Lilongwe City Assembly (LCA)

The Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi (Topographic Mapping)

Final Report

July 2009

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

KOKUSAI KOGYO CO., LTD.

Lilongwe City Assembly (LCA)

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(Topographic Mapping)

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1 MWK = Japanese Yen 0.680

PREFACE

In response to a request from the Government of the Republic of Malawi, the Government of Japan decided to conduct a Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi (Topographic Mapping) and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Satoru Nishio of Kokusai Kogyo Co., Ltd. between February, 2009 and August, 2009.

The team held discussions with the officials concerned of the Government of the Republic of Malawi, 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 the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Malawi for their close cooperation extended to the study.

July 2009

Toshiyuki KUROYANAGI
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Toshiyuki KUROYANAGI
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

We are pleased to submit to you the report on the Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi (Topographic Mapping).

This report is on the work involved in making the 1/10,000 digital topographic map for the Urban Development Master Plan for Lilongwe in the Republic of Malawi, implemented from February to August 2009. From the necessity to make the digital topographic map in a short timeframe, satellite imagery was used and the digital photogrammetry method applied. So to maintain the required accuracy, quality evaluation and the latest technology was employed.

The Government of Malawi formulated a land-use plan for Lilongwe City that designates and secures land for commercial, industrial and residential use, with the purpose of rationally consolidating the capitals' functions. Based on this plan, Lilongwe City is formulating subject plans for each sector that make up the urban development master plan, for the provision of social infrastructure such as, transportation facilities, road widening and waste management. It is hoped that the 1/10,000 topographic map made in this study can be used effectively in the formulation of these plans, and also that this can lead to deeper ties of friendship between our two nations.

Finally, let me express my sincere appreciation to the Japan International Cooperation Agency and other concerned organizations, officials of concerned organizations of the Government of Malawi and donor organizations for their close cooperation extended to the team.

July 2009

Satoru NISHIO
Team Leader
The Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi (Topographic Mapping)

The Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi (Topographic Mapping)

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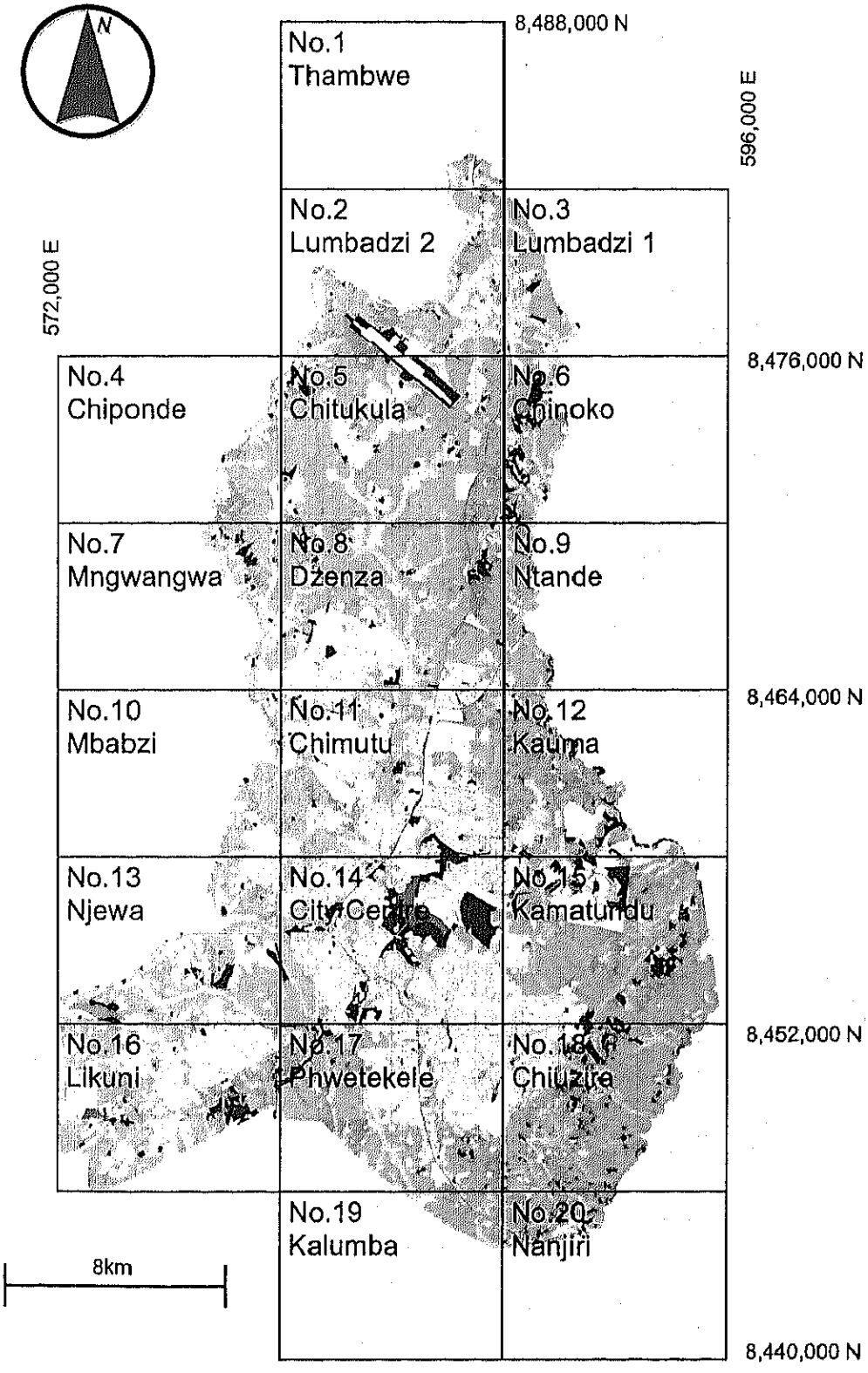

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Chapter 1 Outline of the study

1.1 Background

The Republic of Malawi decided in 1965 to relocate its capital from Zomba to Lilongwe, making this official in 1975. The ideal use of land for the new capital city was presented, firstly in the Lilongwe City Master Plan outlining the basic structure in 1968, then with the Lilongwe Outline Zoning Scheme in 1969. Later, this land-use plan was revised in 1986, prescribing matters such as development, formulation of a well-ordered urban area, and conservation of land for intended end-uses such as road construction. This plan was to be revised every five years, however, this has not happened due to personnel, technical, and financial restrictions.

Presently Lilongwe City has an area of 465 km^2 and a population of 660,000 (preliminary figures of 2008 national census, including the suburb: Area 58). With a rapid population growth of 4.3% annually, designating and securing planned residential land is an issue due to the fact that illegal dwellings--lacking official documentation of land acquisition--are spreading in land for public facilities and industrial zones.
Further, the number of vehicles in the city is increasing causing localized and chronic traffic jams. The international trunk road, the M1, passes through the city center. However, traffic flow is not separated into city and international usage, so upgrading to a more suitable road network will be delt with as a separate issue.

Other issues include road widening and upgrading public transport facilities, such as a bus terminal to cope with future increases in traffic volume.

The city also has a problem with waste management. There is no problem at present with the capacity of the final waste disposal site, but the collection system needs improving.

With no revision of the land-use plan since its formulation more than 20 years ago, the state of development has since diverged from the plan. Thus, the formulation of an urban plan to guide the deliberate provision of municipal facilities and to control disorderly development in the future is a pressing need.

In response to this situation the Government of Malawi requested the Government of Japan's cooperation in formulating a land-use plan suitable for Lilongwe City and subject plans for each sector.

In response, a preliminary study team was dispatched in November 2008 to gather information necessary to implement a full-scale study, and to discuss and sign the Scope of Works (S/W), which was then signed. In the S/W, agreement was reached on the formulation of an urban development master plan for Lilongwe City and adjacent urban area to the southwest (Area 58). This study is to make a new 1/10,000 digital topographic map needed before the plan can be formulated.

1.2 Objective of the study

The objective of the study is as follows:

- To make digital topographic maps on a scale of 1/10,000 for Lilongwe city and the adjacent Area 58 to the southwest.

1.3 Study area

The area of the study is as follows.

- Study area: Lilongwe city and the adjacent Area 58 to the southwest, covering an area of 465km^2.

Here, the map area was expanded to include some areas to the north, southeast, and southwest in response to a request by LCA. These are significant areas where the construction of large-scale shopping centers and housing developments are planned; important areas to make topographical maps for urban planning. This expanded mapping area is shown within the red line in the map below. A detailed description follows in Chapter 2. (2-1.) Explanation and discussion of inception report.

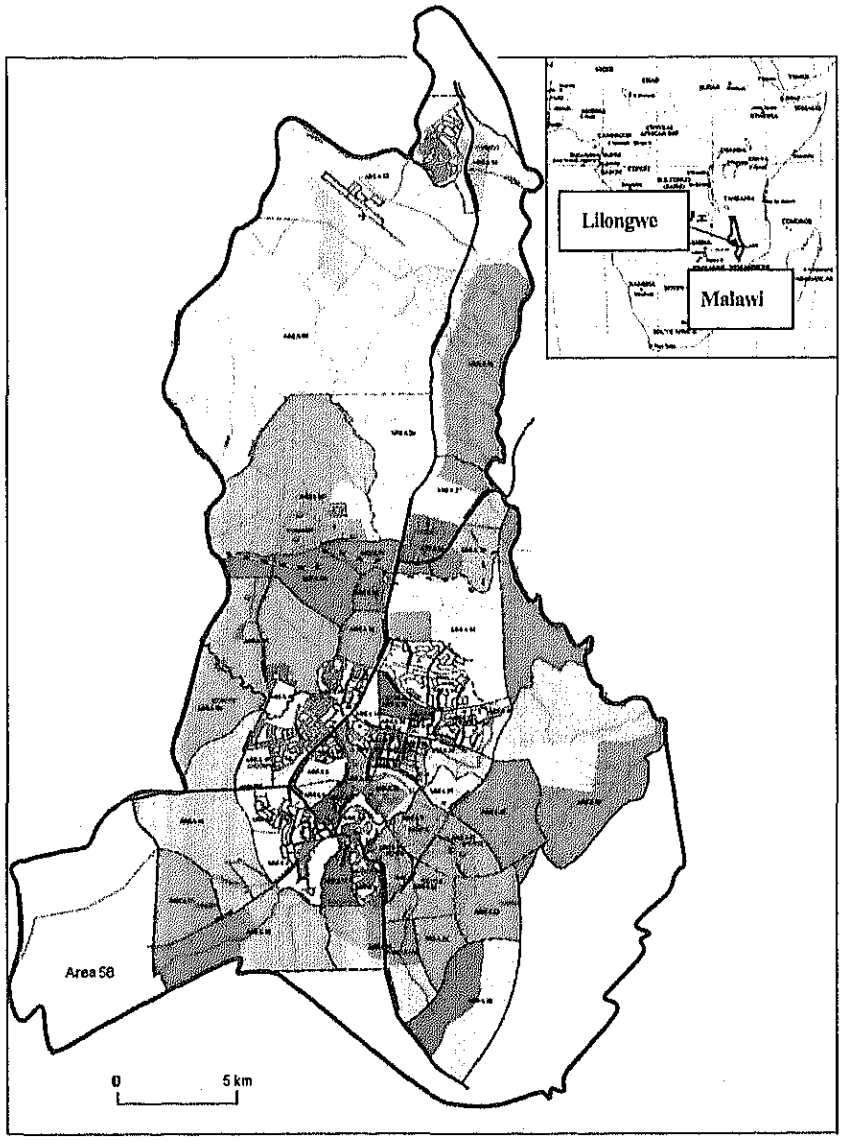


Figure 1 Area of the Study

1. 4 Basic Policy of Study for Implementation

The basic policy of the study is as follows:

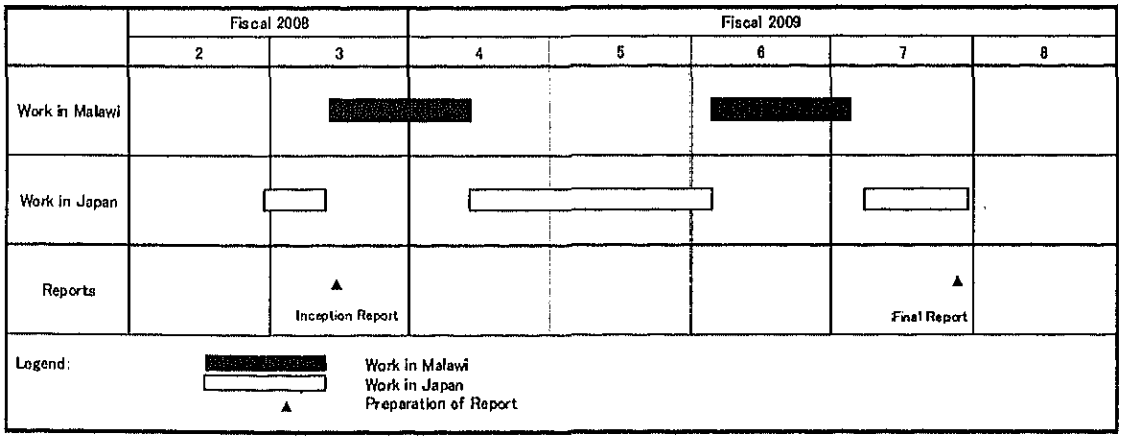
- **Basic Policy 1: Make digital topographic maps using existing documents and data as much as possible**
- **Basic Policy 2: Make digital topographic maps based on world standards**
- **Basic Policy 3: Topographic Map expression and data are to be compatible for use in urban planning**

1. 5 Summary Work Schedule

The summary work schedule of the study is based on the work directive and the basic policy on work implementation, as follows.

- Preparatory Work in Japan: 2009.2.25 - 2009.3.16
- First Work in Malawi: 2009.3.17 - 2009.4.15
- First Work in Japan: 2009.4.16 - 2009.6.2
- Second Work in Malawi: 2009.6.3 - 2009.7.2
- Second Work in Japan: 2009.7.3 - 2009.8.17 (Final product delivery: 2009.7.29)

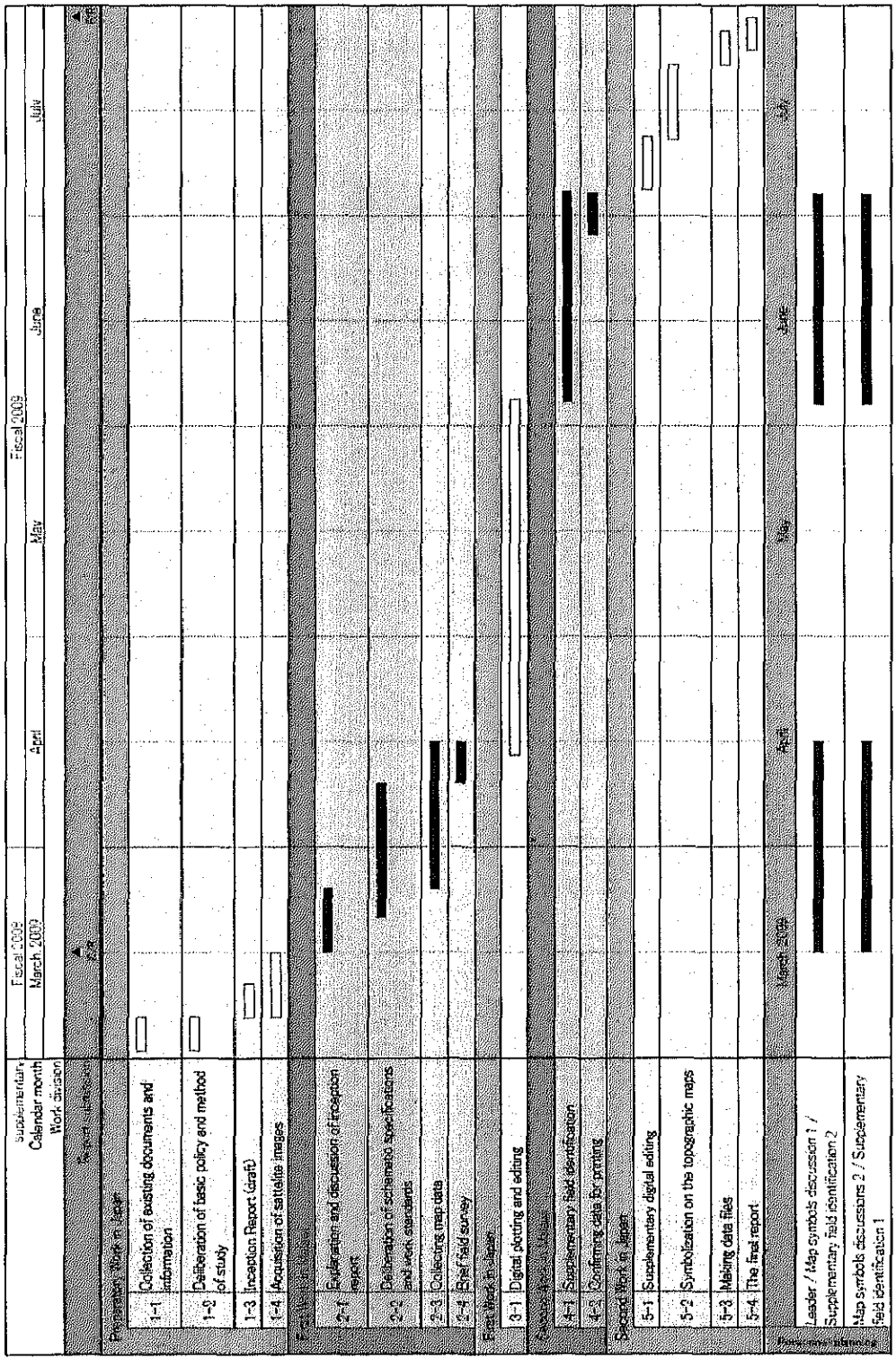
Table 1 : Summarized work schedule



1.6 Detailed Work Schedule

The detailed work schedule was planned as follows:

Table 2 : Detailed work schedule



1.7 The Study Team

The following table shows the name, position and responsibilities of the respective study team members.

Name	Position	Responsibilities
Satoru Nishio	Leader / Map symbols discussion 1 / Supplementary field identification 2	• Head of entire study works • Lead map symbols discussions • Implementation of supplementary field identification
Akira Nishimura	Map symbols discussions 2 / Supplementary field identification 1	• Supplementary map symbols discussions • Lead supplementary field identification

1.8 Work allocation of each member

The work allocation of each member is shown in the work allocation table below.

Table 3 : Work allocation table

Items of Study / Scope of Work / Name			Leader / Map symbols discussion 1 / Supplementary field identification 2	Map symbols discussions 2 / Supplementary field identification 1
			Satoru NISHIO	Akira NISHIMURA
Preparatory Work in Japan				
	1-1	Collection of existing documents and information	◎	○
	1-2	Deliberation of basic policy and method of study	◎	○
	1-3	Inception Report (draft)	◎	○
	1-4	Acquisition of sattelite images	◎	○
First Work in Malawi				
	2-1	Explanation and discussion of inception report	◎	○
	2-2	Deliberation of schematic specifications and work standards	◎	○
	2-3	Collecting map data	○	◎
	2-4	Brief field survey	○	◎
First Work in Japan				
	3-1	Digital plotting and editing	◎	○
Second Work in Malawi				
	4-1	Supplementary field identification	○	◎
	4-2	Confirming data for printing	◎	○
Second Work in Japan				
	5-1	Supplementary digital editing	○	◎
	5-2	Symbolization on the topographic maps	○	◎
	5-3	Making data files	◎	○
	5-4	The final report	◎	○

Legend: ◎Main Engineer ○Sub Engineer

1.9 Products

The following are the products of the study.

Table 4 : List of products

Item	Products	Content	Volume
1) Study reports	Inception Report	*Contents:* • Basic policy of study • Method of study implementation • Implementation plans etc. of work process /study work personnel plan	10 in English
	Final Report	Included matters: chronology and results of study work	10 in English
2) Products	1/10,000 Topographic map digital data		20 sets
	Report on quality control		1 set

Chapter 2 Results of Study Implementation

A flowchart of the work done in the study is shown below.

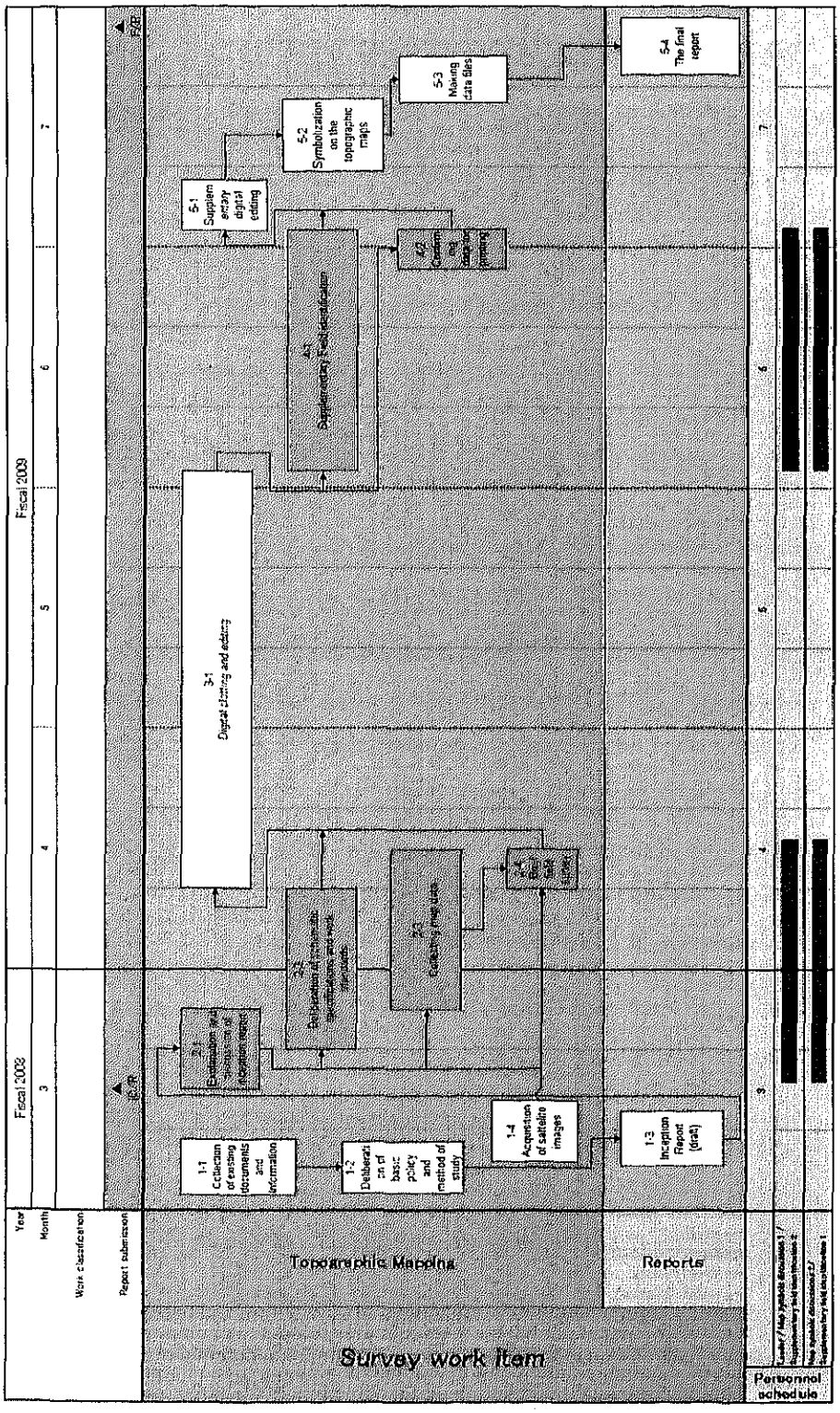


Figure 2: Flowchart of study work

2.1 Preparatory Work in Japan (2009.2.25 - 2009.3.16)

2.1.1 (1-1.) Collection of existing documents and information

1) Gathering together relevant documents in Japan

The following documents were collected in Japan:

- Access information on the survey area and geographic information on the greater capital area
- Image data of the study area (ex. Google Earth)
- Weather and climatic information (ex. MSN-weather forecast)
- Information on topographic map specifications of surrounding African countries (in particular, former British colonies)

2) Arrangement of collected documents

The collected documents were arranged as follows so that they could be used to implement the study:

- Geographic information of the greater capital area was arranged so that an implementation plan for the brief survey and supplementary field identification in Malawi could be deliberated.
- Image data of the study area was arranged so that images of the area could be acquired.
- Weather and climatic information was arranged so that appropriate decisions could be made on the implementation period of the field survey.
- Topographic map specifications of neighboring countries were arranged so that digital map symbol regulations could be prepared.

3) Formulating specifications (draft)

The specifications (draft) were formulated based on a geographic information standard. Specifically, they are to include the following:

- Outline (information regarding data product descriptions)
- Domain of validity (information regarding the application area of specifications)
- Identification of data products (information regarding identification of product data)
- Data content and structure
- Reference system (information regarding coordinates and almanac)
- Data quality (assessment procedures and quality requirements)
- Data products distribution (encoded specifications)

- Metadata

Further, besides the draft specifications, drafts were also made for the following.

- Sheet division
- Marginal information

2.1.2 (1-2.) Deliberation of basic policy and method of study

Based on the results of (1-1.) Collecting existing documents and information, the studies basic policy and methods were deliberated from the following viewpoints leading to implementation of the study.

(1) Type of satellite image data obtained

A search of high resolution satellite image archives on the market found that no stereo satellite images existed covering the whole area. There were existing QuickBird (QB) and IKONOS individual images, as well as SPOT orthophotos and DEM that were taken relatively recently.

Given the short period in which the map was to be made, new satellite images were not included this time.

(2) Technical method applicable to digital plotting

Based on the aforementioned satellite image situation, making digital orthophotos from individual images, then using the map digitizing method (where mapping is based on a digital orthophoto inputted into a numerical plotting machine) was considered in order to make the map.

As a result, it was decided to ground control the QuickBird images based on the SPOT ortho images and SPOT-DEM data, then to make the map with the map digitizing method after making the QuickBird orthophotos.

Initialy the coordinate system or surveying specifications to be employed were not decided, thus it was not certain whether the SPOT orthophoto coordinates needed changing (they eventually needed changing to WGS84).

Elevation data could not be gained from the satellite imagery, so, consideration was given to both using contour lines on the 1/2,500 topographic maps already in the survey departments possession, and acquiring SPOT-DEM data. It was decided to verify the difference between both of these methods, and then determine whether they can withstand use, and how much shifting is necessary between them.

(3) Expected accuracy of the results of the aforementioned technical method

As the resolution of satellite images determines the accuracy, the use of satellite image data with a spatial resolution 1 m and over, necessary to maintain a 1/10,000 level, was considered. This is based on 'overseas surveying regulations (for basic maps).' It was decided to use QuickBird, which can maintain a spatial

resolution of 0.8 m, as mentioned above.

(4) Timing and period of study implementation

There was a time limit of four months to complete the topographic map, so a streamlined work plan was considered where phase 1 only involved overview (basic design) work, while all the field survey work was concentrated in phase 2, so as to eliminate blank periods between work as a much as possible.

This information was put together in the inception report for the purpose of carrying out discussions with LCA.

2.1.3 (1-3.) Inception Report (draft)

The basic policy on the implementation of the study, method and matters of implementation, processes, personnel composition, and assignment were deliberated based on the results of (1-1.) Collecting existing documents and information, and (1-2.) Deliberation on basic policy and method of study. Then, based on these deliberations, the Inception Report (draft) was compiled.

2.1.4 (1-4.) Acquisition of sattelite images

Satellite images that could be identified based on the digital plotting method outlined in (3-1.) Digital plotting and editing, were acquired.

When doing so, image data quality was evaluated by checking the resolution, cloud cover, etc., and whether the satellite images cover the whole study area.

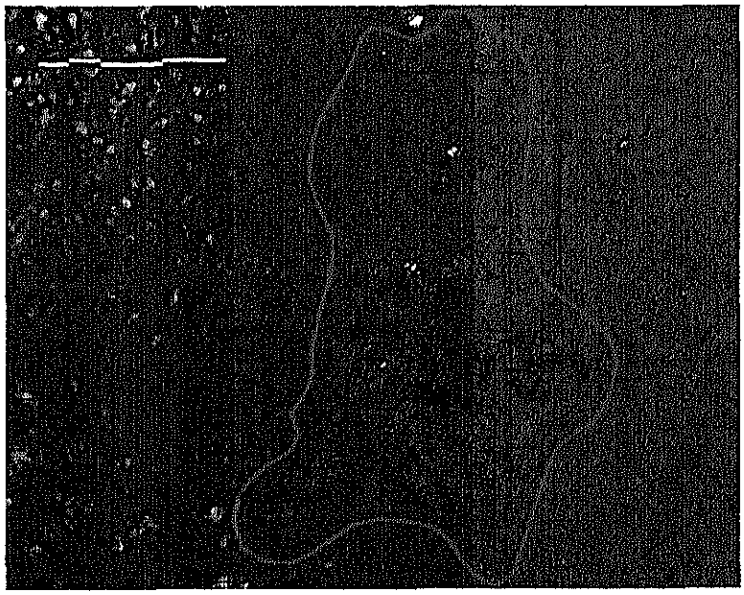


Figure 3 : High resolution satellite (QB) archive status in the study area

Also, DEM and orthophoto data for the study area were acquired considering the digital plotting method that was to be employed.

As the study area (size and position) was decided officially in the specification meeting, satellite images were acquired covering a larger area than in the plan.

The satellite imagery purchased is as follows.

(1) QuickBird satellite image data

Area: 500km2

Catalog ID: 1010010001F6FB00 (20030607), 1010010002045900 (20030625)

Image enhancement level: standard images/pan-sharpen images (standard orthophoto images)

Image colour: Multi spector 4 band colours (near-red, red, green, blue)

Resolution: 60 cm

File type: GeoTIFF1.0

Image quality: 16bit

Coordinate system: WGS84

Media: DVD

(2) SPOT View Level 3 orthophoto data

Scene ID: 5 138-377 2007/06/15 08:09:55 1A B SAT 6

Scene size: 30'×30'

Resolution: 2.5m panchromatic

Map projection method: UTM WGS 84

Format: DIMAP

(3) SPOT-DEM data

Land area of survey target: 680.9km2

Map projection method: UTM WGS 84

Mesh size: 20m

Format: DIMAP

2.2 First Work in Malawi (2009.3.17 - 2009.4.15)

2.2.1 (2-1.) Explanation and discussion of inception report

The explanation and discussion of the inception report was carried out as follows.

(1) Time

March 30, 2009. From 9:55 to 10:55

(2) Place

The Chamber of the Lilongwe Civic Offices

(3) Proceedings of meeting

1) Opening prayer: Ms. M. Mpakule

2) Self Introduction: Everyone present (see list of attendants below)

3) Welcoming remarks: Mr J. Tsogolani

Welcoming remarks were made by Mr J. Tsogolani, Director of Engineering Services on behalf of the Chief Executive. He told those present that the Lilongwe City Assembly with assistance from the Government of Japan through the Japan International Cooperation Agency (JICA) has embarked on the process of reviewing the Lilongwe Outline Zoning Scheme.

The JICA study team from Japan had organized this meeting with the stakeholders. The objective of the meeting was to source technical input into the topographic mapping inception report from the stakeholders. The topographic mapping inception report was part of the preliminary works towards the comprehensive review of the Lilongwe Outline Zoning Scheme. He thanked the Japanese Government for their assistance.

4) Presentation: Mr. Nishio

The Leader of JICA Study Team explained the following based on the Inception Report.

a) Objectives of the project.

b) Basic policies of the project.

c) Project implementation procedures.

d) Final product.

e) Work planning.

f) Personnel planning

5) Q&A

The JICA Study Team answered the following questions that were raised in the meeting.

Q1) Is cadastral information going to be indicated on the topographic map scale 1/10,000?

A1) The cadastral information will not be captured and indicated on the topographic map based on the JICA study team's experience.

Q2) How has the study area been determined?

A2) The JICA Study Team discussed with LCA the study area from the day the study team arrived here and the study team agreed with LCA. The tentative study area is being considered by JICA head quarters. The study team will get the results of consideration for the study area within a few days.

Q3) What kind of data will be used when the topographic map is produced?

A3) The JICA Study Team will use the satellite images to produce the maps.

Q4) Are you going to carry out capacity building?

A4) Capacity building related to the mapping component of the project will not be carried out in

principal. The purpose of the project is to produce the topographic maps and there are not enough time and resources to carry out capacity building.

Q5) In the basic policy in the inception report, the world geodetic system is recommended to be introduced as a survey standard, but the Malawi side would like to apply the local system. What do you think of using the local system?

A5) The JICA Study Team recommended the world geodetic system based on tendencies in the survey sector, as mentioned in the inception report. There would be no technical problems if the local system was employed for the project mapping.

Q6) What do you think about counterpart (C/P) duties and the implementation schedule?

A6) It is very important to cooperate with C/P, LCA and Survey Department. The JICA Study Team informs and explains their duties and the schedule in advance.

6) Closing prayer: Ms. M. B. Dube

(4) LIST OF ATTENDANTS

Malawi Side:

1. Mr. Julius TSOGOLANI, Director of Engineering Service, Lilongwe City Assembly
2. Mr. Yohane NYANJA, Acting Director of Planning and Development, Lilongwe City Assembly
3. Mr. K. J. BANDA, Lilongwe City Assembly
4. Ms. M. B. DUBE, Regional Commissioner for Physical Planning, Ministry of Lands and Natural Resources
5. Mr. F. C. J. TUKULA, Commissioner for Physical Planning, Ministry of Lands and Natural Resources
6. Mr. K. G MLINDE, Lilongwe City Assembly
7. Ms. Mercy MPAKULE, Lilongwe City Assembly
8. Mr. Jones K. GONDWE, Lilongwe City Assembly
9. Mr. Brown MPHALO, Survey Department
10. Mr. Dalitso MPOOLA, Representative, Ministry of Local Government and Rural Development
11. Mr. Neeton MHURA, Commissioner for Lands, Ministry of Lands and Natural Resources
12. Mr. Y. K. CHEWELE, ESCOM, Lilongwe
13. Ms. Catherine KULEMEKA, Town Planning Manager, Lilongwe City Assembly
14. Mr. H.S.K. MUMBA, Housing Manager, Lilongwe City Assembly
15. Mr. H.T. KAMELA, Development Control Manager, Lilongwe City Assembly

Japanese Side:

1. Mr. Satoru NISHIO, Team Leader of JICA Study Team
2. Mr. Akira NISHIMURA, Surveyor

JICA Malawi Office

1. Mr. Shunsuke TAKATOI, Assistant Resident Representative
2. Mr. Godfrey KAPALAMULA, Senior Programme Officer

The Minutes of Meeting (M/M) signed during this study are attached in Appendix 1.

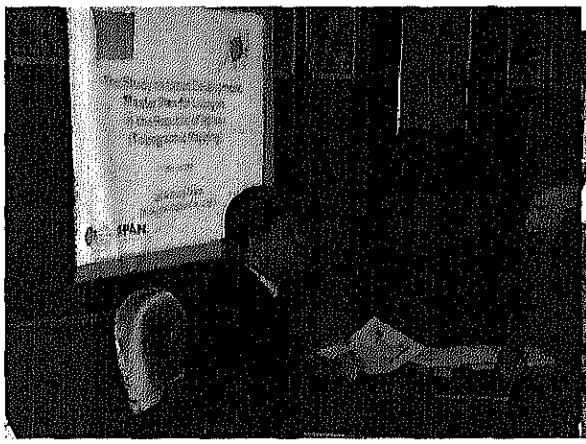


Photo 1 : Explanation of IC/R

Photo 2 : Participants of IC/R Meeting

2.2.2 (2-2.) Deliberation of schematic specifications and work standards

The following items were agreed upon among Lilongwe City Assembly, Department of Surveys and JICA Study Team for the Study on Urban Development Master Plan for Lilongwe in the Republic of Malawi (Topographic Mapping):

The results of considerations and discussions are included in the memorandum (see Appendix 2). Survey specifications taken from the discussion results are shown below.

Also, a specification sheet in the form of product specifications is attached in Appendix 3.

Table 5 : Survey specifications to be used

Reference Ellipsoid	Clarke 1880 (Modified) a = 6,378,249.145326, 1/f = 293.4663076
Projection System	Transverse Mercator
Grid System	U.T.M. (Zone 36)

Meridian of Origin	33°00' East of Greenwich
Latitude of Origin	Equator
Scale Factor at Origin	0.9996
False Coordinate of Origin	Y (False Easting) =500,000m X (False Northing)=10,000,000m
Unit of Measurement	Meter
Base of Height	The Indian Ocean (Mean Sea Level)
Sheet Size	80 cm (8 km) by 60 cm (6 km) for scale 1:10,000.

Further, in these discussions there was a request from LCA to expand the mapping area slightly in the north, southeast, and southwest. There is a planned large-scale shopping center in the north, and rapid housing development in the south-east and south-west, where a bypass is also planned. These are all important map making areas to implement the urban plan. This matter was promptly reported to JICA to check whether it was permissible and JICA approved the additional request for the expanded mapping area. Moreover, there was no extra cost involved in mapping the additional area.

Photo 3: Specification discussions

2.2.3 (2-3.) Collecting map data

Procurement of topographic maps (large to small scale maps, including 1/2,500 scale maps) from the Survey Department.

The existing 1/2,500 topographic maps were obtained from the survey department in order to acquire contour information and satellite image ground control factors.

A request for all the 1/2,500 topographic maps within the study area was made to the survey department, however, many of these maps are stored not in Lilongwe, but in the office in the second biggest city, Blantyre. It took a long time to procure these maps, visiting the office four times, between the first and the

ninth of April, 2009. Further, only 194 sheets of a total 290 (approximately 67%) could be obtained due to missing maps and so forth. The missing maps however, were mostly of the suburban areas, so most of the central city was covered (see map below). The original map was on a polyester base, and so a blueprint map was acquired. The coloured sections of the map below are the topographic maps that were acquired.

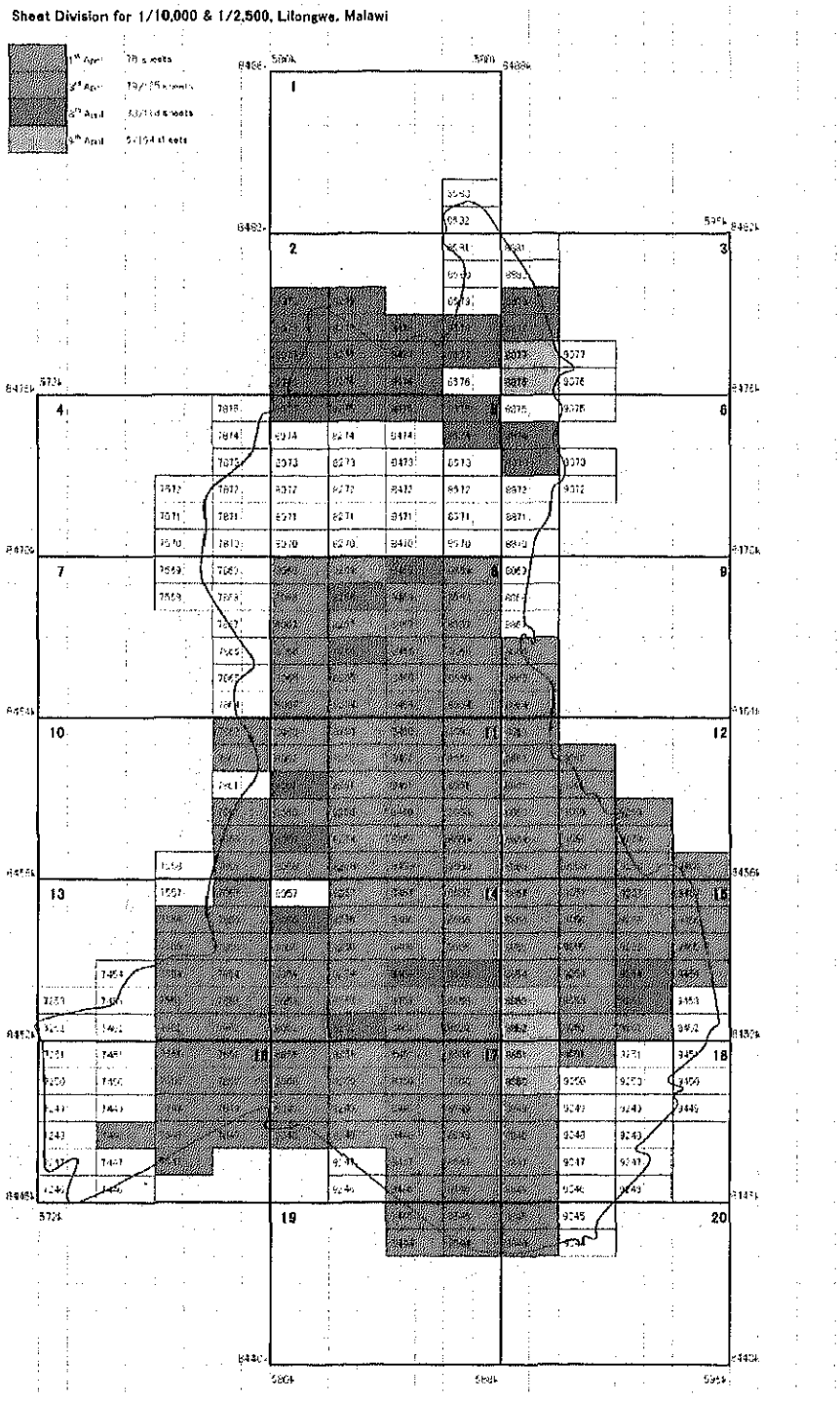


Figure 4 : Sheet division map for scale 1/10,000 and 1/2,500

2.2.4 (2-4.) Brief field survey

(1) Outline of brief field survey

Here a brief field survey of the target terrain and features to be displayed on the topographic map was implemented.

Moreover, as a result of discussions on working standards, it was decided to utilize the previously used coordinate system, Clarke 1880. For this reason, a survey of ground control points based on the Clarke 1880 coordinate system was carried out.

1) Implementation period

The following are the time periods the work was implemented:

Brief field survey; April 6 – 10, 2009

Ground control point survey; April 6 – 10, 2009

2) Implementation structure

The following is the implementation structure.

Group A (Brief field survey)	Mr. Keissar S.C. Kaluba (LCA) Mr. Akira Nishimura (JICA study team)
Group B (Ground control point survey)	Mr. Stephen Phiri (LCA) Mr. Satoru Nishio (JICA study team)

(2) Brief field survey of target terrain and features for topographic map

Printed out SPOT orthophotos were taken to implement the brief field survey.

1) Brief survey of important features based on map specifications.

The brief field survey was conducted using printed SPOT orthophotos based on the map specifications decided through discussions with relevant agencies.

The following items were confirmed on the SPOT orthophotos and photographed during the brief field survey:

a. Important bridges,

b. Important buildings (churches, schools),

c. Confirming important smaller objects (high towers such as cell towers), and

Furthermore,

d. the overall condition and visibility of vegetation was confirmed on the SPOT images

These brief field survey results for target features, their map symbol or code number and orientation of confirmation photograph, were displayed on the SPOT orthophoto printouts. Also the result of field confirmation of vegetation on the SPOT orthophoto is to be interpreted singularly for numerical plotting

and editing.

2) Brief field survey of secular change based on SPOT orthophotos

A brief field survey was undertaken, based on SPOT orthophotos taken in June 2007 of places where secular change has occurred since. These secular changes confirmed in the brief field survey were displayed on the SPOT orthophoto printouts.

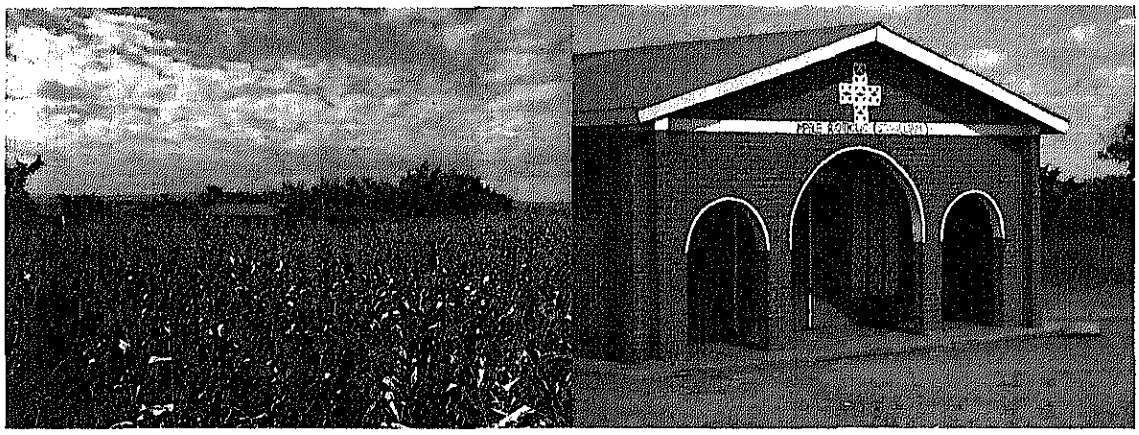


Photo 4: Vegetation confirmation survey (maize) Photo 5: Survey of important buildings (church)

(3) Ground control point survey

As it was decided to use the Clarke 1880 (Modified) coordinate system, it was necessary to change the coordinates of the image data (WGS84) to this system. To ground control for this, coordinates based on Clarke 1880 (Modified) were needed, for points where the position could be clearly identified on satellite images. Fortunately, there are national triangulation points with coordinates based on Clarke 1880 (Modified) in the target areas of the survey, many of which are pillar type and can be clearly identified on satellite images.

Fifteen (15) ground control points were made using these national triangulation points.

The results of this are in "Descriptions for Ground Control Points" (see Appendix 4).

Photo 6: Ground control point (No. 142/MWT) Photo 7: Survey of ground control point (No. 88/MWT)

2. 3 First Work in Japan (2009.4.16 - 2009.6.2)

2. 3. 1 (3-1.) Digital plotting and editing

(1) Preparations for digital plotting and editing

The following data was prepared to start digital plotting and editing.

- QuickBird satellite image data
- SPOT View Level 3 orthophoto data
- SPOT-DEM data
- Scanned data of existing 1/2,500 topographic maps

(2) Making QuickBird orthophotos

The QuickBird images were photocontrolled using SPOT orthophotos and SPOT-DEM data. These QuickBird orthophotos were made for plotting using the map digitizing method.

Further, the coordinate system was changed from WGS84 to Clarke 1880 (Modified) using the ground control point results.

(3) Digital plotting

The defined topographic features and so on were plotted (digitized) onto these QuickBird orthophotos, made with satellite images using the map digitizing method.

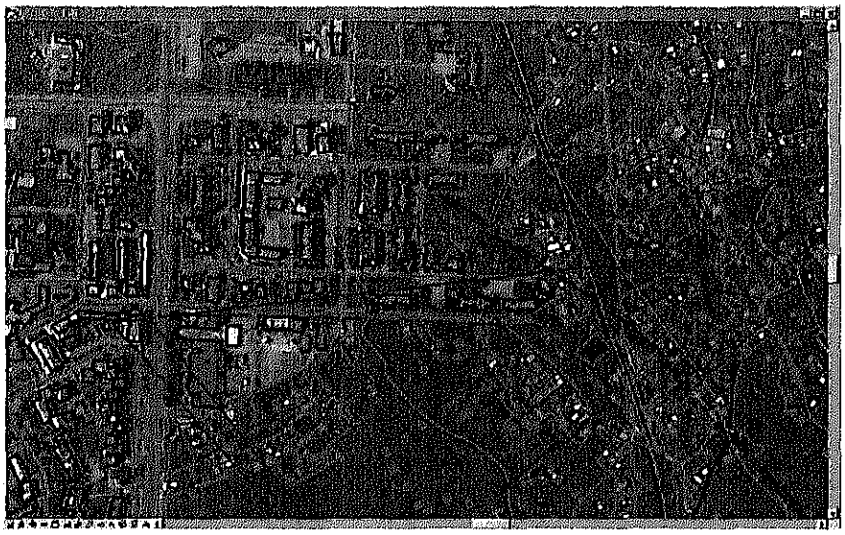


Figure 5: Digital mapping

(4) Plotting contour lines

Contour lines from the existing 1/2,500 topographic maps were plotted with the map digitizing method onto the scanned existing 1/2,500 topographic map data. The contour lines are at 2 meter intervals.

On the other hand, for areas where 1/2,500 topographic maps could not be obtained during (2-3.) Collect map data, contour line data was made from these SPOT-DEM. In order to check the practicality of using SPOT-DEM data, the elevation difference between the same points on this data and the contour lines of the 1/2,500 topographic maps was verified (see below). In all, 74 points were cross-checked, resulting in a standard deviation of 0.44 m.

According to JICA overseas surveying rules (for base maps), the height accuracy (standard deviation) must be within 1/3 of the contour interval. As the contour interval used this time is 2 m, the height limit is 0.67 m. The standard deviation of 0.44 m is within the height limit so the SPOT-DEM data could be used as is, without impacting the shift amount, in the same manner as the 1/2,500 topographic map contour line data that is considered correct for this study.

Table 6 :Elevation differences between SPOT-DEM and 1/2,500 topographic map contour line data

	1/2500地図から			SPOT20DEMから			較差x(m)	x2
	X	Y	Z	X	Y	Z		
9001	590611.6	8460479.0	1037.2	590611.6	8460479.0	1040.642	3.442	11.847
9002	588218.6	8478671.9	1224.0	588218.6	8478671.9	1229.047	5.047	25.472
9003	588334.9	8466423.6	1104.0	588334.9	8466423.6	1107.976	3.976	15.809
9004	589882.7	8464601.5	1082.0	589882.7	8464601.5	1086.512	4.512	20.358
9005	589187.7	8461435.1	1061.4	589187.7	8461435.1	1062.250	0.850	0.723
9006	587955.4	8478975.3	1226.0	587955.4	8478975.3	1231.595	5.595	31.304
9007	586690.7	8477121.2	1192.0	586690.7	8477121.2	1196.628	4.628	21.418
9008	587845.7	8474424.1	1243.4	587845.7	8474424.1	1245.924	2.524	6.371
9009	586712.1	8469862.8	1204.0	586712.1	8469862.8	1203.704	-0.296	0.088
9010	586988.7	8467469.1	1194.2	586988.7	8467469.1	1193.821	-0.379	0.144
9011	586727.1	8465608.2	1136.0	586727.1	8465608.2	1137.000	1.000	1.000
9012	587911.1	8463648.3	1102.0	587911.1	8463648.3	1102.899	0.899	0.808
9013	586511.5	8462476.0	1122.9	586511.5	8462476.0	1124.526	1.626	2.644
9014	587902.4	8460238.5	1052.0	587902.4	8460238.5	1053.574	1.574	2.477
9015	585602.3	8478065.2	1198.0	585602.3	8478065.2	1199.040	1.040	1.082
9016	585274.7	8475581.5	1225.5	585274.7	8475581.5	1226.051	0.551	0.304
9017	584228.7	8468696.2	1144.0	584228.7	8468696.2	1145.974	1.974	3.897
9018	584345.5	8466658.2	1128.0	584345.5	8466658.2	1127.672	-0.328	0.108
9019	584119.5	8464309.3	1120.0	584119.5	8464309.3	1122.053	2.053	4.215
9020	585437.3	8461231.3	1104.3	585437.3	8461231.3	1110.000	5.700	32.490
9021	583427.5	8476560.6	1228.2	583427.5	8476560.6	1229.670	1.470	2.161
9022	583778.1	8462662.3	1081.1	583778.1	8462662.3	1094.251	13.151	172.949
9023	581674.7	8475132.1	1206.0	581674.7	8475132.1	1205.878	-0.122	0.015
9024	580369.1	8469794.8	1161.2	580369.1	8469794.8	1163.000	1.800	3.240
9025	581864.4	8467850.0	1166.0	581864.4	8467850.0	1166.398	0.398	0.158
9026	580154.4	8466396.8	1120.0	580154.4	8466396.8	1124.009	4.009	16.072
9027	581748.7	8464639.8	1128.0	581748.7	8464639.8	1131.545	3.545	12.567
9028	580344.1	8462408.5	1095.0	580344.1	8462408.5	1099.008	4.008	16.064
9029	581715.6	8461168.1	1081.7	581715.6	8461168.1	1084.842	3.142	9.872
9030	579046.2	8463595.0	1081.5	579046.2	8463595.0	1082.896	1.396	1.949
9031	578325.9	8460952.7	1062.5	578325.9	8460952.7	1066.976	4.476	20.035
9032	592405.9	8459266.6	1004.7	592405.9	8459266.6	1009.722	5.022	25.220
9033	592353.4	8459339.4	1006.0	592353.4	8459339.4	1009.740	3.740	13.988
9034	593380.5	8452290.5	1059.0	593380.5	8452290.5	1059.500	0.500	0.250
9035	593367.7	8455156.7	1042.0	593367.7	8455156.7	1045.410	3.410	11.628
9036	593564.2	8457378.6	1015.1	593564.2	8457378.6	1020.770	5.670	32.149
9037	590802.6	8458256.0	1050.7	590802.6	8458256.0	1054.928	4.228	17.876
9038	590879.4	8456485.7	1100.5	590879.4	8456485.7	1106.551	6.051	36.615
9039	590709.6	8453429.1	1131.1	590709.6	8453429.1	1134.544	3.444	11.861
9040	591803.0	8451047.7	1104.6	591803.0	8451047.7	1101.785	-2.815	7.924
9041	589630.6	8459355.8	1029.8	589630.6	8459355.8	1035.531	5.731	32.844
9042	589062.5	8457481.4	1028.0	589062.5	8457481.4	1032.509	4.509	20.331
9043	589784.1	8452182.4	1124.7	589784.1	8452182.4	1129.584	4.884	23.853
9044	589188.6	8450582.0	1123.0	589188.6	8450582.0	1126.228	3.228	10.420
9045	589419.6	8448068.2	1096.0	589419.6	8448068.2	1096.438	0.438	0.192
9046	587235.6	8456202.0	1033.3	587235.6	8456202.0	1035.205	1.905	3.629
9047	587820.7	8453036.3	1091.2	587820.7	8453036.3	1094.000	2.800	7.840
9048	586808.4	8451187.1	1069.8	586808.4	8451187.1	1072.176	2.376	5.645
9049	587152.2	8449466.0	1119.1	587152.2	8449466.0	1123.000	3.900	15.210
9050	586366.2	8447530.3	1117.2	586366.2	8447530.3	1122.979	5.779	33.397
9051	587807.6	8446328.7	1121.1	587807.6	8446328.7	1122.218	1.118	1.250
9052	586808.3	8444518.4	1124.0	586808.3	8444518.4	1126.173	2.173	4.722
9053	585943.6	8458448.0	1078.0	585943.6	8458448.0	1083.912	5.912	34.952
9054	584138.1	8456880.3	1034.0	584138.1	8456880.3	1039.611	5.611	31.483
9055	585785.1	8454539.3	1021.1	585785.1	8454539.3	1026.612	5.512	30.382
9056	584744.6	8452584.4	1085.1	584744.6	8452584.4	1092.478	7.378	54.435
9057	585529.9	8446360.3	1117.5	585529.9	8446360.3	1122.612	5.112	26.133
9058	583189.6	8459487.8	1068.1	583189.6	8459487.8	1071.092	2.992	8.952
9059	583175.2	8455470.0	1079.0	583175.2	8455470.0	1083.000	4.000	16.000
9060	583869.8	8450828.0	1080.0	583869.8	8450828.0	1082.885	2.885	8.323
9061	583847.7	8448117.6	1082.0	583847.7	8448117.6	1084.332	2.332	5.438
9062	581565.1	8458209.6	1048.9	581565.1	8458209.6	1050.187	1.287	1.656
9063	581878.5	8453530.3	1098.8	581878.5	8453530.3	1103.000	4.200	17.640
9064	581182.2	8451369.1	1045.5	581182.2	8451369.1	1047.778	2.278	5.189
9065	581670.5	8449527.9	1068.0	581670.5	8449527.9	1068.155	0.155	0.024
9066	579610.8	8459372.9	1057.5	579610.8	8459372.9	1058.035	0.535	0.286
9067	578404.7	8457600.3	1097.0	578404.7	8457600.3	1098.000	1.000	1.000
9068	579661.2	8454984.6	1100.8	579661.2	8454984.6	1104.030	3.230	10.433
9069	579705.0	8452407.9	1072.7	579705.0	8452407.9	1075.159	2.459	6.047
9070	578772.6	8450623.7	1082.8	578772.6	8450623.7	1084.487	1.687	2.846
9071	577474.0	8453561.2	1082.9	577474.0	8453561.2	1083.538	0.638	0.407
9072	577848.8	8449158.4	1056.0	577848.8	8449158.4	1054.651	-1.349	1.820
9073	576821.8	8451639.9	1108.6	576821.8	8451639.9	1109.703	1.103	1.217
9074	576325.3	8456388.5	1127.6	576325.3	8456388.5	1130.401	2.801	7.846
							Σ	1026.992
							点数	74
							標準偏差	0.436

(5) Digital editing

The maps were edited to represent symbols the on the digital plotting data.

The symbols were edited with CAD software to align and change their position and angle, and also the position of annotations.

After the digital editing, maps for supplementary field identification were made.

(6) Producing sample map with draft map symbols

After the digital editing, a sample map was produced with draft map symbols based on the specifications decided upon in the discussions.

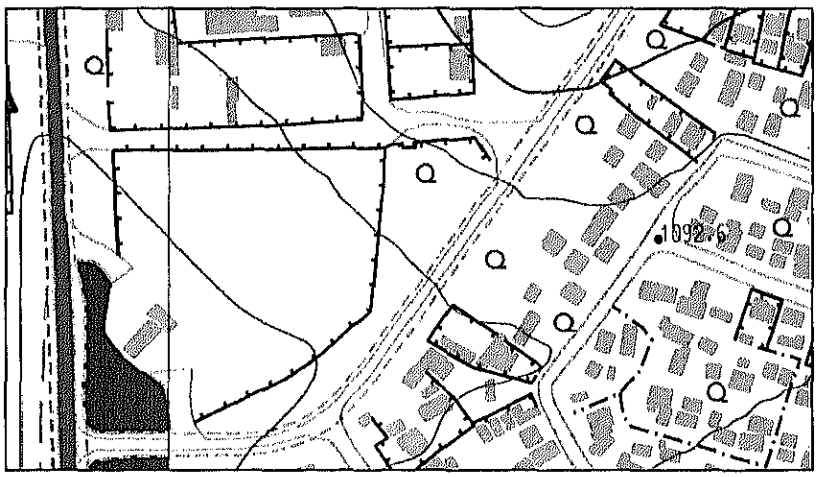


Figure 6: Final image output map

2.4 Second Work in Malawi (2009.6.3 - 2009.7.2)

2.4.1 (4-1.) Supplementary field identification

The supplementary field identification was conducted with the following procedures.

(1) Preparation

1) Making printouts of acquired satellite images

Orthophoto map prints were made from acquired or produced SPOT and QuickBird orthophoto images, 20 sheets on a scale of 1/10,000, according to the neatline decided upon in discussions.

2) Printed maps of numerical plotting/editing data

Printed maps of post-numerical plotting/-editing data were made according to the specifications on a sheet by sheet basis.

(2) Implementation structure and period of supplementary field identification

1) Formation of supplementary field identification teams

Two teams were organized, as shown below per team, to conduct the supplementary field identification:

- 1 study team member
- 1 guide/public relations
- 1 vehicle (4WD)

Further, the guide/public relations members appointed are employees of Lilongwe City Assembly, the counterpart agency.

Group A	Mr. A. N. Chirwa (LCA) Mr. Akira Nishimura (JICA study team)
Group B	Mr. Stephen Phiri (LCA) Mr. Satoru Nishio (JICA study team)

2) Supplementary field identification period

The supplementary field identification was carried out from June 9-29, 2009.

(3) Content of the supplementary field identification

1) Preparation

The points that needed clarifying after the numerical plotting/editing on a sheet basis were re-checked. Also the differences (secular change) as a result of satellite image acquisition period (June 2007 for SPOT; June 2003 for QuickBird) were re-checked on the print maps of numerical plotting/editing data.

2) Preliminary photo interpretation

Preliminary photo interpretation was carried out by satellite image for small rural villages where schools and churches and such are common. Every effort was made not to overlook any important buildings in small villages.

In addition to the above interpretation, the suspected location of features, which it was decided need displaying, were marked on the printed image and numerical plotting/editing data maps.

3) Supplementary field identification

a. Supplementary field identification of points needing clarifying after numerical plotting/editing

The items (such as the type of building/structure, connection of high voltage power lines and position of pylons) re-checked in 1. Preparation, were confirmed in the field.

b. Supplementary field identification of preliminary photo identification results

The existence of features selected in the preliminary photo identification as map specifications was confirmed.

c. Supplementary field identification

As carried out in a. and b., confirmation of the necessary features (those in the map specifications) to be displayed on the topographical maps was implemented by visiting as many of the target areas as possible.

Secular change information, since the acquisition of SPOT images, was gathered for features that are landmarks (such as large buildings and new roads).

When the feature was not able to be identified on each of the print-out maps, its position was taken on portable GPS and identified on the topographic maps. (Moreover, the shift amount of the portable GPS were taken as that observed at neighboring control points)

d. Annotation survey

Features needing annotations (names of large facilities, schools, churches, hospitals, public buildings and so on) were confirmed in the field by photographing signs and so forth. Also, information on place names was gathered from local residents.

Photo 8: Supplementary field identification 1 Photo 9: Supplementary field identification 2

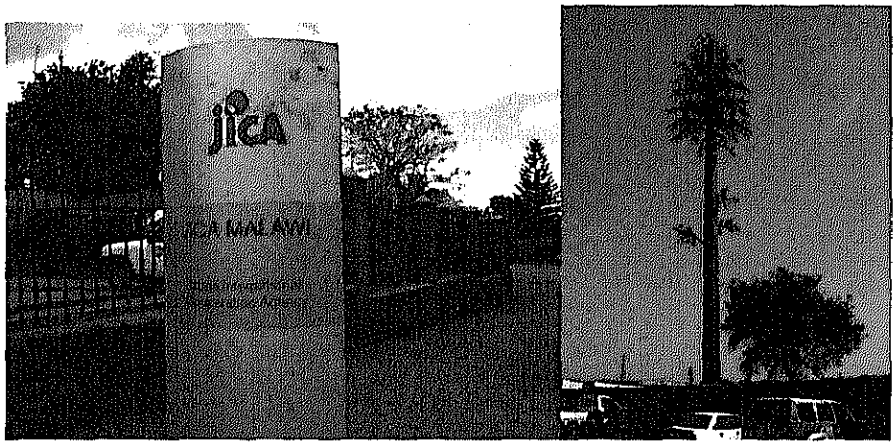


Photo 10: Confirming important building annotations; Photo 11: Confirming tree-shaped cell tower

4) Displaying results of supplementary field identification

The results of the supplementary field identification were arranged in the following manner so as to be useful for future work.

a. The results of the supplementary field identification were all displayed within the maps, using symbols -- A: add; D: delete; CG: change -- and leading lines to the sides.

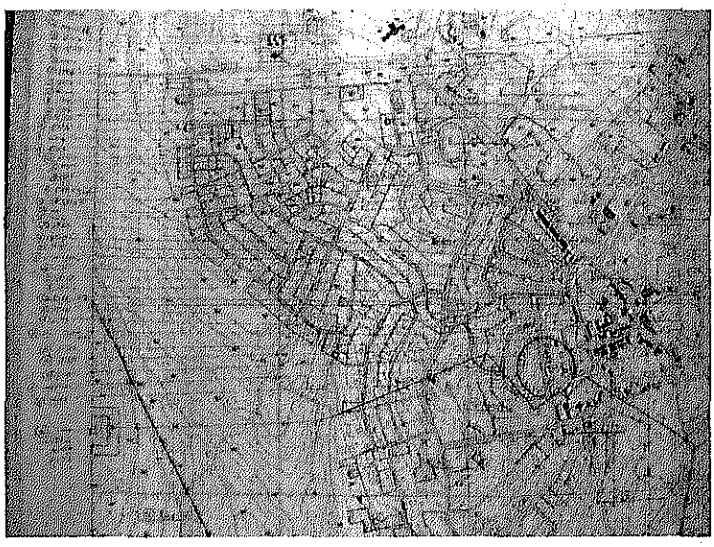


Figure 7: Results of supplementary field survey

b. Annotations were assigned a code for each map sheet, which were listed in an Excel file.

Table 7 : Sample of annotation list

No.	Annotation	Code
1	CIVIC OFFICES	9301
2	Kang'ombe House	9301
3	PACIFIC HOTEL	9301
4	JICA MALAWI	9301
5	NATIONAL LIBRARY SERVICE	9301
6	RESERVE BANK OF MALAWI	9301
7	LILONGWE NATURE SANCTUARY	9301
8	UNDP	9301
9	LCA, Dept. of Parks and Recreation and Environment	9301
10	SUNBIRD CAPITAL HOTEL	9301
11	Lingadzi C.C.A.P. Church	9301
12	CITY CENTRE CLINIC	9301
13	NEW APOSTOLIC CHURCH	9301
14	Embassy of Japan	9301
15	KAMUZU INSTITUTE FOR SPORTS	9301
16	KAWALE L.E.A. SCHOOL	9301
17	CHIWOKO L.E.A. SCHOOL	9301
18	Kawale	9109
19	Chilinde	9109
20	CHILINDE L.E.A. SCHOOL	9301
21	KAMUZU COLLEGE OF NURSING	9301
22	Baylor College of Medicine	9301

2.4.2 (4-2.) Confirming data for printing

(1) Implementation structure

Study period: June 15 (Mon) to June 29 (Mon), 2009.

Members: 2 people from the study team, 2 people from LCA; 1 person from the survey department.

(2) Overview of Implementation

Upon arrival, LCA and the survey department were given one sample map each, and a request was made to confirm the landscape and feature symbols and such.

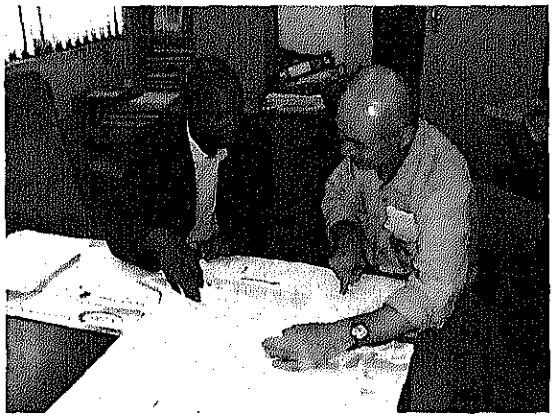


Photo 12 : Scene of confirming data for printing

The results were deliberated and discussed to confirm small changes to the map specifications, correct errors in the legend and marginal information, confirm position of marginal information, and decide sheet names and the style of the printed maps, while gaining LCA's final approval. Below is a list of sheet names procured from LCA and the survey department.

Corrections to the content were made as a result of discussions and deliberation. Further, corrections were made to the map specifications affected by these changes.

Table 8: List of sheet names

Sheet No.	Sheet names	Sheet No.	Sheet names
1	Thambwe	11	Chimutu
2	Lumbadzi 2	12	Kauma
3	Lumbadzi 1	13	Njewa
4	Chiponde	14	City Centre
5	Chitukula	15	Kamatundu
6	Chinoko	16	Likuni
7	Mngwangwa	17	Phwetekele
8	Dzenza	18	Chiuzira
9	Ntande	19	Kalumba
10	Mbabzi	20	Nanjiri