digital topographic mapping data developed in this study can be operated as GIS basic data in an effective, immediate and practical way will be recommended.

## 3.2. Operational plan of the Study

### 3.2.1. Work process and flowchart of the Study

The work process and flowchart of this study are shown in Figure 23.
In Figure 23, the process indicated with a tag number affixed to the work process number is an additional process under the additional request determined through the mutual discussions in each year.

### 3.2.2. Survey design

#### (1) Survey of second-order GPS control points and photo control points

The design diagram of second-order GPS control point survey and photo control point survey are shown in Figure 24.

#### (2)Third-order leveling

The third-order leveling design diagram is shown in Figure 25.

#### (3)Aerial photography

The aerial photography plan diagram is shown in Figure 26.

### 3.2.3. Establishment of Management Council

A Management Council was organized to generally coordinate the integration of the work processes to be implemented under the IGB's initiative with the work processes under the JICA study team's initiative, and to conduct the technology transfer that ensure the further development of the transferred technology in compatibility with the technical conditions of Burkina Faso. For this purpose, a coordinator in each field was appointed from both sides for daily coordination and communications to ensure the mutual understanding and close cooperation in each technical field of work process.

### 3.2.4. Formation of GIS basic data user conference

Efforts was made to set up a GIS Users Conference consisting of GIS basic data user agencies and organizations for the purposes of high value-added development and application of the digital topographic data produced in this study and promotion of wide-range application of GIS using GIS basic data.

## 4. DESCRIPTION OF THE STUDY

### 4.1. Development of 1/50,000 national topographic digital mapping system

#### 4.1.1.Functional Improvement Design of 1/50,000 National Topographic Digital Mapping System

The outline of the functional improvement design of the 1/50,000 national topographic digital mapping system implemented based on the basic objectives of this study is shown in Figure 6.

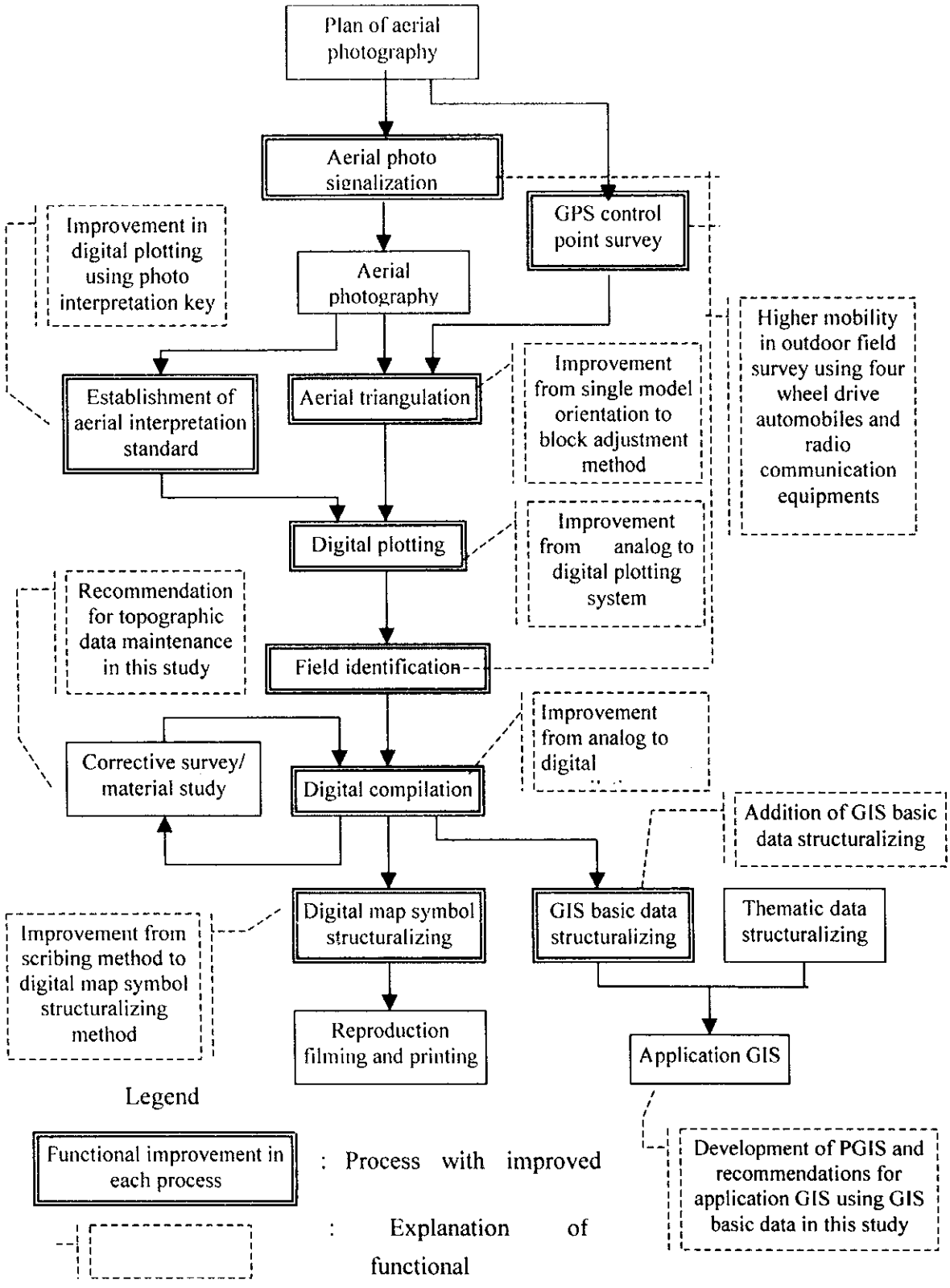



**Figure 6 Functional improvement of 1/50,000 national topographic digital mapping system**

### 4.1.2. Design and equipment of aerial triangulation process

The mechanical failure in the class 1 plotter Wild A10 was repaired. For the mechanism for converting coordinate values from pulses and for magnetic tape recording, a digital pulse-based coordinates converter was manufactured and the PC software having the functions of accuracy control in the photo model coordinates measurements and PATM-386 input filing was newly developed.

### 4.1.3. Design and equipment improvement of digital plotting process

For selection of the digital plotting system, the following three methods were compared and evaluated in the points of required accuracy, equipment investment expenses and maturity for practical technology:

① Digitizing at analog plotting output section
② Digitizing at precision optical analyzer
③ Digitized image analysis

When IGB plans to improve the version of the plotter in the national topographic digital mapping system in several years, the digitized image analysis system will be first examined. However at this moment of the study, it was evaluated that the method of digitizing at the analog plotting output section was the best.

### 4.1.4. Introduction of equipment for digital compilation, symbol structuralization and GIS basic data structuralizing processes

The digital compilation, symbol structuralization and GIS basic data structuralizing processes require the following; to introduce new equipment because there is no existing equipment at IGB and to use the computer information processing technology. The main equipment including personal computers and basic software were introduced as shown in Figure 7.

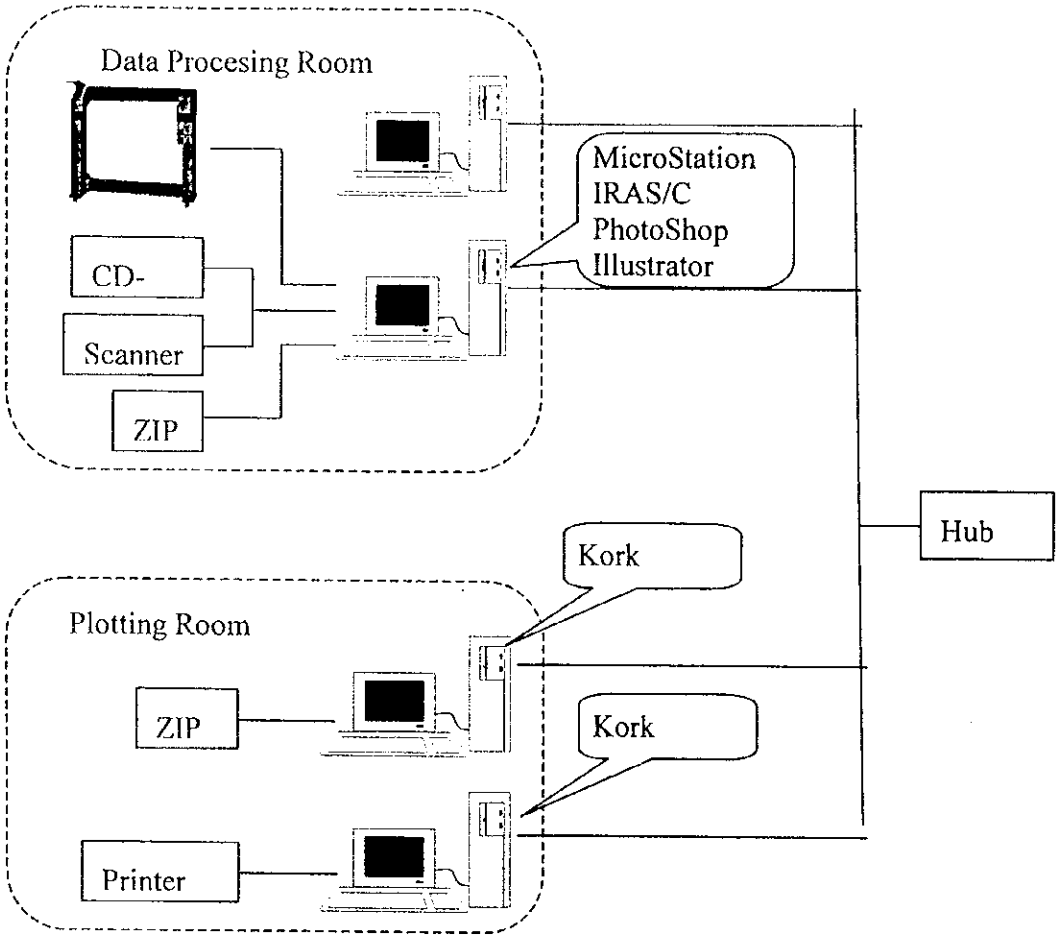



**Figure 7 Introduction of equipment for digital compilation, symbol structuralization and GIS basic data structuralizing processes**

### 4.1.5. Customizing of digital plotting and compilation, and map symbol and GIS basic data structuralization

#### (1) Basic software

The basic software configuration as shown in Figure 8 was selected in considering the commercially available, inexpensive and universal software and the positive use of the technology that IGB's engineers had acquired.

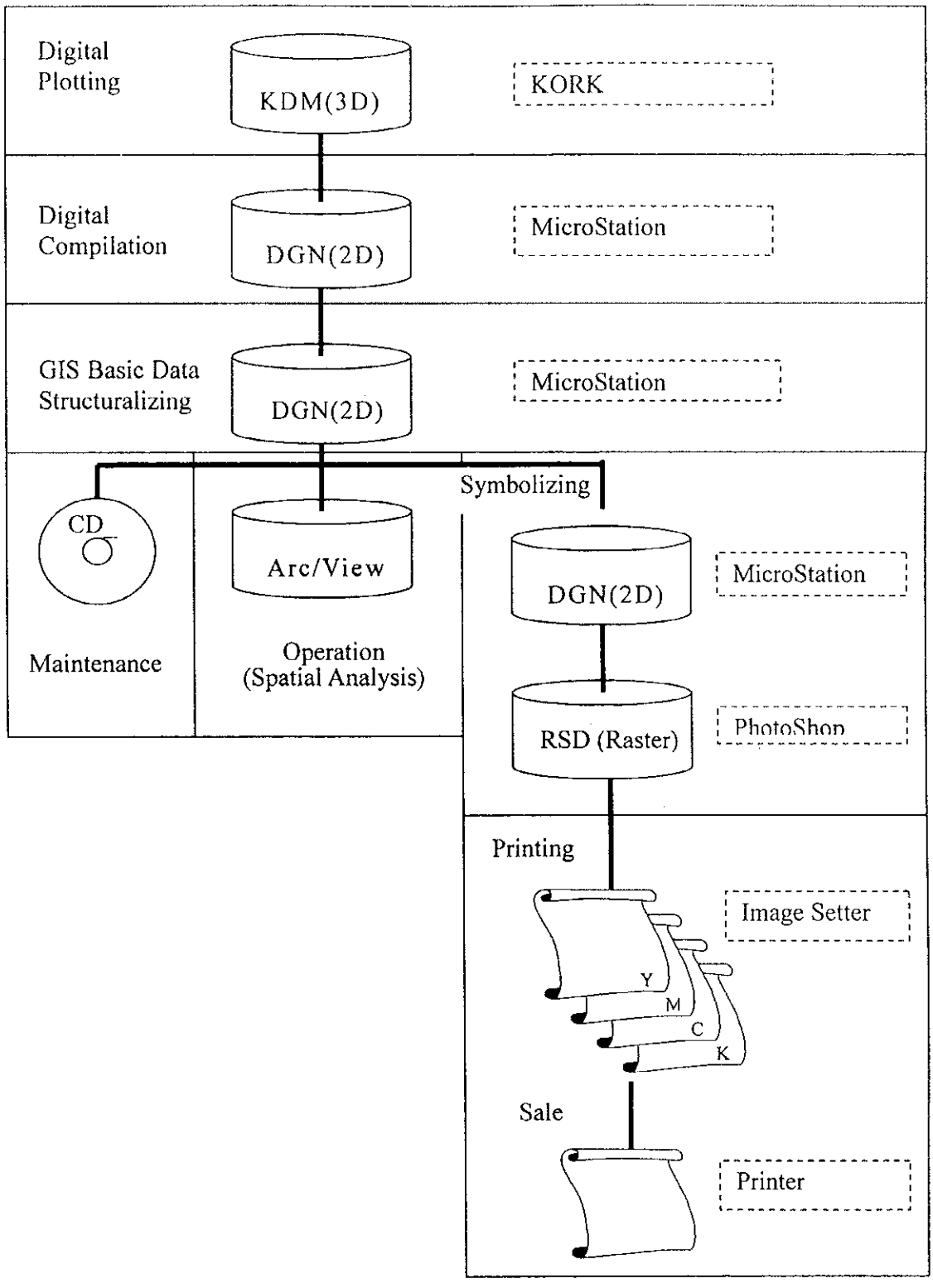



**Figure 8 Basic software configuration for digital plotting, digital compilation, symbol structuralization and GIS basic data structuralization**

### (2) Customizing of digital plotting and compilation, and map symbol and GIS basic data structuralization

#### (a) Customizing of digital plotting process

In the digital plotting process, the photos were interpreted in accordance with the photo interpretation standard and the symbols were plotted in accordance with the symbol representation classification, but these involved some uncertain points. These uncertain points were verified in the field verification survey and corrected in the digital compilation process.

To make the correction work effective, the functions of changing the line representation category codes, symbols and parts of the planimetric features were customized. Figure 9 shows the menu view of the symbol replacing function.

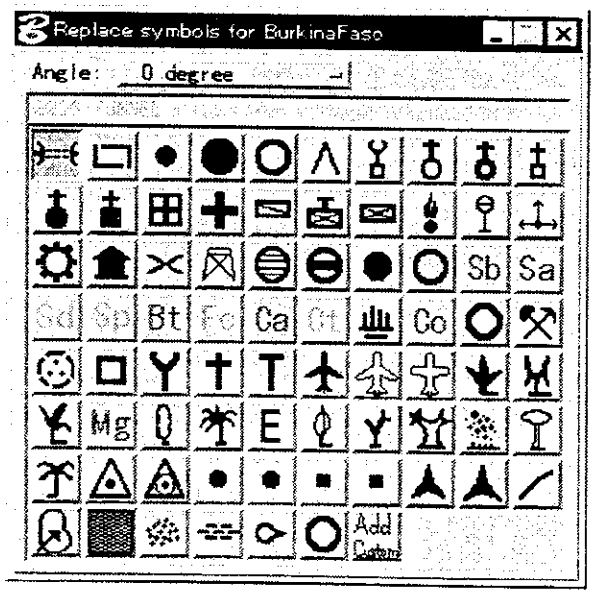



**Figure 9 Menu view of symbol replacing function**

Detailed symbol design diagrams were prepared based on the topographic map samples presented by IGB and registered together with the annotation fonts.

In addition, the main input menu, sub-input menu, annotation-input menu and compilation support functions were customized to carry out the digital compilation work effectively. This customization allowed instructions from field survey, correction of irrational points such as inconsistent points between contour lines and single elevation points, and the relational positions of roads, water channels and buildings, and entry of annotations and administrative boundaries to be compiled effectively.

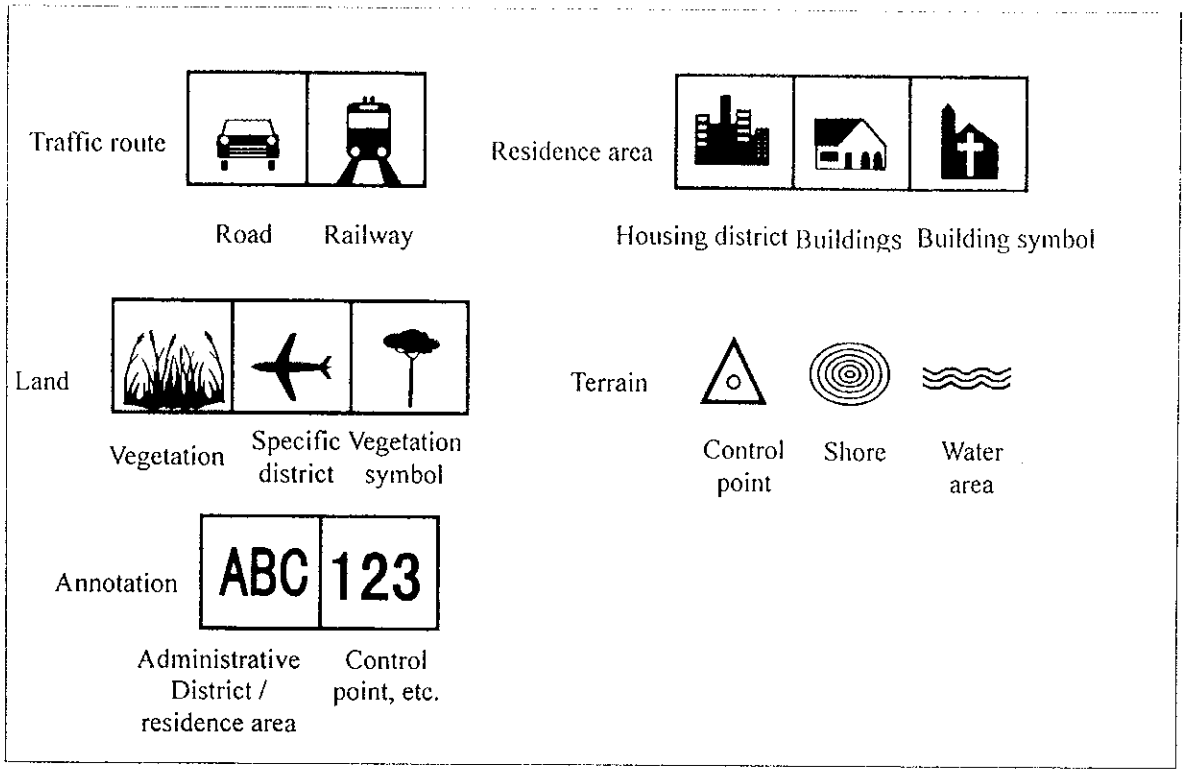



**Figure 10 Sub-input menu**

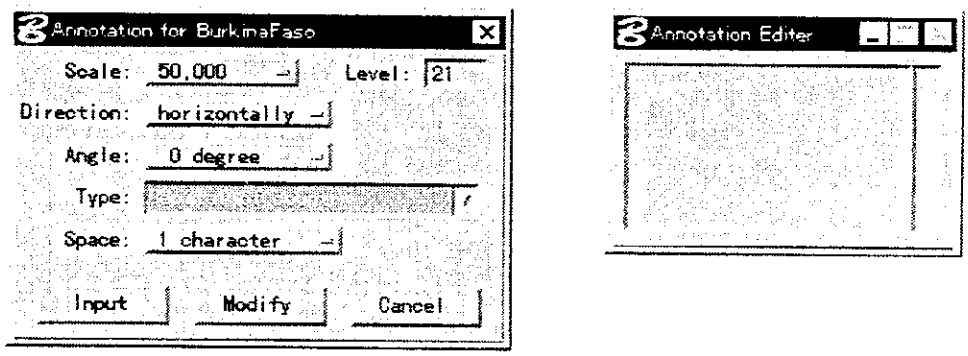



**Figure 11 Annotation input menu**

Digital compilation should be distinctly separated from structuralization. The data to allow the map symbol structuralizing data and the GIS structuralizing data be converted through program processing in a smooth manner was created and stored in the core files for future data management and updating.

**(b) Customizing of GIS basic data structuralizing process**

To make spatial analysis in the GIS, the strict mathematical relation of spatial information has to be established. It is important to connect the lines and form them as a single line for the

planimetric features to configure the networks such as roads, water channels and railways. For the planimetric features to be represented as planes such as vegetation, it is necessary to configure planes and affix them with their attribute information to indicate the meaning of each plane.

**(c) Customizing of map symbol structuralizing process**

In general, printing of maps based on digital topographic data is less efficient because the digital topographic data is imported in the image processing software such as typically the Illustrator, on which symbolizing is made in the man-machine transactions. In this study, the digital map symbol structuralizing process was customized to ensure that the digital topographic data was subject to the map symbol structuralizing process using semi-automatic processing, and that the symbol representations were raster-transformed while being rearranged in their order of priority in order to obtain the reproduction film outputs for 4-color offset printing.

**(d) Outline functions and types of customizing software**

The outline functions and types of customizing software are shown in Table 3.

**Table 3 Outline functions and types of customizing software**

| Process | Outline function | Type |
|---|---|---|
| Digital plotting | Editing/plotting menu, etc. | Macro |
| | Conversion of digital plotting data to digital compilation data | Batch |
| Field survey | Change in attributes | MDL |
| | Replacement of symbols | MDL |
| | Partial change in planimetric features (stged1) | MDL |
| Digital compilation | Development of representation category codes | Batch |
| | Input menu | MDL |
| | Annotation input menu | MDL |
| | Form adjustment | Batch |
| | Attribute copy | MDL |
| GIS basic data structuralization | Line connection | Batch |
| | Single-line forming | Batch |
| | Intersected line dividing | Batch |
| | Plane creation | Batch |
| | Check on integrity of planes with attribute symbols | Batch |
| Map symbolizing | Compound line symbolizing | Batch |
| | Line stick-up symbolizing | Batch |
| | Plane development symbolizing | Batch |
| | Character/symbol outlining | Batch |
| | Data arrangement in printing order | Batch |
| | Rasterization for printing | Batch |

### 4.1.6.Improvement of digital topographic information network and installation of stabilized power supply equipment within IGB

A local area network (LAN) was installed within the IGB facility to ensure efficient, accurate information processing through communication of digital information among the departments and sections related to the 1/50,000 national topographic digital mapping system. In addition, the stabilized power supply facilities were installed because the electronic equipment and the information in operation may be subject to a serious damage if power failure occurs during the operation of the national topographic digital mapping system.

### 4.1.7. Higher Mobility in Outdoor Field Survey

Four (4) units of 4-wheel drive automobiles for outdoor survey were provided to obtain the high mobility in outdoor surveys. A radio communication system was also installed, which consists of a key station installed within the IGB facility and mobile stations installed in the four 4-wheel drive automobiles for outdoor survey in order to operate several GPS receivers in synchronization to each another for higher efficiency of GPS survey.

### 4.1.8. Improvement of Geographical Naming System

The National Geographical Name Committee (La Commission Nationale de Toponymie, CONATOP) of Burkina Faso has the role of correcting those geographical names that the long-time influence in the era of the French colony reflected on and may impair the dignity and independence of the nation. The National Geographical Name Committee had to take a long time to investigate those geographical names on the basis of the historic and linguistic researches.

On the other hand, the early development of the topographic maps was also the important requirement for the cultural and economic development of Burkina Faso.

To satisfy these two requirements, the IGB Geographical Naming Committee was established within IGB. IGB has carried out a quick study with the help of local researchers specializing in various fields, according to the principle of "Locally used names" (to adopt the geographical names in current use in local areas) to adopt the geographical names for use in the topographic maps. The results of discussions were immediately reported to the National Geographical Name Committee to accelerate the deliberations among its members. In this system, there were cases with low probability in which some geographical names adopted by the IGB geographical naming committee might be rejected by the National Geographical

Name Committee, but the digital mapping system allowed those names to be promptly corrected in a simple way.

#### 4.1.9. Preparation of 1/50,000 National Digital Mapping System Technical Standard and Work Specifications

In the project of producing the 1/50,000 national topographic maps and digital topographic data, the technical standard and work specifications for the 1/50,000 national topographic digital mapping system were used in order to enhance the technical level and secure the overall quality of maps and data while keeping the technical integrity of the work processes without repeating the problems that had occurred in the past.

### 4.2. Training of maintenance and operation personnel for 1/50,000 national topographic digital mapping system

#### 4.2.1. Training of operating personnel

For the new technical work processes introduced in order for the counterparts to attain the technical level to allow the independent further development of the products and the system as a national project, the system equipment was provided and the necessary manuals were prepared, and the on-the-job training (OJT) scheme was adopted to conduct the training while producing the 1/50,000 national topographic maps and digital topographic data.

The trainees in the OJT were appointed by IGB in consideration of the scale of the topographic map development project. The list of the OJT trainees is shown in Table 4.

**Table 4 List of OJT trainees**

| Work No. | Item of Training | Number of trainees | | System manager | Trainee |
|---|---|---|---|---|---|
| | | Chief | Members | | |
| [5-1] | Correction of geoid undulation in GPS survey | 1 | 2 | SAWADOGO Jean | ZIO Issa<br>SANOU Yaya |
| [21] | Aerial triangulation 2 | 1 | 3 | COMPAORE Désiré | TOURE Ladji<br>NIKIEMA Sagado |
| [22] | Digital plotting 2 | 1 | 5 | COMPAORE Désiré | TOURE Ladji<br>NIKIEMA Sagado<br>KOUDOUGOU Sibiri J<br>SANOGO Sié |
| [35] | Digital compilation & structuralization 2 | 1 | 6 | KABORE Salifou | SOMDA Lucie<br>KIEMA Béatrice<br>YAGO Idrissa<br>BOULSA Charles<br>BOLLY Ahamadou<br>BAKOUAN Hortense<br>☆COMPAORE Désiré |
| [36] | Map symbol structuralization 2 | 1 | 6 | KABORE Salifou | SOMDA Lucie<br>KIEMA Béatrice<br>YAGO Idrissa<br>BOULSA Charles<br>BOLLY Ahamadou<br>BAKOUAN Hortense<br>☆COMPAORE Désiré |
| [37] | GIS basic data structuralization 2 | 1 | 4 | KABORE Salifou | TAPSOBA Martine<br>OUEDDOUDA Rosalie<br>PARE Françis<br>BOLLY Ahamadou<br>☆COMPAORE Désiré |
| [47] | Pilot GIS operation | | 4 | KABORE Salifou | DEMBELE Ousmane<br>YAGO Idrissa<br>BOLLY Ahamadou<br>☆COMPAORE Désiré |

### 4.2.2. Training of System Managers

The manager in a work process of the system was appointed as the system manager of the work process. The system manager has the role of instructing any proper measures for any problem in system operation and giving a solution to it after completion of this study.

The training scheme was as follows:

(1) All the system managers attend the Management Council of this study to experience the problems and solutions to those in the system operation through this study.

(2) The system managers for the work of introduction of new technologies participate in the necessary part of OJT. Participants are shown in Table 4.

(3) The system managers for the work processes of aerial triangulation and digital plotting participate in the long-term collective training "Planning and Management of National Mapping and Surveying Course" in Japan.

Participant: Mr. COMPAORE Désiré (Chief of Aerial Triangulation and Digital Plotting Work Processes)

Training period: October 2, 2000 to July 29, 2001

### 4.2.3. Training for GIS Design and Configuration Method using GIS Basic Data

The creation of GIS basic data and development of pilot GIS in this study were implemented to recommend the prompt promotion of the effective use of the 1/50,000 national digital topographic data.

In response to the recommendation, the members of the "GIS Users Conference", which consists of the delegates of IGB and other related governmental agencies, strongly requested the study team for transfer of technology in the GIS design and configuration using GIS basic data, which was adopted and added to the third-year work.

The Training Method was as follows:

(1) The GIS development department was newly established in IGB and the development manage received the individual training in Japan.

(2) Preparation of pilot GIS operation manual and operational training of the IGB's GIS engineers and the members of GIS User Conference in charge of pilot GIS work.

(3) The seminar on GIS design and configuration using GIS basic data was held for the members of GIS Users Conference and IGB's GIS engineers.

Participant: Mr. BOLLY Ahamadou (IGB's GIS development department manager)

Training period: September 27, 2000 to October 28, 2000

### 4.2.4. Training of IGB's High-Level Management

For the purpose of studying the actual conditions of the National Survey Projects of Japan having many years of achievements and smooth promotion of technical cooperation between Japan and Burkina Faso, Mr. Ousseny TARNANGUIDA, the general director of IGB visited Japan between June 21 to July 3, 1999 and Mr. Claude Obin TAPSOBA, the technical director of IGB, between June 21 to July 16, 1999 respectively to conduct a study and held discussions at Geographical Survey Institute, and with various survey education organizations, survey-equipment manufacturers, survey-related organizations and companies in Japan.

### 4.2.5. General Seminar

The general seminar was held in the following forms:

(1) Ceremony of delivery of various products such as equipment of the 1/50,000 national topographic digital mapping system, the national basic maps for the southwestern area, the digital topographic mapping data and GIS basic data, in which the Ministers of the Government of Burkina Faso and the representative of Japanese Embassy in Burkina Faso participated.

(2) Seminar for promoting the GIS using GIS basic data for the members of the GIS Users Conference consisting of delegates of GIS-related governmental agencies, and IGB's GIS engineers.

(3) Seminar for explaining the general products of this study for the officials of the agencies as users of the national topographic maps and IGB's staff

## 4.3. Development of 1/50,000 national topographic maps for southwestern area and digital topographic information

### 4.3.1. Technical standard for topographic mapping

The technical standard for topographic mapping will be outlined as follows:

| | |
|---|---|
| Reference ellipsoid: | Clarke 1880 |
| Radius of the equator: | 6,378,249 m |
| Flatting rate: | 1/293.4663 |
| Unit: | Meter |
| Map projection: | UTM |
| Map scale: | 1/50,000 |
| Contour line interval: | 10 m |
| Neat line: | 15' x 15' |

The outline standards of the symbols and digital data acquisition are shown in Figure 28.

### 4.3.2. Processes of study works and work procedures

In the development of the 1/50,000 topographic digital mapping system, the subcontract method was adopted for the processes of aerial photography and map printing in considering the technical conditions in Burkina Faso. The aerial photography process was subcontracted

to CINTEC and the map printing process was originally planned to be subcontracted to any company in the neighboring country Côte d'Ivoire, but it was subcontracted to Nakasha Creative Co., Ltd. in Japan because of the unstable political conditions the recommendation for forbidden entry into the country.

The IGB's 1/50,000 digital mapping system consisted of 2 sets of digital plotter. In addition, the processes of digital plotting, digital compilation, map symbol structuralization and GIS basic data structuralization that were the new technology introduced in this Study were implemented through OJT (on-the-job training), so that the production pace was limited. In consideration of the above circumstances, some portions of these processes were implemented in Japan. The study work processes are shown in Figure 12.

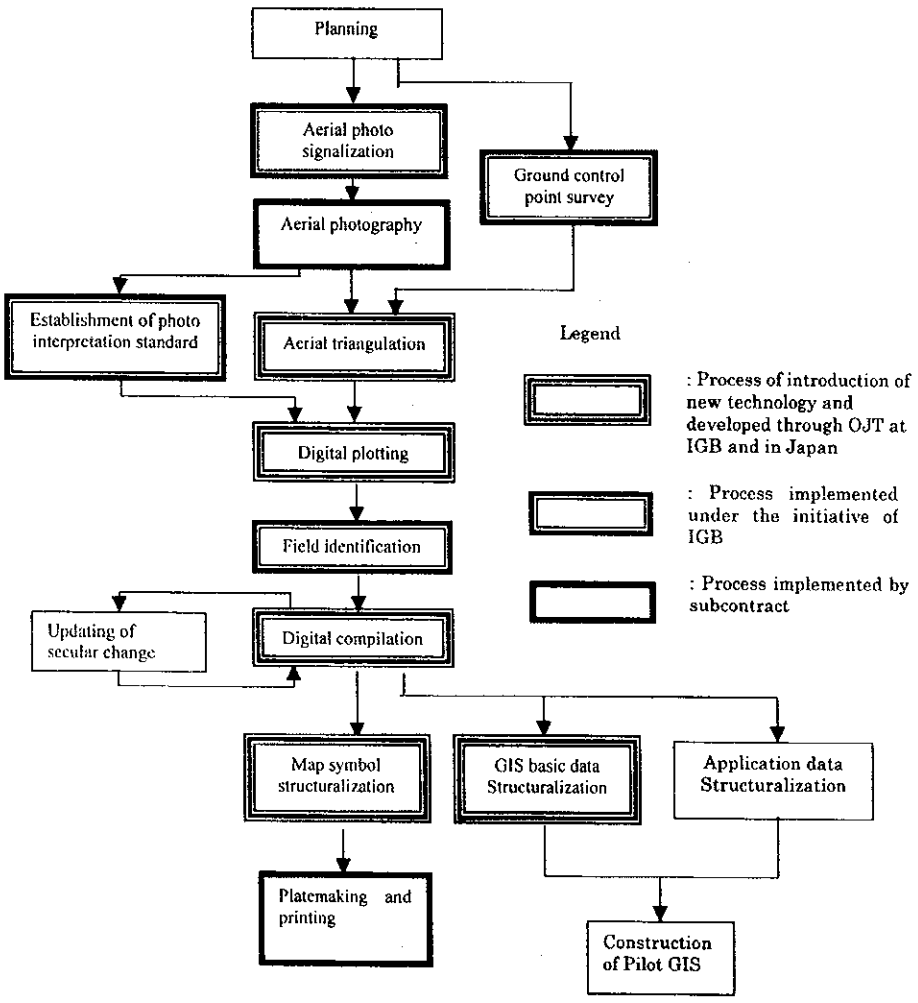



**Figure 12 Processes of production of topographic maps and digital topographic data and study implementation procedures**

### 4.3.3. Work details of topographic mapping process

#### (1) Process of installation of aerial photo signals

For absolute orientation for the aerial photography, signals were installed. The signal structure was designed as shown in Figure 13. The material of the signal was made of locally available, white-painted stones of 10 to 20 cm diameter laid on the ground. The sites of signal installation and the quantities of those are shown in Figure 24 and Table 5 respectively.

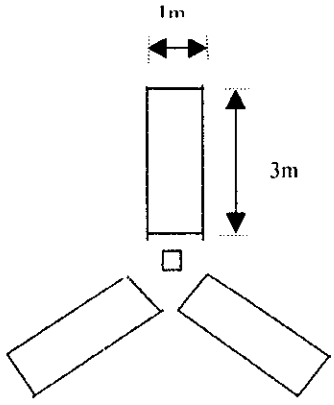



**Figure 13 Structure of aerial photo signal**

#### (2) Process of ground control point survey

The observation of GPS survey for the second-order ground control points was carried out for 2 hours per session. The net adjustment was performed based on the first-order ground control points as known points. To indicate a point as its elevation value, the correction using the local geoid method was made.

To obtain the high elevation accuracy, the leveling route was set through the third order leveling and pricking was carried out. The points for which these works were made and the work volumes are shown in Figure 24 and Table 5 respectively.

### (3) Aerial photography

As a result of investigation of the technical capability and price and other conditions of candidate companies, the aerial photography process was subcontracted to CINTEC as the most appropriate subcontractor. The photography base was posted at Bobo Dioulasso Airport. The discussions with IGB, the contract with CINTEC and the installation work of aerial signals preceded so that all the process of aerial photography could be finished before harmattan hit this area.

| | |
|---|---|
| Aircraft: | Cheftain Navajo |
| Aerial camera: | RC-10 (f = 88.01 mm) |
| Film: | AGFA AVIPHOT PAN 200 PEI |
| Photography scale: | 1/50,000 |

The photographing courses are shown in Figure 26.

After their processing, the photographs were subject to inspection under the same specifications as the JICA Work Specifications and it was verified that those photographs satisfied the inspection criteria.

### (4) Aerial triangulation process

To obtain the integrity in accuracy, aerial triangulation survey of all models were conducted using the block adjustment method, separately from the OJT products.

① Main equipment

| | |
|---|---|
| Pricker: | PUG II/IV type (Wild) |
| Coordinate observation equipment: | Stecometer (Carl Zeiss Jena) |
| Computer: | ACOS PX 7800 (NEC) |

② Work details

1) 5 path points were selected for each photo taking into account the photography using the super-wide angle camera.
2) 2 tie points were selected for each model for higher connectivity.
3) The ground control points were actually checked by stereoscopic observation in accordance with the detailed description sheets of ground control points and transferred.

4) The benchmarks were observed on the basis of the quadruple-enlarged photo, pricked photo materials and the points were transferred.
5) The coordinate observation was made twice independently and the major errors due to discrepancies were checked and rechecked in the polynomial expression method.
6) The block adjustment was made using the bundle method.

③ Results of adjustment

1) Number of used ground control points: 52 points (horizontal)
128 points (elevation)
2) Standard deviation presumed from the residuals of ground control points:
±0.616 m (horizontal)
±0.633 m (elevation)
3) Standard deviation of path points and tie points:
±6.56 μ (coordinate component)

**(5) Photo interpretation standards establishment process**

In the digital plotting process, the aerial photos were interpreted in an appropriate way to standardize the accuracy, so that the information under the map symbol specifications was not different depending upon the interpreters.

The interpretation standards were made up on the basis of the map symbol specifications by arranging the applicable criteria, aerial photo samples, ground photo samples and the representation method in digital plotting and compilation in order to obtain easy to read photos.

The target features are as follows:

Road type
River and seasonal river
Village and its extent
Vegetation
Terrain

### (6) Digital plotting process

In the digital plotting process, the photo models were oriented using the results of aerial triangulation. Then, the information to be acquired was interpreted in accordance with the photo interpretation standards and the planimetric features, vegetation and other topographic data to be represented as line and positional data were plotted and fitted with attribute symbols in accordance with the data acquisition standard.

In the data acquisition in the digital plotting process, the plotting work proceeded in an efficient and systematic manner in accordance with the customized map symbol representation specifications. The area of 2,150 square kilometers that IGB undertook was digitally plotted through OJT.

### (7) Field identification process

The output maps from the digital plotting process were carried to the field to identify and acquire the geographic names and planimetric features that were not acquired by aerial photography and to correct the omissions in data acquisition and the errors of interpretation. For the geographic names that were local language was recorded on the tape recorder in order to acquire the right notation in French. And they ware decided through careful inspection by IGB Toponymy Committee.

### (8) Digital compilation process

In the field identification, the lacking data in the checked digital plot information was additionally plotted and the errors were corrected. Further, the line data, connected line and closures of polygonal data that were incompatible with the digital data acquisition standard were corrected. The geographical names, annotations of planimetric features and administrative boundaries were also compiled.

The compilation work was conducted efficiently using the customized digital compilation software to perform automatic logical check and to cause no oversight in checking.
The area of 1,500 square kilometers that was undertaken by IGB was digitally compiled through OJT.

### (9) Map symbol structuralizing process

In the map symbol structuralizing process, the data such as line and plane information, planimetric features and vegetations that were compiled in the digital compilation process were symbolized in accordance with the map symbol specifications in order to output those on printed maps. Vector-type data was also converted into raster-type data. The symbolized data was divided into color-separated layers. This process was performed in a semi-automatic procedure using customized map symbol structuralizing software.

The area of 1,500 square kilometers that was undertaken by IGB was processed through OJT.

### (10) GIS basic data structuralizing process

In the GIS basic data structuralizing process, the geographic data compiled in the digital compilation process was structuralized as the logical structures that were adequate for spatial operation to generate GIS basic data. This process was performed in a semi-automatic procedure using customized GIS data structuralizing software.

The area of 1,500 square kilometers that was undertaken by IGB was processed through OJT.

### (11) Platemaking and map printing process

In the platemaking and map printing process, the structuralized map symbol data was separated into 4 colors of green, orange, blue and black and reproduction films and plates were produced. Then, the maps were printed from those plates.

Originally, it was planned to subcontract this filming and printing process to a subcontractor in the neighboring country, Côte d'Ivoire, but the political conditions became unstable during the period for implementing this process and the forbidden entry into the country was recommended. Thus, this process was implemented in Japan.

### 4.3.4. Study period and work volumes of 1/50,000 topographic mapping and digital mapping data creation

The study period of 1/50,000 topographic mapping and digital mapping data creation work is shown in Figure 29.

The work volumes by process in the 1/50,000 topographic mapping and digital mapping data creation work are shown in Table 5.

**Table 5 Work volumes by process in the 1/50,000 topographic mapping and digital mapping data creation work**

| Process | Work Volume | Remarks |
|---|---|---|
| Installation of aerial signals | 51 points | |
| Ground control point survey (GPS) | 69 points | |
| Ground control point survey (Leveling and GPS leveling) | 521 km | Leveling with 2 GPS units |
| Aerial photography | 20,600 $km^2$ | Subcontract |
| Establishment of photo interpretation standards | 1 set | |
| Aerial triangulation | 618 models | |
| Digital plotting | 18,450 $km^2$ | 2,150 $km^2$ by OJT |
| Field survey | 20,600 $km^2$ | |
| Digital compilation | 19,100 $km^2$ | 1,500 $km^2$ by OJT |
| Map symbol structuralization | 19,100 $km^2$ | 1,500 $km^2$ by OJT |
| GIS basic data structuralization | 19,100 $km^2$ | 1,500 $km^2$ by OJT |
| Platemaking and printing | 32 map sheets | Subcontract |

### 4.3.5. 1/50,000 national topographic maps produced

The printed 1/50,000 national topographic maps are produced using the customized software for automatic processing to perform the map symbol structuralizing process efficiently. Compared with the maps for which the map symbols are structuralized with any drawing software, these produced maps features the uniformity and high mechanical accuracy. Although a few people familiarized with the manually drawn maps had objections, the management committee made the overall evaluation that the customized semi-automatic map

drawing software absolutely contributed to the superior products. The index map of the printed 1/50,000 national topographic maps is shown in Figure 27.

### 4.4. Development of the pilot GIS

#### 4.4.1. GIS Users Conference

The "GIS Users Conference" consisting of delegates from various related agencies and organizations was formed to promote the GIS applications using GIS basic data. The GIS Users Conference is expected to play the important roles as a users' body to make various recommendations for administrative policies and technical issues and as a joint development body together with IGB.

#### 4.4.2. Development of Pilot GIS's

**(1) Simple GIS**

The simple GIS is a system in which the GIS basic data configured from the 1/50,000 national topographic information including not less than 150 types of huge geographic information is operated with the GIS engines commercially available.

The promotion of simple GIS applications in which necessary information can be retrieved from the GIS basic data by theme is very important for promotion of GIS.

The commercially available GIS engines are so easy to purchase that the simple GIS applications with popular PCs will be promoted among the people having interest in taking a GIS in their work. Figure 14 shows an example of water system map produced using a simple GIS.

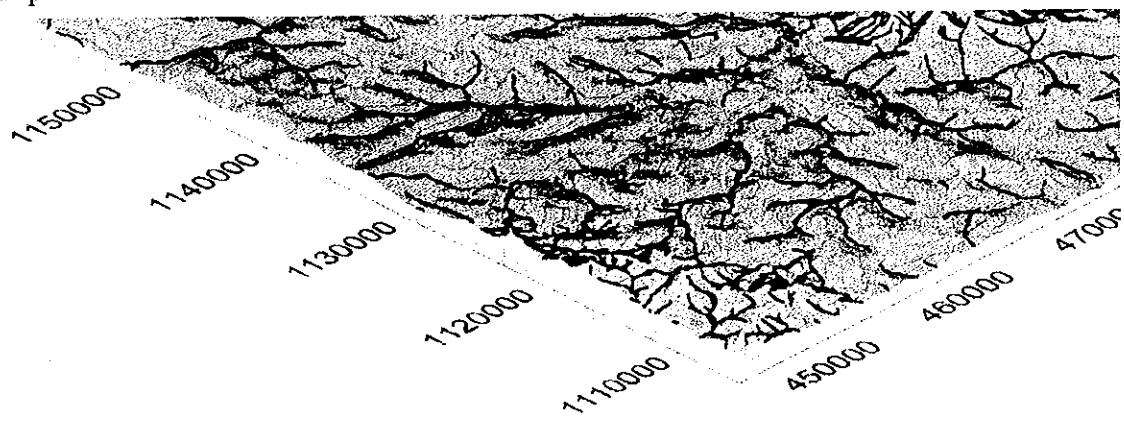



**Figure 14 Example of water system map produced using a simple GIS**

**(2) Pilot GIS for support of regional agricultural development**

This pilot GIS system has the following functions to contribute to formulating the master plan for regional agricultural development:

① Indication of topographic features

In the southwestern area of Burkina Faso, there are a few topographical undulations in general, but many alluvial plains (Bas Fonds) formed with fertile soil owing to the floods from the Mouhoun and the Komoe rivers. The alluvial plains have a high water conserving capacity suitable for rice farming and a high potential for agricultural development.

The interpretation of alluvial plains is so highly accurate in the maps with 10m contours. However, the topographic features can be clearly indicated by creating the 3-dimensional topographic models with the GIS, enlarging the scale of elevation components and displaying the map in a bird eye's view.

② Acquisition of accurate information on alluvial plains by addition of aerial photo vegetation information

If the aerial photos of abundant vegetation information are attached to the 3-dimensional topographic model to display a bird's eye photo map, the extent of alluvial plains can be interpreted accurately and the accurate information on the alluvial plains can be acquired.

③ Evaluation of water resources, etc.

By calculating the water collection area at a developed site and multiplying it with a monthly rainfall, the water resource evaluation is partly available.

④ Support of evaluation of land use and development infrastructure

By overlaying roads, villages and cultivated farms on the alluvial plain districts, the development infrastructure and land use conditions can be evaluated.

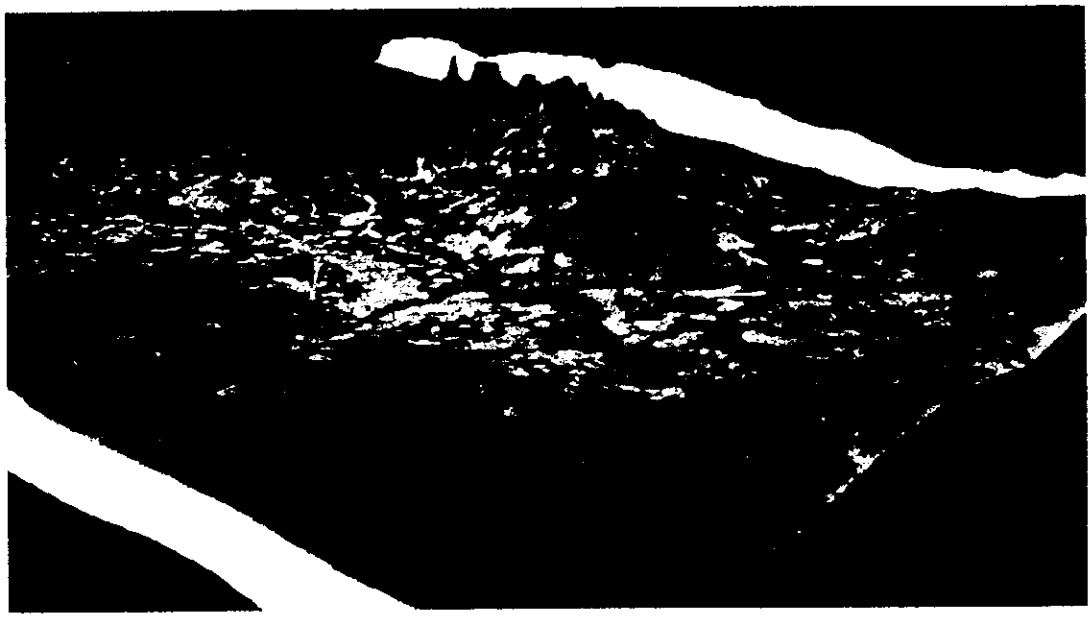


Figure 15 Bird's eye photo map for interpretation of alluvial plains

Figure 16 Conditions of roads and villages around alluvial plains

### (3) Pilot GIS for support of elementary school construction, management and operation

This system is a pilot GIS to support the new or additional construction, maintenance, management and operation of elementary schools. Its major functions are as follows:

① Presumptive local distribution of children

A target area is divided into 500m grid meshes and the number of houses per mesh is counted. The number of children is obtained from the statistic of population for each administrative area. Then, the number of children per mesh in the administrative area is calculated assuming that it is proportional to the number of houses per mesh.

② Support of plan for additional construction to existing elementary schools

The children in a mesh within a 4km range from an existing school are deemed to be the children within an area to be provided with a school. Which school is the nearest from each mesh within such school-satisfied area is determined and the mesh nearest to the school is deemed to be the nearest mesh to school.

Assuming that the children attend the nearest school, the number of children within each mesh near a school is counted to obtain the total child capacity of each school. Then, the rate of children's attendance to school for a near future is estimated and the total number of children for each school is multiplied by this rate to plan the total number of children for a school. If it is necessary to increase the current total child capacity of a school in order to admit the planned total number of children, a plan of additional construction is made as given by the following number of children: Planned total number of children – current child capacity = number of children for additional construction.

③ Support of construction of new school

The children within meshes outside of the 4km coverage of an existing school are those requiring a new school. For these children, an efficient school distribution is designed under the Christaller theory to count the number of children to be admitted in a new school as the standard number of children for a new school construction plan. Then, this plan is corrected in compliance with the surrounding conditions by overlaying roads, rivers and other topographic features.

④ School information

This pilot GIS provides the image information to offer visual displays of major structures such as school buildings and the text information such as school facilities, teachers and children. If the location of a school on a map is clicked, the school is displayed and the information on the management and operation of the school is also supported.

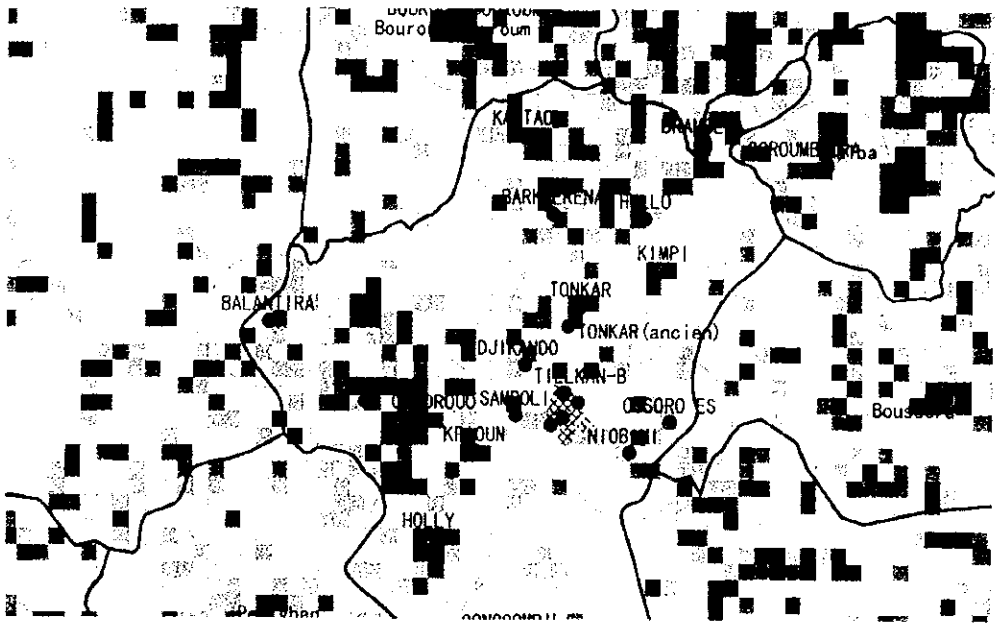



**Figure 17 Child distribution by mesh in Gaoua rural district and its environs**

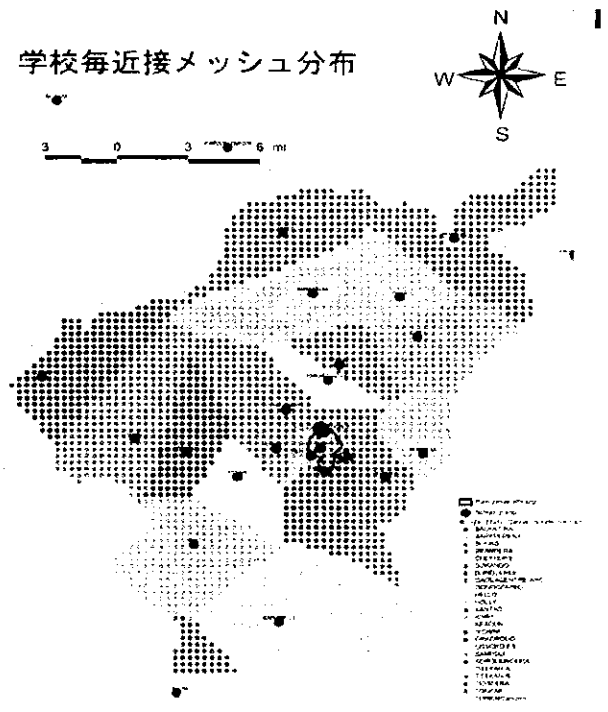



**Figure 18 Meshes near the existing schools in Gaoua rural district**

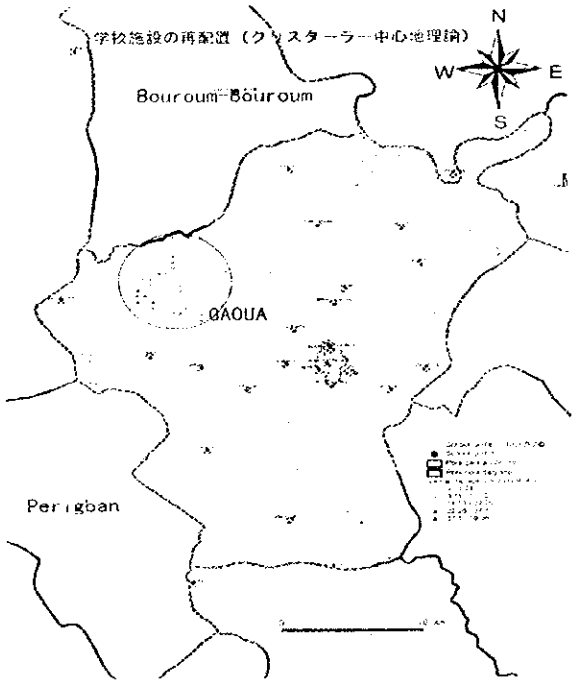



**Figure 19 Selection of new school construction sites under the Christaller theory**

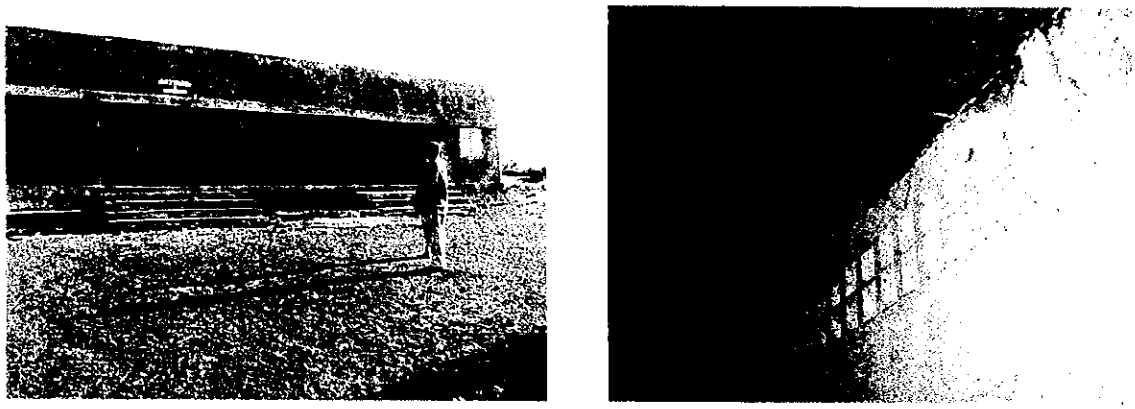


**Figure 20 Image information on school buildings**

## 5. RECOMMENDATION

### 5.1. Background of the recommendations

#### (1) Progress in desertification

Burkina Faso is basically a country located at the southern end of the Sahara in which the basis of its social development consists in the struggle against the pressure of desertification as common in the Sudan-Sahel region.

According to the researches into land devastation in the dry areas (UNEP, 1993), devastated land is concentrated in the semi-arid zones distant from the center of the desert, because the human activities in the agricultural and stock-raising zones have been expanding from the dry semi-humid zones to the semi-arid zones along with increase of population.

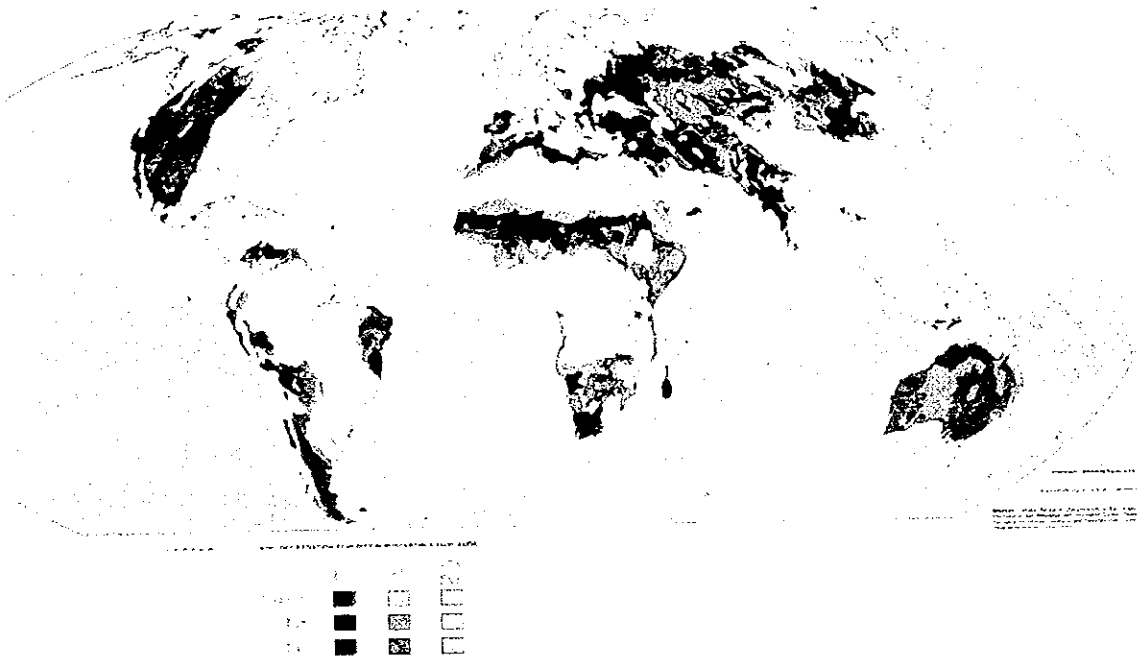


**Figure 21 Local characteristics in progress of desertification**

#### (2) Integrated Strategic Approach against Desertification

The national approach against desertification consists of cooperation between the Government and the local residents in the selection and implementation of their activities for the great goal of recovering and maintaining the balance between the nature, society and economy for the

national development. This approach consists of sharing the activities in the levels of agricultural and livestock-raising production units, villages, rural districts, provinces and nation and defining the approach of activity, support, cooperation and management in each level.

### (3) Role of Geo-referenced Information

The last chapter "Information for Decision Making" in the UN Agenda 21 indicates that the key to the sustainable development including the struggle against desertification and to the environmental conservation is the information for decision making.

#### (a) Global maps

The basic information for environmental analysis and development projects in global or continental scale was advocated by Japan as a global map concept in 1992, and the necessity for it was adopted and defined in the document at the UN special general assembly for environmental development in 1997. This concept is being promoted by the International Global Map Management Council at present.

Burkina Faso declared its participation in this concept in 1997. The number of countries that declared participation reached 81 in November 2000. As Burkina Faso has basically completed the digitization of 1/200,000 national topographic maps through IGB's efforts, it can be evaluated that Burkina Faso has the technical capability to complete its portion of the global map data through its participation in "the Training for Transfer of Technology Necessary for Production of Global Map". Strong information resources cannot be developed through the efforts of only one country unless each country in the Sahel region makes the same efforts. It is important for Burkina Faso to take the leadership as the adviser to the other countries in the Sahel region.

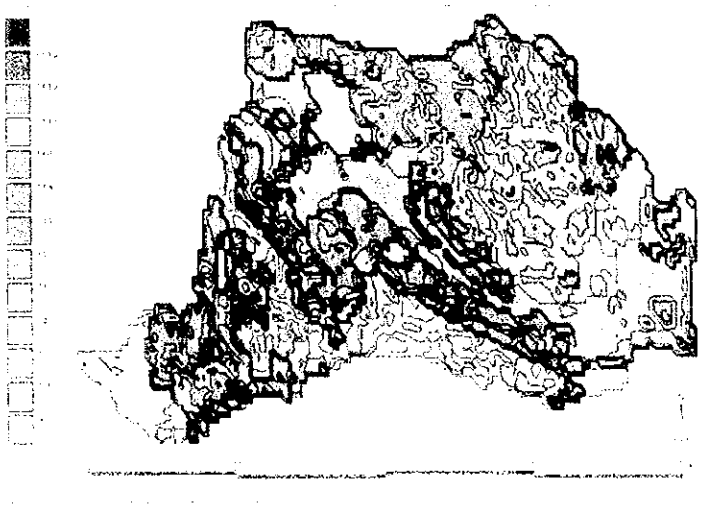


**Figure 22 Example of simulated environmental changes due to development of the Mekong basin using a global map**

From the global point of view, it is important to examine the use of high-resolution satellite images with high time resolution and use those as necessary. For exchange of related information with the neighboring countries, importance should also be attached to the Web GIS concept advocated by the African Map Association.

### (b) 1/50,000 national topographic maps and digital topographic data

The information on the projects in the national, municipal or village level or the production unit level including relatively large-scale agricultural and stock-raising organizations has the most basic value of information. The last level is a personal level including private agricultural and stock-raising entrepreneurs, in which they can plan their sustainable development actions and provide the information environment that they can positively participate in. The 1/50,000 national topographic maps and digital topographic data will play a pivotal role as the basic information in this level.

### (c) Development of cadastral maps

The cadastral survey has been made using the local coordinate system in the urban area, but in the future, it is necessary to take the measures to control the land use in accordance with the environmental policies using the standardized maps based on the national standard coordinate system.

## 5.2. Recommendations for Operation of 1/50,000 National topographic maps and Digital Topographic Data

### 5.2.1. Support by operation of GIS basic data in decision of policies in administrative agencies

#### (1) Popularization of simple GIS

Some administrative offices that use geographic information on the business were visited in order to investigate the situations of GIS use.
The offices of about 70% of the visited offices had the personal computers and the marketed GIS engines according to the result of the investigation. However, the number of offices that construct a business data base and operate GIS effectively was about 20% of the number of offices that have personal computers and the marketed GIS engines.
In popularization of business use GIS, these situations are shown that the data base construction is a load for GIS users.
The GIS basic data produced by this study have about 150 kinds of useful data, so that even when the business data base is not constructed, it can support some business easily.
Therefore, it is possible to popularize a simple GIS which was explained on 4.4. in this report even when the business data base is not completed.
And, the popularization of simple GIS promotes digital computerization in each business field in the Burkina Faso.

#### (2) For GIS Development Stage

#### (a) Construction of the regional agricultural development support system

The regional agricultural development is important to promote the agricultural development policies because an overwhelming majority of the population of Burkina Faso is engaged in agriculture that is a major share of the gross national product (GNP) of this country. Therefore, it is recommended to develop a full-scale GIS system based on the evaluation of the pilot GIS for support of regional agricultural development and the agricultural development program in the framework of the Second Five-Year National Development Plan. This full-scale system is required to comprehensively arrange, reconstruct and enhance the efficiency of the services of the Department of Surveying and Planning and National Bureau of Soil of Ministry of Agriculture, various agricultural research institutes and local agencies. The regional agricultural development support system has a high utility effect even in the stage in which 1/50,000 GIS basic data is provided only for a part of regions in the country. Therefore, it is recommended to implement this project as early as possible.

**(b) Construction of simulation GIS for regional environment evaluation**

In Burkina Faso, its sustainable development has to be pursued under the pressure of desertification unique to the Sudan-Sahel region. For this purpose, it is necessary to evaluate the effect on the environment in formulating the development plan. In the environmental evaluation in the global scale or in the scale of the entire Sudan-Sahel Region, the global maps serve greatly as the basic data, but in the regional development in Burkina Faso, the environmental evaluation in the regional scale is indispensable. Therefore, it is recommended to construct the simulation GIS for regional environmental evaluation by using the GIS basic data. This system will greatly contribute to higher efficiency of administrative services if all the relevant agencies of Ministry of Environment, Ministry of Agriculture, Ministry of Infrastructure, Housing and Urban Planning and Ministry of Mining cooperate in it's development.

**(c) Construction of service GIS for administrative agencies and research institutes handing geographic information**

It was found that the administrative agencies and research institutes handling geographic information did not utilize computers and GIS engines effectively because the information database was not available. It is, therefore, recommended that a service GIS will preferentially be developed and used for the services in which the use of GIS has a high effect.

In particular, for the services of municipalities, it is recommended that the agencies doing the services closely related to the local areas and provided with facilities and equipment as well as operating personnel will develop their own service GIS systems. Most of municipal services are common to all municipalities, so that if a typical service GIS is developed, it can be customized with a little of modification and used by each municipality with high efficiency.

### 5.2.2. Provision of Printed Maps

There are many villages that have not introduced computers. In such villages, the printed maps are usable. To make the printed maps available in an easy way, it is necessary to set up the points of sale on consignment in major rural districts. In the rural districts that are provided with 1/50,000 national topographic maps, it is recommended to adopt the methods of reading and using maps in school education.

### 5.2.3. Supply and Management of GIS Basic Data

It is important that the GIS basic data can be utilized in any level and that it is an indispensable information to be promoted to any level of the nation.

It is deemed to be appropriate that IGB, an author of the information will be invested with the right to assign or transfer the right to use the information. Only the right to use the information will be granted to the users of the information, but the rights of reproduction and transfer of the information will not be granted to the users. Any user to whom the right to use the information is granted by IGB shall become or appoint as the information manager to have responsibility for managing the information. On the other hand, IGB will be responsible for registration management of the transferred GIS basic data.

## 5.3. Recommendations for Maintenance of 1/50,000 National topographic maps and Digital Topographic Information

In general, the development agencies that make changes in the national topographic maps are mostly related to roads, agricultural development and urban development, and they request the related agencies to provide development information. In the case that the national topographic maps are modified based on the provided development information, it is important that the new version of national topographic maps or GIS basic data will be supplied free of charge and that the users of information as specified in Agenda 21 will be the providers of such information.

If the design maps or certified survey maps of any development agency are produced and digitized under the national survey standard, this work will ensure the highest cost performance. Therefore, it is important to make full discussions and include the results in the agreement between the development and IGB.

## 5.4. Recommendations for Nationwide Promotion of Production of 1/50,000 National topographic maps and Digital Topographic Data

### 5.4.1. Enhancement of Information Resource Values in Early Development of Nationwide Maps

The national topographic maps that cover the entire country will have a substantially high value of information in terms of quality. The administrative agencies controlling the entire country are apt to hesitate the introduction of a service system using the national topographic

information that does not cover the entire country. It is because two types of service system for the covered areas and for the uncovered areas are required, resulting in making the services troublesome and the wide-area analysis over the country almost impossible. The Ministry of Elementary Education is reluctant to adopt the incomplete national topographic maps that cover a part of the country.

If the entire country is covered, any GIS application system can be used nationwide with high universality. In this sense, the utility value of the GIS basic data and the GIS application systems will synergetically be enhanced by covering the entire country for a period as short as possible.

### 5.4.2. Period of Nationwide Coverage by 1/50,000 National Topographic Digital Mapping System

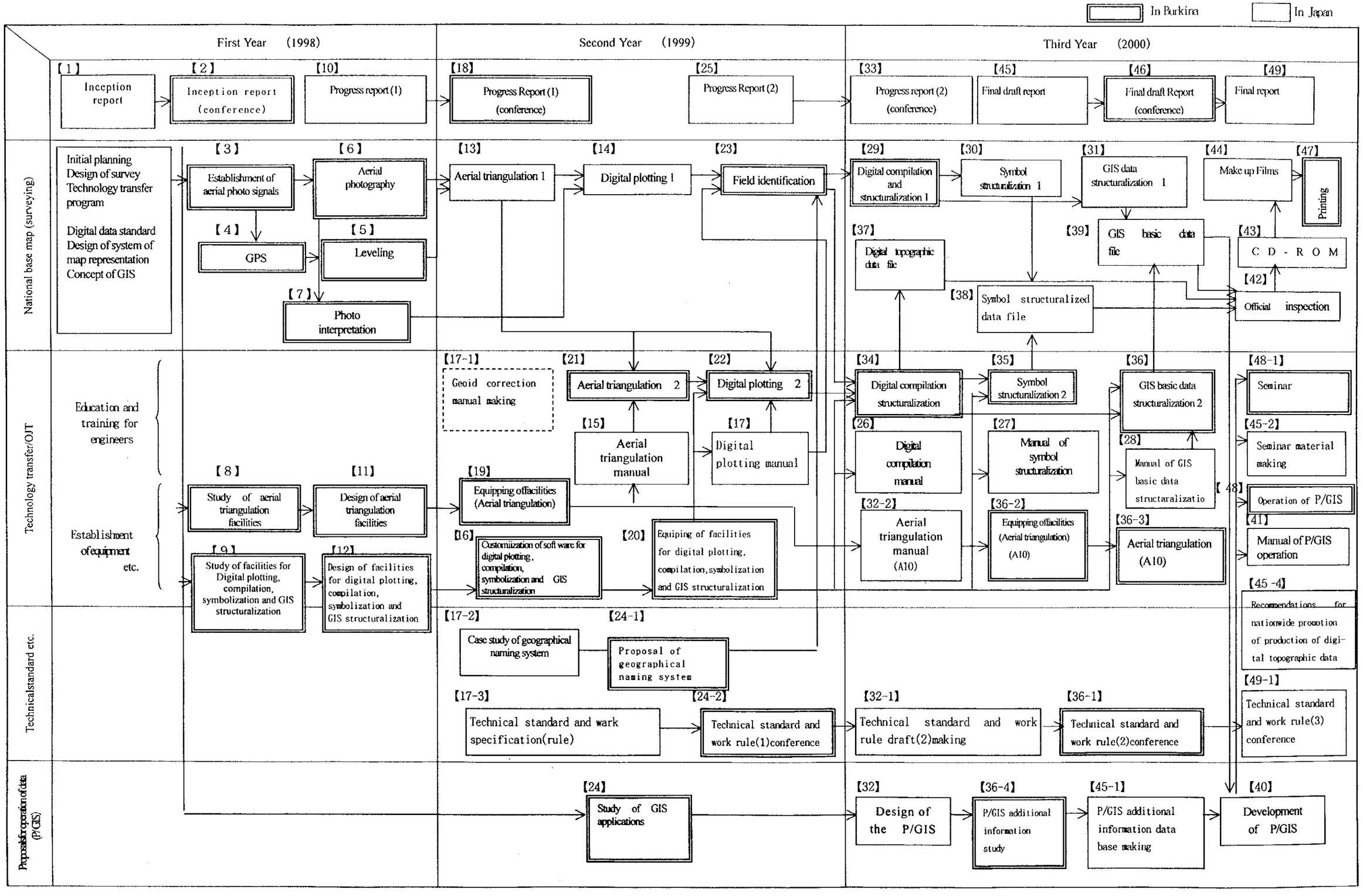
The efficiency of production of the 1/50,000 national topographic maps in operating the national topographic digital mapping system improved in this system is equivalent to the plotting efficiency of 1.2 models/plotter/day when one of the plotters provided in this study is operated for 7 hours per day.

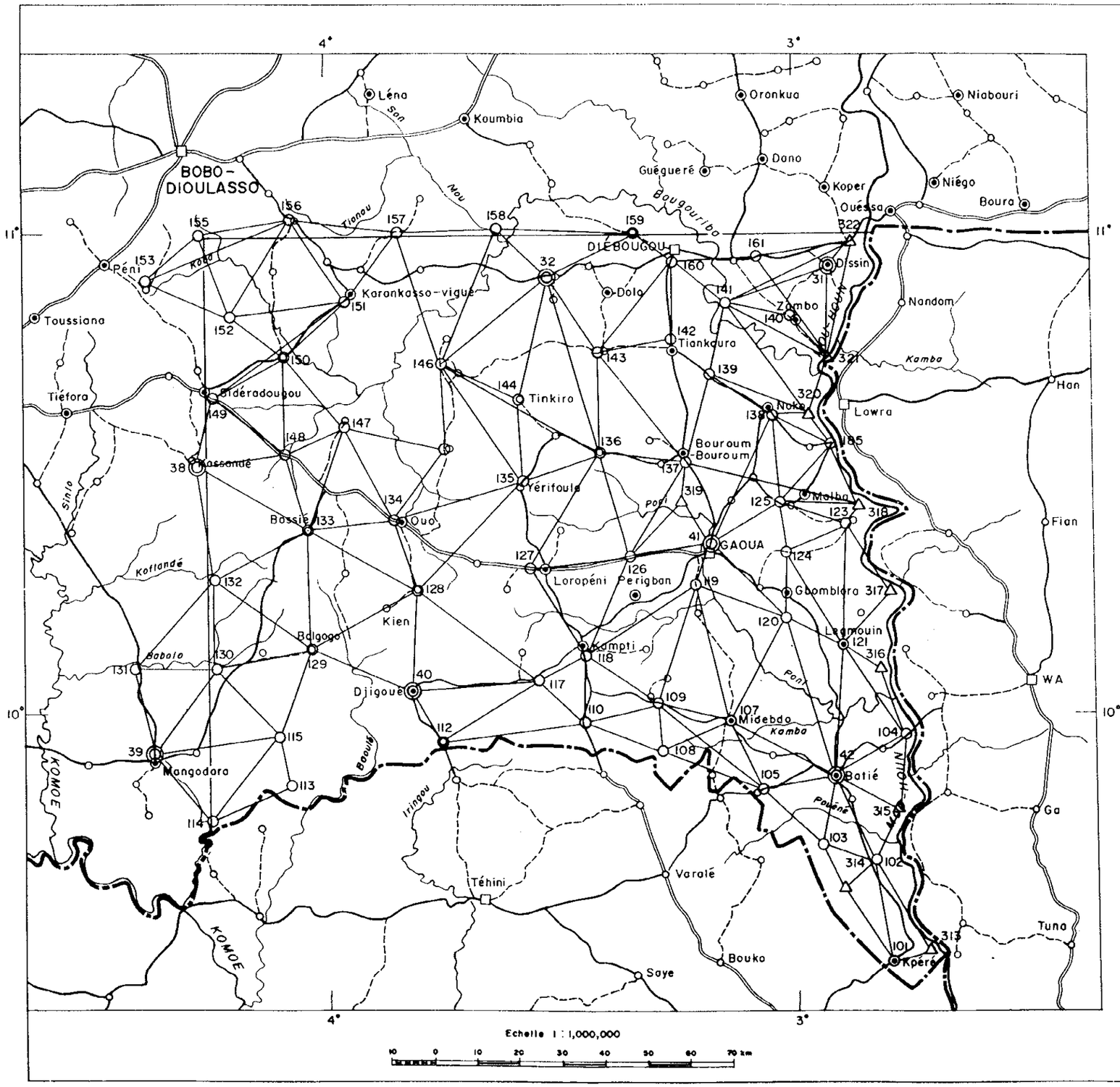
If 2 plotters are operated in 2 shifts from 7 to 13 hours and from 13 to 19 hours to enhance the operating efficiency of 2 sets of plotter, 46.6 map sheets can be produced for a period of 250 days per year.

This is a simple assumption, but the map sheets to cover the entire country can be produced with in a period of about 6 years.

Work schedule and flowchart

Figure 23



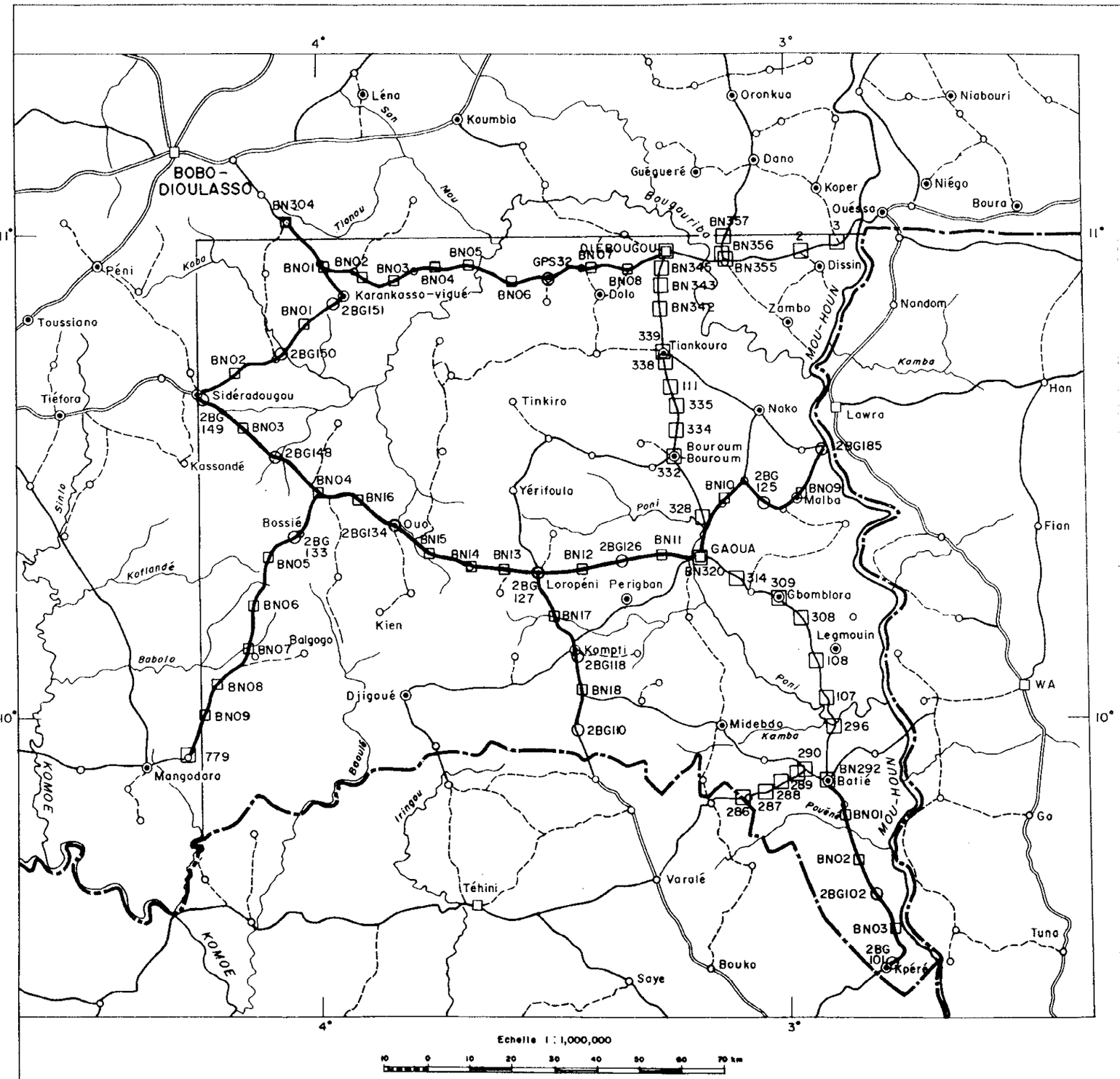



## GPS Network

◎ First order control points (7 points)

○ Second order control points (54 points)

△ New control points (10 points)

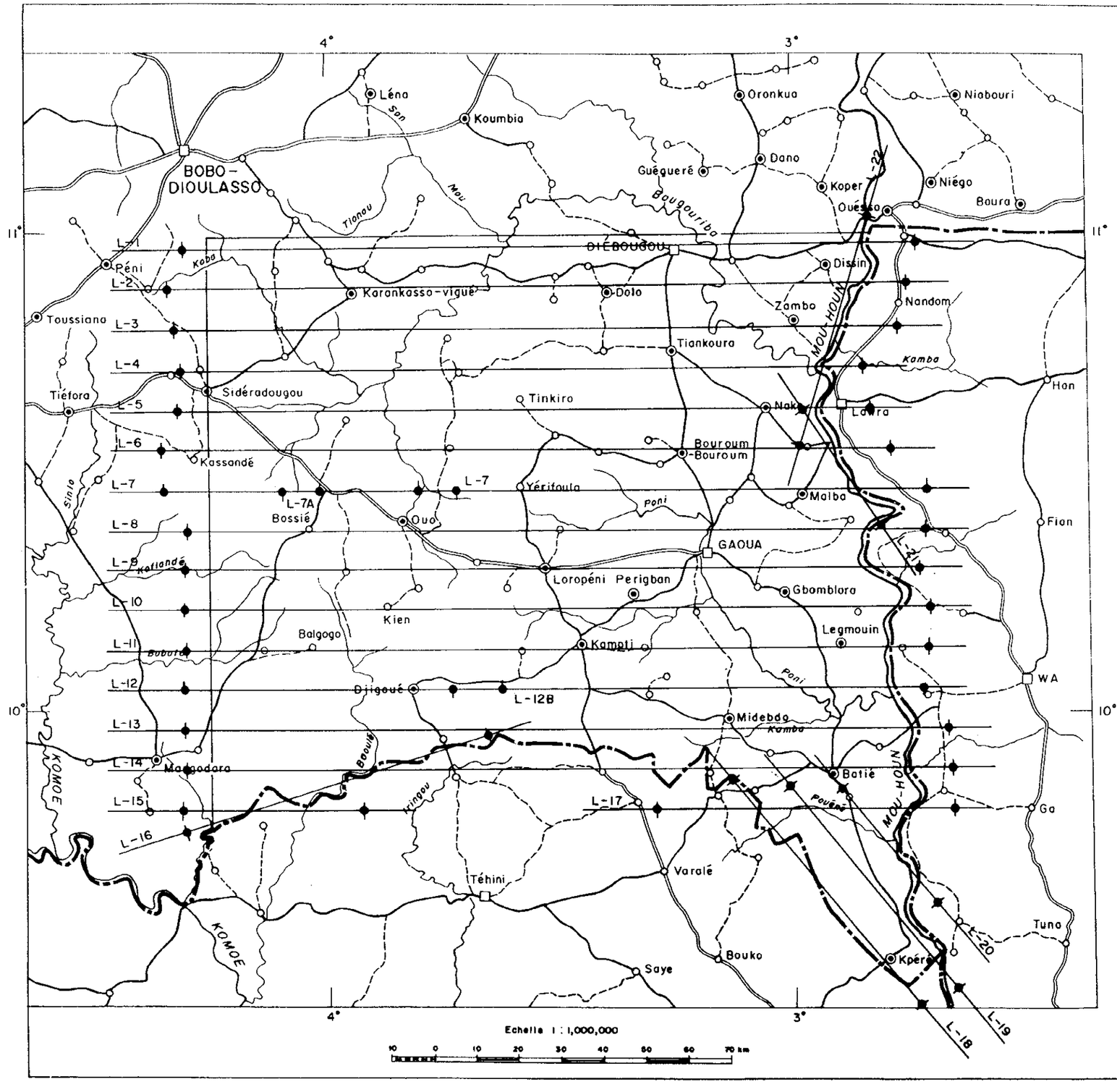



## Leveling Routes

☐ **New bench mark (31 points)**

**Length of leveling route**

| | |
|---|---|
| ① | **64km** |
| ② | **140km** |
| ③ | **79km** |
| ④ | **47km** |
| ⑤ | **50km** |
| ⑥ | **55km** |
| ⑦ | **87km** |
| **Total** | **522km** |




## Index Map of Aerial Photography

| | |
|---|---|
| **Total area photographed** | **= 20,600km²** |
| **Scale** | **= 1:50,000** |
| **Focal length of camera(f)** | **= 88.03** |
| **Overlap** | **= 60%** |
| **Sidelap** | **= 20%** |
| **Size of camera** | **= 23 x 23** |

Map index of 1/50,000 national topographic map in the study area

Figure 27

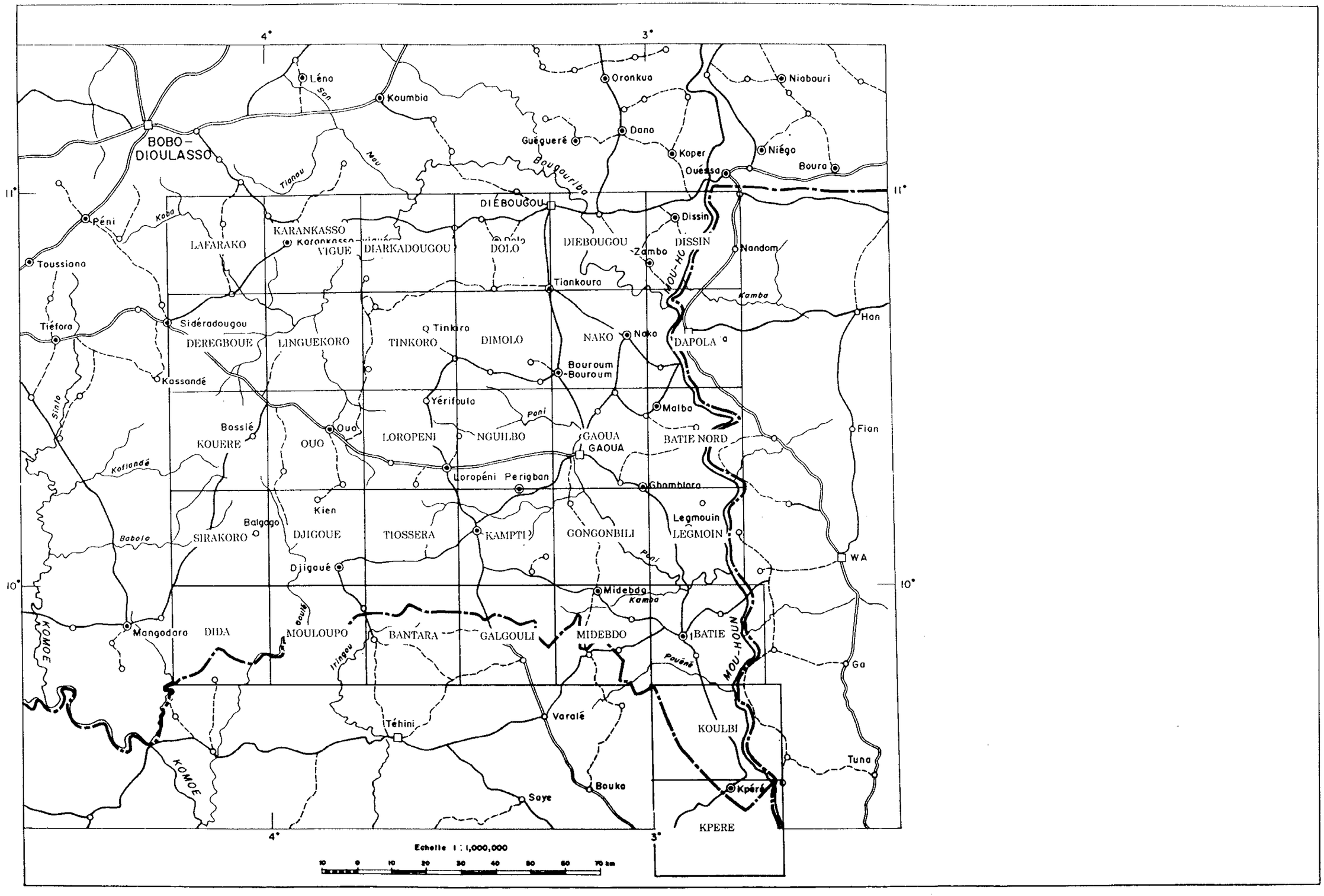


Figure Outline standards of the symbols and digital data acquisition

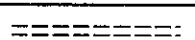
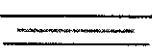
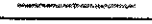
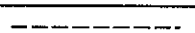
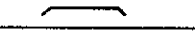
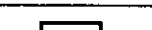
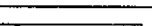
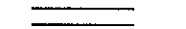
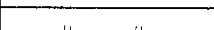
| Attribute Code | | | Description | Symbol in Work File | Symbol Representation | Data Type | Acquisition Method |
|---|---|---|---|---|---|---|---|
| 21 | 01 | 00 | Paved road with median strip |  |  | Line | To acquire the road center (to connect) |
| 21 | 02 | 01 | Paved road (large) |  |  | Line | To acquire the road center (to connect) |
| 21 | 02 | 02 | Paved road (small) |  |  | Line | To acquire the road center (to connect) |
| 21 | 03 | 00 | Unpaved road usable at all times |  |  | Line | To acquire the road center (to connect) |
| 21 | 04 | 00 | Unpaved road with seasonal change |  |  | Line | To acquire the road center (to connect) |
| 21 | 05 | 00 | Road passable by 4WD vehicles |  |  | Line | To acquire the road center (to connect) |
| 21 | 06 | 00 | Road lined with trees |  |  | Line | To acquire the center of a row of trees as a line |
| 21 | 10 | 00 | Road under construction |  |  | Line | To acquire the road center (to connect) |
| 21 | 11 | 00 | Paved road with center median strip under construction | | | | |
| 21 | 12 | 00 | Paved road (large) under construction | | | | |
| 21 | 13 | 00 | Paved road (small) under construction | | | | |
| 21 | 21 | 00 | Walking road |  |  | Line | To acquire the road center (to connect) |
| 21 | 22 | 00 | Path |  |  | Line | To acquire the road center (to connect) |
| 21 | 31 | 00 | Bridge |  |  | Line | To acquire the bridge center (to connect) |
| 21 | 32 | 00 | Invert or submersible road |  |  | Line | To acquire the road center (to connect) |
| 21 | 33 | 00 | Jetty |  | | Line | To connect line |
| 22 | 01 | 00 | Double-track railroad |  |  | Line | To acquire the center of a railroad (to connect) |
| 22 | 02 | 00 | Single-track railroad |  |  | Line | To acquire the center of a railroad (to connect) |
| 22 | 03 | 00 | Station, depot |  |  | Line | To connect line |
| 22 | 04 | 00 | Depot |  |  | Line | To connect line |
| 22 | 05 | 00 | Sidetrack |  |  | Line | To acquire the center of a railroad (to connect) |
| 22 | 06 | 00 | Tunnel (tunnel entrance/exit) |  |  | Symbol | To acquire a direction symbol |



Figure 28

Figure Outline standards of the symbols and digital data acquisition

| Attribute Code | | | Description | Symbol in Work File | Symbol Representation | Data Type | Acquisition Method |
|---|---|---|---|---|---|---|---|
| 21 | 01 | 00 | Paved road with median strip |  |  | Line | To acquire the road center (to connect) |
| 21 | 02 | 01 | Paved road (large) |  |  | Line | To acquire the road center (to connect) |
| 21 | 02 | 02 | Paved road (small) |  |  | Line | To acquire the road center (to connect) |
| 21 | 03 | 00 | Unpaved road usable at all times |  |  | Line | To acquire the road center (to connect) |
| 21 | 04 | 00 | Unpaved road with seasonal change |  |  | Line | To acquire the road center (to connect) |
| 21 | 05 | 00 | Road passable by 4WD vehicles |  |  | Line | To acquire the road center (to connect) |
| 21 | 06 | 00 | Road lined with trees |  |  | Line | To acquire the center of a row of trees as a line |
| 21 | 10 | 00 | Road under construction |  |  | Line | To acquire the road center (to connect) |
| 21 | 11 | 00 | Paved road with center median strip under construction | | | | |
| 21 | 12 | 00 | Paved road (large) under construction | | | | |
| 21 | 13 | 00 | Paved road (small) under construction | | | | |
| 21 | 21 | 00 | Walking road |  |  | Line | To acquire the road center (to connect) |
| 21 | 22 | 00 | Path |  |  | Line | To acquire the road center (to connect) |
| 21 | 31 | 00 | Bridge |  |  | Line | To acquire the bridge center (to connect) |
| 21 | 32 | 00 | Invert or submersible road |  |  | Line | To acquire the road center (to connect) |
| 21 | 33 | 00 | Jetty |  | | Line | To connect line |
| 22 | 01 | 00 | Double-track railroad | |  | Line | To acquire the center of a railroad (to connect) |
| 22 | 02 | 00 | Single-track railroad | |  | Line | To acquire the center of a railroad (to connect) |
| 22 | 03 | 00 | Station, depot |  |  | Line | To connect line |
| 22 | 04 | 00 | Depot |  |  | Line | To connect line |
| 22 | 05 | 00 | Sidetrack |  |  | Line | To acquire the center of a railroad (to connect) |
| 22 | 06 | 00 | Tunnel (tunnel entrance exit) |  |  | Symbol | To acquire a direction symbol |

## Study Team

Table 6

| Assignment | Name | Company |
|---|---|---|
| Team Leader | Kokichi Kimura | Aero Asahi Corporation |
| Sub-leader/subcontract control | Katsuyuki Hatakeyama | Aero Asahi Corporation |
| GPS observation supervision | Dr.Bandula Senakasiri | Aero Asahi Corporation |
| Leveling supervision | Yoshikazu Ogasawara | Aero Asahi Corporation |
| Preparation of interpretation keys | Kentaro Usuda | Aero Asahi Corporation |
| Aerial triangulation supervision | Seiji Nakanishi | Aero Asahi Corporation |
| Digital plotting supervision | Takashi Tomura | Aero Asahi Corporation |
| Field verification supervision | Kentaro Usuda | Aero Asahi Corporation |
| Digital compilation/structuralization supervision I | Kosuke Tsuru | Aero Asahi Corporation |
| Digital compilation/structuralization supervision II | Masami Yoshimoto | Aero Asahi Corporation |
| Instruction of GIS | Kiichiro Nishioka | Aero Asahi Corporation |
| DM system improvement (modification) | Hiroshi Matsushita | Eni Tech Co. Ltd. |
| Additional GIS survey | Takashi Yashiro | Aero Asahi Corporation |
| Work Coordination | Yuji Ouchi | Aero Asahi Corporation |
| Work Coordination | Naoki Goto | Aero Asahi Corporation |
| Interpretation | Tadao Maruyama | Techno Staff Co.,Ltd. |

## IGB Key Persons

| Name | Position |
|---|---|
| Oussény TARNANGUIDA | Gneral Director |
| Claude Obin TAPSOBA | Technical Director |
| Ernest ILBOUDO | Chief Counterpart of The Project |
| Salifou KABORE | Chief of Information Processing Service |
| Justin R.YAMEOGO | Chief of Photogrammétric Surveying Service |
| Ousmane DEMBELE | Chief of controle service |
| Jean ZONGO | Chief of Aerial Photography Section Ousséni KONATE |
| Ousséni KONATE | Chief of Laboratory |
| Lucie SOMDA | Chief of Map Compilation Section |
| Thierry SOUAHIBOU | Computer Engineer |
| Yay SANON | Chief of Topographic Service |

**Work process schedule for development of national topographic maps for the Southwestern Area**

| Process | 1998 fiscal year<br>11·12·01·02·03 | 1999 fiscal year<br>04·05·06·07·08·09·10·11·12·01·02·03 | 2000 fiscal year<br>04·05·06·07·08·09·10·11·12·01·02 | Remarks |
|---|---|---|---|---|
| Aerial photo signalization | | | | |
| Control point survey | | | | |
| Aerial photography | | | | |
| Aerial triangulation | | | | |
| Establishment of aerial interpretation standard | | | | |
| Digital plotting | | | | |
| Field identification | | | | |
| Digital compilation | | | | |
| Digital map symbol structuralizing | | | | |
| GIS basic data structuralizing | | | | |
| Reproduction filming and printing | | | | |

Legend= ▬ :IGB, in Burkina Faso ═══ :JICA,in Japan ▬ :Processing on commission

Figure 29

# APPENDIX

# SCOPE OF WORK
# ON
# THE NATIONAL TOPOGRAPHIC MAPPING
# OF
# THE SOUTHWESTERN AREA
# IN
# BURKINA FASO

AGREED UPON BETWEEN

INSTITUT GEOGRAPHIQUE DU BURKINA,
MINISTERE DES INFRASTRUCTURES, DE L'HABITAT ET DE L'URBANISME
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

OUAGADOUGOU
August 3rd, 1998

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## I. INTRODUCTION

In response to the request of the Government of Burkina Faso, the Government of Japan has decided to conduct "The National Topographic Mapping of The Southwestern Area in Burkina Faso" (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 program of Japan, will undertake the Study in close cooperation with the authorities concerned of the Government of Burkina Faso.

The present document sets forth the scope of work with regard to the Study.

## II. OBJECTIVES OF THE STUDY

The objectives of the Study are

1) to prepare digital topographic data for regional development plans and infrastructure development projects in southwestern area, and

2) to transfer related technology to Burkina counterpart personnel.

## III. STUDY AREA

The digital topographic mapping shall cover the southwestern area (approximately 20,600 km2) including Gaoua region and its surroundings. The location of digital topographic mapping area is shown in ANNEX-1.

## IV. SCOPE OF THE STUDY

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

1) Signalization

Before starting aerial photography, signals shall be established on the necessary ground control points.

2) Aerial photography

Black and white aerial photos covering the study area shall be taken at the scale of 1:50,000.

3) Ground control point survey

Ground control point survey with GPS survey shall be carried out by using the existing geodetic network in the study area.

4) Leveling

Leveling shall be carried out to determine the geoid model.

5) Aerial triangulation

Aerial triangulation shall be carried out to establish photo control points.

6) Interpretation criteria

The criteria shall be prepared for the interpretation of aerial photos.

7) Plotting

Plotting shall be carried out to prepare 1:50,000 scale digital topographic data with 10 m contour intervals.

8) Field identification

Field identification shall be carried out in the study area to identify natural and artificial terrain features, geographic names and boundaries which are difficult or impossible to recognize on the aerial photographs.

9) Compilation

Compilation of the plotted data shall be carried out based on the result of field identification.

10) Structurization

Topological structurization shall be carried out for completion of digital topographic data.

11) Printing of maps

Digital topographic data shall be printed at the scale of 1:50,000.

12) Technology transfer

In order to facilitate technology transfer to the counterpart personnel, a part of process of making digital topographic data shall be carried out by Burkina Faso side under the technical supervision of

the Study Team.

## V. STUDY SCHEDULE

The Study shall be conducted in accordance with the attached tentative schedule shown in ANNEX-2.

## VI. REPORTS AND FINAL PRODUCTS

JICA shall prepare and submit the following reports and final and intermediate products of topographic mapping works to the Government of Burkina Faso.

1. Inception Report (written in English)
   20 copies At the beginning of the Study
2. Progress Reports (written in English)
   20 copies At the end of the first year and the second year
3. Draft Final report (written in English and French)
   20 copies At the end of the third year
4. Final report (written in English and French)
   20 copies At the end of the Study
5. Final and intermediate products of topographic mapping

| | |
|---|---|
| a. Negative films of aerial photos | 1 set |
| b. Contact prints of aerial photos | 1 set |
| c. Result of ground control point survey | 1 set |
| d. Result of aerial triangulation | 1 set |
| e. 1:50,000 scale topographic maps | |
| - films for printing | 1 set |
| - printed maps | 500 copies |
| f. 1:50,000 scale digital topographic data | |
| - digital data files (eg. CD-ROM) | 50 sets |

## VII. UNDERTAKING OF THE GOVERNMENT OF BURKINA FASO

1. To facilitate smooth conduct of the Study, the Government of Burkina Faso shall take the following necessary measures:

(1) to secure the safety of the Study Team ;

(2) to permit the members of the Study Team to enter, leave and sojourn in Burkina Faso for the duration of their assignment therein and exempt them from alien registration requirements and consular fees;

(3) to exempt the member of the Study Team, from taxes, duties, fees and any other charges on equipment, machinery and other materials brought into and out of Burkina Faso for the conduct of the Study;

(4) to exempt the member of the Study Team from income taxes and charges of any kind imposed on or in connection with any emoluments or allowance paid to the members of the Study Team for their services in connection with implementation of the Study;

(5) to provide necessary facilities to the Study Team for remittance as well as utilization of the funds introduced into Burkina Faso from Japan in connection with the implementation of the Study;

(6) to secure permission for entry into private properties and restricted areas for the implementation of the Study;

(7) to secure permission to acquire necessary radio frequency for the implementation of the Study ;

(8) to secure permission for the Study Team to take all data and documents including topographic maps, original manuscripts, aerial photos related to the Study out of Burkina Faso;

(9) to secure necessary permission for aerial photography by foreign registered aircraft for the implementation of the Study;

(10) to obtain the necessary permission from the Government of Ivory Coast and the Government of Ghana for the execution of aerial photography by the Study Team at the area of border line; and

(11) to provide the medical services as needed, including Air transportation. Its expenses will be chargeable on the members of the Study Team.

2. The Government of Burkina Faso shall bear claims, if any arises against the members of the Study 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 Study Team.

3. Institut Géographique du Burkina, Ministère des Infrastructures, de l'Habitat et de l'Urbanisme (hereinafter referred to as "IGB") shall act as a counterpart agency to the Study Team

and also as a coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study, and IGB shall support the Study Team technically for the implementation of the Study .

4. IGB shall, at its own expense, provide the Study Team with the following, in cooperation with other organization concerned:

(1) Available data and information related to the Study;

(2) Counterpart personnel;

(3) Suitable office space with necessary equipment in Ouagadougou ;

(4) Vehicles with drivers; and

(5) Credentials or identification cards.

## VIII. UNDERTAKING OF JICA

For the implementation of the Study, JICA shall take the following measures:

(1) to dispatch, at its own expense, the Study Team to Burkina Faso; and

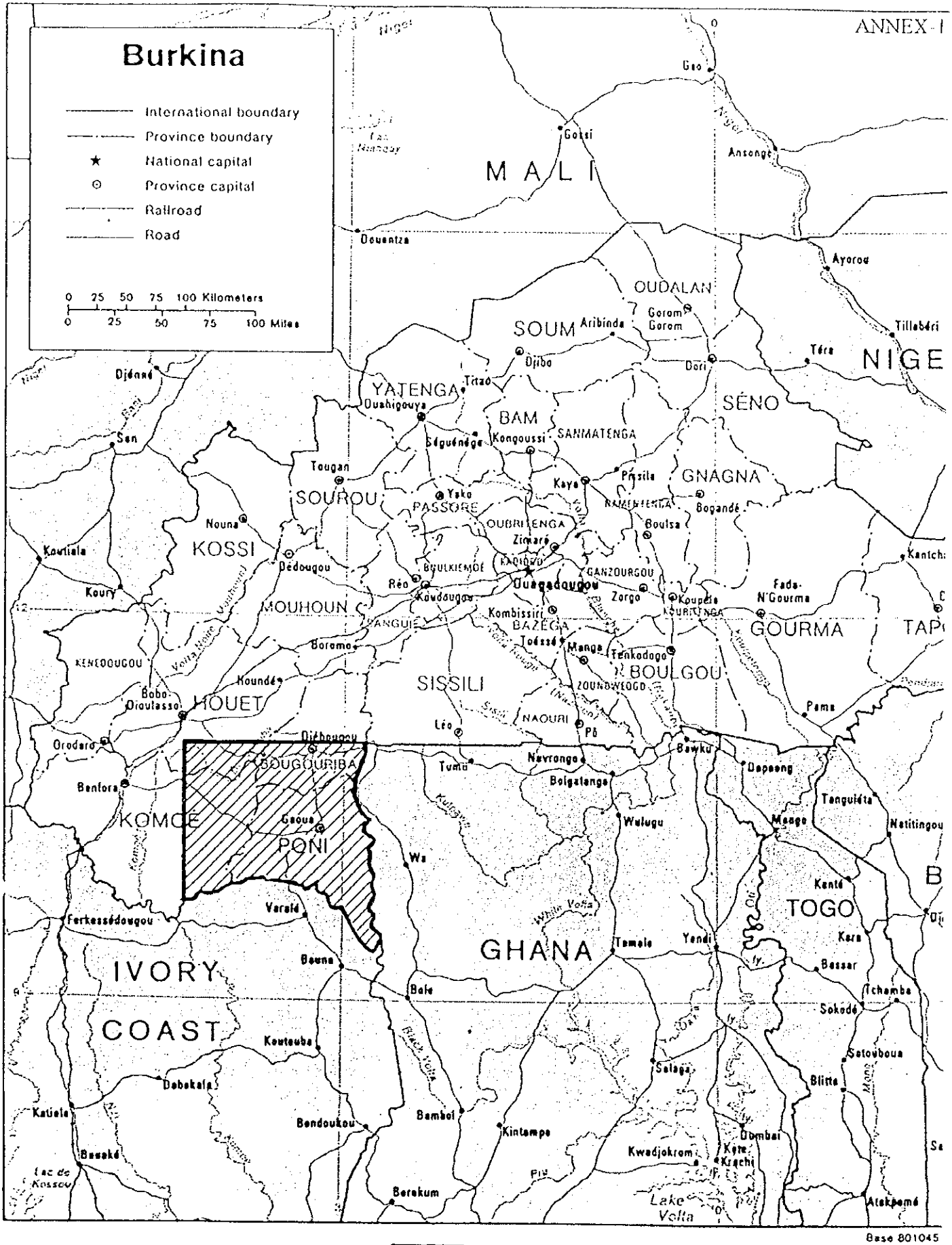
(2) to pursue technology transfer to the Burkina counterpart personnel in the course of the Study.

## IX. CONSULTATION

1. IGB and JICA 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 was written in English and French, and their validity should be equivalent. However, in case that any contradiction arises in writing, the English text shall be predominant.

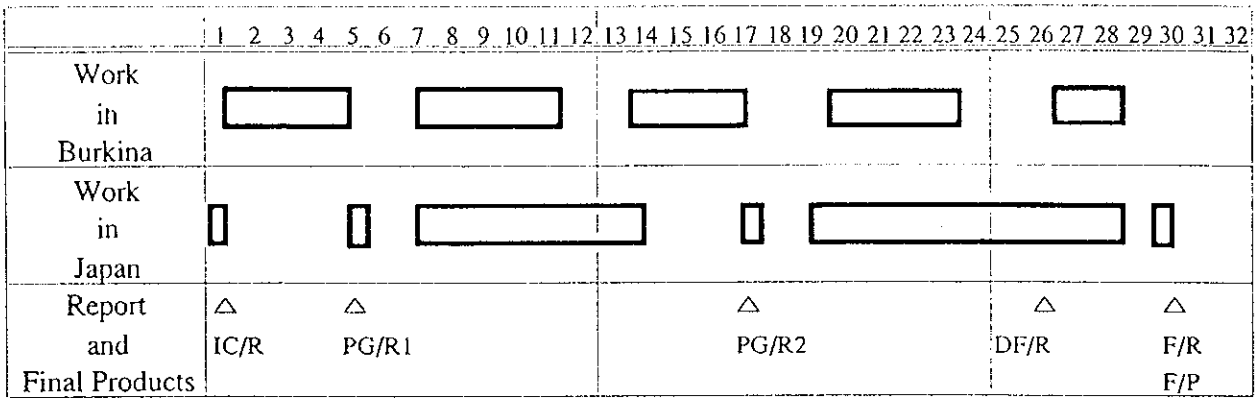
ANNEX - I




Study area

ANNEX-2

# TENTATIVE SCHEDULE




IC/R : Inception Report
PG/R: Progress Report
DF/R: Draft Final Report
F/R : Final Report
F/P : Final Products