REPUBLIC OF BURUNDI
IGEBU: INSTITUT GEOGRAPHIQUE DU BURUNDI

THE STUDY ON ESTABLISHING DIGITAL TOPOGRAPHIC DATABASE FOR BUJUMBURA CITY, BURUNDI

Final Report

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PASCO CORPORATION

EI
JR
13-095

Currency exchange rate

Currency unit: Burundian franc (BIF)

1 dollar = 1,535.82 BIF (interbank exchange rate on 28 February 2013)

1 dollar = 91.84 JPY (interbank exchange rate on March 2013)

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Abbreviations

CAD	Computer Aided Design
CPU	Central Processing Unit
DEM	Digital Elevation Model
DF/R	Draft Final Report
DGPS	Differential Global Positioning System
GIS	Geographic Information System
GNSS	Global Navigation Satellite System(s)
GPS	Global Positioning System
GRS80	Geodetic Reference System 1980
GSD	Ground Surface Distance
IC/R	Inception Report
IGEBU	Institut Géographique du Burundi
IGN	Institut Géographique National
IGS	International GNSS Service
IMU	Inertial Measurement Unit
ISO/TC211	ISO/TC 211 Geographic information/Geomatics
ISABU	Institut des Sciences Agronomiques du Burundi
ITRF	International Terrestrial Reference Frame
IT/R	Interim Report
JICA	Japan International Cooperation Agency
MM	Minutes of Meeting
OJT	On the Job Training
REGIDESO	Régie de production et de distribution d'eau et d'électricité
RTK	Real Time Kinematic
SETEMU	Services techniques de la Mairie de Bujumbura
TIFF	Tagged Image File Format
UPS	Uninterruptible Power Supply
UTM	Universal Transverse Mercator

1. Outline of the Study

1-1. Objectives

The objectives of the Study are as follows:

(1) Aerial photography of Bujumbura City (approximately 230km^2) in the Republic of Burundi (hereinafter referred to as Burundi) shall be performed to create digital topographic maps and ortho photographs at a scale of 1/5,000.

(2) Aerial photography of the suburbs (approximately 800km^2) of Bujumbura city shall be performed to create digital topographic maps and ortho photographs at a scale of 1/25,000.

(3) Aerial photography of Gitega City (approximately 70km^2) shall be performed to create ortho photographs.

(4) Technology transfer for creating digital topographic maps shall be performed to the counterpart organization of Burundi, Geographic Institute of Burundi (hereinafter referred to as "IGEBU").

1-2. Study Area

Figure 1 shows the area for which digital topographic maps shall be created. Figure 2 shows the area for which aerial photography shall be performed in Gitega City.

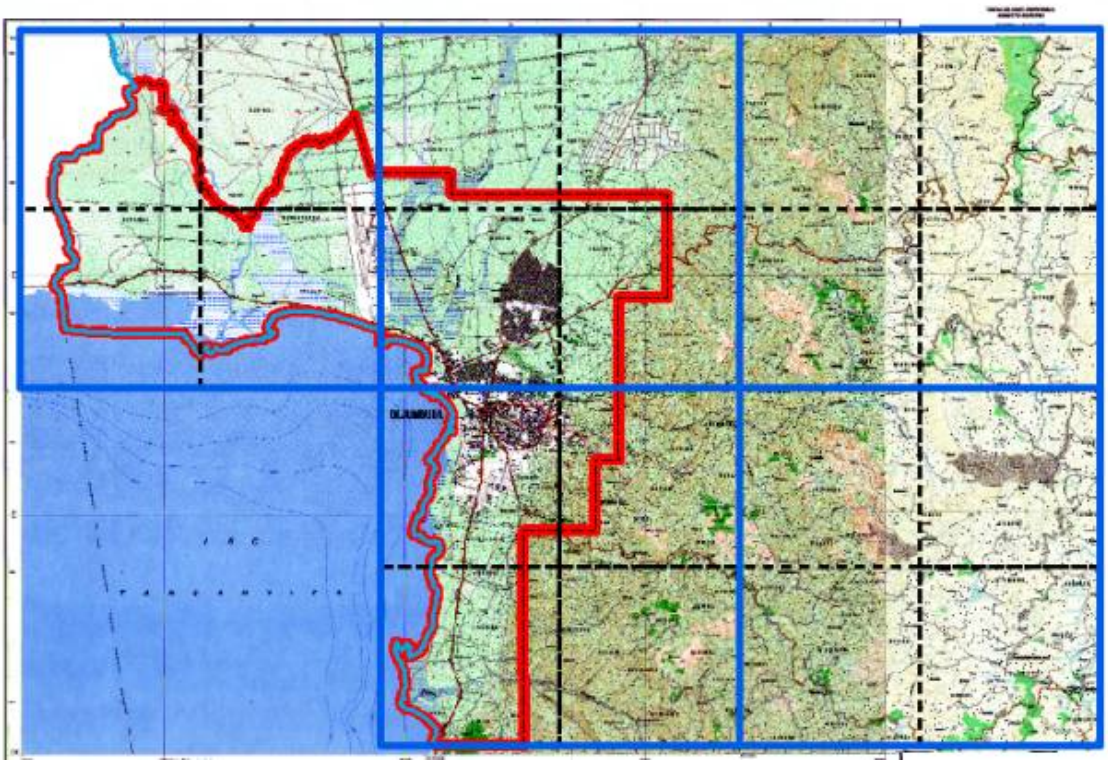


Figure. 1 Digital Topographic Mapping Area

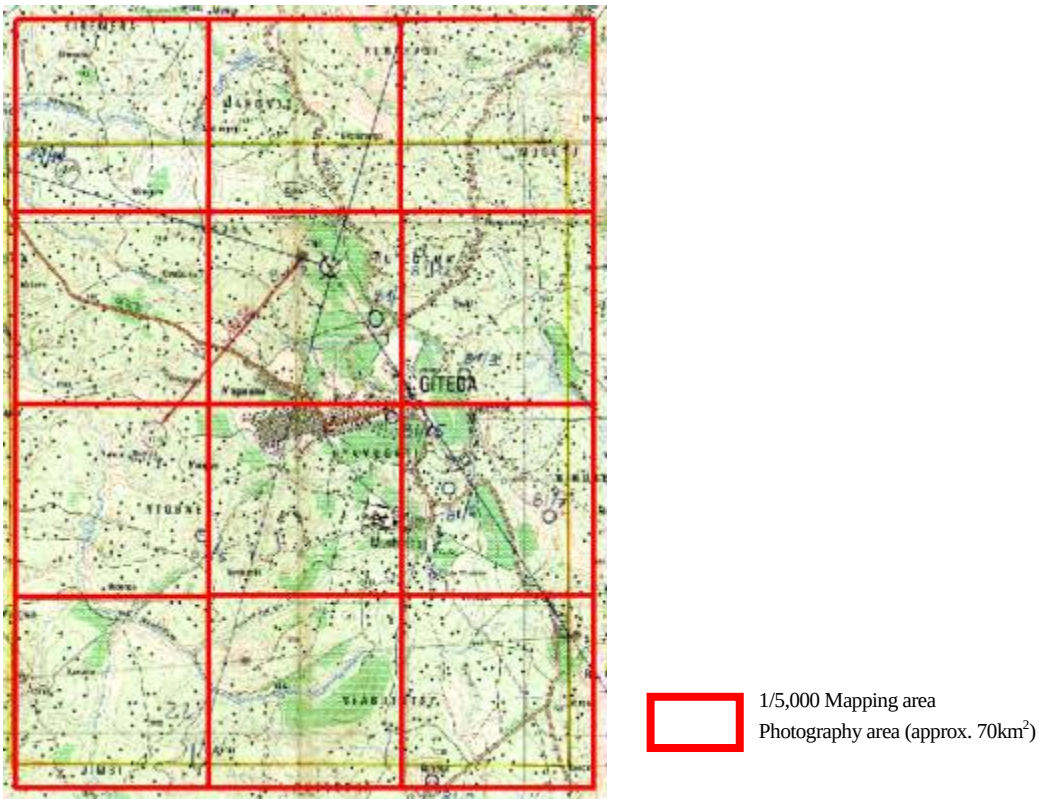


Figure. 2 Aerial Photography Area in Gitega

1-3. Details and Workload of Study

The following table shows details and workload of this Study:

Table. 1 Details and Workload of the Study

Study Items		Quantity	Details
Control point survey and installation of pre-marks	Bujumbura	13 points Control point origin: 1 Control points: 12	Work in Burundi Technology transfer targets (OJT)
	Gitega	5 points Control point origin: 1 Control point origins: 4	
Leveling	Bujumbura	4 routes (New simple leveling)	Work in Burundi Technology transfer targets (OJT)
	Gitega	1 route (New simple leveling)	
Aerial photography	1/5,000 (Bujumbura)	11 courses 184 images (GSD: 30cm)	Work in Burundi
	1/5,000 (Gitega)	3 courses 84 images (GSD: 30cm)	
	1/25,000 (Bujumbura)	5 courses 148 images (GSD: 50cm)	Work in Burundi
Aerial triangulation	1/5,000	257 models	Work in Japan Technology transfer (Indoor)
	1/25,000	143 models	Work in Japan Technology transfer (Indoor)
Field identification	1/5,000	46 maps (230km^2)	Work in Burundi Technology transfer (OJT)
	1/25,000	5 maps (800km^2)	
Digital Plotting	1/5,000	257 models 46 maps (230km^2)	Work in Japan Technology transfer (Indoor)
	1/25,000	143 models 5 maps (800km^2)	Work in Japan Technology transfer (Indoor)
Digital Compilation	1/5,000	46 maps (230km^2)	Work in Japan Technology transfer (Indoor)
	1/25,000	5 maps (800km^2)	Work in Japan Technology transfer (Indoor)
Field Completion	1/5,000	46 maps (230km^2)	Work in Burundi Technology transfer (OJT)
	1/25,000	5 maps (800km^2)	
Digital Completion	1/5,000	46 maps (230km^2)	Work in Japan Technology transfer (Indoor)
	1/25,000	5 maps (800km^2)	
Map Symbolization	1/5,000	46 maps (230km^2)	Work in Japan Technology transfer (Indoor)
	1/25,000	5 maps (800km^2)	
Data Structuralization	1/5,000	46 maps (230km^2)	Work in Japan Technology transfer (Indoor)
	1/25,000	5 maps (800km^2)	
GIS Model Systems creation	Bujumbura	・Flood countermeasures ・Landslide countermeasures ・Waste countermeasures ・Health care	Work in Japan Technology transfer (Indoor)

1-4. Workflow

The following figure shows workflow of this Study:

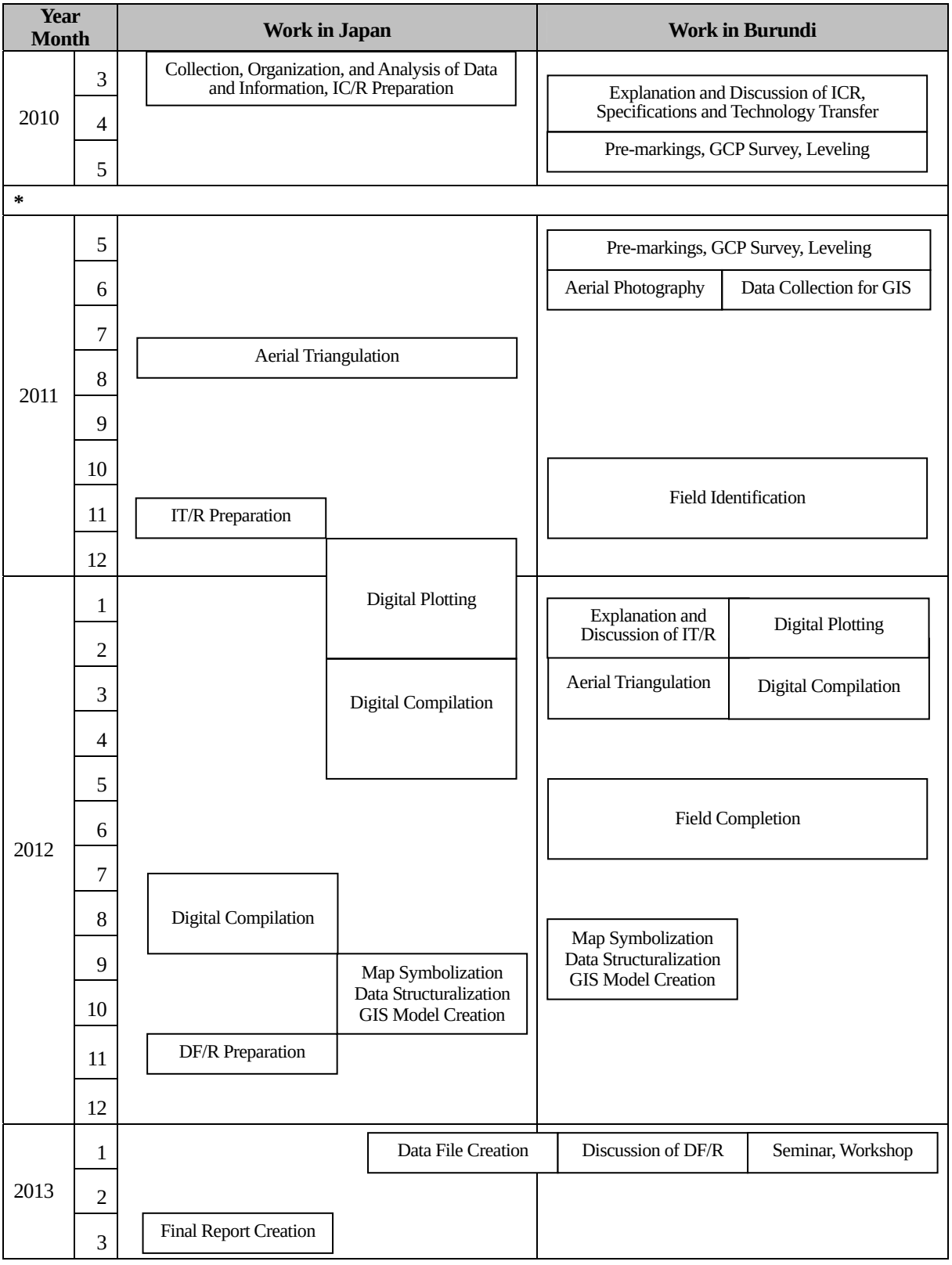


Figure. 3 Workflow of the Study

*****The aerial photography was scheduled for the dry season in Burundi, *i.e.* May and June 2010, when the Project commenced. However, a travel restriction to Burundi was issued for the period between 15th May and 10th August 2010 because of the security situation. Since the past precipitation record predicted an increase in rainfall from mid-August in Burundi, it was impractical to go to Burundi and implement aerial photography after 10th of August.

The aerial photography is the critical path in the entire project and its progress will have significant effects on the entire operation process plan. Therefore, the Study Team concluded that it was appropriate to make a fundamental change in the project processes so that the aerial photography could be commenced in May 2011, when the weather was suitable for aerial photography.

1-4-1. Operation of Each Project Member

The following table shows the Study Team members engaged in the operations hitherto described and the operations under their supervision.

Table. 2 Project Members and Operations under their Supervision

Name	Operation	Details of Operations
Akira SUZUKI	Team Leader/Discussion on specifications	・Management and supervision of the study operations in general ・Planning and evaluation of technology transfer (including seminars) ・Coordination with relevant organizations
Daikichi NAKAJIMA	Aerial Photography	・Management of aerial photography
Masakuni NAKAYAMA	Control Point Survey 1	・Guidance, management, and technology transfer on GPS observation and leveling
Atsushi MOCHIZUKI	Control Point Survey 2	・Guidance, management, and technology transfer on GPS observation and leveling
Akihiro SUGITA	Field Identification and Field Completion 1	・Guidance and technology transfer on field identification and field completion for topographic maps
	Aerial Triangulation	・Guidance and technology transfer on Aerial triangulation
Sadao MATSUMOTO	Field Identification and Field Completion 2	・Guidance and technology transfer on field identification and field completion for topographic maps
	Digital Plotting	・Guidance and technology transfer on Digital Plotting
A.K. SAH	Digital Data Structuralization / Creation of GIS Model Systems	・Technology transfer on digital data structuralization ・Guidance and technology transfer on creation of GIS model systems
Akira OTA	Digital Compilation and Digital Completion	・Guidance and technology transfer on Digital Compilation / Digital Completion
Hitoshi YAMAGA	Map Symbolization	・Guidance and technology transfer on Map symbolization
Eisaku TSURUMI	Project Advisor	・Guidance and advice on the project in general
Marie-Line CHARLES	Interpreter	・Interpretation
Takashi SHIRANI		
Akira OTA	Project Coordinator	・Coordination

1-4-2. Implementation structure in the Study

Implementation structure between Burundian side and Japanese side in the Study is shown below.

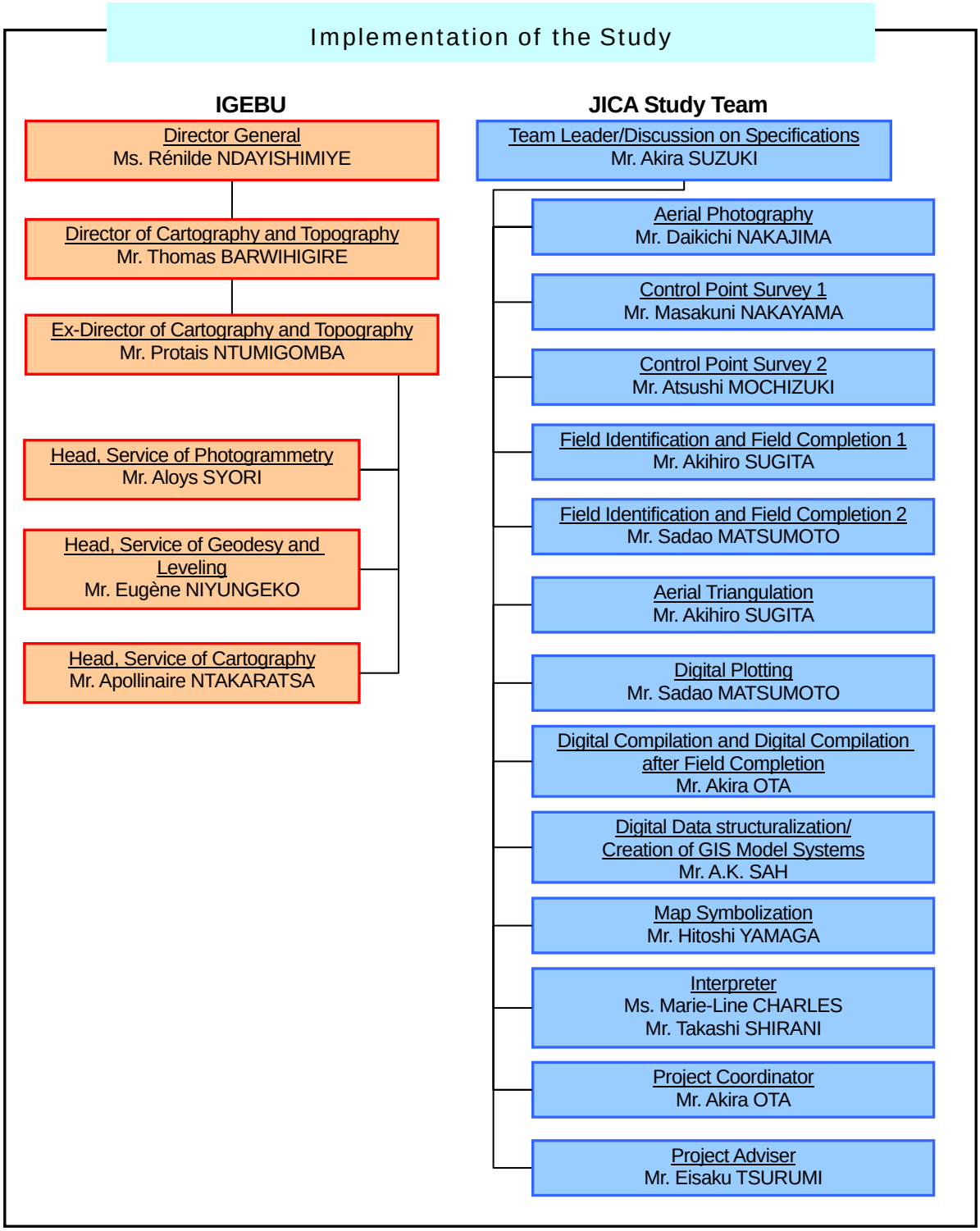


Figure. 4 Implementation Structure in the Study

2. Outputs of the Study and Their Outcome, Recommendation

The implementation of this Study has led to creation of highly accurate and up-to-date topographic maps of the capital city, Bujumbura, and its suburbs and creation of geospatial data required for the formulation and implementation of a capital development plan which is considered as the first step toward national development. The use of the geospatial data created in this Study in background maps will enable sharing of information among government offices using maps and international donor organizations and establishment of the consistency of the positional information. The use of the geospatial data is also expected in the formulation and implementation of various development plans. Additionally, because national original control points were installed and observed their coordinates in the study, new national original control points make up for shortage of existing national control points and will be used into various projects in the future.

2-1. Expected Cases of the Utilization of the Topographic Map Data

Two types of the data, 1/5,000-scale data and 1/25,000-scale data, were created in this Study. The table below shows the characteristics of the two types of topographic maps. The characteristics of the respective maps are expected to create opportunities for their use in the cases described below. The study team discussed with IGEBU on these cases then determined 4 GIS sample models. (See chapter3, 3-22)

Table. 3 Characteristics of the Topographic Maps Created in this Study

	1/5,000-scale topographic maps	1/25,000-scale topographic maps
Area represented on the maps	Bujumbura City	Bujumbura City and its suburbs
Acquisition Standards	Data at the level at which positional information of all residential houses is obtained. Water areas smaller than 20m x 20m are not represented on a map. Vegetation areas smaller than 50m x 50m are not represented on a map.	Data of areas with high building density may be obtained as area data or some buildings in such areas may not be represented on maps. Water area smaller than 100m x 100m are not represented on a map. Vegetation area smaller than 200m x 200m are not represented on a map.
Accuracy	Horizontal accuracy: less than 3.5m	Horizontal accuracy: less than 17.5m
	Contour line interval: 5m Vertical accuracy: less than 2.5m	Contour line interval: 10m Vertical accuracy: less than 5.0m
Use	The use is expected in the formulation and implementation of detailed developmental plans, including those for infrastructure development, for Bujumbura City.	The use is expected in the formulation and implementation of plans concerning people's living and industries in the area including Bujumbura City and its environs.

2-1-1. Expected Cases of Utilization (of the 1/5,000-scale maps)

- Urban planning

The use of the data as basic maps for urban planning, including projects for the development of the urban area and the port area and disaster prevention plans, will enable balanced development of the entire country and extension of public welfare.

- Infrastructure development and maintenance

The use of the data as background maps for data on the maintenance of ground and underground urban facilities (electric wires and water supply and sewerage pipelines) and for development planning will enable prompt service provision to the citizens.

2-1-2. Expected Cases of Utilization (of the 1/25,000-scale maps)

- Natural disaster prevention

As the tree felling for expansion of farmland has reduced the strength of the ground in Bujumbura and its suburbs, large- and small-scale landslides occur everywhere when it rains.

Bujumbura City has suffered from floods caused by rising water levels in Lake Tanganyika. The number of floods caused by overflow of rivers due to heavy rain has been on the increase in these few years. There are areas in the city which are permanently inundated during the rainy season.

The analysis of the topographic data and the data on land use and vegetation will enable the measurement of the scales of landslides and floods and the formulation of a plan for the natural disasters in which items to be protected are prioritized, countermeasures have been prioritized by urgency and their effects have been analyzed.

- Health care

It is now impossible for some of the residents in Bujumbura and those in the peripheral areas of the city, in particular, to receive sufficient medical services because of the shortage of medical facilities such as hospitals and health centers due to the influx people into the capital, Bujumbura, and the uneven areal distribution of these facilities.

Acquisition of the knowledge of the existing problems from the analysis of population of medical services and accessibility with the data on the locations of medical facilities and the population data by residential area in the city will enable the formulation of a plan to construct new medical facilities and upgrade medical services.

- Waste management

Private companies contracted by Bujumbura City dispose of waste in Bujumbura City. However, they are not able to dispose of all waste as the influx of people in the urban area has led to the increase in the amount of waste and a further increase in the amount of waste is expected. Under such circumstances, the use of the topographic maps will enable the government of Burundi or Bujumbura City to establish "a basic policy," "concrete targets" and "basic conditions for the implementation of measures" on the reduction of waste and its appropriate disposal.

- Master plan for agricultural development in the suburbs of the capital

Rational land use will be realized with the use of the maps containing information on topography and land use as basic maps of a master plan for the development of land for agriculture, the main industry of Burundi.

- Education

The maps have the potential to be used as teaching materials for learning how to read maps and interpret topography in elementary education.

2-1-3. Institutions Expected to Use the Topographic Map Data

Institutions expected to be user of above utilization, whom the study team conducted hearings and requested to be donor through the study is shown in the following table.

Bujumbura City has been very cooperative to this Study. It was an active data provider in the process of the GIS model systems creation in this Study. Staff of the city participated in the technology transfer in the data structuralization and GIS model systems creation.

Bujumbura City is also expected to be a potential GIS user. The staff of the city who participated in the technology transfer created a GIS model system for "tax collection." The Study Team hopes that IGEBU and Bujumbura City will join efforts to make great use of the technologies transferred and the outputs created in this Study in the formulation of plans aiming at infrastructure development and service improvement.

The institutions mentioned in the table below which provided data for the creation of GIS model systems in this Study as with Bujumbura City are expected to utilize the outputs of this project.

Table. 4 Institutions Expected to Use the Topographic Map Data

	Expected areas of the utilization		Remarks
Bujumbura City	Urban planning Infrastructure development and maintenance	Utilization for waste management, housing and schools construction, management of roads.	Administrative data and road data are managed with GIS software
Régie des Services Techniques Municipaux (SETEMU)	Infrastructure development and maintenance	Improvement in the efficiency of the control system and quality of the services is expected from the use of the data created in this Study.	Sewage data is managed with GIS software
	Infrastructure development and maintenance	Digitalization of disposal of rainwater data achieves data sharing.	Data sharing is inadequate
Département de Géologie et des Mines, Ministère de l'Energie et des Mines	Natural disaster prevention Agricultural development	Creation of updated geological maps with vector data is expected to create an opportunity for the use of the data created in this Study as background map data in the areas of agriculture and disaster prevention.	The data on the geological maps currently available is raster data and used in GIS software
Régie de production et de distribution d'eau et d'électricité (REGIDESO)	Infrastructure development and maintenance	Transfer of power transmission lines into a digital control system can be achieved with the use of the data created in this Study.	Networks of power transmission lines have been managed on hardcopy (analog)
	Infrastructure development and maintenance	Improvement in the efficiency of the maintenance system and quality of the services is expected from the use of the data created in this Study.	Production stations, water transmission pipes and water tanks have been maintained in GIS software
Ministère de la Santé Publique	Health care	Improvement in the efficiency of the management system and quality of the services is expected from the use of the data created in this Study.	While the ministry has digitized the list of hospitals and health centers, it does not have their positional information.
Institut des Sciences Agronomiques du Burundi (ISABU)	Natural disaster prevention Agricultural development	Creation of updated soil maps with vector data is expected to create an opportunity for the use of the data created in this Study as background map data in the areas of agriculture and disaster prevention.	Soil maps has been managed as hardcopy (analog)
Ministère des Travuax Pubulics et du Transport	Urban planning	Utilization into planning of new administrative zone and business zone, new road establishment.	National roads information has been managed as hardcopy (analog)
Institut de Statistiques et d'Etudes Economiques du Burundi (ISTEEBU)	Urban planning	Utilization into census division	Statistical Yearbook has been managed as hardcopy and digital.
University of Burundi	Study and research at the university	Utilization of the data as teaching materials	The university owns GIS software.

2-2. Mechanism for the Utilization of the Topographic Map Data

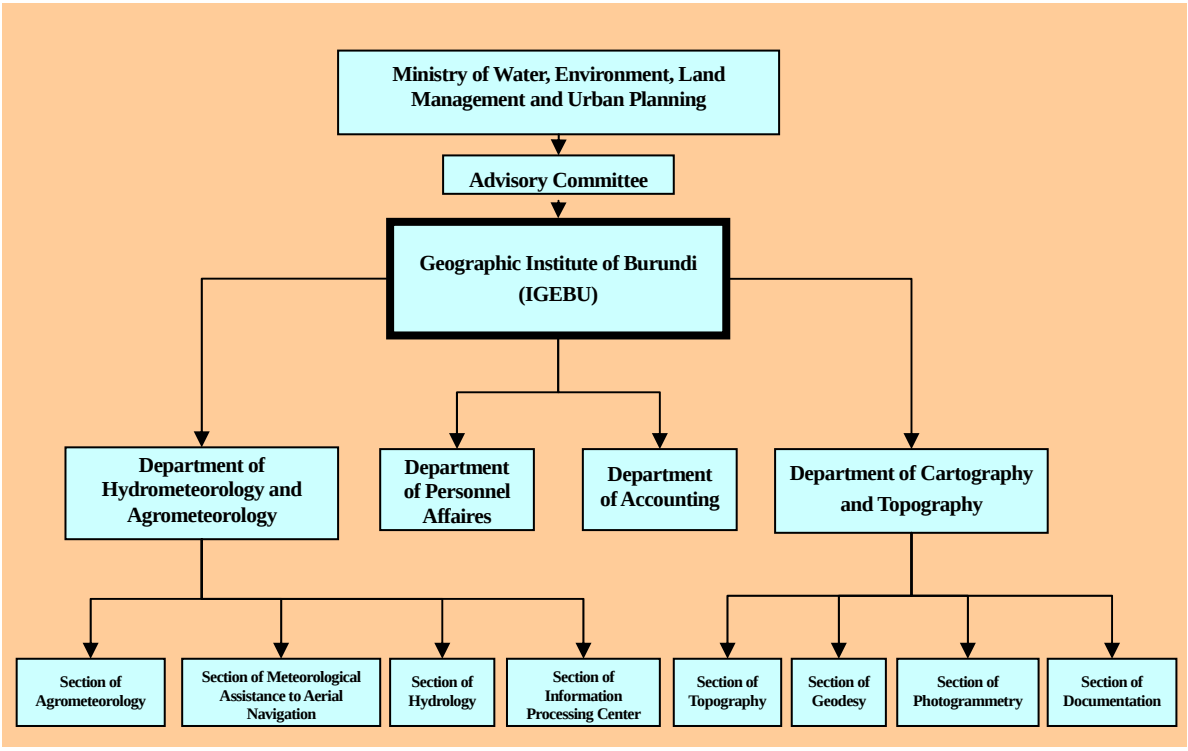
The utilization of the outputs of this Study will be administered by IGEBU. The mechanism for the administration is discussed in the following. It will be also important for IGEBU to cooperate with various government offices, private companies and foreign aid organizations in the administration of the data use.

2-2-1. Organizational Structure and Financial Affairs of IGEBU

IGEBU is under the jurisdiction of the Ministry of Water, Environment, Land Management and Urban Planning. It is headed by the Director General and composed of the Department of Hydrometeorology and Agrometeorology and the Department of Cartography and Topography. The Department of Hydrometeorology and Agrometeorology implements hydrological and meteorological studies and collects hydrological and meteorological data. It has observatories for meteorological observation throughout the country.

The Department of Cartography and Topography takes charge of surveying and map creation. It is the counterpart department of this project. The department has 21 staff members including the director: 5 for the section of geodesy, 4 for the section of photogrammetry, 6 for the section of topography, and 6 for the other service.

The figure below shows the current organizational chart of IGEBU.



The budget for projects excluding the personnel costs of IGEBU is approx. 187.599,360 BIF (approx. 9,380,000 JPY). IGEBU does not have sufficient budget to install control points and create various types of topographic maps. A permanent mechanism for the provision of topographic map data will have to be established for the promotion and extension of the use of the outputs of this project, *i.e.* topographic maps and GIS data, after its completion. In addition, the continuous provision of the maps will always require a stock of consumables for printing. Therefore, financial arrangement will be required for the promotion and extension of the use of the maps and data.

The expected costs of updating the topographic maps will have to be considered when the sales prices of the data created in this Study, including topographic maps, are determined. The concept of the decision-making on the prices is described below. It will be essential to include the costs of depreciation and updating of the topographic maps in the sales prices.

Sales price of a topographic map ＝
(Cost of printing the map) ＋ (Personnel cost) ＋ (Cost of the depreciation of equipment) ＋ (Cost of updating the map)＋(Administrative costs)

The decision on the sales price of a topographic map mentioned above depends on the expected numbers of copies of the topographic maps to be sold in a year. As the number of annual sales of the existing map (1/50,000) is 500, a number of 500 to 1,000 is assumed as the number of annual sales of the topographic map sheets for the time being.

2-2-2. Issues related to Data Utilization

The topographic map data and GIS data to be created in this project are indispensable for the formulation and implementation of development plans for the capital city, Bujumbura, and its environs. Educational activities by IGEBU will be essential for the promotion of their use. IGEBU will have to implement training courses and seminars on the use of the outputs of this project independently. It will also have to promote implementation of GIS projects to be implemented jointly with Bujumbura City and other relevant institutions.

Appropriate control of this digital data will also be an important issue. The digital data shall be stored in appropriate folders in accordance with the rules to be established for data sharing within IGEBU and the stored data shall be backed up on a regular basis for the appropriate management of the digital data.

As Burundi does not have a law controlling unauthorized reproduction of digital data at present, IGEBU is studying an appropriate way to provide the data.

Enactment of such a law will enable establishment of a mechanism to control the unauthorized reproduction, in

which a person who wishes to use the digital data published by IGEBU, such as topographic maps and orthophotos, may do so only after having submitted an application form for the use of the data to IGEBU and having received a permit from IGEBU. Such a permit should state prohibition of reproduction of the data provided by IGEBU, restrictions on the use of the data and prohibition of unintended use of the data.

2-2-3. Recommendation for Operation and Organization of IGEBU in the future

The 1/50,000-scale topographic maps depicting the entire area of Burundi represent the data obtained 30 years ago. Absence of topographic maps representing current data makes the formulation of various development plans difficult. Most of the geodetic control points, reference points for surveying, installed in the past have been lost. Improvement of such poor circumstances requires the implementation of the following projects:

- Creation of 1/50,000-scale topographic maps representing the entire country; and
- Establishment of a network of geodetic control points throughout the country.

The implementation of these projects will require support in the organizational and financial aspects.

For the implementation of these projects, GPS receivers (more than 6 set), Totalstations (more than 3 set), Levels and Staffs (more than 6 set) and vehicles for fieldwork (more than 4) in addition to human resources (more than 15) are recommended to Section of Geodesy. For Section of Topography and Section of Photogrammetry, securement of adequate human resources (more than 10) is recommended to utilize equipments procured in the study effectively. That means Department of Cartography and Topography is required expansion of human resources from present 21 staffs to 31 staffs and also trainings to improve skills of staffs.

What is required in the financial aspect is the increase in the allocation of budget to IGEBU from the Government of Burundi. The revenue from IGEBU's own project activities is also expected. IGEBU will also have to take positive action toward implementation of the projects with assistance from foreign aid organizations such as the EU, the Government of Japan and the World Bank.

2-3. Technology Transfer

2-3-1. Objectives of Technology Transfer

Technology Transfer was implemented about a sequence of work regarding mapping data for the purpose of updating, management and operation of data by IGEBU after the Study.

The Study Team made one of the goals of the technology transfer to give IGEBU staff capability to accomplish independent work such as data updates in the future. As for goal setting, the Study Team considered the limited training period and elementary level of IGEBU staff who have low experience about basic work such as operation of equipment.

After the training, the Study Team evaluated the IGEBU staff based on the goal setting (See Table 5).

Details of each item are described in Chapter 4.

Table. 5 Goal Settings and Achievement Levels of Technology Transfer

Item	Operation	Goal Setting	Achievement Levels and Remaining Issues
Installation of Pre-marks	Installation of pre-marks	Capability of conducting the same operation as in training	The engineers understood appropriate materials, forms, and colors of pre-marks corresponding to image resolutions of photos and conditions on the ground. The speed of installation improved as they repeated the operation.
Control Point Survey and Analysis	Field reconnaissance for selection of control points	Capability of conducting the same operation (survey plan and GPS observation and analysis) as in training	The engineers understood the basic items such as coordinate systems and map projection.
			The engineers understood the point allocation in accordance with the photographing plan. They will be able to formulate a point allocation plan by themselves when they implement a new control point survey in future.
			The engineers understood the basic operations of handheld GPS receivers such as registration of points and point names. The remaining issue is to improve operation speeds, understand accuracies, and understand acquisition locations.
			Training on photo interpretation could not be provided because the technology transfer was conducted using topographic maps.
	GPS observation		The engineers understood basics and basic operations of static survey. They can conduct static observation of new points by themselves. They became capable of implementing applicative operations such as kinematic survey.
	GPS analysis		The engineers understood basic operations of analysis software. They understood analysis results and limit values. IGEBU became able to conduct observation and analysis of a new control point network on their own.
	Theory of GNSS (GPS) Basics of coordinate transformation	Capability of understanding GNSS theory and coordinate transformation	The engineers deepened their basic understanding of GNSS (GPS) theory, coordinate systems, and coordinate transformation.
Field Identification	Pre-Interpretation	Capability of implementing works with the same level as in training	The engineers understood works and targets (map symbols) of the Field Identification.
	Field identification		The engineers came up to the level of implementation of target identification in the field with Handheld GPS and Orthophoto.
	Work result arrangement		The engineers understood works in quality control and result arrangement (leaking, mistake, join).
Aerial Triangulation	Operation of PC and software	Capability of implementing	The engineers acquired basic function and operation.

	Understanding of theory of digital aerial Triangulation		The engineers basically understood general, need, work, and importance.
	Evaluation method of the result		The engineers basically understood investigation and solution of errors from result of adjustment.
Digital Plotting	Operation of PC and software	Capability of IGEBU's own creation for mapping data on Gitega city in the future	The engineers acquired basic function and operation.
	Operation of stereo plotter		The engineers acquired basic function and operation. Further understanding of TopoMouse is favorable.
	Data acquisition based on the SPEC and the map scale		The engineers acquired know-how of data acquisition of each feature after a considerable lag.
Digital Compilation / Digital Completion	Editing of plotting data	Capability of IGEBU's own creation for mapping data on Gitega city in the future	The engineers understood base of digital compilation and also errors occur frequently in digital plotting.
	Detection and modification of logical error (Data cleaning)		The engineers understood setting of tolerance in auto-detection of errors and difference between auto-processing and interactive-processing.
	Polygon creation		The engineers understood purpose and method of polygon generation and errors that occur frequently in polygon creation.
	Administrative boundary and annotation input		The engineers accomplished polygon creation of existing administrative boundary by referring to orthophoto created in the study.
Map Symbolization	Map symbolization	Capability of IGEBU's own creation for mapping data on Gitega city in the future	The engineers understood acquisition rule based on the scale.
	Head-up quality control and modification		The engineers acquired effective work skills such as feature based quality control.
	Printed map quality control and modification		The engineers understood the final picture of 1/50,000 symbolization by quality control with printed map in defined size.
Field Completion	Field completion	Capability of implementing works with the same level as in training	The engineers came up to the level of implementation of target identification in the field with Handheld GPS and maps for field completion.
	Work result arrangement		The engineers understood works in quality control and result arrangement
Data Structuralization	Understanding of GIS overview	Capability of implementing works with the same level as in training	The engineers understood the overview of GIS and definition of GIS structure.
	Operation of GIS software (ArcGIS)		The engineers acquired operation of the latest version of GIS software.
GIS Model Systems Creation	Applied operation of GIS software	Capability of generating GIS models with the same level as in training	The engineers were able to make a presentation about data generation and its result. Edification to concerned organizations and cultivation of new donors are favorable.

2-3-2. Thoughts on the Technology Transfer

The Study Team considers that the achievement in the technology transfer in this Study was satisfactory in all the subjects. The attitude of the IGEBU staff members in the technology transfer clearly showed their eagerness and enthusiasm for acquiring new knowledge and technologies and the eagerness and enthusiasm was a major factor contributing to the successful implementation of the technology transfer.

The IGEBU staff members conducted a ground control point survey independently using the equipment procured in this Study after they had completed the technology transfer. The fact that they managed to obtain outputs which satisfied the specifications proves that the technology transfer in the ground control point survey was successfully implemented.

The IGEBU staff members implemented the indoor processes from the field identification/aerial triangulation to the digital data structuralization independently using a map sheet of Gitega City. They were expected to practice these processes after the completion of the study. The fact that they managed to complete the work in each process proves that they have understood the concept of each process and how to implement basic work in each process during the technology transfer in these subjects.

The IGEBU staff members held discussion and created the four GIS model systems which they were expected to create by themselves in the technology transfer in the GIS model systems creation. This fact proves that their capacities have reached the level at which they can create model systems by themselves.

The Study Team hopes that the IGEBU staff members will improve the efficiency of the work by making use of the functions of the hardware and software provided in this Study while creating topographic maps of the rest of Gitega City with the knowledge and technologies which they have acquired in the technology transfer in this Study.

The Study Team also hopes that the IGEBU staff members will implement educational activities for the purpose of increasing the numbers of donors to other government offices and users of the GIS data.

3. Contents of the work performed

3-1. Collection, Organization, and Analysis of Relevant Data and Information [Work in Japan]

Map specifications (draft) were created based on the data collected by the preliminary Study Team and the results of independent investigation carried out and information collected in Japan by PASCO.

Existing information used for Map specifications was existing map (1/50,000) and in deliberation of Map specifications, Japanese map symbols (1/5,000 and 1/25,000) were referred for acquisition items and result of field reconnaissance was referred for acquisition standard.

3-2. Creation of Inception Report [Work in Japan]

After analyzing and examining the project instructions, preliminary study report, and the above-mentioned collected data, an inception report, which includes work policy of the study, method, and work process, was created.

3-3. Explanation and Discussion on Inception Report [Work in Burundi]

The content of the Inception Report proposed by the Study Team was discussed with IGEBU and the proposal was agreed upon by IGEBU. (See Appendix-1 about MM)

3-4. Discussion on Specifications [Work in Burundi]

As a result of discussion between IGEBU and the Study Team, the specifications of topographical maps to be created were determined as shown in the following table:

Because Burundi is located between 2 UTM zones (zone35 whose central meridian is east longitude 27° and zone36 whose central meridian is east longitude 33°), IGEBU requested to have central meridian as east longitude 30° to manage whole country in a zone. Since the length in the east-west direction of Burundi is less than 200km, IGEBU figured out 0.9999 is adequate value as the scale factor.

Table. 6 Determined Map Specifications

Items		Decision	Grounds
Height criteria		The existing control points shall be used.	Elevation of existing benchmarks
Reference ellipsoid		WGS84	Request from IGEBU
Geographic coordinate system		WGS84	
Central meridian		30°E	
False-Easting (m)		500,000.0	
False-Northing (m)		10,000,000.0	
Scale factor		0.9999	
Map specifications (Acquired items)	1/5,000	See "Appendix-5: Burundi_map_specifications_5000 "	Discussion with IGEBU based on proposition of the Study team
	1/25,000	See "Appendix-6: Burundi_map_specifications_25000 "	
Map specifications (Contour line interval)	1/5,000	Principal contourline: 5m, Index contourline: 25m, Supplementary contourline: 2.5m	Based on Japanese standard
	1/25,000	Principal contourline: 10m, Index contourline: 50m, Supplementary contourline: 5m	
Sheet No. Sheet Name	1/5,000	Rule of Sheet No. was determined through discussion (See Fig. 5).	Divide 1/50,000 sheet into 100
	1/25,000	Rule of Sheet No. and name of each sheet were determined through discussion (See Fig. 5).	Determine in mind user convenience
Marginal information	1/5,000	Determined through discussion (See Fig. 6).	Conform to the rule of existing map 1/50,000
	1/25,000	Complied with the rules of existing topographical maps of 1/50,000 and determined through discussion (See Fig. 6).	
Annotation		Cette carte topographique a été réalisée conjointement par l'Agence Japonaise de Coopération Internationale (JICA) et le Gouvernement de la République du Burundi, dans le cadre du Programme de Coopération Technique du Gouvernement du Japon.	

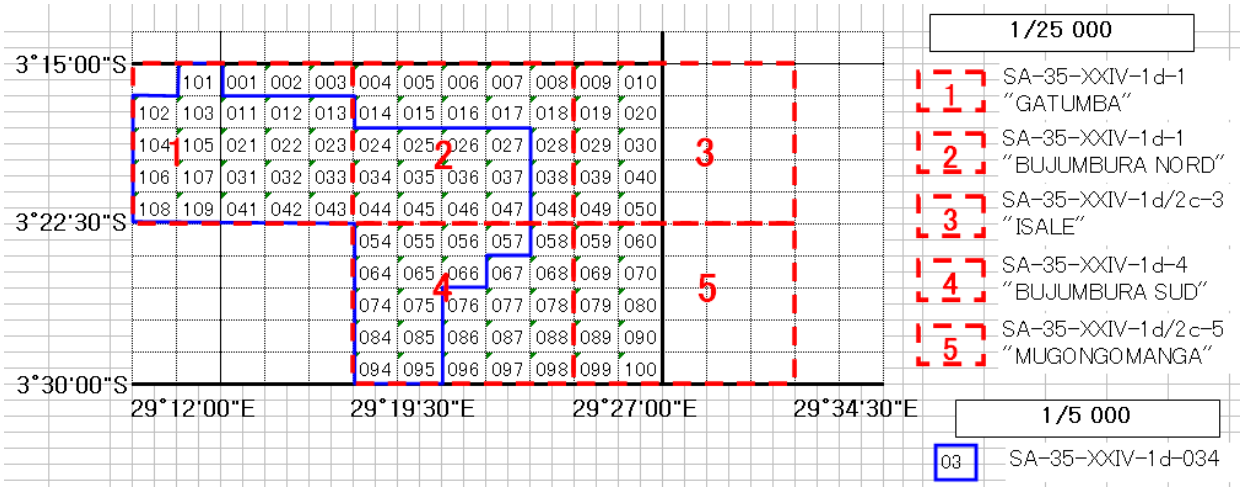


Figure. 5 Sheet No. and Sheet Name Determined between the IGEBU and the Study Team

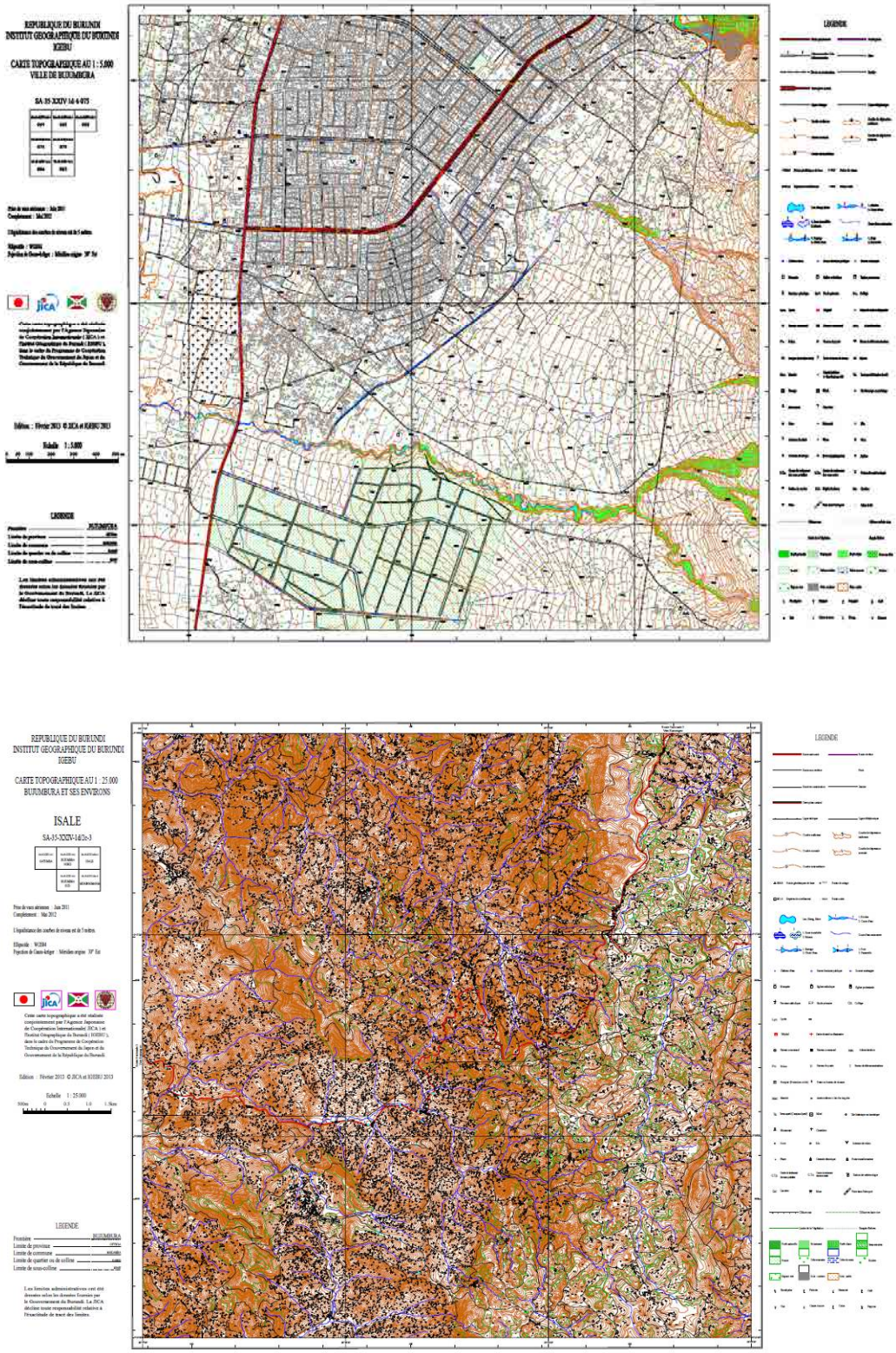


Figure. 6 Marginal Information Determined between the IGEBU and the Study Team (Top: 1/5,000, bottom: 1/25,000)

3-5. Fact-finding [Work in Burundi]

By way of utilizing mapping data and GIS data created in the Study, the IGEBU and the Study Team implemented hearing and field reconnaissance for the purpose of ascertaining difficulties of Burundi and to create sample models exemplifying utilization which make use of characteristics of precision and work area of the mapping data.

Since natural disasters caused by rain fall are the most serious issue in the Bujumbura city, Flood control and disaster-prevention measures and Landslide control measures were chosen as GIS sample model. From the result of hearing, there were some requests concern about utilization of the outputs from the study such as planning of new load establishment from Ministère des Travuax Pubulics et du Transport, management and effective planning of location for medical facilities from Ministère de la Santé Publique, Waste management from Bujumbura City, Census division from ISTEEBU, after discussion between IGEBU and the Study team about these requests, Waste management and Health care were additionally chosen as themes for GIS models.

Table. 7 Chosen GIS sample models

	GIS Sample Model	Description
1	Flood control and disaster-prevention measures	Detection of potential flood area and degree of hazard in urban area by using topographical analysis with contour line.
2	Landslide control measures	Detection of potential landslide area by using slope analysis with topographical data such as contour lines, soil data and land use data.
3	Waste management	Detection of solid waste emission by using special analysis with building, road, population data etc.
4	Health care	Selection of optimal sites for medical facilities through spatial analysis using road data, medical facilities data, statistical data, etc.

3-6. Collection of Survey Results [Work in Burundi]

The collected survey results and field reconnaissance results revealed that there is no national control point usable in this operation but confirmed several national benchmarks.

Table. 8 Result of Verification for National Control Points in the Study Area

National control point	State of preservation	Evaluation
National control points	All have been lost or broken.	Not useful to the Study (Installation of new national control points is required by continuous GPS observation for 48 hours and baseline analysis with IGS points in neighboring countries.)
National benchmarks	Forty-four existing benchmarks usable for this Study were confirmed.	Used in the Study

3-7. Fact-finding of Organizations, etc. Related to Dissemination of Maps and Geographical Information [Work in Burundi]

The Study Team investigated the current situation of organizations that are possible users of topographic maps and GIS data other than IGEBU and held explanatory meetings on this project for these organizations. In the meetings, the IGEBU director and Study Team members explained the outline of this project and the expected GIS models to be created in the project, etc. and promoted exchange of opinions, approximately shareable data and technology transfer. The questions raised in the explanatory meetings and participants are described as follows.

- Method of future update of data generated in the study
- Participation in the technology transfer
- Example of using elevation model generated in the study.

Table. 9 List of Participants in Explanatory Meeting

Name		Organization	Title
1	Gordien NGENDAKUMANA	Municipal Technical Services (SETEMU) of Bujumbura	Section chief of audit, planning, and investigation section
2	Jean-Marie MUCOMWIZA	Bujumbura City	Manager of information science department
3	Frédéric BIGIRUKWAYO	Bujumbura City	Manager of engineering department
4	Célestin MUSAVYI	Municipal Technical Services (SETEMU) of Bujumbura	Manager of road management and rainwater drainage department
5	Judith NTAWUYANKIRA	Municipal Technical Services (SETEMU) of Bujumbura	Manager of maintenance department for heavy machinery, vehicles, and other equipment
6	René MADEBARI	Municipal Technical Services (SETEMU) of Bujumbura	Manager of urban waste and real estate management department
7	Harouna HAMADI	Municipal Technical Services (SETEMU) of Bujumbura	Manager of business and finance department
8	Alice NIJIMBERE	Municipal Technical Services (SETEMU) of Bujumbura	Staff for wastewater piping network management
9	Théophile MAMIRAMPA	Bujumbura City	Staff in engineering bureau
10	Protais NTUMIGOMBA	IGEBU	Director
11	Eisaku TSURUMI	JICA Study Team	Adviser
12	Akira SUZUKI	JICA Study Team	Team Leader
13	A.K. SAH	JICA Study Team	GIS Engineer
14	Marie-Line CHARLES	JICA Study Team	Interpreter


Figure. 7 Presentation Meeting of the Study

3-8. Operations Related to Technology Transfer [Work in Burundi]

The IGEBU and the Study Team discussed the technology transfer regarding items and contents then agreed as per the following table.

Since the IGEBU side additionally requested for technology transfer on the outline and theory of GNSS (GPS) and coordinate transformation, agreement was reached on the implementation of it.

Table. 10 Result of Discussion on Technology Transfer

Item	Decision	
Installation of Pre-marks	IGEBU shall arrange for at least five engineers and one full-time technical coordinator	
Control Point Survey and Analysis	IGEBU shall arrange for at least five engineers and one full-time technical coordinator Technology transfer on the outline and theory of GNSS (GPS) and coordinate transformation shall be included.	
Field Identification / Field Completion	IGEBU shall arrange for at least five engineers and one full-time technical coordinator	
Aerial Triangulation	Use 36 models of Aerial photos on Gitega city area for exercise.	
Digital Plotting	1/5,000	Target area for exercise shall be approx. 7km^2 in Gitega Area.
	1/25,000	Target area for exercise shall be approx. 25km^2 in Bujumbura Area
Digital Compilation / Digital Completion	1/5,000	Target area for exercise shall be approx. 7km^2 in Gitega Area.
	1/25,000	Target area for exercise shall be approx. 25km^2 in Bujumbura Area
Map Symbolization	1/5,000	Target area for exercise shall be approx. 7km^2 in Gitega Area.
	1/25,000	Target area for exercise shall be approx. 25km^2 in Bujumbura Area
Data Structuralization	1/5,000	Target area for exercise shall be approx. 7km^2 in Gitega Area.
	1/25,000	Target area for exercise shall be approx. 25km^2 in Bujumbura Area
GIS Model	1/5,000	GIS Model 1: Flood control and disaster-prevention measures
	1/25,000	GIS Model 2: Landslide control measures
	1/5,000	GIS Model 3: Waste management GIS Model 4: Health care

The equipment and materials procured for the technology transfer were received and their appropriate functioning was verified at IGEBU in October 2010. The equipment and materials for the technology transfer are described as follows.

Table. 11 Equipment and Materials for Technology Transfer

Name of Equipment		Q'ty
GPS Survey Equipment		2
Analysis software for GPS		1
Accessory (RTK mobile station)		1
Simple stereoscopes		4
Handheld GPS		4
Digital Cameras		4
Basic Software for Aerial Triangulation/ Plotting/Compilation	LPS Core	2
	LPS Stereo	2
	ORIMA DP-TE/GPS	1
	PRO600	2
	LPS ATE	1
	LPS TE	1
Software for Plotting/Compilation	MicroStation V8 XM Edition	2
	Bentley Map V8 XM Edition	2
Software for GIS Structuralization	ArcGIS ArcInfo	2
Software for GIS Application	ArcGIS 3D Analyst	2
	ArcGIS Network Analyst	2
	ArcGIS Spatial Analyst	2
Image Processing Software	Adobe Photoshop	1
Software for Map Symbolization	Adobe Illustrator	2
Document preparation software	Adobe Acrobat	1
Hardware	Mouse for Photogrammetry	2
	3D displays	2
	Work stations	2
	PCs	2
	LCD Monitors	4
	UPSs	4
	Printer and consumables for A0	1
	Printer and consumables for A3	1

3-9. Control Point Survey and Installation of Pre-marks [Work in Burundi]

The study implemented the Control survey and installation of pre-marks based on the following workflow. The location of the control points (pre-marks) and the specification referred are described as follows.

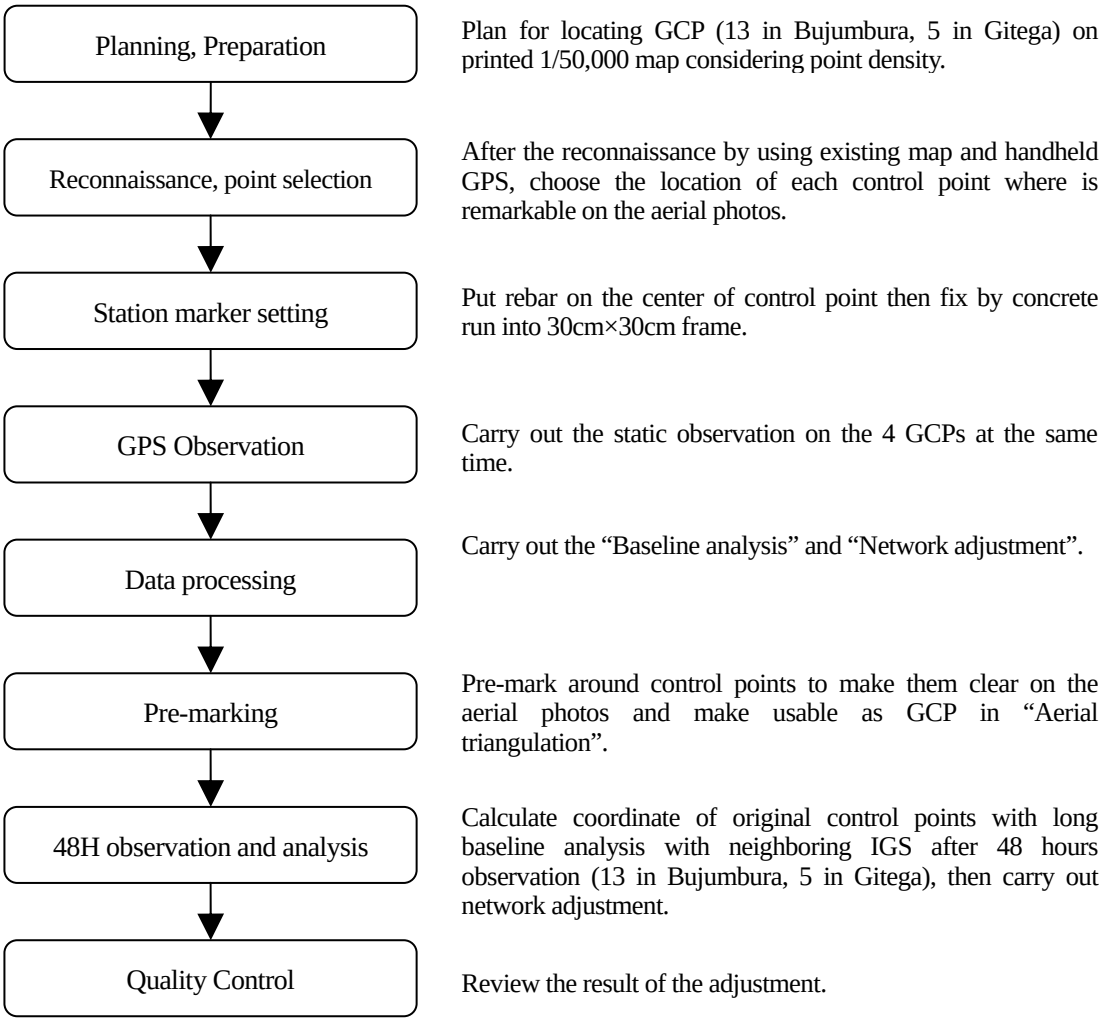


Figure. 8 Workflow of Control Point Survey and Pre-marking

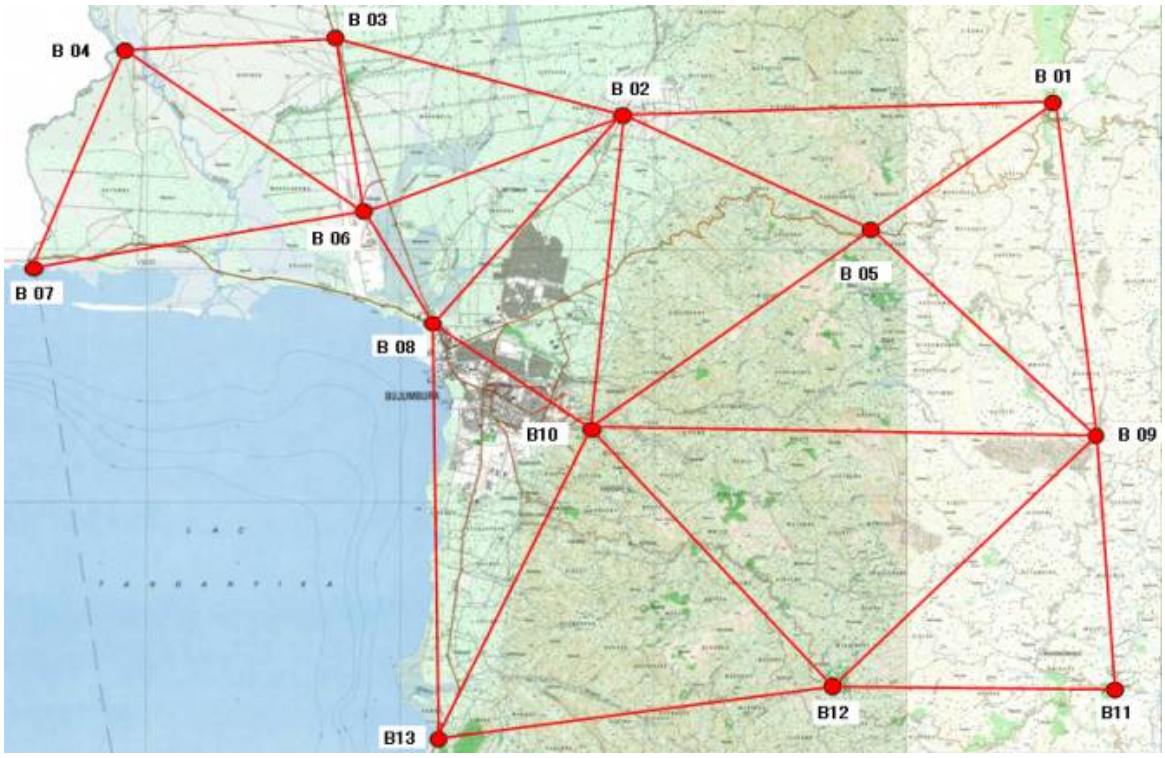


Figure. 9 Location of Control Points and Observation State (Bujumbura Area)

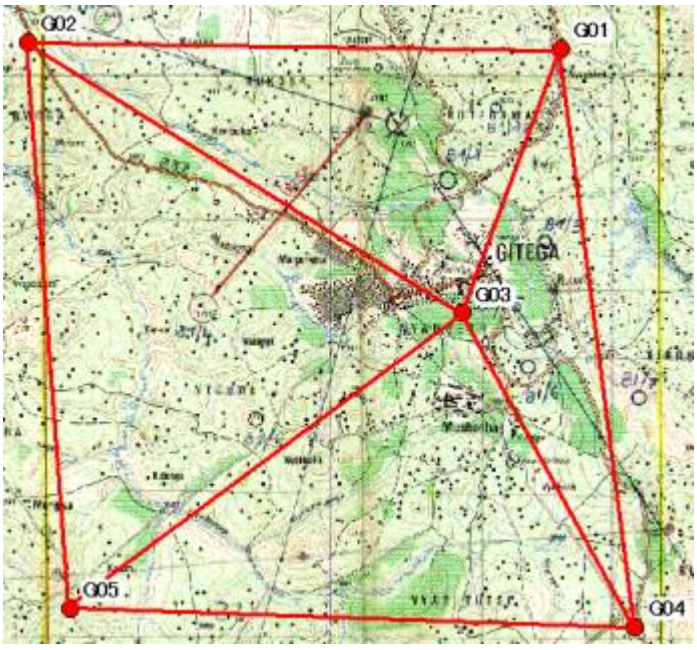


Figure. 10 Location of Control Points and Observation State (Gitega Area)

Table. 12 Specifications and Tolerance of GPS Observation

	Item	Specification or limit value
1	Pre-marks	Cross type (size of a feather: 0.75m×1.5m)
2	GPS receiver	Trimble R7 GNSS
3	Measuring accuracy	±5ppm×distance
4	Elevation angle	15 degrees or more
5	Number of satellites	Six satellites or more
6	Observation time	60 minutes or more
7	Epoch interval	15 seconds
8	Maximum baseline length	About 20km
9	Software for analysis	Trimble Business Center Advanced
10	Reference Ellipsoid	WGS 84

Figure. 11 GPS Observation

(Left: scene of GPS observation, right: Trimble R7 GNSS receiver)

3-10. Leveling [Work in Burundi]

The Study Team implemented the Leveling based on the following workflow. The leveling routes and the specification are described as follows.

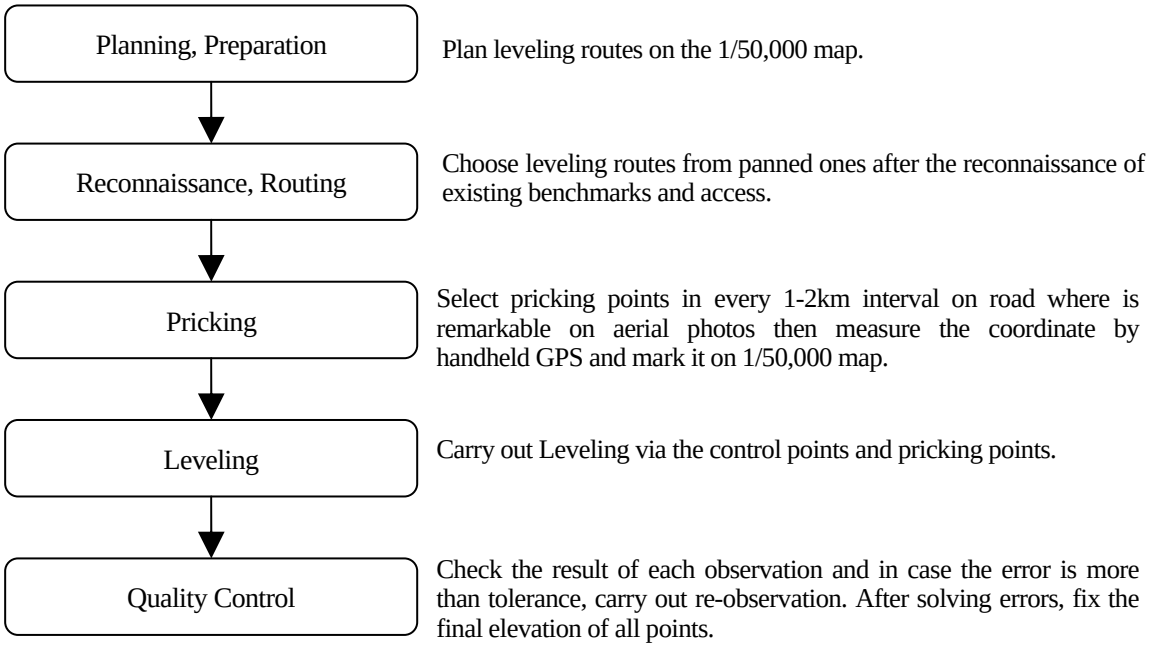


Figure. 12 Workflow of Leveling

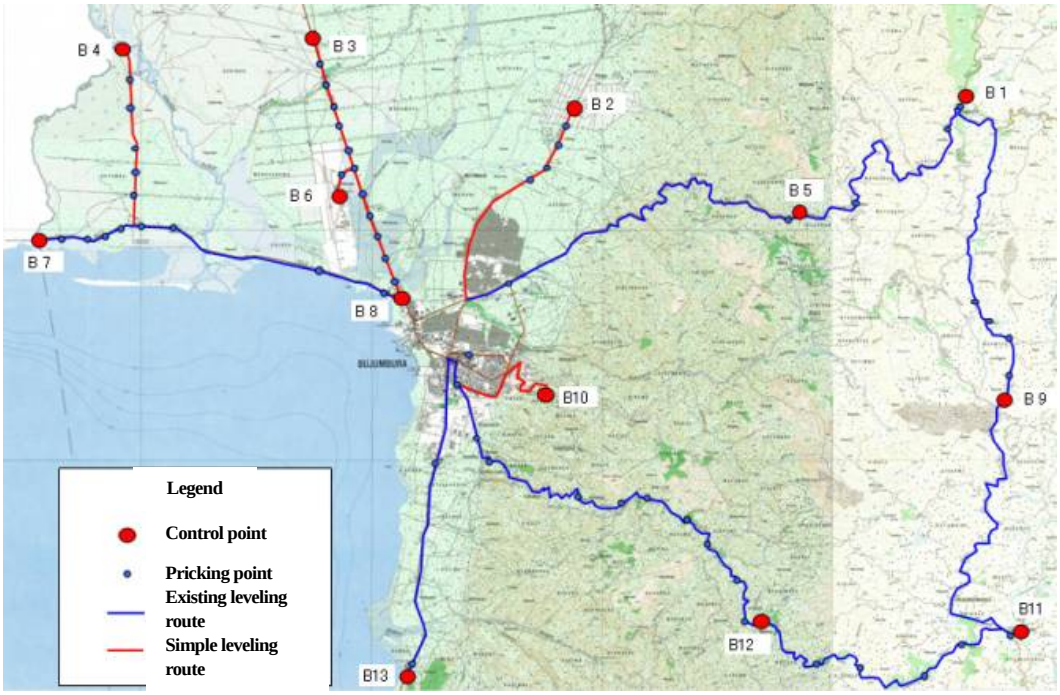


Figure. 13 Leveling Routes (Bujumbura)

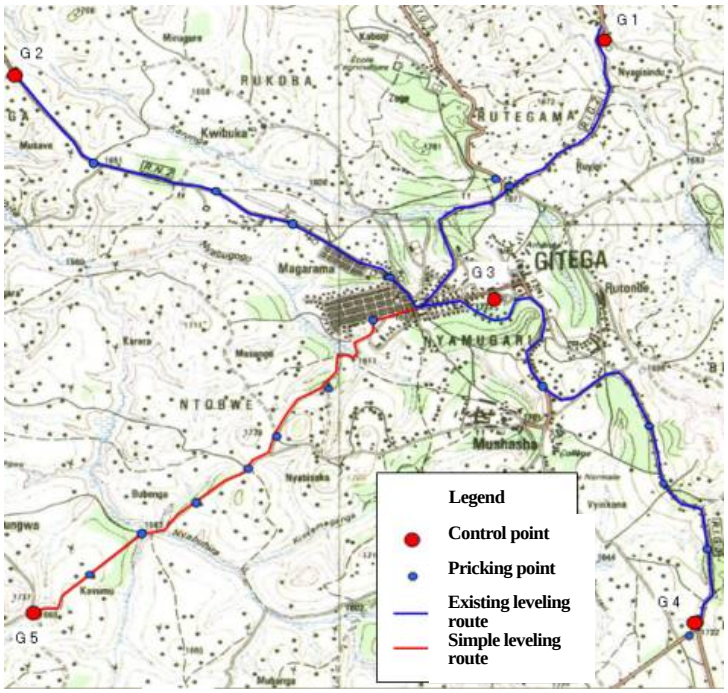


Figure. 14 Leveling Routes (Gitega)

Table. 13 Specifications for Leveling and Tolerance

	Articles	Specification, Tolerance
1	Reference Benchmarks	44 points (national benchmarks) inside the plotting area. (ver. 1991)
	New Benchmarks	97 points (GCP: 18 points, Pricking: 79 points)
2	Method	Direct Leveling
		Go-Around observation
3	Equipment	Auto Level merchandised by Wild Koln
4	Tolerance for operation errors between benchmarks	+-40mm√S (S: distance (km) between benchmarks)

Figure. 15 Leveling work

(Left: existing benchmark, right: leveling)

3-11. Aerial Photography [Work in Burundi]

In this Study, aerial photography was conducted using cutting-edge aerial digital cameras based on a combined use of GPS/IMU. Workflow, flight index and specification of the aerial photography are shown below.

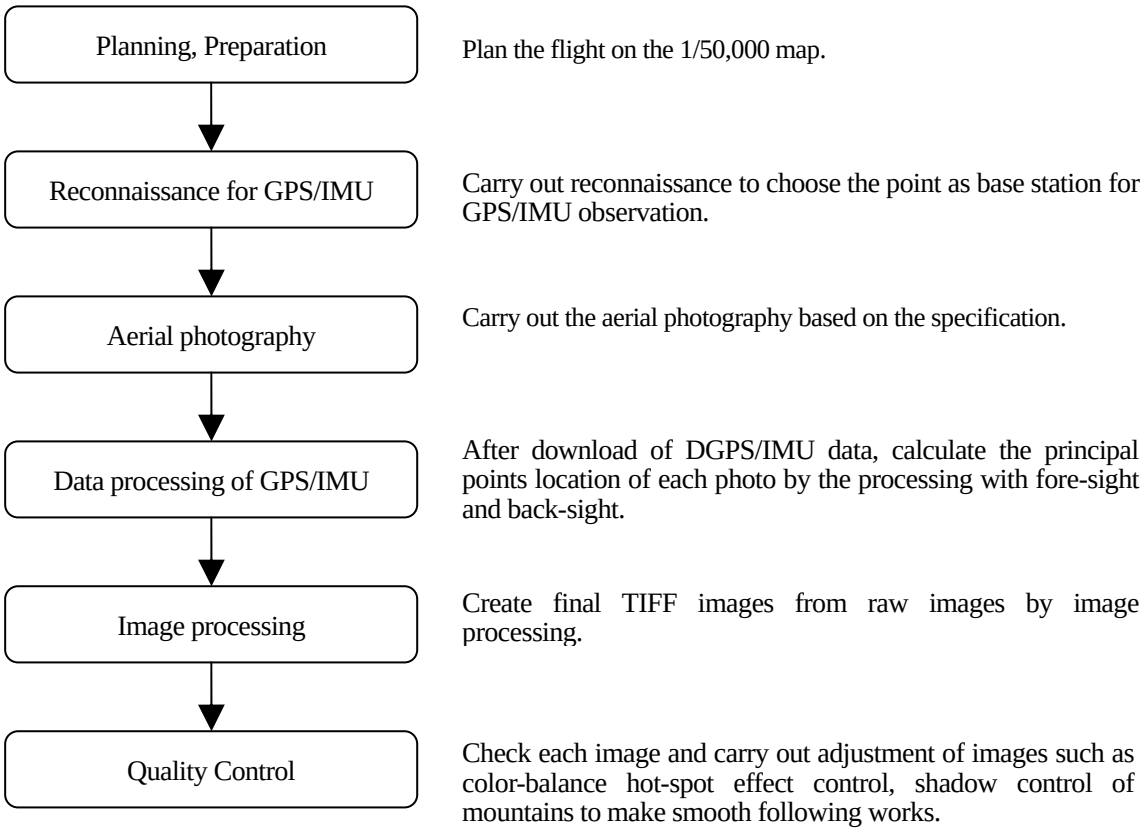


Figure. 16 Workflow of Aerial Photography

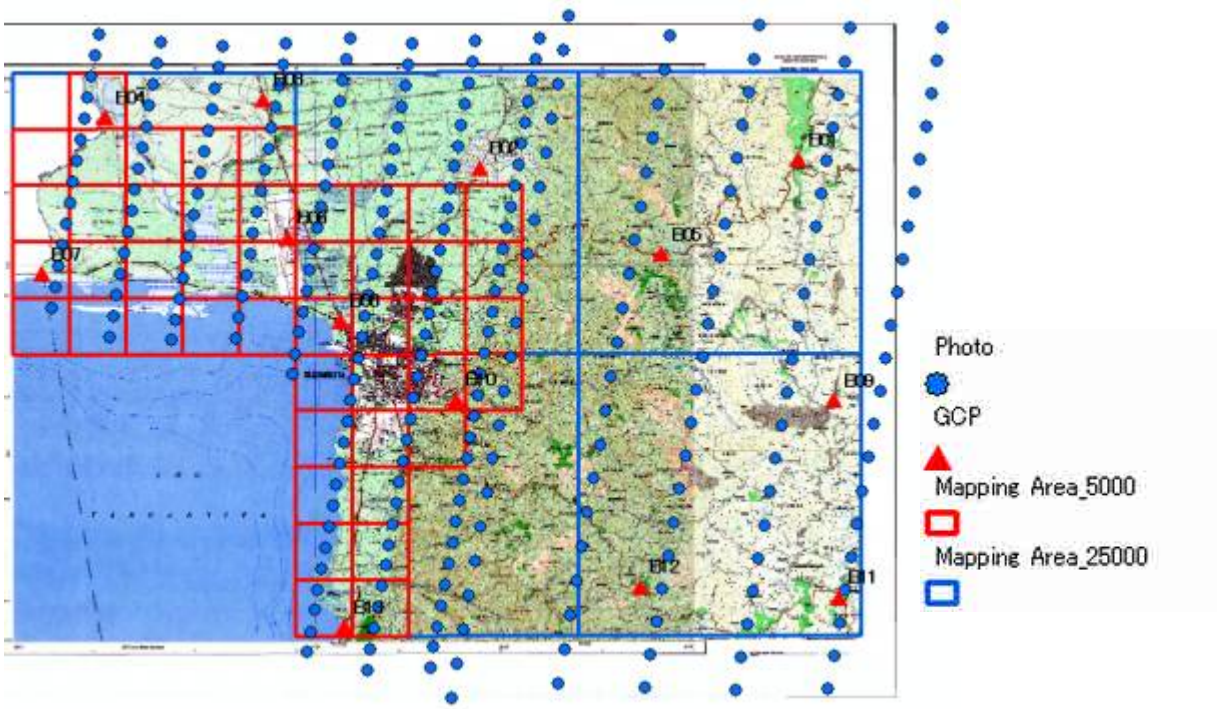


Figure. 17 Photography Map (Bujumbura Area)

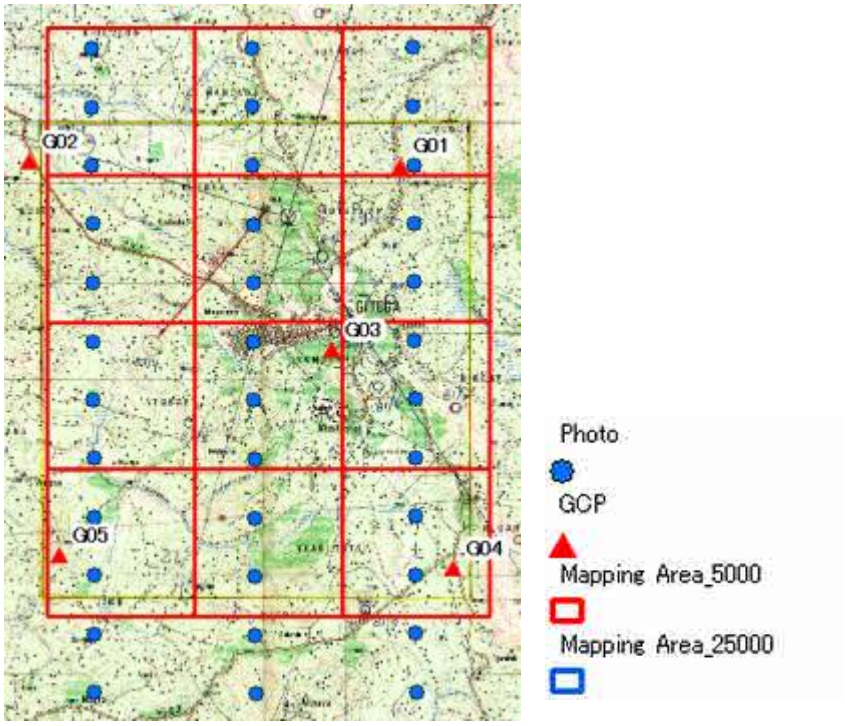


Figure. 18 Photography Map (Gitega Area)

Table. 14 Aerial Photography Specifications

Item		Specifications	
		1/5,000	1/25,000
Photographing resolution		30cm	50cm
Image type		TIFF format, Color (RGB, 8-bit)	
Photographing course		8 courses (Bujumbura) 3 courses (Gitega)	5 courses (Bujumbura)
Number of images acquired		268	148
Aircraft used for photography		Twin Commander 690A (registration number N32PR)	
Camera		Name: UltraCam X digital aerial camera (Vexcel) Image size: 9420pix×11430pix Pixel size: 7.2 micron Focal length: 100.5mm Lens Distortion: <0.002mm	
Above ground level		4,810m to 8,522m	
Lap		Over lap: 60% Side lap: 30%	
Allowable cloud cover		Less than 3% to 5% in five continuous photos	
Photographing conditions		Using the attitude angle acquired by IMU and the coordinates of the photo principal points acquired by DGPS	
GPS/IMU	Material	Airplane: Novatel antenna & ANT-A72GA-TW-N Base station observation: Trimble R7 and JAVAD LGG 100-GG	
	Processing	Software: GrafNav (ver. 8.2)	
Image processing		Processed in Burundi Software: Ultramap Image Processing (ver. 2.1)	

Figure. 19 Photographing Equipment

(Left: aircraft used for photography, right: digital camera, GPS/IMU)

3-12. Aerial Triangulation [Work in Japan / Work in Burundi]

The aerial triangulation in this Study was conducted using the acquired aerial photo image data, GPS/IMU, and coordinates of control points as shown in the flowchart below. The result of Aerial Triangulation (Residual Errors) is described in Table 15.

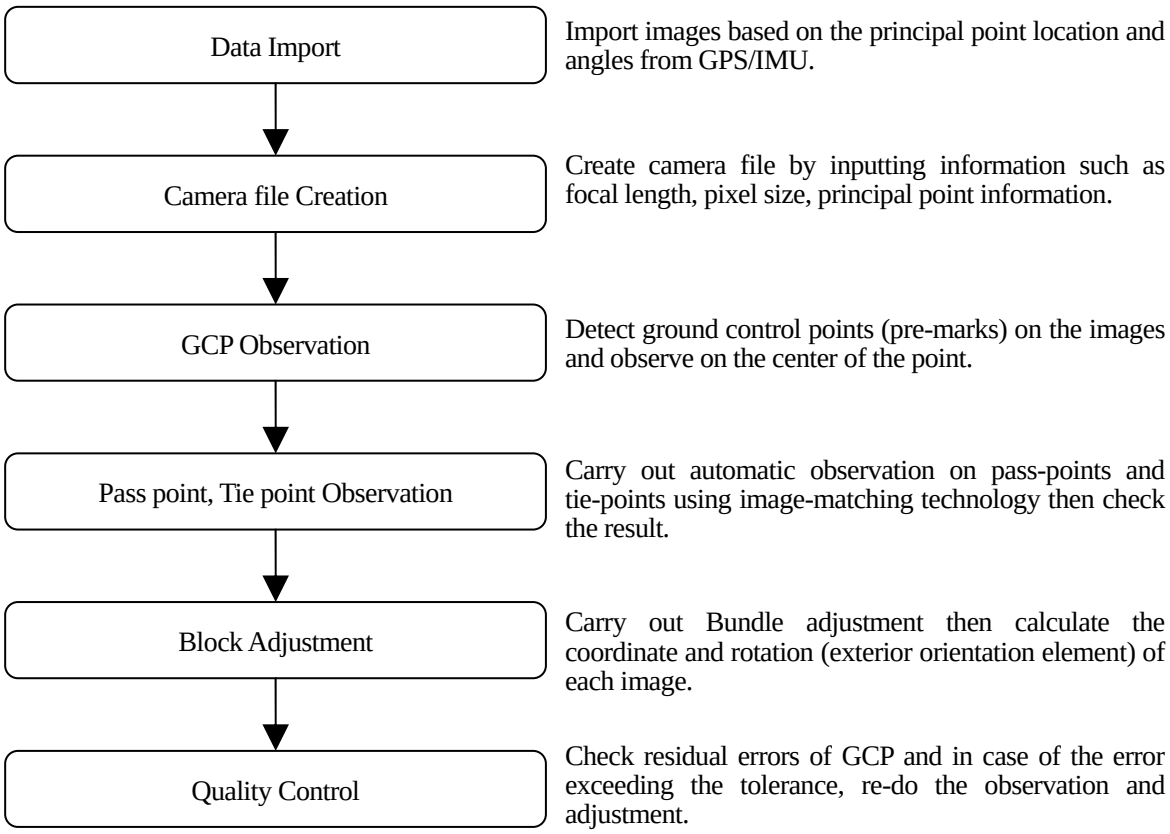


Figure. 20 Workflow of Aerial Triangulation

Table. 15 Control Point Residual Errors

Block		Bujumbura			
		Resolution of 30cm		Resolution of 50cm	
		Residual error	Tolerance	Residual error	Tolerance
Standard deviation (m)	Horizontal location	0.10	0.56	0.09	0.93
	Elevation	0.06	0.56	0.05	0.93
Maximum value (m)	Horizontal location	0.22	1.11	0.15	1.85
	Elevation	-0.08	1.11	-0.06	1.85

The Technology transfer was implemented with Photogrammetric Workstation and Photogrammetric software (LPS: Leica Photogrammetry Suite) on the target area which was determined between IGEBU and the Study Team.

3-13. Preparation of Interim Report (IT/R) [Work in Japan]

The Interim Report was created to summarize the details and results, progress statuses, etc. of work completed so far.

3-14. Field Identification [Work in Burundi]

Field identification was implemented with existing documents and easily created Orthophotos along the following workflow.

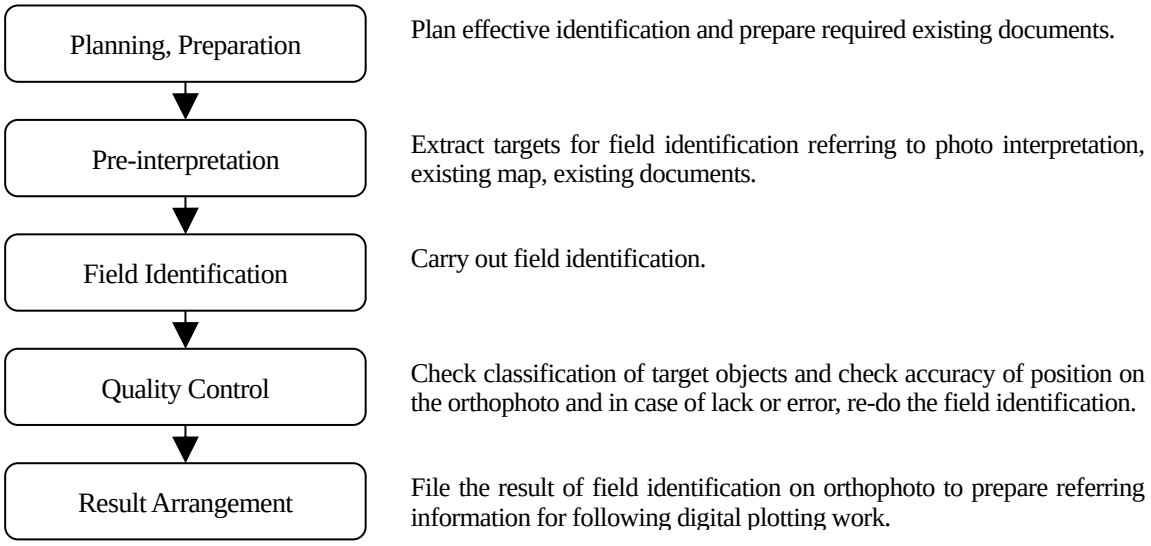


Figure. 21 Workflow of Field Identification

1/5,000 mapping area is included 1/25,000 mapping area as shown in following figure, the result of Field Identification on 1/5,000 area was applied for 1/25,000 duplicate area for the purpose of effective work.

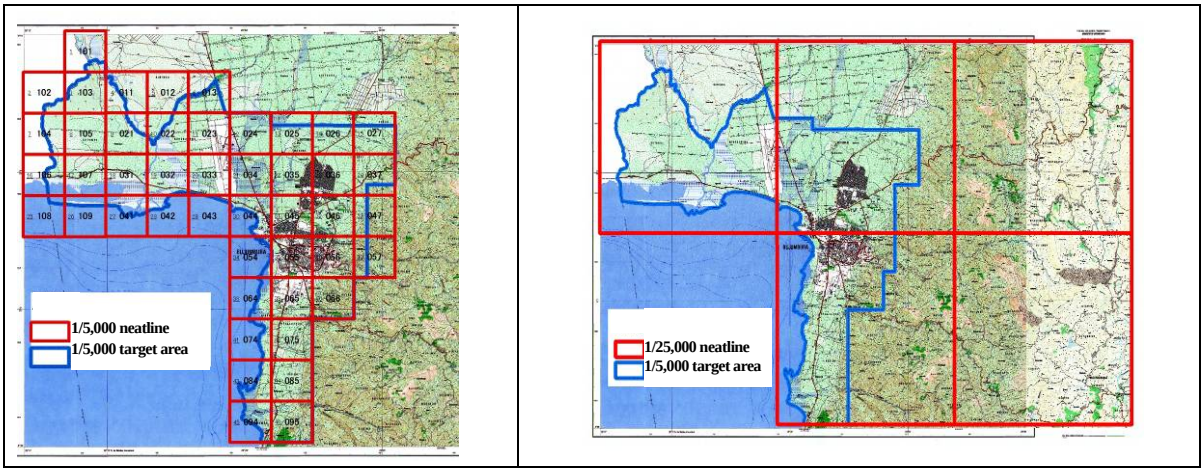


Figure. 22 Work Area of Field Identification

(Left: 1/5,000, right: 1/25,000)

3-14-1. Planning and Preparation

Briefing of the work and method about Field Identification to IGEBU staff was implemented at first, then determined work plan, organization of teams, and assignment of map sheets. The number of IGEBU staff who participated in this work was 8 people therefore 4 teams (2 staffs/team) were organized.

- Road condition according to weather
- Distribution of features and density of settlements
- Experience of IGEBU staff

The Study Team prepared the following items for each team. The Orthophoto was printed on a scale of1/5,000 for the work of 1/5,000 map, and was printed on a scale of 1/12,500 for the work of 1/25,000 to make the interpretation on the orthophoto easier. That means 4 printed orthophotos were required to accomplish 1 map sheet of 1/25,000.

All orthophotos were printed with grid lines which allow the operator to detect position of target on the orthophoto by handheld GPS easily.

- Orthophotos (printed orthorectified images)
- Symbol catalogue for field identification
- Drawing board, stationery (pen, scale, note, etc.)
- Handheld GPS
- Phone number list of Fieldwork members (Security precaution)

Figure. 23 Printed Orthophoto

(Left: 1/5,000, right: 1/25,000)

3-14-2. Pre-Interpretation

Pre-interpretation work was implemented on printed orthophotos with existing map before field identification, extracted and ordered the target objects for the field identification.

3-14-3. Field Identification

Field identification was implemented based on the pre-interpretation and following items were verified in the field. Before going to field, joint training to all participants (8 IGEBU staff) was implemented for several days (See details in Chapter 4).

Target features were traced on printed orthophotos and the location was registered by handheld GPS. The positional data was saved and the coordinate was noted at the same time. This digital and analogue method might be a backup system in case of accidental deletion of data in Handheld GPS.

The work was implemented by IGEBU staff and the study member staff followed each team to instruct the work and manage them.

- Verification of pre-interpretation
- Verification of features which have difficult or impossible interpretation on the aerial photos
- Required information for application of map specification
- Required information annotation

Bad road conditions and rains sometimes prevented the work from going smoothly because the work area included mountainous areas however the work was accomplished without any trouble nor accident with the help of system to keep close contact. The work lasted 3 weeks for the 1/5,000 area and 3 weeks for the 1/25,000 area.

Figure. 24 Field Identification

(Left: location registration, right: acquisition of picture)

3-14-4. Quality Control

Printed orthophoto tracing the result of the field identification was checked then in the case that a lack of information or unclear parts were detected, re-identification was implemented.

3-14-5. Result Arrangement

After modification of result from the quality control, final information was traced on printed orthophotos.

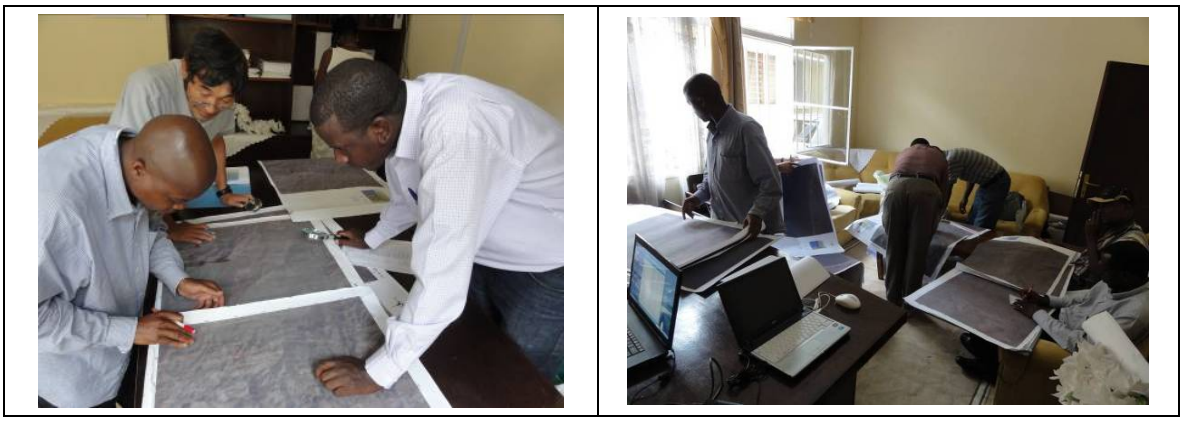


Figure. 25 Arrangement of Field Identification Result

3-15. Explanation and Discussion of Interim Report (IT/R) [Work in Burundi]

The Interim Report was explained to IGEBU and discussion was held on the results of operations up to field identification, reference coordinate system of map, map specification, marginal layout, policy for technology transfer and GIS models, etc. Before the explanation and discussion, a presentation was provided using a PowerPoint file prepared in advance to summarize the content. The result of the discussion was recorded in Minutes of Meeting, which was to be signed by both parties. (See Appendix-2 about MM)

Figure. 26 Discussion for IT/R

(Left: on report, right: on marginal layout)

3-16. Digital Plotting [Work in Japan and Work in Burundi]

Digital mapping data for digital completion was generated through digital plotting with the field identification result and stereo models of the aerial photos from aerial triangulation and feature shapes and locations were acquired as geographic information along the following workflow. Data type and category of features were interpreted and classified based on the acquisition code and definition. Unclear parts in the interpretation work or toward field identification were extracted and filed as the target of field completion.

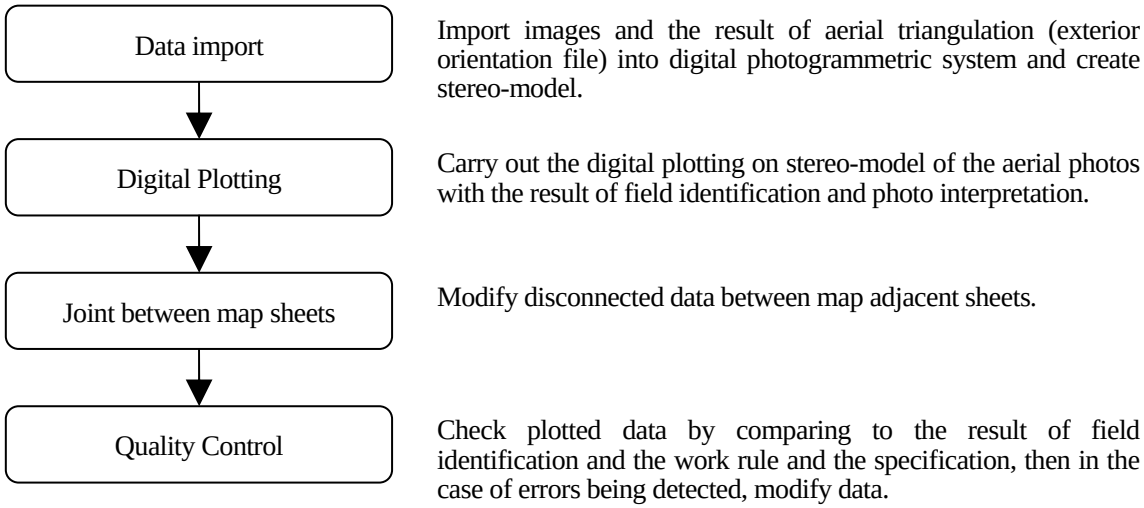


Figure. 27 Workflow of Digital Plotting

Figure. 28 Digital Plotting

(Left: 1/5,000, right: 1/25,000)

The Technology transfer was implemented with photogrammetric workstation and photogrammetric software (LPS: Leica Photogrammetry Suite) and CAD (MicroStation) on the target area which was determined between IGEBU and the Study Team (See Chapter 4).

3-17. Digital Compilation [Work in Japan and Work in Burundi]

Digital compilation of the plotted data was implemented based on map symbols and data acquisition rule, data cleaning such as modification of adequate data shape and elimination of unnecessary data was implemented then used to create topology in the areas which become polygons.

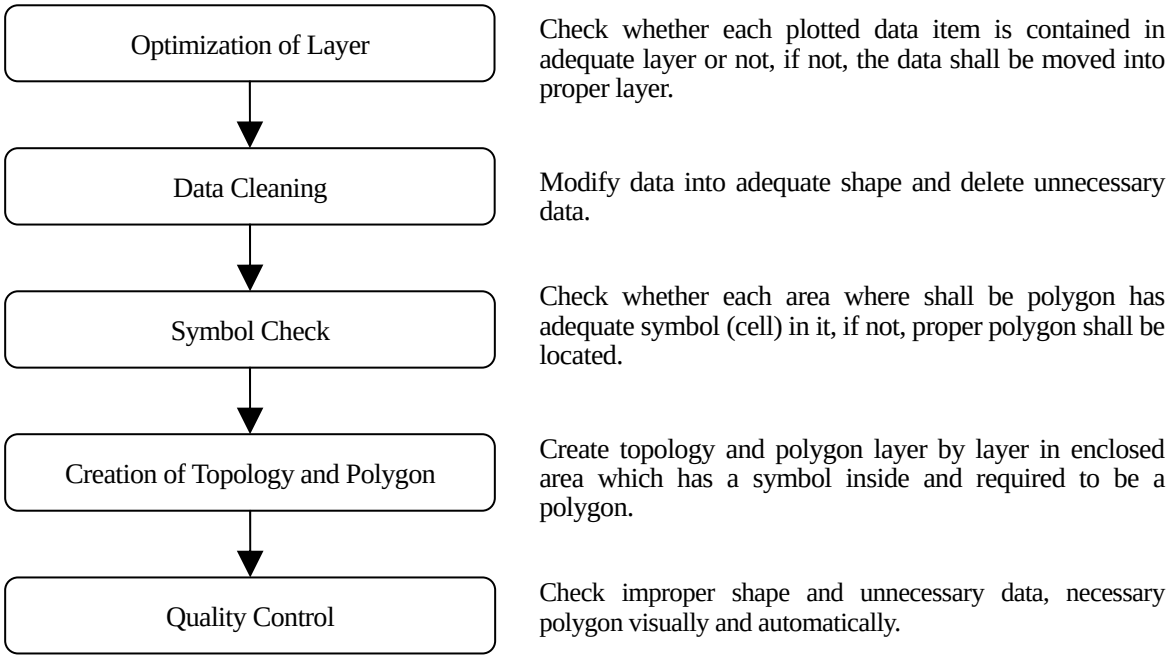


Figure. 29 Workflow of Digital Compilation

The technology transfer was implemented with CAD (MicroStation and Bentley Map) on the plotted data by IGEBU in the technology transfer of digital plotting (See Chapter 4).

3-18. Field Completion for Topographic Maps [Work in Burundi]

Field completion was implemented for the purpose of obtaining high quality of mapping data with re-identification of uncertain information occurred from the digital plotting and the digital compilation work. Additionally, verification of annotations such as river names and university names was implemented. The work area was same as the field identification.

In the work, printed maps with simplified symbolization after digital compilation of both 1/5,000 and 1/25,000 scale were carried into the field.

As well as the field identification, duplicate areas in 1/25,000 area to 1/5,000 area use the result of 1/5,000 field completion.

The workflow is described as follows.

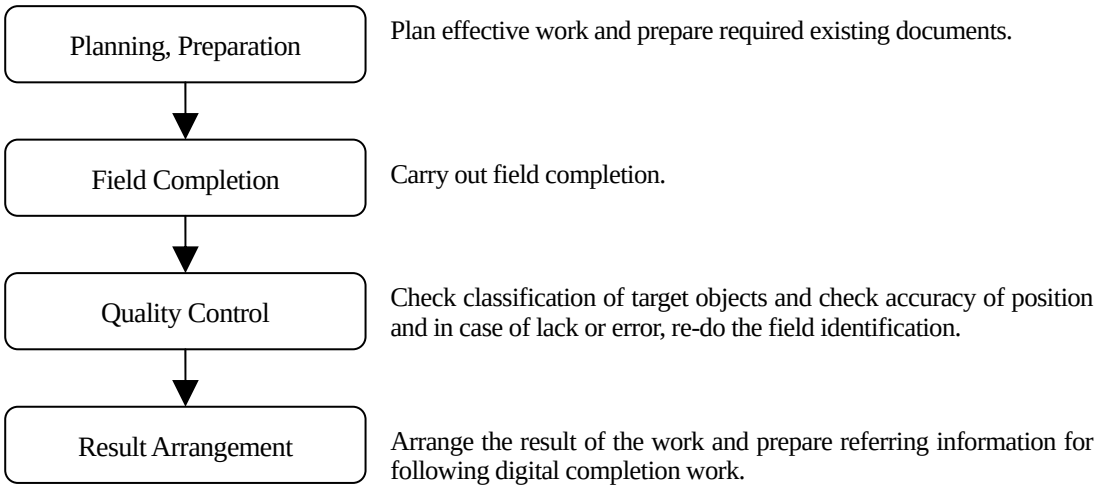


Figure. 30 Workflow of Field Compilation

3-18-1. Planning, Preparation

Briefing of the work and method about Field Identification to IGEBU staff was implemented at first. Work method, team organization (2 staff / team × 4 teams) and equipment carried into the field were the same as the field identification except the maps. Additionally, the orthophotos described the result of the field identification were carried as reference information.

- Printed map for the field completion (with simplified symbolization and the result of the field identification)
- Symbol catalogue for field identification
- Drawing board, stationery (pen, scale, note, etc.)
- Handheld GPS
- Phone number list of field work members (Security precaution)

3-18-2. Field Completion

The following survey items were verified in the field and results were described on the map also the locations were registered by Handheld GPS. If needed, comparison to the result of the field identification was implemented.

- Unclear and invisible features on the stereo model in the plotting work
- Necessary items for application of map symbols
- Necessary items for annotations

3-18-3. Quality Control

Check the result of field completion on the map, in the case leaking or unclear parts were detected, re-field

completion was implemented.

3-18-4. Result Arrangement

The maps which were used in field completion had been tainted from field work and disorder of description for following work. Results of the field completion were neatly copied on newly printed maps to allow effectiveness of following work of the digital completion.

Figure. 31 Result Arrangement

(Left: work, right: result)

3-19. Digital Compilation after Field Completion [Work in Japan and Burundi]

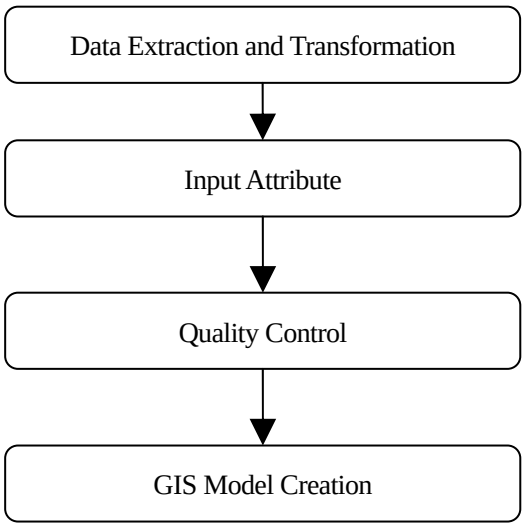
The digital compilation after field completion was implemented for the purpose of incorporating the outputs of the field completion into the topographic map data. In practice, new data obtained in the field completion at certain positions was processed in the same way as in the digital compilation. The data on administrative boundaries and annotations were added to the output data of the digital compilation after field completion to create topographic map data.

The technology transfer was implemented with the data of the target area of the technology transfer selected in the consultation between the IGEBU and Study Team created by the IGEBU side, and the CAD application (Bentley Map). (See Chapter 4.)

3-20. Structuralization of Digital Data [Work in Japan and Burundi]

The topographic map data created in the digital compilation after field completion was structuralized into digital data which could be used in GIS in accordance with the provisions of the specifications determined in the Discussion on the Specifications. The topographic map data was structuralized into practical and easy-to-use GIS basic data which could be used for a wide variety of purposes.

The 1/5,000-scale and 1/25,000-scale topographic map data was structuralized into two sets of GIS data at respective scales.



Extract required data from the data created in the digital compilation after field completion and convert the data formats to those which can be read with the GIS software by data type.

Add attributes required for the GIS analysis to the data using the GIS software.

Verify whether the data required for GIS basic data is included in the structuralized data with the visual and automatic inspection.

Define the range of each model, analyze the structuralized data with the collected reference data and create a GIS model.

Figure. 32 Workflow of Data Structuralization

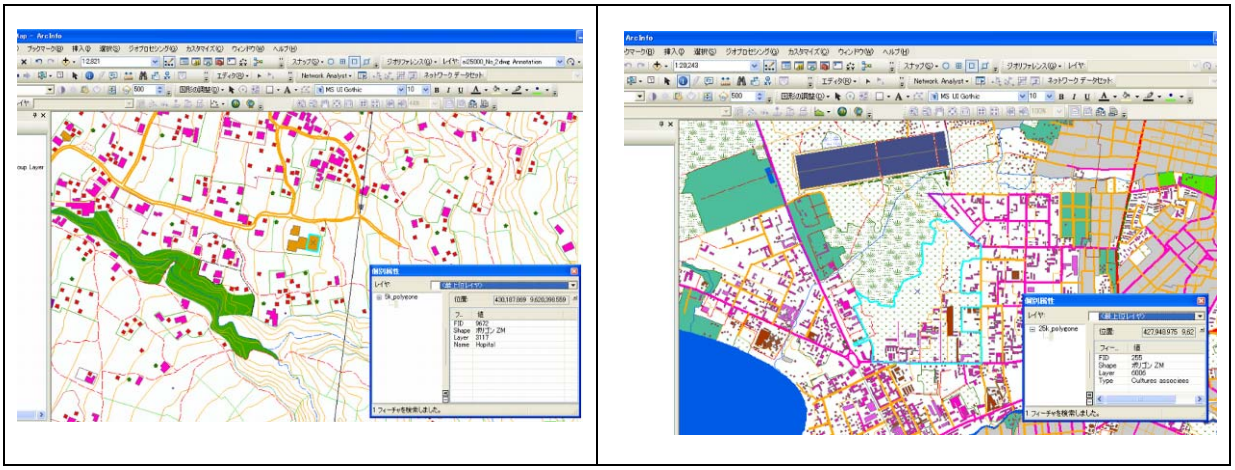


Figure. 33 Structuralization Data

(Left: 1/5,000, right: 1/25,000)

In the technology transfer, GIS software (ArcGIS) was used for the structuralization of the topographic map data of the target area of the technology transfer selected in the consultation between the IGEBU and the Study Team which were created by the IGEBU staff members in the digital compilation after field completion. (See Chapter 4.)

3-21. Map Symbolization of Topographic Maps [Work in Japan and Burundi]

Map symbols were provided to the topographic map data created in the digital compilation after field completion in the map symbolization in accordance with the map specifications determined in the Discussion on the Specifications. As the representations on topographic maps and data acquisition criteria differ between the topographic maps at the different scales, CAD software (MicroStation) and graphic software (Illustrator) were used in the map symbolization for the creation of the 1/5,000 and 1/25,000 topographic maps, respectively. While data of many planimetric features is acquired with actual shapes and at actual positions at the scale of 1/5,000, a large number of features are symbolized with simplified shapes and approximate positions at the scale of 1/25,000. Illustrator is very useful in the symbolization of features for the creation of the 1/25,000 topographic maps as it is good at creating colors and printing in color. For the reasons mentioned above, the two different types of software were used in the map symbolization in order to maximize the work efficiency and to make the best use of the two types of software at the respective scales.

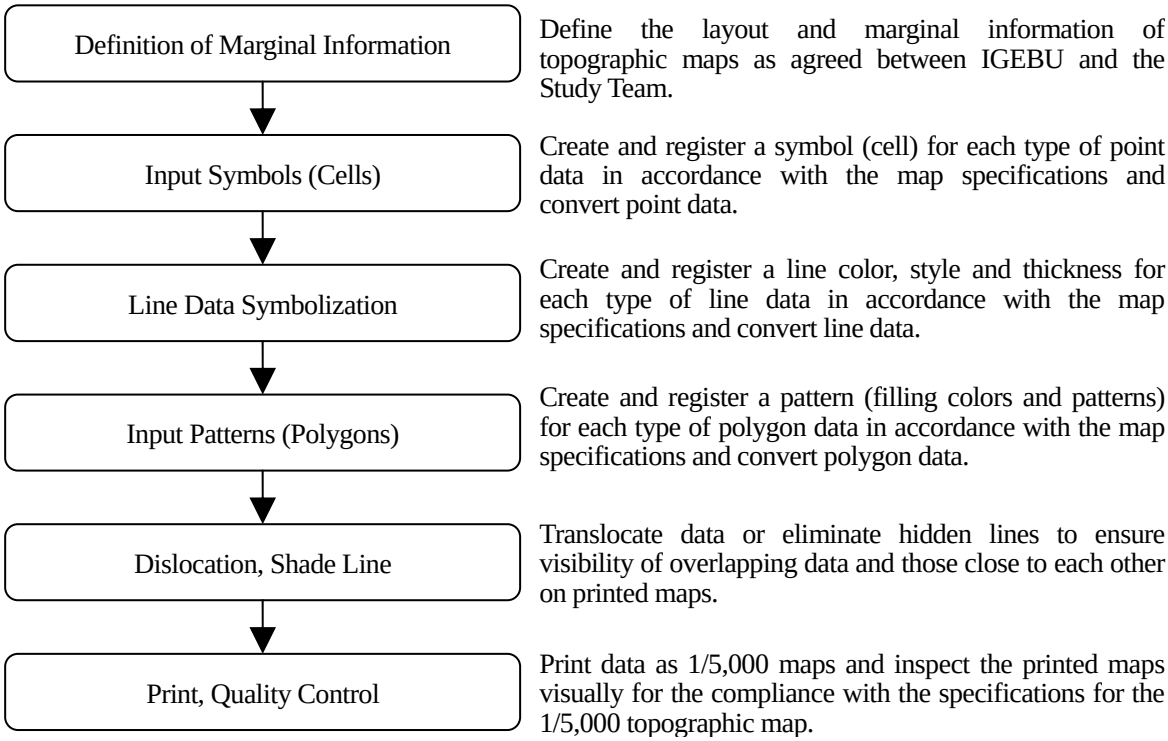


Figure. 34 Workflow of Map Symbolization (1/5,000)

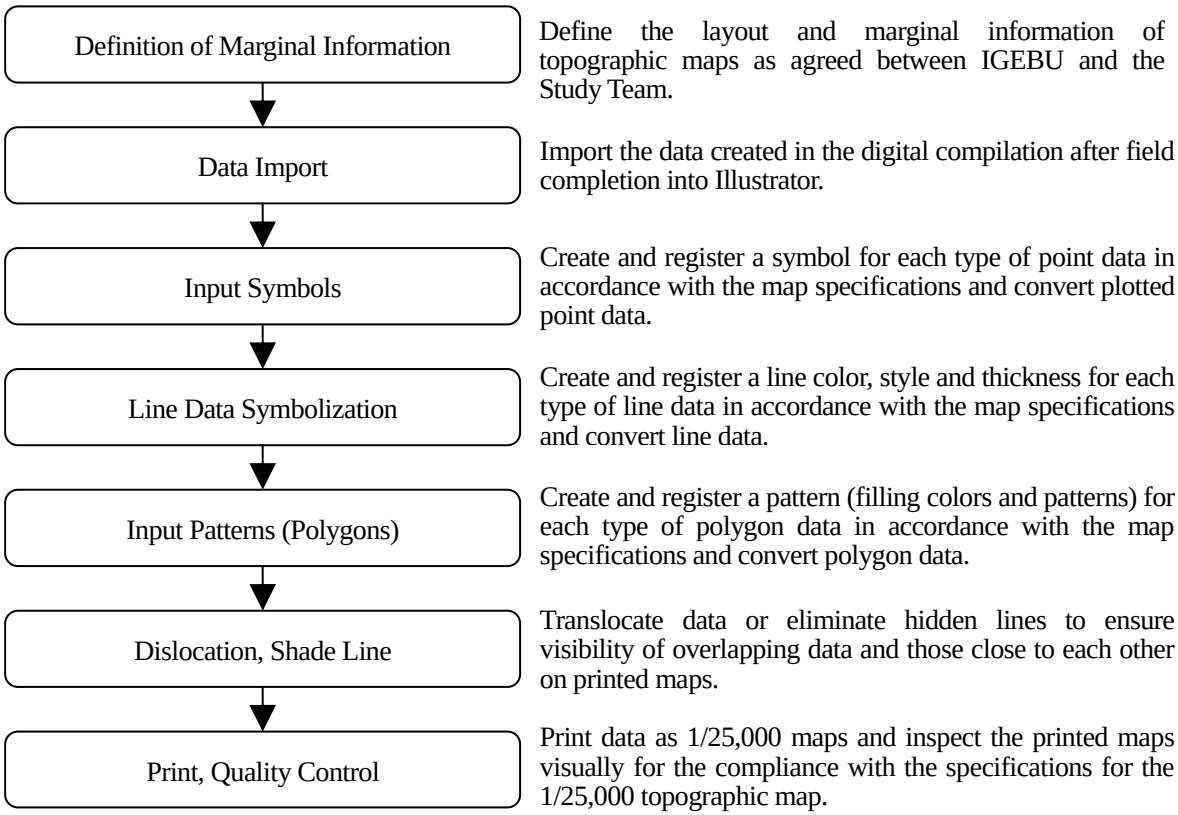


Figure. 35 Workflow of Map Symbolization (1/25,000)

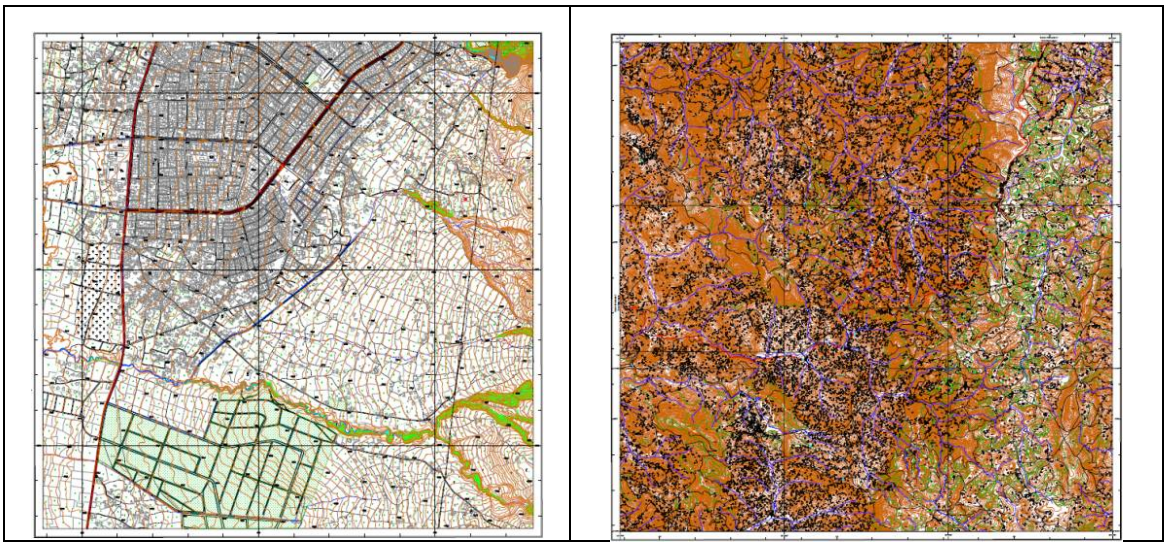


Figure. 36 Map symbolized Data

(Left: 1/5,000, right: 1/25,000)

The technology transfer was implemented with the data of the target area of the technology transfer selected in the consultation between the IGEBU and the Study Team which was created by the IGEBU staff members in the digital compilation after field completion. (See Chapter 4.)

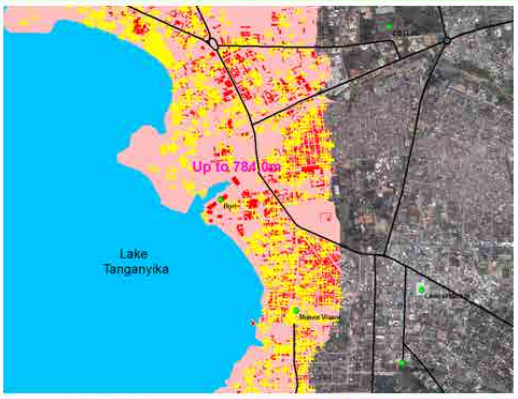
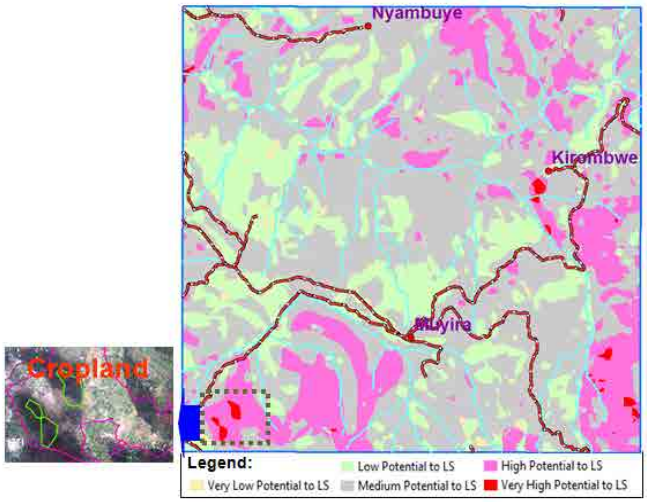
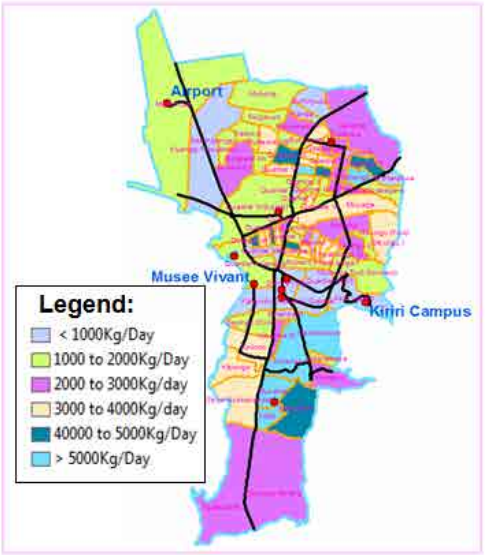
3-22. Creation of GIS Model Systems [Work in Japan and Burundi]

The contents of the created 1/5,000- and 1/25,000-scale GIS basic data, problems in Burundi and the results of the field study on the actual conditions were analyzed for the selection of GIS model systems to be created in the technology transfer. Then, the data required for the creation of the four selected GIS model systems was collected.

Table. 16 Data Collected for the Creation of GIS Model Systems

Data	Data provider	GIS model system
Geological maps (1/50,000)	Ministère de l'Energie et des Mines	Landslide control
Statistical Yearbook - 2009	Institut de Statistiques et d'Etudes Economiques du Burundi (ISTEEBU)	Flood control Waste management Health care
Data on the administrative boundaries in Bujumbura	Marie de Bujumbura	Flood control Waste management Health care
List of hospitals and health centers	Ministère de la Santé Publique	Health care
Soil maps (1/50,000)	Institut des Sciences Agronomiques du Burundi (ISABU)	Landslide control
Change in the water levels of Lake Tanganyika	IGEBU	Flood control
Household waste production	Marie de Bujumbura	Waste management

The figures below show the four types of GIS application models created with the collected data mentioned above and the topographic map data. A presentation on the GIS model systems created in this Study was made at the Seminar as the first step for the disclosure of the GIS data and extension of the use of geographic data in Burundi.

Flood control	To predict flood damage caused by the rising water levels in Lake Tanganyika by analyzing the data of the change in the water level, building data and elevation data	➢ ***Highest Water Level: 783.3m (In 1878)*** ■ With Water Level up to 784.0m (10m rise than normal level), then  ➢ **5,436 Large buildings and 2,341 Small building will be flooded.**
Landslide control	To identify the locations prone to landslides and the locations where urgent measures are required for them by analyzing data on slopes created from the data on soil and land use, and elevation data	■ Potential Land Slide Area and in Existing Cultivation Areas 
Waste management	To estimate household waste production per day by quarter by analyzing statistical data (on population) and data on administrative boundaries, household waste and buildings	■ Garbage Production in Each Cartier with Average Stand 

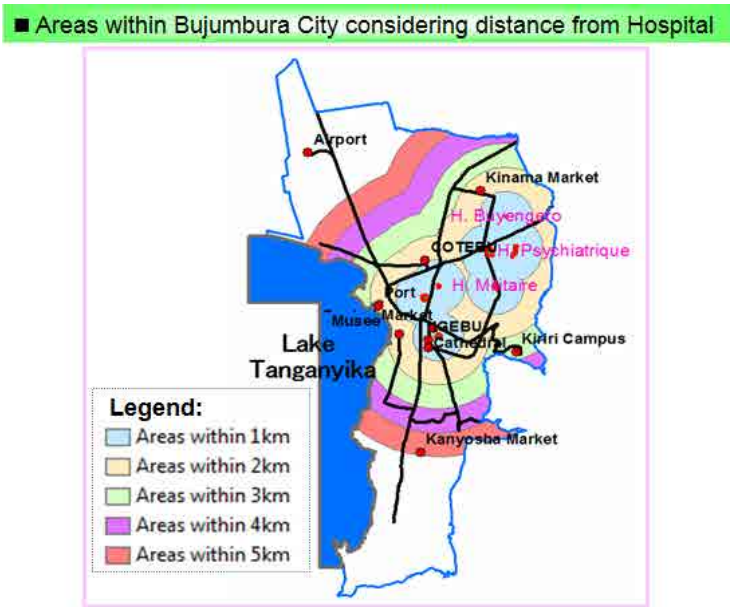
Health care	To elucidate distribution of healthcare facilities and access to the facilities by area residents by analyzing the positional data of hospitals and health centers and building data	

Figure. 37 Outline of GIS Models

As was the case with the data structuralization, GIS software (ArcGIS) was used for the implementation of the technology transfer. (See Chapter 4.)

3-23. Data File Creation [Work in Japan and Burundi]

The created 1/5,000- and 1/25,000-scale topographic map data, GIS basic data and orthophotos were converted into formats suitable for their use and saved in appropriate recording media. The technology transfer on the format conversion was implemented.

3-24. Creation of Draft Final Report (DF/R) [Work in Japan]

The Study Team prepared a draft final report (DF/R) which summarized the work implemented so far in the Study. The work manuals prepared in the process were also included in the report. The manuals were attached to the report for the convenience of use.

3-25. Holding of Seminar [Work in Burundi]

The Study Team held the Seminar for the purpose of extending the use of the digital topographic maps, GIS data and geographic information on 14th February 2013. Ninety-two people from 23 organizations participated in the Seminar. The participants from the organizations that had interest in using the data asked questions and expressed their views on the use of the data and the GIS models. After the seminar, a ceremony to commemorate the presentation of the outputs of this Study to the Burundian side was held in the presence of the Second Vice President of Burundi and the Japanese Ambassador to Kenya. The Vice President expressed his gratitude for the creation of digital topographic maps. The Ambassador mentioned

that the outputs of this Study would facilitate infrastructure development and farmland reform in Burundi and emphasized the necessity of topographic maps in his address.

The seminar and the ceremony were attended by many members of the media and reported on the radio and television on the same day. Newspapers had long articles on them on the following day. Through the media coverage, not only the members of the relevant institutions but also all ranks of people in Burundi became aware of the outline and the outputs of this Study. The subjects of the presentations at the seminar were:

- Explanation of the work in this Study;
- Explanation of the outputs;
- Explanation of the digital technologies used in this Study;
- Presentation on the use of the GIS basic data on the created digital topographic maps and GIS model systems; and
- Vision for the construction of a system for the extension of the use of the geographic data.

The table below shows the breakdown of the number of the participants of the seminar by organization.

Table. 17 Participants of the Seminar

	Organization	Number of participants
1	Cabinet de Deuxieme Vice-président	2
2	Ministère de l'Eau, de l'Environnement, de l'Aménagement de territoire, de l'Urbanisme	10
3	Ministère de l'Interieur	1
4	Comite pilotage, Bureau de centralisation geomatique	2
5	Bureau des etudes strategiques, Presidence de la Republique	1
6	ISTEEBU(Institut de Statistiques et d'Etudes Economiques du Burundi)	1
7	Ministère de l'Agriculture et l'Elevage	1
8	Ministère de l'Energie et des Mines	1
9	Ministère des Travaux Publics et du Transport	1
10	Ministère des Affaires Etrangères	3
11	Mairie de Bujumbura	2
12	Province de Gitega	1
13	SETEMU(Régie des Services Techniques Municipaux)	3
14	REGIDESO(Régie de production et de distribution d'eau et d'électricité)	7
15	Université du Burundi	4
16	Cadastre national	3
17	Ambassade du Japon	2
18	JICA Kenya	1
19	JICA Burundi	6
20	JICA Rwanda	1
21	JICA Study Team	6
21	IGEBU	22
22	PROJET EUROSHA(EUROPEAN OPEN-SOURCE HUMANITARIAN AID VOLUNTEERS)	2
23	Media organizations (five TV and radio stations)	9
	Total	**92 people**

Table. 18 Questions and Answers at the Seminar

Name	Affiliation	Questions and answers
NIKOBAGOMBA Nestor	Ministry of Water, Environment, Land Management and Urban Planning	1. Have the GIS models and orthophotos been made available? (Answer by the Director of the Department of Cartography and Topography, Mr. Thomas) No. IGEBU is having a discussion on the method to provide this data. 2. How will potential users exchange this data among themselves? (Answer by the Director of the Department of Cartography and Topography, Mr. Thomas) IGEBU is having a discussion on the way to exchange the data.
MINANI Bonaventure	Municipal Technical Service Corporation (SETEMU) of Bujumbura	1. What are the horizontal accuracies of these maps ? (Answer by the JICA Study Team) They are 3 m on the 1/5,000-scale maps and 15 m on the 1/25,000 maps.
SINDAYIHEBURA Bernard	University of Burundi	1. What coordinate system was used in the Study? (Answer by the Head of the Service of Geodesy and Leveling, Mr. Eugène) WGS 84 was used.
NAHIMANA Louis	University of Burundi	1. What is the number of layers? (Answer by the JICA Study Team) It is 170. 2. Is it possible to overlay the 1/50,000-scale old maps on the maps created in this Study? (Answer by the JICA Study Team) Yes, it is.
NGENDAKURIYO Daniel	University of Burundi	1. Why are the directions of the flight courses of the aerial photography of Bujumbura and Gitega different? (Answer by the JICA Study Team) Because there was a mountain range near Bujumbura, the flight courses of the aerial photography of Bujumbura were set parallel to it. 2. Was the contour data of the old maps used in this Study? (Answer by the JICA Study Team) No. The data on the old maps was not referred to in this Study.
RASTRY Florent	Central Control Room for Computer Mapping, the Office of the Second Vice President	1. How can this data be accessed? (Answer by the Director of the Department of Cartography and Topography, Mr. Thomas) IGEBU is having a discussion on the way to allow access to the data.
SINDAYIHEBURA Bernard	University of Burundi	1. Was the data of the floods in the past used in the creation of the GIS model for floods? (Answer by the Head of the Service of Geodesy and Leveling, Mr. Eugène) Yes. Past flood data was used as a reference.

Figure. 38 Seminar

3-26. Discussion of Draft Final Report (DF/R) [Work in Burundi]

The Study Team provided the IGEBU with explanation on the Draft Final Report and held discussion with them on the matters related to the creation of the digital topographic maps which had been implemented from the commencement until the completion of the Study, including the details of the surveys, the technology transfer and the map specifications. The proceedings of the discussion were compiled in a Minutes of Meeting (MM) and the minutes were approved by both sides, with the signatures of their respective representatives. (See Appendix-3 for the MM.)

3-27. Creation of Final Report (F/R) [Work in Japan]

The Study Team completed the preparation of the final report by editing the DF/R as necessitated by the comments on the DF/R of the Burundian side.

4. Technology Transfer

The Study Team transferred the technologies for implementing a series of work required for the creation of topographic map data to the counterparts in this Study.

4-1. Technology Transfer on Ground Control Point Survey and Installation of Pre-marks

The Study Team implemented the technology transfer on ground control point survey and installation of pre-marks in the format of OJT while implementing the scheduled work in these processes.

4-1-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on ground control point survey and installation of pre-marks.

Table. 19 Impacts and Evaluation of the Technology Transfer on Ground Control Point Survey and Installation of Pre-marks

Subject	Main objective	Impacts on IGEBU
Reconnaissance and selection and installation of control points	Understanding of the basics of ground control point survey	Application to other projects
	Installation of control points appropriate for the photography plan	Application to other projects
	Operation of the handheld GPS devices	Application to other projects (Identification and registration of planimetric features in field identification)
	Selection of locations easily-recognized on imagery	Application to other projects (*e.g.* capacity development in photo interpretation)
GPS observation	Understanding of the ground control point survey Operation of the GPS devices	Reconstruction of a control point network Promotion of the use of GPS data
GPS analysis	Operation of the analysis software Interpretation of the analysis results	
Installation of pre-marks	Understanding of the aerial photography	Understanding of aerial photo interpretation Capacity development in interpretation of aerial photographs
	Selection of materials of markers	
	Selection of the size, shape and color of the markers	

4-1-2. Participants of the Technology Transfer

Eight survey engineers of IGEBU and survey assistants employed at the site conducted GPS survey and installed pre-marks under the guidance of a Study Team member. Four work teams, each consisting of two IGEBU engineers and two survey assistants, were formed. The Study Team provided the IGEBU engineers with training on how to operate the GPS receivers before the GPS observation.

The focus of the technology transfer on the GPS observation was on the basic operation of various types of equipment, in addition to the basics of "control point survey" and "analysis of the GPS survey results."

Table. 20 Participants of the Technology Transfer

Name		Experience in the work concerned	Remarks
1	NIYUNGEKO Eugene	No	Team 1
2	NKUNZIMANA Didace	No	
3	SYORI Aloys	No	Team 2
4	BARIVUMA Tharcisse	No	
5	NSABIMANA Etienne	No	Team 3
6	HAJAYANA Gaspard	No	
7	NTAKARATSA Apollinaire	No	Team 4
8	NDAYISABA Elkana	No	
9	BANZIRUMUHITO Léopold	No	

4-1-3. Schedule and Contents of the Technology Transfer

The following table shows the schedule of the implemented technology transfer on ground control point survey and installation of pre-marks.

Table. 21 Schedule of the Technology Transfer on Ground Control Point Survey and Installation of Pre-marks

Subject		Contents of the technology transfer	Expected outcome
2010	Week 1	Briefing and joint training	Standardization of the work methods Safety control methods
	Week 2	Reconnaissance and selection and installation of control points	Acquisition of efficient work methods
	Week 3	Installation of pre-marks and GPS observation (in Bujumbura)	Understanding of the basic operation of the equipment
	Week 4	Installation of pre-marks and GPS observation (in Gitega)	Review of the contents of the technology transfer
	Week 5	Leveling (in Bujumbura)	Acquisition of the quality control method and recognition of its importance Review of the contents of the technology transfer
	Week 6	Leveling (in Gitega) GPS observation (48 hour observation) at the orientation origins	
2011	Week 1	Inspection of pre-marks	
	Week 2	Application of the GPS survey Network adjustment	Understanding of the kinematic observation Operation of the analysis software
	Week 3	Outline and theories of GNSS (GPS) Lecture on coordinate transformation	Understanding of the basic theories

The Study Team implemented the technology transfer on the outline and theories of GNSS (GPS) and coordinate transformation upon request from IGEBU. In this technology transfer, a member of the Study

Team provided the counterparts with a lecture on the outline of the artificial-satellite-based GNSS (GSP) survey of late, the history of the changes in coordinate systems, the coordinate system used in the existing topographic maps of Burundi and coordinate systems widely used in recent years.

Figure. 39 Scenes in the Technology Transfer on the Ground Control Point Survey (Upper left: GPS observation, upper right: installation of a pre-mark, lower left: network adjustment, lower right: application of the GPS observation

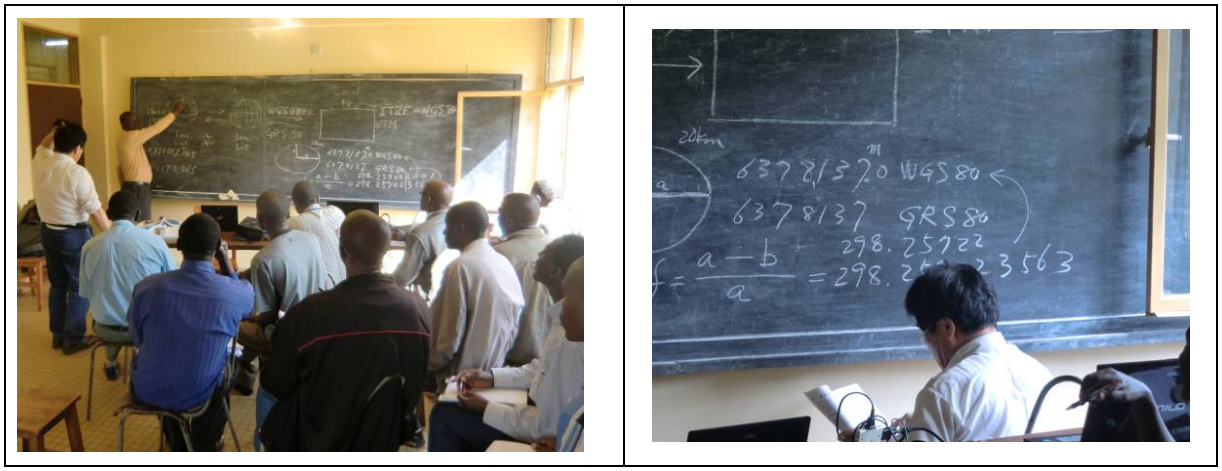


Figure. 40 Lecture on GNSS (GPS) and the Coordinate Systems

4-1-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The IGEBU staff members have been using the equipment for the ground control point survey procured in this Study frequently in other projects since the completion of the technology transfer and departure of the member of the Study Team in charge from Burundi. The Team has received a report that they have defined a coordinate system, installed the equipment and implemented the observation methods appropriately and obtained good analysis results.

The Study Team considers that the technology transfer on the above-mentioned subjects has achieved the goal as the team has confirmed that the IGEBU staff members have applied the transferred technologies to other projects and managed to complete the work independently.

Figure. 41 GPS Observation Implemented Independently by IGEBU Staff Members

4-2. Technology Transfer on Field Identification

4-2-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on field identification.

Table. 22 Impacts and Evaluation of the Technology Transfer on Field Identification

Subject	Main objective	Impacts on IGEBU
Pre-interpretation	Understanding of the field identification Identification of the subjects of the field identification	Formulation of effective work plans Improvement in the understanding of subjects of identification
Field identification	Operation of the handheld GPS devices Comparison between the situation in the field and photographs Capacity development in photo interpretation	Acquisition of the effective way to use the handheld GPS devices Capacity development in spatial perception Application to the digital plotting
Arrangement of the results of the field identification	Acquisition of the methods for inspection and arrangement of the identification results	Improvement in quality of the results

4-2-2. Participants of the Technology Transfer

IGEBU selected the eight staff members listed in the following table as the participants of the field identification. An interview survey with the participants conducted before the technology transfer revealed that only one of them had experience in field identification.

Table. 23 Participants of the Technology Transfer

Name		Experience in the work concerned	Remarks
1	NIYUNGEKO Eugene	No	Team 1
2	KAZARI Zacharie	No	
3	SYORI Aloys	Yes	Team 2
4	BARIVUMA Tharcisse	No	
5	NSABIMANA Etienne	No	Team 3
6	KAMANA Michel	No	
7	NDAYISABA Elkana	No	Team 4
8	HAJAYANA Gaspard	No	

4-2-3. Schedule and Contents of the Technology Transfer

The following table shows the schedule of the implemented technology transfer on field identification.

Table. 24 Schedule of the Technology Transfer on Field Identification

Subject	Contents of the technology transfer	Expected outcome
Week 1	Briefing and joint training	Standardization of the work methods
Week 2	Field identification for the creation of 1/5,000 topographic map data	Acquisition of the methods of field identification by map scale Acquisition of efficient ways to implement the work Use of methods suited to the conditions at sites Safety control methods
Week 3		
Week 4		
Week 5	Field identification for the creation of 1/25,000 topographic map data	
Week 6		
Week 7		
Week 8	Inspection and arrangement of the results of field identification	Acquisition of the quality control method and recognition of its importance

Figure. 42 Scenes in the Technology Transfer on Field Identification

(Left: lecture, right: identification of a position on a photograph)

4-2-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The field identification was implemented by the eight IGEBU staff members in four work teams. The member in charge of the field identification of the Study Team accompanied different teams in turn every day and provided them with OJT. The Study Team had decided to evaluate the level of understanding of the details of the work in the field identification by the IGEBU staff members by inspecting their behaviors at sites and the quality of the results of their field identification in the second half of the field identification. Although the participants were observed to make errors on code numbers and locations of the subjects for the identification and omit subjects in the first half of the field identification, the number of the omissions and errors on locations decreased as their understanding of the identification subjects improved as the work progressed, with the daily instruction and advice from the member of the Study Team.

The Study Team noticed no problem in their attitude toward the work as they listened to the advice from the Study Team member intently.

The above-mentioned observations have led the Study Team to conclude that the eight participants have acquired the capacity to implement the work in field identification independently without serious problems.

Table. 25 Evaluation of the Outcome of the Technology Transfer on Field Identification

Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Pre-interpretation	The Participants have understood what they should do and what subjects they should study in the field identification (the map specifications).	The IGEBU staff members can implement the work independently without problems. They will have to be careful when implementing the work at a scale different from the scales used in this Study.
Field identification	The capacity of the participants has reached the level at which they can verify identification subjects in the field using handheld GPS devices and orthophotos without serious problems.	The participants have mastered the field identification methods. However, they should improve their capacity in photo interpretation with further practice.
Inspection and arrangement of the results of the field identification	The participants have understood what they should do in the inspection and arrangement (inspection of the results for omissions, errors and matching between map sheets).	They will have to use the results of the inspection to realize how they should implement the work in the field.

Figure. 43 A Result of the Field Identification Implemented Independently by IGEBU Staff Members (Gitega City)

4-3. Technology Transfer on Aerial Triangulation

4-3-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on aerial triangulation.

Table. 26 Impact and Evaluation of the Technology Transfer on Aerial Triangulation

Subject	Main objective	Impacts on IGEBU
Aerial triangulation	Operation of PC and the software Understanding of the concept of the digital aerial triangulation Understanding of the method for the evaluation of the results of aerial triangulation	Improvement in the efficiency and productivity and cost reduction with the use of digital technologies and an effective combination of automatic and interactive processing

4-3-2. Participants of the Technology Transfer

IGEBU selected two staff members from those who had participated in the field identification as the participants of the technology transfer on aerial triangulation on the basis that it was recommendable for IGEBU to have someone who understands the entire process of the creation of the topographic maps. The Study Team conducted a questionnaire inquiry of the participants listed in the following table before the technology transfer. (See Appendix-4 for the results of the inquiry).

The inquiry revealed that, although one of the participants had experience in the analog aerial triangulation, neither of them had experience in digital aerial triangulation or the use of the software for photogrammetry (LPS from ERDAS, Inc.) to be used in the technology transfer.

Table. 27 Participants of the Technology Transfer

Name		Experience in the work concerned	Remarks
1	SYORI Aloys	Experience in analog aerial triangulation	Neither had experience in digital aerial triangulation or the use of the software concerned.
2	KWITONDA Sosthène	No knowledge of the theory of or the technologies for aerial triangulation	

4-3-3. Schedule and Contents of the Technology Transfer

The technology transfer was implemented with the focus on the concept of the aerial triangulation and basic operation of the software (LPS from ERDAS, Inc.) in response to the result of the above-mentioned inquiry. The table below shows the schedule of the technology transfer on aerial triangulation.

The purpose of this Study was the creation of topographic map data at the two different scales, 1/5,000 and 1/25,000. Almost the same work procedure is used in the aerial triangulation for the creation of the data at any scale. The only difference in the procedure is the allowable limits used after the adjustment

calculation. Therefore, the Study Team selected an approximately 70 km^2 area of Gitega City as the area for the technology transfer on the aerial triangulation in this Study after having considered the time available for the technology transfer and the experience and capacity of the participating IGEBU staff members revealed by the questionnaire inquiry.

The Study Team prepared PowerPoint slides and a manual providing general description of the aerial triangulation and the digital plotter to be used before the implementation of the technology transfer. Thirty-six sheets of aerial photographs, five control points, 13 benchmarks and 19 simple benchmarks were used in the aerial triangulation. (The control points, benchmarks and simple benchmarks are the outputs of the activities in the first year of this Study.)

The member of the Study Team in charge of the technology transfer on aerial triangulation explained the details of the work in each step in the workflow of the aerial triangulation before he implemented the work and, then, the IGEBU staff members implemented the work. At the end of the technology transfer on aerial triangulation, they implemented the entire work of the aerial triangulation by themselves while the team member provided advice whenever it was needed.

Table. 28 Schedule of the Technology Transfer on Aerial Triangulation

Subject	Contents of the technology transfer	Expected outcome
Week 1	A method for the import of data on aerial photographs	Acquisition of the method for the import of the data on the aerial photographs taken with a digital camera and GPS/IMU data into a digital plotter
Week 2	A method for the entry of the data on a camera used in the aerial photography	Understanding of the necessity for the accurate entry of the camera data
Week 3	A method for the measurement of ground control points, benchmarks and tie points	Understanding of the methods for the accurate measurement of control points and benchmarks and the number and arrangement of tie points Acquisition of the measuring method with a digital plotter Capacity development in three-dimensional measurement
Week 4		
Week 5		
Week 6	Adjustment calculation method and accuracy verification method	Understanding of various parameters for the adjustment calculation Acquisition of a method for the adjustment calculation with digital plotter Understanding of the points of note in the accuracy verification
Week 7	Digital terrain model (DTM) creation and correction methods	Acquisition of an automatic DTM creation method and a DTM correction method
Week 8	Method for the creation of orthophotos	Acquisition of an orthophoto creation method

Figure. 44 Scenes in the Technology Transfer on Aerial Triangulation
(Left: lecture on the theories, right: practice)

4-3-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The IGEBU staff members acquired the capacity to implement the aerial triangulation independently in the technology transfer. The results of their aerial triangulation satisfied the specifications for the 1/5,000 topographic map creation. (See below.)

The same method as the one used by the Study Team in this Study (which used the outputs of digital aerial photography) was used in the technology transfer. IGEBU asked the Study Team whether the old analog photographs of theirs could be used on the digital plotter in future. In response, the Study Team provided a brief explanation on the method of aerial triangulation using analog photographs.

These facts suggest that the IGEBU staff members have acquired the capacity required for the independent implementation of aerial triangulation with analog and digital aerial photographs in projects in future. The Study Team recommended that the two IGEBU staff members who participated in the technology transfer should try to share the knowledge and technologies acquired in the technology transfer with other staff members (internal technology transfer), instead of keeping them to themselves, and train themselves to improve their capacity for the improvement of the functions of IGEBU as a whole.

Table. 29 Results of the Practice in the Technology Transfer on Aerial Triangulation

Type of error			Error	
			Residual	Allowable limit
Standard deviation (m)	Horizontal location	X	0.16	0.56
		Y	0.18	
	Elevation	Z	0.28	0.56
Maximum (m)	Horizontal location	X	0.21	1.11
		Y	0.26	
	Elevation	Z	0.42	1.11

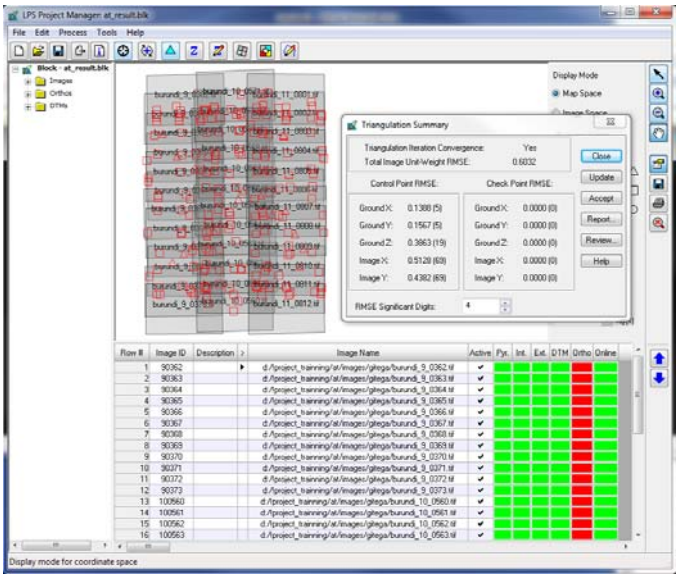


Figure. 45 An Output of the Aerial Triangulation Created Independently by the IGEBU Staffs

Table. 30 Evaluation of the Outcome of the Technology Transfer on Aerial Triangulation

Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Operation of PC and the software	The participants did not have major problems in operating PCs from the beginning. They have learned the basic functions and operation of the software in the technology transfer.	The participants have acquired the basic capacity required for implementing the highly-accurate and efficient work with a digital plotter (as hardware and software). However, the software has many other functions which were not used in the technology transfer. Therefore, the participants will have to develop their capacity further through self-training.
Understanding of the concept of the digital aerial triangulation	The Study Team considers that the participants have acquired basic understanding of the role of the aerial triangulation in the creation of topographic map data and the outline, necessity, details of the work and importance (the fact that the outputs of the aerial triangulation are used as standards in the subsequent processes) of it.	The participants have acquired the knowledge of and capacity in digital aerial triangulation. However, since their capacity in the three-dimensional measurement which is required for the aerial triangulation is not satisfactory, they will have to improve the capacity through self-training.
Understanding of the method for the evaluation of the results of the aerial triangulation	The Study Team considers that the participants have acquired basic understanding of the methods to investigate causes of abnormal results of the adjustment calculation and to take countermeasures for the causes.	The participants have learned the accuracy control method which prevents abnormal measurements in the aerial triangulation from affecting the accuracy of the subsequent processes. However, as abnormal measurements affecting the accuracy of the subsequent processes could be caused by a wide variety of factors, the participants will have to acquire capacity and knowledge to identify the causes quickly with experience.

4-4. Technology Transfer on Digital Plotting

4-4-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on digital plotting.

Table. 31 Impacts and Evaluation of the Technology Transfer on Digital Plotting

Subject	Main objective	Impacts on IGEBU
Digital plotting (1/5,000) (1/25,000)	Operation of PC and the software Operation of the stereo plotter Capacity development in three-dimensional measurement Data acquisition methods compliant with the specifications and appropriate for the scales	Improvement in efficiency and productivity and cost reduction with the understanding of the effective methods for the acquisition of 2-D and 3-D data and the data creation method

4-4-2. Participants of the Technology Transfer

The two IGEBU staff members shown in the table below participated in the technology transfer on the digital plotting. IGEBU selected them from its staff members who participated in the field identification as they did in the technology transfer on aerial triangulation. In order to prepare a plan for the efficient technology transfer, the Study Team conducted a questionnaire inquiry of the participants before the technology transfer. (See Appendix for the result of the inquiry.)

The inquiry revealed that neither of the participants had experience in using the photogrammetric software (LPS from ERDAS, Inc.) or the CAD software (MicroStation from Bentley Systems, Inc.) to be used in the technology transfer.

Table. 32 Participants of the Technology Transfer

Name		Experience in the work concerned	Remarks
1	NDAYISABA Elkana	No	He did not have experience in using the software used in the technology transfer.
2	HAJAYANDI Gaspard	No	He had PC skills, however, did not have experience in using the software used in the technology transfer.

4-4-3. Schedule and Contents of the Technology Transfer

In response to the results of the above-mentioned inquiry, the technology transfer was implemented with the focus on the basic subjects required for the plotting and the basic operation of the software (LPS from ERDAS, Inc. and MicroStation from Bentley Systems, Inc.) and the hardware. The following table shows the schedule of the technology transfer on digital plotting.

Table. 33 Schedule of the Technology Transfer on Digital Plotting

Subject	Contents of the technology transfer	Expected outcome
Week 1	3D-measurement	Capacity development in the measurement in 3-D space
Week 2	Acquisition of the features by type in accordance with the pre-determined map specifications	Capacity development in 3-D measurement Acquisition of the method for the data acquisition compliant with the acquisition standards Acquisition of the software operation method
Week 3	Methods for the acquisition of features by type in accordance with the map specifications (planimetric features)	
Week 4		
Week 5	Methods for the acquisition of features by type in accordance with the map specifications (contour lines)	
Week 6		
Week 7	Methods for setting various parameters in the software for digital plotting	Understanding of the details of the work to be prepared before the plotting Acquisition of the software operation method
Week 8	Methods for setting various parameters in the software for digital plotting	

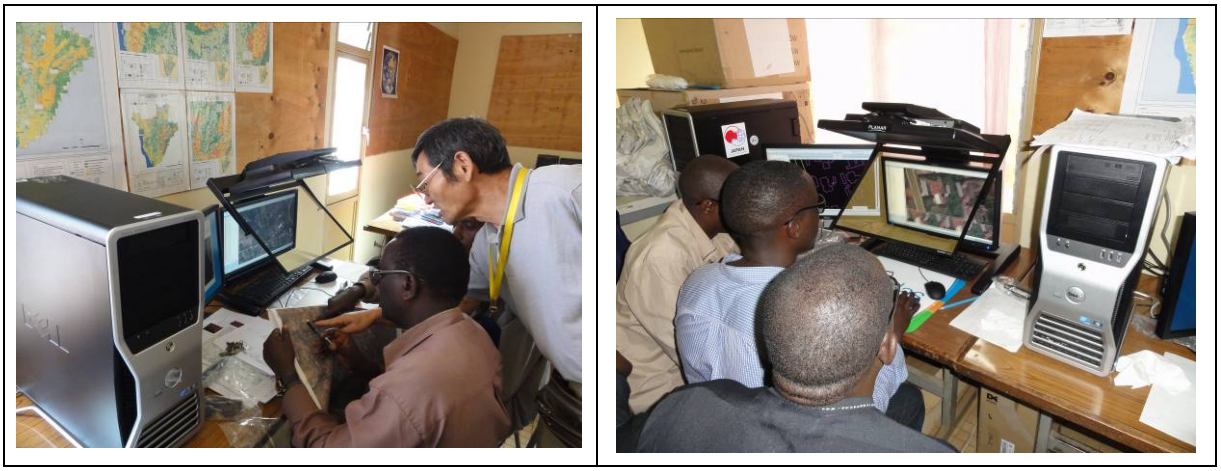


Figure. 46 Scenes in the Technology Transfer on the Digital Plotting
(Right: the member of the Study Team in charge of the digital plotting giving instruction to a participant, right: practice by the IGEBU staff members)

4-4-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The participants have mastered the basic operation of the hardware and software, on which the focus of the technology transfer was. However, the technology transfer on the use of the special mouse used in the digital plotting (TopoMouse) was limited to the use of the absolutely indispensable functions, despite the fact that it had many buttons to improve the efficiency of the plotting and the effective use of all these buttons would increase the speed of the work significantly.

The most important and absolutely indispensable capacity required in the digital plotting is the capacity to measure a feature on a stereo model constructed with two aerial photographs accurately in 3-D space.

This is because horizontal positions of features such as buildings and roads cannot be measured accurately unless their heights are measured accurately in the 3-D space. The Study Team considers that the IGEBU staff members have learned the important basics of the digital plotting as they have learned how to measure objects with correct heights in the 3-D environment.

The participants practiced the 1/5,000 plotting of a (approx. 7km^2) part of Gitega City in the technology transfer. Although it took them a long time, they managed to implement the work staying aware of the difference in the acquisition methods of the data of features which appeared in models. At the same time, they practiced creation of 1/25,000 data from the results of the above-mentioned practice. In this way, the participants managed to complete the technology transfer while learning the difference in data acquisition and representation methods at the different scales.

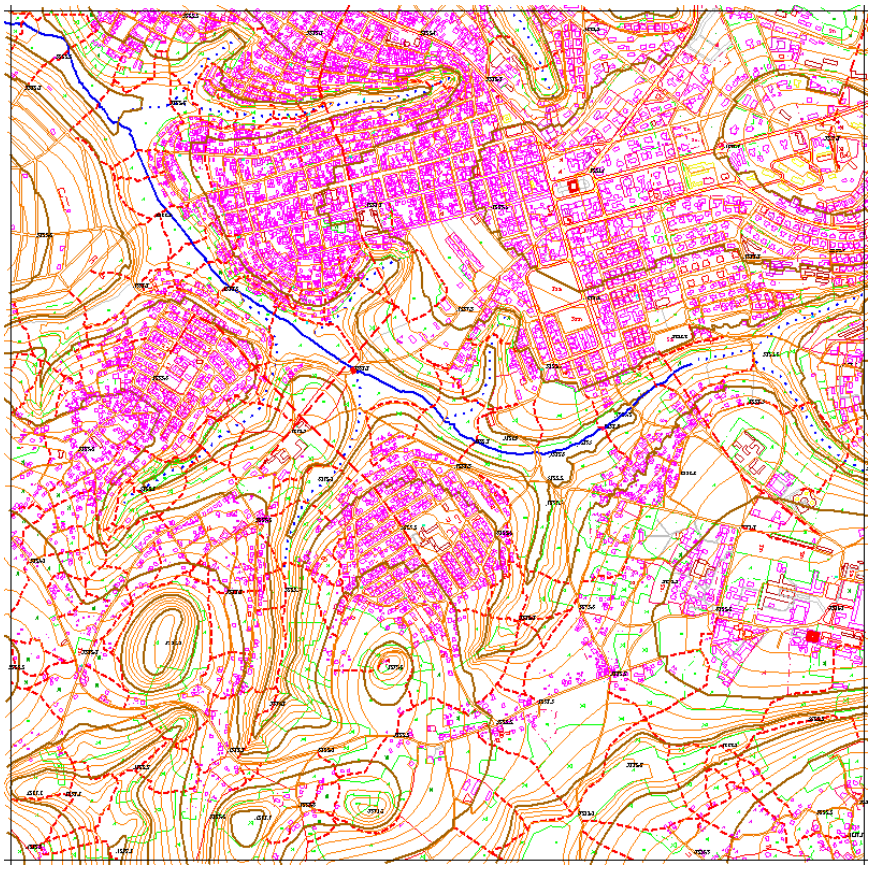


Figure. 47 An Output of the Practice of the Digital Plotting (1/5,000)

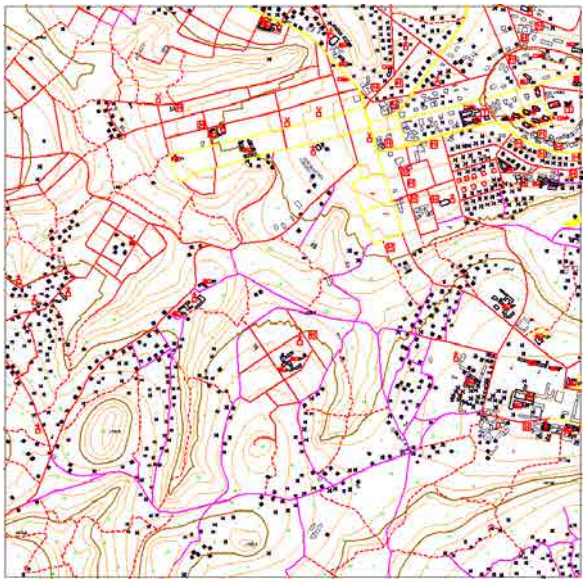


Figure. 48 An Output of the Practice of the Digital Plotting (1/25,000)

Table. 34 Evaluation of the Outcome of the Technology Transfer on Digital Plotting

Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Operation of PC and the software	The participants did not have major problems in the operation of PC itself from the beginning. They have learned the basic functions and operation of the software in the technology transfer.	The participants have acquired the basic capacity required for the implementation of highly-accurate and efficient work with digital plotter (as hardware and software). However, since the software has many other functions which were not used in the technology transfer, the participants will have to develop their capacity through self-training.
Operation of the stereo plotter	The participants have mastered the basic operation of TopoMouse (see Manual for details) used in the digital plotting.	The technology transfer was so designed that the IGEBU staff members learned technologies absolutely indispensable to the digital plotting, as they might be confused if they were given explanation on a wide variety of different functions. They will have to self-study all the functions to improve the efficiency of their work.
Scale-specific data acquisition methods compliant with the specifications	The participants have mastered the know-how of the methods for the acquisition of data of different types of features, though they require some time for the data acquisition.	The Study Team is convinced that the participants will be able to reduce the time required for acquiring data of each feature with experience. They will also require experience or self-learning for the improvement of the productivity of their work.

4-5. Technology Transfer on Field Completion

4-5-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on field completion.

Table. 35 Impacts and Evaluation of the Technology Transfer on Field Completion

Subject	Main objective	Impacts on IGEBU
Field completion	Understanding of the field completion work Operation of the handheld GPS devices Verification of topographic maps in the field	Acquisition of know-how for implementation of the work Acquisition of the effective way to use the handheld GPS devices Capacity improvement in interpretation of topographic maps
Arrangement of the results of the field completion	Arrangement of the results on maps	Improvement in quality of the results Application to the digital compilation after field completion

4-5-2. Participants of the Technology Transfer

IGEBU selected the eight (nine) IGEBU staff members shown in the table below as the participants of the technology transfer on field completion. Most of them had participated in the field identification.

Table. 36 Participants of the Technology Transfer

Name		Participation in field identification		Remarks
1	SYORI Aloys	Yes	Participation in the first half	Team 1
2	KAMANA Michel	Yes	Participation in the second half	
3	KWITONDA Sosthène	No		
4	NIYUNGEKO Eugene	Yes		Team 2
5	SINZINKAYO Juvenal	No		
6	NDAYISABA Elkana	Yes		Team 3
7	KABERA Gilbert	No		
8	HAJAYANA Gaspard	Yes		Team 4
9	BARIVUMA Tharcisse	Yes		

4-5-3. Schedule and Contents of the Technology Transfer

The following table shows the schedule of the implemented technology transfer on field completion.

Table. 37 Schedule of the Technology Transfer on Field Completion

Subject	Contents of the technology transfer	Expected outcome
Week 1	Briefing and joint training	Standardization of the work methods
Week 2	Field completion for the creation of 1/5,000 topographic map data	Acquisition of the methods of field completion by map scale Acquisition of efficient ways to implement the work Use of methods suited to the conditions at sites Safety control methods
Week 3		
Week 4		
Week 5	Field completion for the creation of 1/25,000 topographic map data	
Week 6		
Week 7		
Week 8	Inspection and arrangement of the results of field completion	Acquisition of the quality control method and recognition of its importance

Figure. 49 Scenes in the Field Completion

(Left: briefing, right: joint training)

4-5-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The methods used in the field completion differ little from those used in the field identification. Topographic maps are used in the field completion where orthophotos are used in the field identification.

As in the technology transfer on field identification, the member of the Study Team in charge of the field completion accompanied different teams in turn every day and provided them with OJT. The Study Team decided to evaluate the level of their understanding of the work in field completion by observing their attitude in the field and inspecting the quality of the results of the field completion in the second half.

Partly because most of the participants had also participated in the field identification, they had no problem in understanding the details of the work. Although they required some time to find correspondence between data on the topographic maps and features in the field in the beginning, the time required for

finding correspondence had decreased as the work progressed. The Study Team concludes that the participants have identified the points to be noted in the fieldwork through the implementation of the inspection and arrangement.

Table. 38 Evaluation of the Outcome of the Technology Transfer on Field Completion

Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Field completion	The participants have understood what they should do and what subjects they should study in the field completion (the map specifications). The capacity of the participants has reached the level at which they can verify study subjects in the field using portable GPS devices and topographic maps without serious problems.	The IGEBU staff members can implement field completion without problems. The participants mastered the field completion method. However, they should improve their capacity in interpretation of topographic maps with further practice.
Inspection and arrangement of the results of the field completion	The participants have understood what they should do in the inspection and arrangement (inspection of the results for omissions, errors and edge matching between map sheets).	They will have to use the results of the inspection to realize how they should implement the work in the field and what they should do in the field completion for the subsequent processes.

4-6. Technology Transfer on Digital Compilation/Digital Compilation after Field Completion

4-6-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on digital compilation.

Table. 39 Impacts and Evaluation of the Technology Transfer on Digital Compilation

Subject	Main objective	Impacts on IGEBU
Digital compilation (at 1/5,000 and at 1/25,000)	Operation of PC and the software Digital compilation of plotted data Data cleaning Polygon data creation	Improvement in efficiency and productivity and cost reduction with the understanding of the various commands for the digital compilation and the understanding of the combined use of the automatic and interactive error detection and correction

4-6-2. Participants of the Technology Transfer

The two IGEBU staff members shown in the table below participated in the technology transfer. The inclusion of participants of the digital plotting in the digital compilation gives them an opportunity to correct the errors which they made in the digital plotting by themselves and, thus, to learn the errors likely to be made in the digital plotting. The participation is also expected to give them an opportunity to review the operation of the software and to deepen the understanding of the software operation, since the same software (MicroStation from Bentley Systems, Inc.) is used in both digital plotting and digital compilation. For these reasons, IGEBU selected the participants of the technology transfer on the digital plotting as the

participants of the technology transfer on the digital compilation. In order to design an efficient technology transfer, the Study Team conducted a questionnaire study of the two participants before the technology transfer. (See Appendix-4 for the result of the questionnaire.)

The study revealed that, although both participants had understanding of the basic drawing functions as they had learned them in the technology transfer on digital plotting with MicroStation, they knew almost nothing about the compilation functions.

Table. 40 Participants of the Technology Transfer

Name		Experience in the work concerned	Remarks
1	NDAYISABA Elkana	No	The participant attended the technology transfer on digital plotting.
2	HAJAYANDI Gaspard	No	The participant attended the technology transfer on digital plotting.

4-6-3. Schedule and Contents of the Technology Transfer

What is important in digital compilation is to understand logically correct data and data shapes appropriate for certain map scales and to use the compilation functions of CAD software effectively.

The Study Team decided to implement the technology transfer on digital compilation with the focus on the above-mentioned subjects because the IGEBU staff members had no experience in the digital compilation and little understanding of the compilation functions of MicroStation. The team decided to implement the training on the polygon creation after the team had confirmed that the participants had learned these subjects. The following table shows the schedule of the technology transfer on digital compilation.

Table. 41 Schedule of the Technology Transfer on Digital Compilation

Subject	Contents of the technology transfer	Expected outcome
Week 1	Orientation and the questionnaire study	Evaluation of the experience and skill of the IGEBU staff members
Week 2	Basic operation of MicroStation Practice of digitization of the existing maps	Review of the commands used in the digital plotting Understanding of the basic operation of the CAD software
Week 3	Understanding of the functions and operation of the commands for the correction of the data created in the digital plotting Basics of data cleaning	Understanding of data shapes and map representations appropriate for different map scales Understanding of the method for detection and correction of logical errors
Week 4	Basics of polygon creation Practice: Correction and cleaning of the 1/5,000-scale data of Gitega	Understanding of the significance of and the method for the polygon creation
Week 5	Practice: Creation of polygons for the 1/5,000 topographic maps of Gitega City	Understanding of the data shapes and map representations at the scale of 1/5,000
Week 6	Practice: Creation of polygons for the 1/25,000 topographic maps of Gitega City	Understanding of the data shapes and map representations at the scale of 1/25,000
Week 7	Practice: Creation of polygons of administrative boundaries	Repeated practice of the contents of the technology transfer, improvement in the speed of the work
Week 8	Review of the technology transfer, compilation of a manual	Information sharing among IGEBU staff members

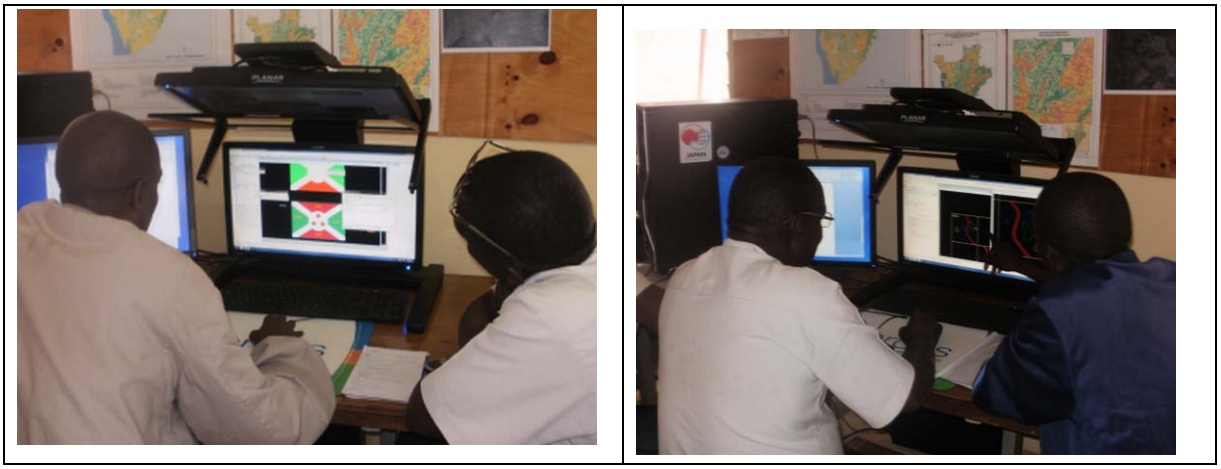


Figure. 50 Scenes in the technology transfer on digital compilation
(left: basic operation of the software, right: basics of digital compilation)

4-6-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The Study Team evaluated the technology transfer on digital compilation in which data of Gitega City created by the counterparts at the scales of 1/5,000 and 1/25,000 in the digital plotting were used as follows:

The counterparts were able to master digital compilation at the scale of 1/5,000 and practice the appropriate digital plotting methods for the second time by revising unnecessary point data and the data of buildings and roads which had been acquired in shapes too complex for the scale of 1/5,000 in the digital plotting in the practice of the digital compilation for the creation of 1/5,000 topographic maps.

The counterparts managed to implement the digital compilation for the creation of 1/25,000 topographic maps with the understanding of the difference in the scale from the 1/5,000 topographic maps and by selecting appropriate compilation functions in the practice of the digital compilation at the scale of 1/25,000.

As the counterparts had multiple opportunities to practice data cleaning and polygon creation in the practices of creating polygons from the data plotted at the scales of 1/5,000 and 1/25,000, they managed to complete the last practice, the creation of polygon data of administrative boundaries, without relying on the member of the Study Team.

Table. 42 Evaluation of the Outcome of the Technology Transfer on Digital Compilation

Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Compilation of the data created in the digital plotting	The IGEBU staff members understood that they had created too much point data and data with too complex shapes in the digital plotting	Implementation of the plotting of the unplotted area in the Gitega District with the appropriate data shapes and map representation for 1/5,000 maps kept in mind
Detection and correction of logical errors (data cleaning)	The IGEBU staff members understood how to set allowable limits for the automatic detection and the characteristics of the automatic and interactive processing.	Improvement in the efficiency of the work with the use of the automatic detection
Polygon creation	The IGEBU staff members understood the significance of the polygon creation, a method for the polygon creation, and errors generated in the polygon creation.	Application of the contents of the technology transfer to the edge matching between map sheets and creation of seamless data
Entry of data of administrative boundaries and annotations	The IGEBU staff members managed to create polygons of the data of administrative boundaries created by updating the existing data on the background of the orthophotos created in this Study.	Application of the contents of the technology transfer to the edge matching between map sheets and creation of seamless data

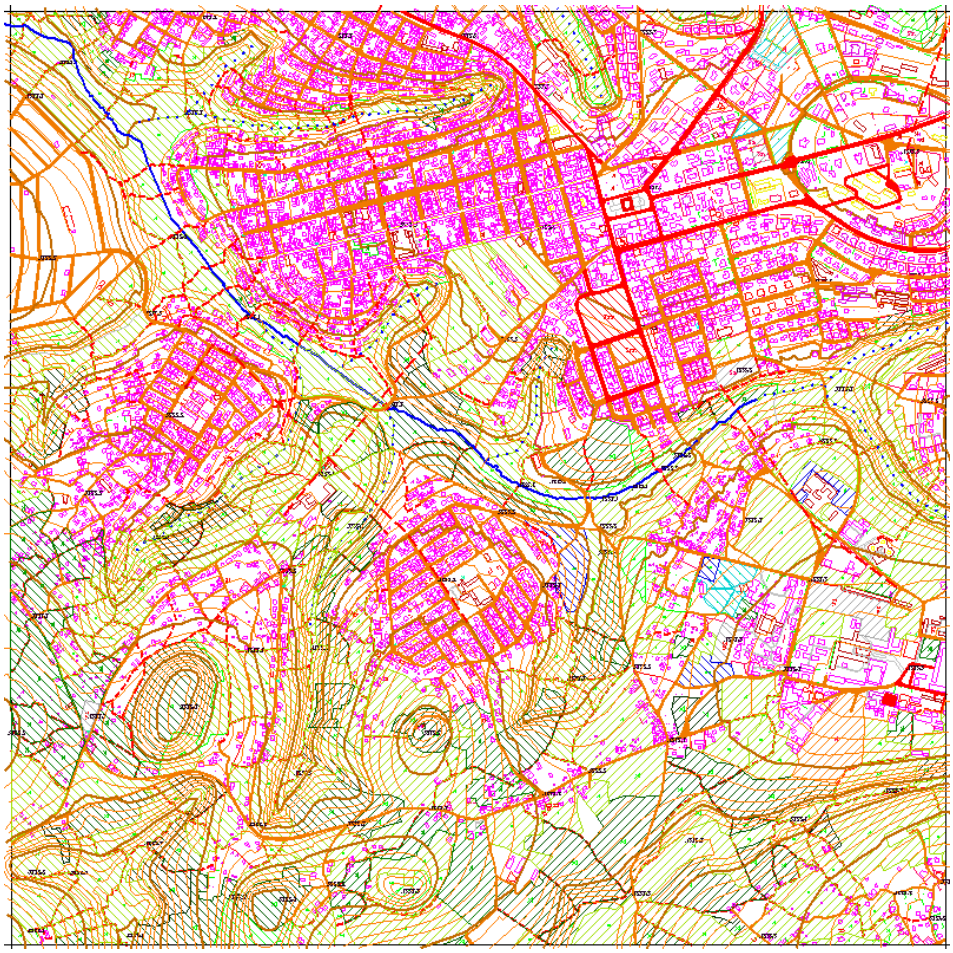


Figure. 51 Output of the Digital Compilation Created by an IGEBU Staff Member (1/5,000)

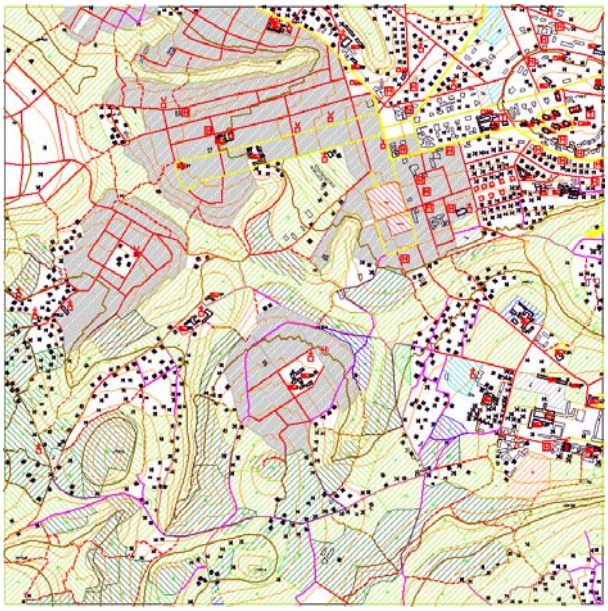


Figure. 52 Output of the Digital Compilation Created by an IGEBU Staff Member (1/25,000)

4-7. Technology Transfer on Map Symbolization

4-7-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on map symbolization.

Table. 43 Impacts and Evaluation of the Technology Transfer on Map Symbolization

Subject	Main objective	Impacts on IGEBU
Map symbolization (at 1/5,000)	Operation of PC and the software (MicroStation) Creation of symbols by data type (point, line or plane) Symbolization of the data for printing 1/5,000 topographic maps	Understanding of map symbols and topographic maps Capacity development in the creation of data for printing
Map symbolization (at 1/25,000)	Operation of the software (Illustrator) Creation of symbols by data type (point, line or plane) Symbolization of the data for printing 1/25,000 topographic maps	

4-7-2. Participants of the Technology Transfer

Two IGEBU staff members participated in the technology transfer. The Study Team conducted a questionnaire study of them before the technology transfer. (See Appendix for the result of the study.)

The study revealed that, although neither of them had experience in using either MicroStation or Illustrator to be used in this technology transfer, they had knowledge of the concept of the symbolization because they had used the map symbols in the field identification and field completion.

Table. 44 Participants of the Technology Transfer

Name		Experience in the work concerned	Remarks
1	SYORI Aloys	No	
2	KABERA Gilbert	No	

4-7-3. Schedule and Contents of the Technology Transfer

The Study Team implemented the technology transfer focused on the basic operation of the software because the two participants had little experience in its use. The Study Team implemented a weeklong training on the basic operation of MicroStation with the trainees participating in the digital compilation. The Study Team used one week on the basic operation of Illustrator.

The Study Team began the technology transfer from the creation of map symbols as the team considered that the participants had knowledge of the basic concept of the symbolization.

The following table shows the schedule of the technology transfer on map symbolization.

Table. 45 Schedule of the Technology Transfer on Map Symbolization

Subject	Contents of the technology transfer	Expected outcome
Week 1	Orientation and the questionnaire study	Evaluation of the experience and skill of the IGEBU staff members
Week 2	Basic operation of MicroStation	Acquisition and understanding of the basic operation
Week 3	Creation of symbols and lines with MicroStation	Understanding of symbols and map representation
Week 4	Creation of polygons and marginal information with MicroStation	Understanding of symbols and map representation
Week 5	Creation of symbols, lines and polygons with Illustrator	Acquisition of the basic operation and understanding of the map representations
Week 6	Symbolization for the creation of the 1/5,000 topographic maps of Gitega	Understanding of the arrangement and translocation of symbols on 1/5,000 maps
Week 7	Symbolization for the creation of the 1/25,000 topographic map of Gitega	Understanding of the arrangement, translocation, omission and priority orders of symbols on 1/25,000 maps
Week 8	Review of the technology transfer, compilation of the manual	Repeated practice of the contents of the technology transfer, improvement in the speed of the work

Figure. 53 Scenes in the Technology Transfer on Map Symbolization
(left: basics of the symbolization at 1/5,000, right: symbolization at 1/25,000)

4-7-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The Study Team evaluated the technology transfer on map symbolization as follows, on the basis of the quality of the map symbolization at the scales of 1/5,000 and 1/25,000 performed by the counterparts.

The participants seemed confused and disoriented with the use of the two different types of software for the map symbolization at the different scales (MicroStation at 1/5,000 and Illustrator at 1/25,000) in the beginning. However, they had managed to understand the advantages and characteristics of each type of the software by the end of the technology transfer. They were also able to deepen their understanding of the difference in the representations on maps at the different scales.

One of the two trainees had experience in using a CAD application, though not MicroStation, in the past and sufficient knowledge with regard to topographic maps including the understanding of the necessity for printed maps and implemented the work accurately while taking memos earnestly.

The training for the other participant had to begin from the introductory level as he had little experience in using computers. He improved his capacity extremely fast by taking notes all the time and repeating reviews. His interest in art contributed significantly to the work that required “artistic taste,” such as translocation of symbols. He performed even monotonous work without complaints.

As both of them have capacity to transmit information and apply technologies to other projects, the team expects them to play a central role in renewal of map data and creation of new maps.

Table. 46 Evaluation of the Outcome of the Technology Transfer on Map Symbolization

Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Symbolization	The participants understood that different map representations are used on maps at different scales.	To develop capacity to decide priority orders in data translocation, omission, selection, etc.
Inspection and correction on a screen display	The participants have learned the methods to implement the work efficiently, such as the inspection of data by data type.	To develop capacity to apply tools which make the work simple, such as a tool to change colors of objects
Inspection and correction on printouts	The participants understood the map representations appropriate for the final outputs by inspecting the data on maps printed on pieces of paper of the specified size	To develop capacity to decide whether the data is represented appropriately or not on maps

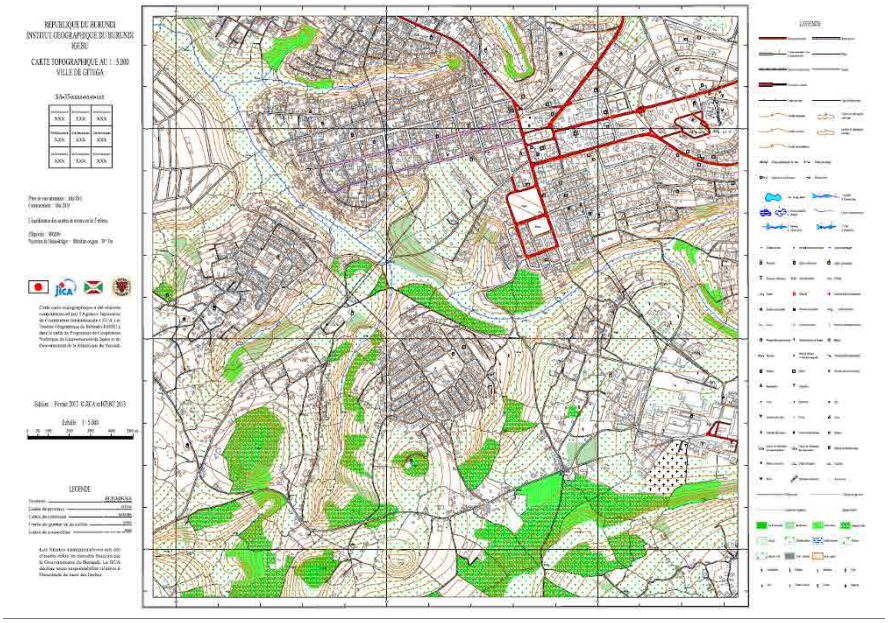


Figure. 54 Output of the Map Symbolization by an IGEBU Staff Member (1/5,000)

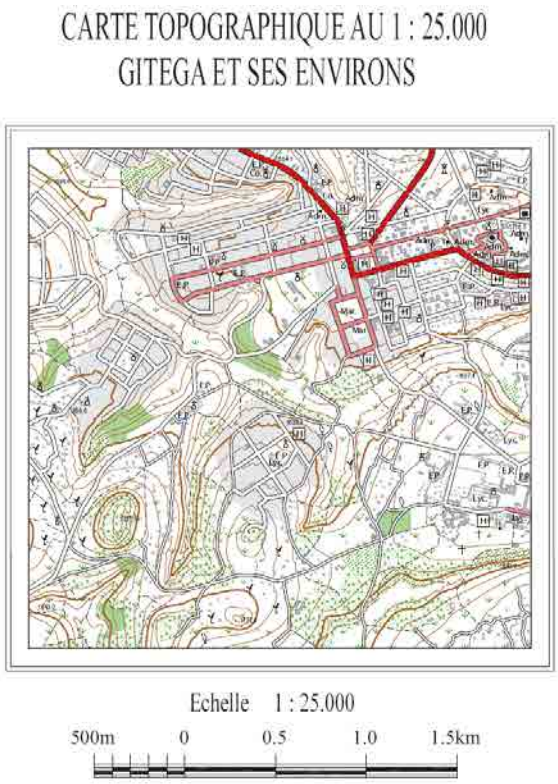


Figure. 55 Output of the Map Symbolization by an IGEBU Staff Member (1/25,000)

4-8. Technology Transfer on Data Structuralization

4-8-1. Purposes and Main Objectives

The following table shows the main objectives of the implementation of the technology transfer on data structuralization.

Table. 47 Impacts and Evaluation of the Technology Transfer on Data Structuralization

Subject	Main objective	Impacts on IGEBU
Definition of the GIS structuralization Creation of GIS basic data	Understanding of the outline of GIS Operation of the GIS software (ArcGIS)	Extension and promotion of the use of GIS in the assistance to formulation of priority projects in the National Development Plan and establishment of the basis for the existence of IGEBU
Creation of GIS model systems	Use of GIS	

4-8-2. Participants of the Technology Transfer

The following table shows the five IGEBU staff members who participated in the technology transfer. The Study Team conducted a questionnaire study of them before the implementation of the technology transfer. (See Appendix for the result of the study). The study revealed that four of them had already had experience in using ArcGIS.

Table. 48 Participants of the Technology Transfer

Name		Affiliation	Experience in data structuralization	Remarks
1	NTUMIGOMBA Protais	IGEBU Director	No	Experience in using ArcGIS
2	NIYUNGEKO Eugene	IGEBU Urban Planning	No	Experience in using ArcGIS
3	BARIVUMA Tharcisse	IGEBU Géomètre - Topographe	No	
4	NIBITEGUZA Sylvestre	IGEBU Photogrammètre	No	Experience in using ArcGIS
5	MUCOMWIZA Jean-Marie	Bujumbura Mairie Chef Service Informatique	No	Experience in using ArcGIS

4-8-3. Schedule and Contents of the Technology Transfer

Most of the IGEBU staff members who participated in the technology transfer had experience in operation of the software used in this Study, ArcGIS. However, as they had used an old version of the software, the Study Team provided them with training on the latest version using comparison between the two versions.

The data created in the digital compilation and the map symbols were used for the training on the data structuralization including sorting of data and data conversion required for the GIS analysis.

The participants held discussion on the GIS model systems to be created before the creation of GIS model systems. The subjects of the discussion were materials required for the analysis, analysis methods and accuracy required for the analysis. After the discussion, the participants entered and converted the data required for the analysis individually.

Creation of GIS model systems will serve as an important case of the use of the outputs of this Study and the created systems have potential to be useful tools for the extension of the use of geographic information. The IGEBU and the Study Team decided to give a presentation on the GIS model systems in the final seminar in order to promote the information use aggressively. Therefore, creation of presentation materials and practice of presentation were included in the technology transfer.

Table. 49 Schedule of the Technology Transfer on Data Structuralization

Subject	Contents of the technology transfer	Expected outcome
Week 1	Briefing on ArcGIS 10 Data structuralization	Understanding of the concept and basic theories of GIS
Week 2	Data structuralization	Understanding of the concept and basic theories of GIS
Week 3	Discussion on GIS model systems Data collection and conversion	Understanding of the basics of the GIS analysis, understanding of the methods for data collection and classification
Week 4	Creation of GIS model systems	Understanding of advanced operation of ArcGIS
Week 5	Creation of GIS model systems	
Week 6	Creation of GIS model systems	
Week 7	Creation of GIS model systems	
Week 8	Presentation on the created model systems	Review of the contents of the training, improvement in the skills to create materials for presentation and make presentations

Figure. 56 Scenes in the Technology Transfer on Data Structuralization

(upper left: discussion, upper right; data entry, lower left: GIS model system creation, lower right: practice of presentation)

4-8-4. Outputs of the Technology Transfer, Impact on IGEBU and Problems

The Study Team evaluated the outcome of the data structuralization and the GIS model system creation as follows:

All the trainees managed to master the basic operation of the software and reach the technical level at which they could structure the data created in the digital compilation and enter the created data into the software at an acceptable speed. All the participants were able to express their views on the basic concept of GIS and data analysis in GIS to the others and understood the views of the others fully through active exchange of views in the discussion.

The participants acquired the capacity to create data for presentation on the created GIS model systems and make presentations using the created data in the training.

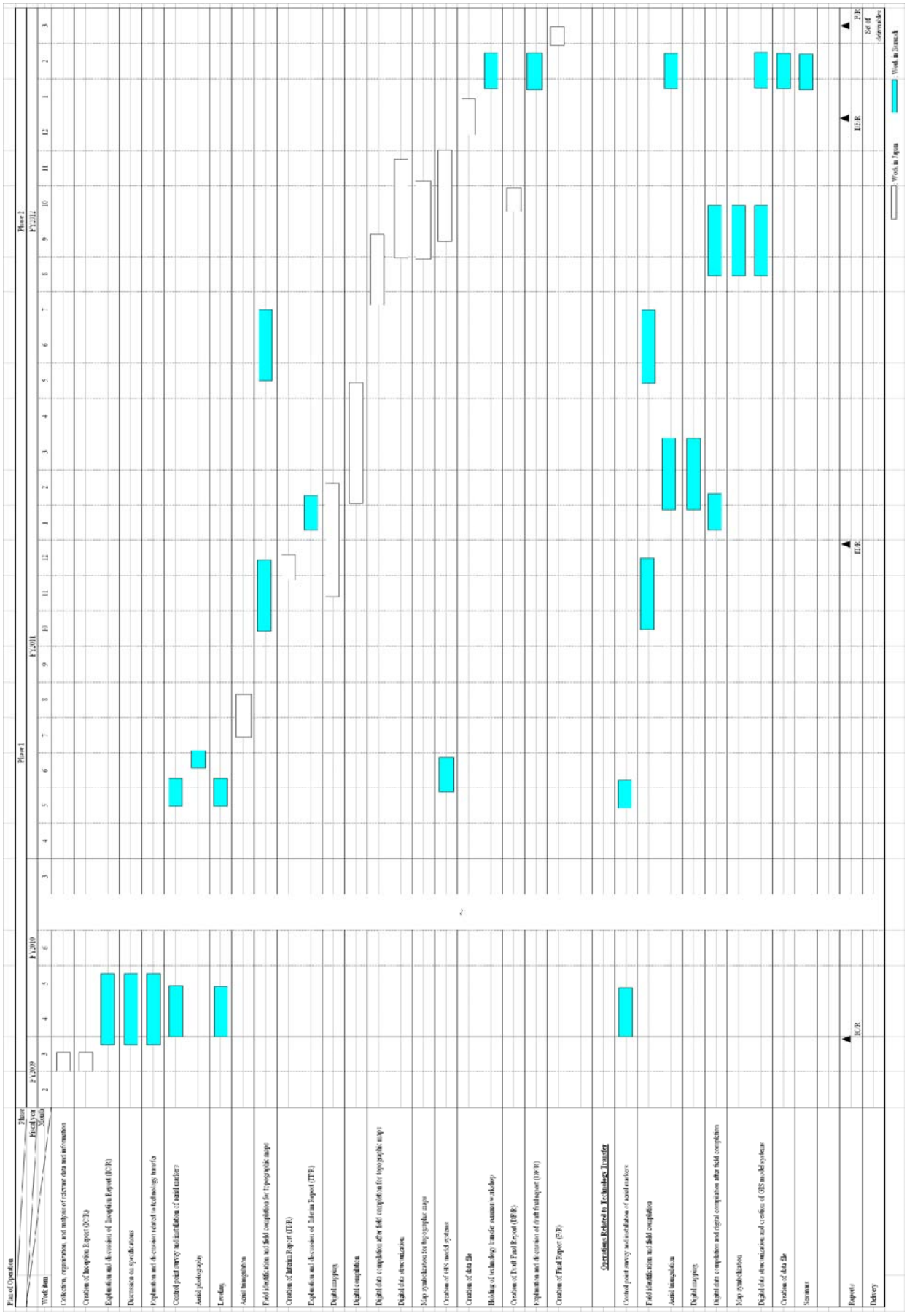
Table. 50 Evaluation of the Outcome of the Technology Transfer on Data Structuralization

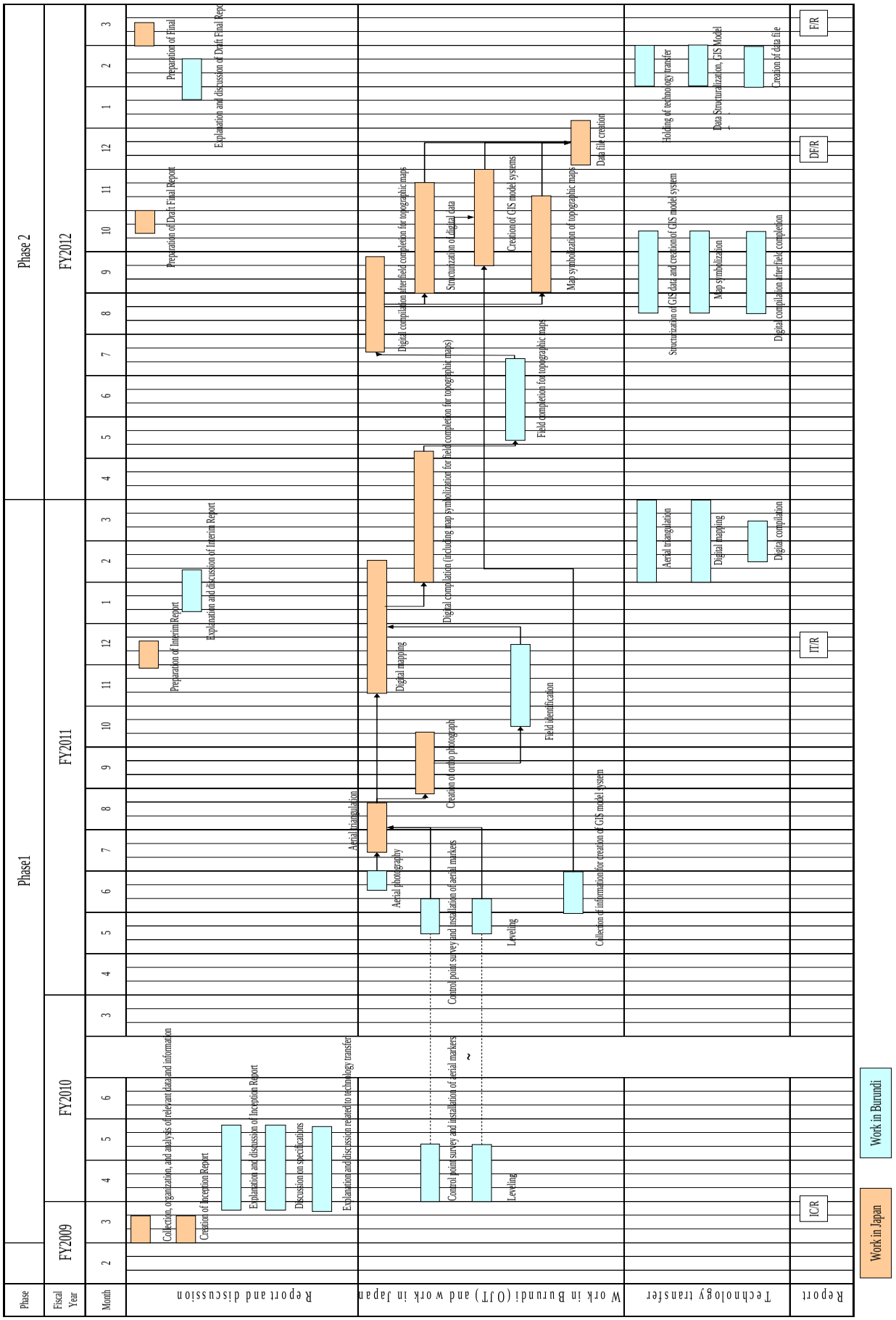
Subject	Outputs of the technology transfer	Impacts on IGEBU and problems
Understanding of the outline of GIS	The IGEBU staff members were able to deepen their understanding through the two-way information exchange between them and the Study Team members realized by implementation of the discussion.	N/A
Operation of the GIS software (ArcGIS)	As most participants had experience in the operation of the GIS software, they were able to perform the basic operation of its latest version without problems. The participant who did not have experience in using the software managed to learn how to enter data into the software with support from the other participants.	Updating of the manual created in this Study
Creation of the GIS model systems	The participants managed to create GIS models, from data collection to data creation, without assistance from the member of the Study Team. Some of the IGEBU staff members were able to compile the outputs into presentation material and use it in the presentation.	Solicitation of donors with further appeal to the relevant government offices and extension of the use of geographic data through joint model creation and educational activities

5. Operation Process Plan and Personnel

5-1. Operation Process Plan and Project Flowchart

The operation process plan and project flowchart of this Study are provided on the next pages.


Plan of Operation
Phase
Fiscal Year
Month
Work Item
Phase 1
Phase 2
FY2009
FY2010
FY2011
FY2012
Collection, organization, and analysis of climate data and information
Creation of Inception Report (ICR)
Explanation and discussion of Inception Report (ICR)
Discussion on specifications
Explanation and discussion related to technology transfer
Control point survey and installation of aerial markers
Aerial photography
Leveling
Aerial triangulation
Field identification and field completion for topographic maps
Creation of Interim Report (ITR)
Explanation and discussion of Interim Report (ITR)
Digital mapping
Digital compilation
Digital data compilation after field completion for topographic maps
Digital data structuralization
Map symbolization for topographic maps
Creation of GIS model systems
Creation of data file
Holding of technology transfer seminar/workshop
Creation of Draft Final Report (DFR)
Explanation and discussion of draft final report (DFR)
Creation of Final Report (FR)
Operations Related to Technology Transfer
Control point survey and installation of aerial markers
Field identification and field completion
Aerial triangulation
Digital mapping
Digital data compilation and digital compilation after field completion
Map symbolization
Digital data structuralization and creation of GIS model systems
Creation of data file
Seminars
Reports
Delivery
ICR
ITR
DFR
FR
Set of Deliverables
Work in Japan
Work in Burundi


Phase
Fiscal Year
Month
Report and discussion
Work in Burundi (OJT) and work in Japan
Technology transfer
Report
Phase1
Phase 2
FY2009
FY2010
FY2011
FY2012
Collection, organization, and analysis of relevant data and information
Creation of Inception Report
Explanation and discussion of Inception Report
Discussion on specifications
Explanation and discussion related to technology transfer
Control point survey and installation of aerial markers
Leveling
Aerial photography
Aerial triangulation
Digital mapping
Digital compilation (including map symbolization for field completion for topographic maps)
Creation of ortho photograph
Field identification
Field completion for topographic maps
Digital compilation after field completion for topographic maps
Structurization of digital data
Creation of GIS model systems
Map symbolization of topographic maps
Data file creation
Collection of information for creation of GIS model system
Preparation of Interim Report
Explanation and discussion of Interim Report
Preparation of Draft Final Report
Explanation and discussion of Draft Final Report
Preparation of Final
Holding of technology transfer
Data Structurization, GIS Model
Creation of data file
Aerial triangulation
Digital mapping
Digital compilation
Structurization of GIS data and creation of GIS model system
Map symbolization
Digital compilation after field completion
IC/R
ITR
DF/R
F/R
Work in Japan
Work in Burundi

5-2. Personnel Plan

The personnel plan is as shown below.