No.

JAPAN INTERNATIONAL COOPERATION AGENCY
INSTITUTO GEOGRÁFICO AGUSTÍN CODAZZI
IN THE REPUBLIC OF COLOMBIA

THE STUDY ON THE FORMULATION OF GEOGRAPHIC DATA BASE OF THE PRINCIPAL CITIES IN THE ATLANTIC COAST IN REPUBLIC OF COLOMBIA

FINAL REPORT

SUMMARY

DECEMBER 2007

ASIA AIR SURVEY CO., LTD.

PASCO CORPORATION

SD
JR
07-092

Exchange Rate

US$1.00=Col.$1,837＝¥115.73　　as of September 2007

PREFACE

In response to a request from the Government of Colombia, the Government of Japan decided to conduct a study on The Study on the Formulation of Geographic Data Base of the Principal Cities in the Atlantic Coast in the Republic of Colombia and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Yoshitaka GOMI of ASIA AIR SURVEY Co., LTD. and consists of ASIA AIR SURVEY Co., LTD. and PASCO Corporation between August, 2005 and November, 2007.

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

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

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

December 2007

Eiji HASHIMOTO,
Deputy Vice President
Japan International Cooperation Agency

Letter of Transmittal

Mr.Eiji HASHIMOTO
Deputy Vice President
Japan International Cooperation Agency

Dear Mr.Hashimoto

It is my great pleasure to submit herewith the Final report for the Study on the Formulation of Geographic Data Base of the Principal Cities in the Atlantic Coast in Republic of Colombia.

The Study team consists of Asia Air Survey Co., Ltd and Pasco Corporation conducted field survey in Colombia during the period from August 2005 to October 2007, and office work such as digital topographic mapping during the period from August 2005 to December 2007 as per the contract with the Japan International Cooperation Agency.

During the field survey in Colombia, discussions with the officials of Instituo Geográfico Augustín Codazzi (IGAC) were held. Base on the results of the discussions with IGAC, digital topographic maps, other final results and final report was prepared.

On behalf of the Study team, I would like to express may heartfelt appreciation to IGAC in Colombia and other authorities concerned for the their diligent cooperation and assistance for the heartfelt hospitality which they extended to the Study team during our stay in Colombia.

I am also greatly indebted to the Japan International Cooperation Agency, the Ministry of Foreign Affairs and the Embassy of Japan in Colombia for giving us valuable suggestion and assistance during the preparation of this report.

Yours faithfully,

Yoshitaka GOMI

Team Leader for the Study on the Formulation of Geographic Data Base
of the Principal Cities in the Atlantic Coast in Republic of Colombia

Metropolitan area of Barranquilla

Santa Marta

Cartagena

Location Map

Abbreviation

Abbreviation	Spanish	English
ACCI	Agencia Colombiana de Cooperacion Internacional	Agency for International Cooperation
CAD	Computer Aided Design	Computer Aided Design
CIAF	Centro de investigación y Desarrollo en Información Geográfica	Center for Interpretation of Aerial Photographs
DANE	Departamento Administrativo Nacional de Estadística	National Statistical Department
DNP	Departamento Nacional de Planeación	National Planning Department
DTM	Modelo Digital del Terreno	Digital Terrain Model
GIS	Sistema de Informacion Geográfica	Geographical Information System
GPS	Sistema de Posicionamiento Global	Global Positioning System
ICDE	Infrastructura Colombiana de Datos Espaciales	Colombia Spatial Data Infrastructure
IDB	Inter-American Development Bank	Inter-American Development Bank
IGAC	Instituto Geografico Agustin Codazzi	Instituto Geografico Agustin Codazzi
JICA	Agencia de Cooperación Internacional del Japón	Japan International Cooperation Agency
POT	Plan de Ordenamiento Territorial	Land use plan

Summary of the Study

	Item of work	Volume of Work
1	**Aerial photography**	
	Photo scale	1/10,000
	Aerial photography area	400km²
	Positive film making	Cartagena 328 photos Barranquilla 622 photos Santa Marta 380 photos
	Scanning of positive film	1,330 photos
2	**Ground control point survey**	
	GPS observation	Cartagena 37 points Barranquilla 42 points Santa Marta 26 points
	Pricking	Cartagena 37 points Barranquilla 42 points Santa Marta 26 points
	Field identification	400km²
3	**Aerial triangulation**	
	Aerial triangulation	Cartagena 198 models Barranquilla 331 models Santa Marta 175 models
4	**Digital topographic mapping**	
	Map scale	1/2,000
	Mapping area	400km2
	Number of sheets	Cartagena 120 sheets Barranquilla 196 sheets Santa Marta 103 sheets
	Contour interval (Main contour interval)	2 m
5	**Basic Data creation**	
	Area	400km2
6	**GIS model system**	
	GIS model system CD-Rom	1 sets
7	**Production of CD-Rom**	
	Digital map data file	5 sets
8	**Polyester base map**	
	1/2,000cale of polyester base map	2 sets
9	**Report**	
	Inception Report	English 20 sets Spanish 10 sets
	Interim Report	English 20 sets Spanish 10 sets
	Draft Final Report (Main, Summary)	English 20 sets Spanish 10 sets
	Final Report (Main, Summary)	Japanese 10 sets (Summary) English 20 sets Spanish 10 sets

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SCOPE OF WORK FOR THE STUDY ON THE FORMULATION OF GEOGRAPHIC DATA BASE OF THE PRINCIPAL CITIES IN THE ATLANTIC COAST IN REPUBLIC OF COLOMBIA

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CHAPTER 1 INTRODUCTION AND BACKGROUND OF THE STUDY

1.1 Background of the Study

Colombia is striving to implement social and economic development, following the guide line of the Quadrennial Development Plan which support the part of Plan Colombia

Colombia is striving to implement social and economic development, following the guideline of the Quadrennial Development Plan which support the part of Plan Colombia.

In Colombia, making or updating Plano Ordinaminento Territorial (POT) is a pre-requisite condition before any infrastructure development project is implemented.

However, in many municipalities, making high quality POT is hampered by the lack of reliable and up-to-date geographic information.

As the national survey and mapping institute of Colombia, IGAC (Instituto Geográfico Agustín Codazzi) is responsible for the production of maps and geographic information of Colombia. IGAC has a long history and experience in photogrammetric mapping and its production facilities have been modernized constantly. However, as for the 1/2,000 scale digital map production using modern digital mapping systems, IGAC had not fully established procedures for the full scale production and was seeking for an opportunity to improve efficiency of production.

In responding to the request from the Colombian government for technical assistance, JICA decided to produce 1/2,000 scale digital maps and basic GIS data of three Atlantic cities, namely, Santa Marta, Barranquilla and Cartagena. Total mapping area is 400 km^2. During the course of this map production, it was expected that technologies for mass production of 1/2,000 digital maps and basic GIS data are transferred to IGAC by the JICA Study Team. Also, it was planned that IGAC's mapping procedures and methods are reviewed by IGAC and The JICA Study Team to check to see if IGAC is going to be self sustainable in terms of the 1/2,000 map and basic GIS production of 100 municipalities.

1.2 Scope of the study

1.2.1 Purpose

The purpose of the study is summarized as follows:

(1) To support making POT aimed at the urban planning for the 103 municipalities in Colombia. And as for three Atlantic coastal cities where urban area is spreading and therefore making reliable urban development plan is given high priority, the JICA Study Team made basic GIS data based on the 1/2,000 scale digital topographic maps. Also a sample of GIS model system is made to show the value of reliable and accurate geographic information and the method to use them.

(2) Carrying out self sustainability analysis of IGAC's 1/2,000 scale map and basic GIS data making program for the remaining 100 municipalities.

(3) Transfer technologies required in modern digital mapping to IGAC through the activities described in item (1) and (2) above.

1.2.2 Target area

The target of this study is the three cities located along the Atlantic coast, namely, Cartagena, Santa Marta and Metropolitan area of Barranquilla. Colombia Total mapping size is 400 km^2 (Figure 1-1).

Figure 1-1 Study Areas (Cartagena, Metropolitan area of Barranquilla and Santa Marta.)

1.2.3 Physical output

The following material or system were made in the Study

- Field classification result
- Aerial triangulation result
- Printed maps in polyester paper
- Basic GIS data made from 1/2,000 scale map
- Sample of GIS model system

1.3 Summary of the study

The contents of work implemented in the study are summarized as follows.

First of all the study was started in July, 2005 when the JICA Study Team started its preparatory work in Japan. The JICA Study Team visited Colombia total five times and the study was completed in December 2007 when the JICA Study Team delivered the final output of the study to JICA Tokyo office.

Aerial photography, film scanning, ground control point survey and field identification survey were planned and implemented by IGAC. JICA studied team arrived at Colombia after the completion of aerial photography and film scanning. The JICA Study Team provided various advice on ground control point survey and field identification survey.

Aerial triangulation, digital mapping, digital editing and data structurization were carried out in Japan.

Through the process of the study, IGAC staff and The JICA Study Team tried new techniques such as the use of data recorder with GPS in field identification survey.

Since IGAC technical staff already had knowledge in the operation of digital mapping instruments, technology transfer was made mainly as a form of technical discussions rather than giving instructions on the operation of instruments. A series of discussions were made to check problems of current production process or to exchange opinion on production techniques.

Major subjects of discussion and examination were as follows:

- Number and distribution of GCP used in aerial triangulation
- Use of orthophoto in field identification survey

- Use of data recorder with GPS (RECON) in field identification survey
- Format of point description
- Specifications of map symbols
- Geographic feature catalogue
- Contents of the basic GIS data
- Sheet allotment of 1/2,000 scale maps
- Handling of local coordinate systems
- Cooperation and communication among different division or group
- Use of orthophotos as background in the inspection of map quality

Map production methods being employed by IGAC have been formulated based on specific conditions of Colombia including history of the organization. Therefore, some of the methods advised by the JICA Study Team may not directly fit to IGAC's situation. However, observation of the JICA Study Team which was made from different point of view from IGAC contributed to the identification of problems which cannot be noticed by IGAC.

Further, since the JICA Study Team actually made maps and geographic data in the study, the JICA Study Team could review and examine IGAC's technical specifications. Findings of the JICA Study Team on the specifications will be useful for IGAC when it subcontracts out the digital mapping work to local private firms.

As for the results of the self sustainability analysis, it was concluded that IGAC has basic technical skills required in the production of 1/2,000 scale digital maps and basic GIS data. As for the promotion of the use of GIS, it was found that almost all the local municipalities do not have knowledge, experience, staff and instruments for handling paper maps. Therefore, it would be useful to use IGAC regional offices in the promotion of GIS data.

CHAPTER 2 FRAMEWORK OF THE STUDY

The Study was conducted in close communication between the JICA Study Team and IGAC. A series of meetings were held to confirm the detailed scope of work of the study and technical specifications. Coordinating committee was organized to share project information with major stakeholders of the study. This chapter explains how the study was managed.

2.1 Project Management Tools

Smooth communication among stakeholders of the study is a key for the successful implementation of the study. For this purpose, several devices were used in the study. They are coordinating committee meetings, discussion on reports and specifications, seminars and workshops.

2.1.1 Coordinating committee

Coordinating committee was organized to monitor the progress of the study by major stakeholders. Committee members are:

- IGAC (Instituto Geográfico Agustín Codazzi), DANE (Departamento Administrativo Nacional de Estadística), DNP(Departamento Nacional de Planeación), ACCI(Agencia Colombiana de Cooperacion Internacional), Municipalities of Cartagena and Barranquilla, Santa Marta.
- Director of Territorial office of IGAC (Cartagen, Barranquilla and Santa Marta)
- The JICA Study Team

(1) The First Coordinating Committee Meeting

The First Coordinating Committee Meeting was held on February 10, 2006 at the IGAC territorial office in Santa Marta.

Comments from the participants were as follows:

- Participants have high expectation on the new topographic maps
- As for the problem of cities the following two points were listed.
  - Even if new data are provided, local offices do not have sufficient enough number of machine and staff who have sufficient training
  - Data updating cannot be done

(2) The Second Coordinating Committee meeting

The second coordinating committee meeting was held on September 10, 2006 at the IGAC territorial office in Cartagena. Discussion was made mainly on the use of the data to be made in the study. During the discussions, territorial director and her staff asked IGAC to strengthen its education and training

(3) The Third Coordinating Committee meeting

The Third Coordinating Committee meeting was held on October 22, 2007 at IGAC. This was the last Coordinating Committee meeting for the study and the results of the study were presented to the participants.

2.1.2 Presentation of reports

The JICA Study Team prepared draft Inception Report and submitted it to IGAC at the beginning of the Study. The Inception Report contains the understanding of the JICA Study Team on the project contents and schedule. A series of meetings were held between IGAC and the JICA Study Team to discuss the project contents and the results of the meetings were compiled as a Minutes of Meeting.

The JICA Study Team prepared Interim Report in the middle of the project period to report to IGAC the progress of the Study and also to propose any changes to be made in the contents or schedule of the Study. Minutes of Meetings were also made to record the results of the discussion.

Draft Final Report was made by the JICA Study Team in September 2007 and submitted to IGAC to confirm the results of the two and a half years work.

2.1.3 Seminars and Workshop

One workshop and three seminars were held. The purpose of the seminars and workshop was to inform the participants of the purpose and outcome of the Study as well as to exchange technical opinions on the method of survey and mapping with the participants.

(1) Workshop

After the completion of the first year's activities and at the beginning of the second year's work, a workshop was held at IGAC headquarters in Bogotá to report the progress of the study and also to introduce the output of the study to stakeholders and potential user of the project output. At the same time, the participants were asked how they are going to use the project output. Their answers showed that they are expecting to use the 1/2,000 scale maps and basic GIS data

for various purposes such as cadastral surveys, urban planning and land use planning

(2) Seminar #1

The first seminar was held in September 2006 at IGAC headquarters in Bogotá. Progress of the study and findings were presented to IGAC staff and stakeholders.

(3) Seminar #2

The second and last seminar was held at IGAC headquarters in Bogotá to report the progress of the study as well as findings of the JICA Study Team. Also in order to disseminate the information on the outcome of the Study, the JICA Study Team member visited all of the three municipalities and had a small seminar in each city. In this small seminars, particular emphasis was placed on the explanation on the use of GIS for POT making.

CHAPTER 3 DISCUSSION ON TECHNICAL SPECIFICATIONS

During the course of the study the JICA Study Team and IGAC had a series of meetings to confirm the contents and specifications of the study. In the meetings on the contents of reports also related to technical specifications. Scope of work and specifications discussed and confirmed in the meetings are summarized below.

3.1 Inception Report Meeting

The discussion on the contents of the Inception Report was held on August 31, 2005 （Figure 3-1）. Contents of the discussion were recorded as Minutes of Meeting.

Figure 3-1 Inception report meeting

3.2 Discussions on map symbols and specifications

Discussions on map symbols and specifications was done during the first visit of the JICA Study Team to Colombia in 2005 and the second visit of the JICA Study Team to Colombia between January 2006 and February 2006.

3.3 Interim Report Meeting

In order to report the activities between August 2005 and June 2006 and also to discuss the work plan between July 2006 and the end of the project, the JICA Study Team made Interim Report and presented to IGAC. Meeting on this report was held on July 14, 2006 (Figure 3-2). The items discussed and confirmed are as follows.

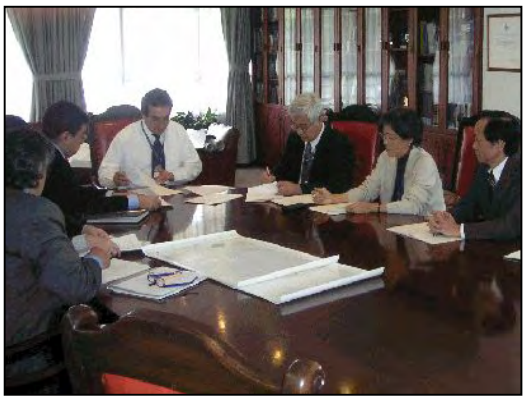



Figure 3-2 Interim report meeting

3.4 Draft Final Report Meeting

Meeting for the explanation and discussion of Draft Final Report was held between IGAC and the JICA Study Team on September 2007. The JICA Study Team explained the outline of the project and result of the product.

After the explanation and discussion between IGAC and the JICA Study Team, IGAC confirmed about some numerical value that was quoted in the report, and IGAC accepted the contents of draft finals report.

3.5 Dealing with flexibility

Beside from official meetings and discussions, the JICA Study Team and IGAC had frequent meetings to discuss technical issues and exchange opinions. The JICA Study Team tried its best to deal with requirements from IGAC in flexible manner. For instance, IGAC requested the JICA Study Team to change map symbols even after they were officially determined in February 2006. The JICA Study Team discussed the issue with IGAC and did its best to incorporate such changes.

CHAPTER 4 DESCRIPTION OF IGAC

In order to make plan for technology transfer, to analyze self sustainability of the 1/2,000 scale mapping program as well as to make plan for the promotion of GIS, it was necessary to understand the characteristics and capability of IGAC. This chapter summarizes the information collected by the JICA Study Team on IGAC.

4.1. Organization of IGAC

4.1.1 History of IGAC

IGAC is the national survey and mapping organization of Colombia and a leading geographic institute in Central and South America.

While IGAC is an independent institute, its management is supervised by a board which consists of representatives of other ministries and public agencies. Member of the board area as follows:

- DANE (Departamento Administrativo Nacional de Estadistica)
- Ministerio de Medio Ambiente, Vivienda y Desallojo Territoria
- Ministry of Defense
- DNP (Departamento Nacional de Planeacíon)
- Presidential office

4.1.2 Organizational structure of IGAC

IGAC consists of three divisions and one research and development institute.
Organization chart of IGAC is as shown in Figure 4-1.

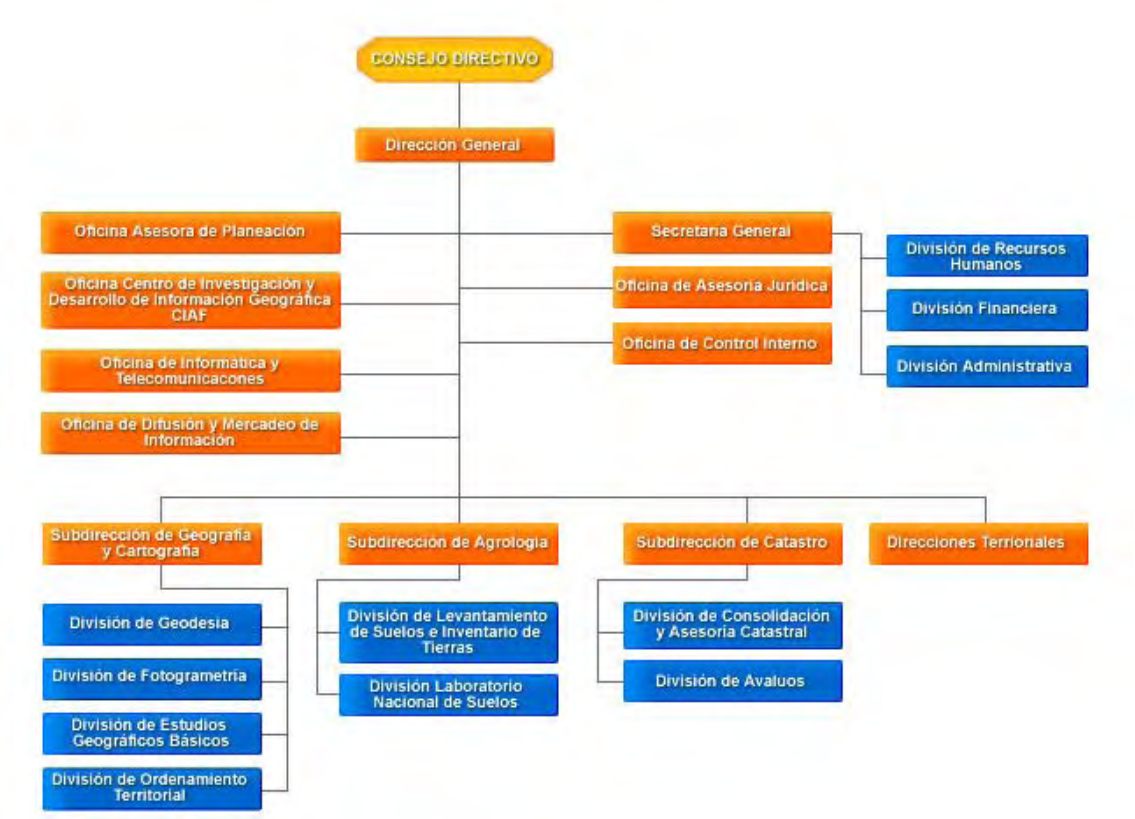


Figure 4-1 Organization chart of IGAC

4.1.3 Role of IGAC

As the organization chart indicates, IGAC has five major roles.

- Production of maps and geographic information
- Maintenance and management of cadastral data
- Production of soil data
- Research on the use of GIS
- Research and development of technologies in geodesy, photogrammetry, remote sensing and the use and management of geographic information

One unique feature of IGAC is that IGAC is not only responsible for topographic map production but also for the maintenance and management of cadastral data. This fact seems to be related to the contents of field identification survey. In IGAC's field identification survey wider variety of data is collected comparing to the survey for ordinary topographic mapping work.

4.2 Operation Plan

According to Report of the Management Plan published by IGAC in February 2006, pre-conditions of IGAC's five years plan covering 2005 - 2010 were as follows:

- Budget from the central government shrunk and introduction of modern mapping technologies is delayed. However, IGAC has to carry out its mission.
- After 1994, IGAC is updating maps according to the budget, but still parts of the country are not yet updated.
- Since 1997 IGAC has been the leader of ICDE (Infrastructura Colombiana de Datos Espaciale). The purpose of ICDE is to promote the production of geographic information as well as the access and usage of geographic information.
- Make development plan according to "Hacia un Estado Comunitario"
- Innovate organization according to the Decree 208 of 2004.
- Make necessary maps by DANE-IGAC program for Year 2005 Census.
- Modernize cadastral management with the assistance from IDB.
- Activate mapping system with the assistance from EU.
- Make quality control mechanism to get ISO9001:2000 certificate.

4.3 Budget

Total budget of IGAC for the year 2005, 2006 and 2007 are as follows:

2005: CO$84,260,264,321
2006: CO$53,166,500,053
2007: CO$72,823,500,000

Year 2005, 2006 and 2007 budget for mapping are as shown on Table 4-1. In Year 2005, special budget for DANE mapping is included.

Table 4-1 Mapping Budget of IGAC Year 2005,2006 and 2007(CO$)

Cost Item	2005	2006	2007
Total mapping budget	26,187,569,000	480,000,000	8,443,000,000
1. Production and updating of general maps	300,000,000	300,000,000	4,108,000,000
2. DANE	10,987,569,206	0	0
3. Contract with other ministries	0	0	4,280,000,000
4. System modernization	14,900,000,000	180,000,000	55,000,000

4.4 Income

IGAC makes efforts to promote the sale of its products. New types of products are being produced at rapid pace. Revenue from the sale of the products was CO$7,127,400,000 in 2005 and CO$8,034,000 in 2006.

4.5 Situation of map and geographic information production

1/100,000 scale map production was completed in 2006. Production of 1/2,000 and 1/25,000 scale maps being implemented and budget is needed.

4.6 Production capacity of the Division of Photogrammetry

For the production of photogrammetric maps and basic GIS data, there are two divisions under the Sub Directorate of Geography and Cartography. They are:

- Sub Division of Photogrammetry
- Sub Division of Geodesy

Their capacity is as described below.

4.6.1 Number of staff

First of all, IGAC staff is classified under the following categories.

(1) Administrative staff
Director, Sub-Director, Adviser: Consultants, Chiefs of office and/or Chiefs of Division (15 people)
(2) Technical staff
Coordinators, Professionals, Technicians

Number of staff working at Bogotá headquarters is 290 and those of regional office are 646.

4.6.2 Training of technical staff

Every year CIAF makes annual training program and send it to each Sub Directorate. Heads of the Sub Directorates select their staff who are going to take the training courses that year. However, it should be noted that above mentioned training opportunities are open only for legitimate staff of IGAC.

4.6.3 Instruments and equipment

IGAC started digital mapping in 1990 when encoder was attached to Wild B8 analogue plotting machine. In 1999 the first soft copy stereo restitution machine was installed. And since 2005 IGAC was rapidly changing its photogrammetric mapping instruments to soft copy machines.

4.6.4 Assistance from other donors

EU, U.S.A., Sweden, and France were providing technical support to IGAC in various fields of survey, photogrammetry, remote sensing and GIS.

4.7 Situation of IGAC regional offices

Currently, the productions of 1/2,000 scale digital maps are being handled by the headquarters of IGAC. If IGAC territorial offices can take over some part of the field work currently being carried out by the personnel of IGAC headquarters, cost saving is possible.

With this hypothesis, the situation of territorial offices was surveyed. Offices in Cartagena, Santa Marta, Barranquilla, Cali, Manisalez and Perelia were visited.

4.7.1 Role of IGAC territorial offices

IGAC has total 22 territorial offices. They are under the Sub-Directorate of Cadastre. Their main role is the management of cadastral data including data updating. Territorial offices sell cadastral maps and data to the public.

4.7.2 Technical capacity

Regional offices are equipped with cadastral GIS with the assistance from IDB. For cadastral data updating and management, every office has 2 to 3 field surveyors and 2 to 3 cartographic and GIS staff.

4.7.3 Issues

Most offices visited by the JICA Study Team feel that more comprehensive training in GIS is required for their staff. Particularly, more formal education and training will be required to handle problems associated with digitizing maps of unknown parameters or changing projection system from one to the other.

CHAPTER 5 1/2,000 MAPPING AND BASIC GIS DATA PRODUCTION IN THIS STUDY

In this chapter, the 1/2,000 scale maps and basic GIS data production process employed in the study are described. As for very important things, they are summarized in Chapter 8.

5.1 Preparatory work in Japan

Information and material collected by the Preliminary Study Team and also by the JICA Study Team were analyzed in order to make basic strategy for the Study.

5.2 Aerial photography and scanning

5.2.1 Aerial photography

Aerial photography and scanning of the aerial photos were undertaken by IGAC before the JICA Study Team visited Colombia in August 2005. Plan for aerial photography was also made by IGAC.

Santa Marta area:	Approximately 330 photos
Cartagena area:	Approximately 380 photos
Metropolitan area of Barranquilla:	Approximately 620 photos

5.2.2 Scanning of aerial photos

IGAC made digital images of the aerial photos in TIFF format, by using VEXEL Ultrascan5000. Setting selected by IGAC for scanning was:

Gray scale:	256 levels
Scanning resolution:	15 microns (Approx. 1600dpi)

Size of one image file was 221MB. These image files were provided to the JICA Study Team.

5.3 Ground control point survey

5.3.1 Collection of data on existing GPS points and bench marks

The JICA Study Team collected information required for the subsequent survey and mapping work from IGAC.

5.3.2 IGAC'S Specifications for GPS survey

The Study Team found that IGAC usually does not use direct leveling method to measure the

elevation of ground control points which are within 10 kilometers distance from the known points. The JICA Study Team also confirmed that the total volume of work for ground control point survey would not change too much. Therefore, the JICA Study Team agreed to carry out only GPS survey for the ground control point survey.

5.3.3 Selection of ground control points

The JICA Study Team explained the ground control point allocation plan prepared in Japan to IGAC. The point allocation plan was for block adjustment.

5.3.4 GPS observation

GPS survey was carried out by using Leica System500 receivers following IGAC's specifications for ground control point survey for 1/2,000 scale mapping (Figure 5-1). First, reference points were established. Then, by using two reference points a triangle was formed with a new point. Length of one side of the triangle was approximately 10 kilometers.

GPS Observation

Checking of elevation data by direct leveling

Figure 5-1 Ground Control Point Survey

5.3.5 Pricking of GCP's and making description of points

IGAC usually use pricking method to identify the locations of GCP's on aerial photos. Aerial signals are not established before aerial photography. Pricking method is also employed in this study.

As for the point description of GCP's, two types of description were made. One follows IGAC method and the other one follow the design proposed by the JICA Study Team.

The JICA Study Team proposed to use satellite image obtained from WWW as background image so that relative locations of GCP's are easy to understand. Further, the team took photos of GCP's and their surrounding areas from relatively close distance and paste the image on the description. This image makes it easy to understand the elevation of the GCP's when aerial triangulation is carried out.

5.3.6 Computation of GCP coordinates

According to IGCA's work flow, computation of coordinates after GPS observation is not carried out while the survey team is still in the survey area. Field survey team brings back the GPS observation data to IGAC headquarters in Bogotá and coordinate computation is done by engineers in charge of computation.

Further, IGAC usually uses precise ephemeris for GPS coordinate computation and it takes about 15 days. The JICA Study Team proposed to use broadcasted ephemeris because the purpose is the calculation of ground control points for photogrammetric mapping. IGAC agreed and broadcasted ephemeris was used.

5.3.7 Quality control

All the GPS surveys were conducted according to IGAC's technical specifications and the results of the baseline analysis computation for all of the three mapping areas were within the specified limits. That is,

- Sigma value of the final computation was 0 – 2mm for horizontal and 1 – 5 mm for vertical.
- All the points pricked on photos were objects clearly identifiable on photos.

5.3.8 Output

Results produced in this process are as follows:

- Description of points of GCP's: 2 types
- Results of GPS computation : Coordinate list and accuracy table
- GCP location map

5.4 Aerial triangulation

The JICA Study Team carried out aerial triangulation in Japan.

5.4.1 Data used

- Aerial photo image data files
- Flight index maps
- Ground control point survey results (Coordinate list and point description)
- Camera parameters

5.4.2 Instruments used

- Observation of fiducial marks, GCP's and pass points: Somerset
- Adjustment (Bundle block adjustment): In-Block

5.4.3. Quality Control

Required accuracy was set as follows according to IGAC's technical specifications for aerial triangulation.

Residual of control points: For both vertical and horizontal +/-0.5m for 90% of the points.

The results were as listed below. The results of all of the three areas satisfied this accuracy requirement.

【Cartagena】 Models：198 Courses：12

Adjustment method: Bundle block adjustment

Number of control points		Number of points excluded		Residuals of control points				Bundle method	
Horizontal	Elevation	Horizontal	Elevation	Horizontal (m)		Elevation(m)		Horizontal(mm)	
				SD	Max	SD	Max	SD	Max
38	38	0	0	X=0.018	0.048	0.018	0.046	X=0.005	0.024
				Y=0.015	0.039			Y=0.005	0.022

【Barranquilla Metropolitan area】 Models：331 Courses：17

Adjustment method：Bundle block adjustment

Number of control points		Number of points excluded		Residuals of control points				Bundle method	
Horizontal	Elevation	Horizontal	Elevation	Horizontal(m)		Elevation(m)		Horizontal(mm)	
				SD	Max	SD	Max	SD	Max
41	42	0	0	X=0.233	0.554	0.191	0.469	X=0.005	0.027
				Y=0.183	0.401			Y=0.005	0.030

【Santa Marta area】 Models：175 Courses：11

Adjustment method：Bundle block adjustment

Number of control points		Number of points excluded		Residual of control points				Bundle method	
Horizontal	Elevation	Horizontal	Elevation	Horizontal(m)		Elevation(m)		Horizontal(mm)	
				SD	Max	SD	Max	SD	Max
26	26	0	0	X=0.253	0.646	0.291	0.628	X=0.004	0.024
				Y=0.175	0.367			Y=0.005	0.020

5.5 Digital Orthophoto Production

Orthophoto mosaic which were used in the confirmation of the extent of mapping areas and also in recording the results of field identifications survey was made by the JICA Study Team in Japan.

5.5.1 Generation of digital terrain model (DTM)

30 meter mesh DTM which is required to make orthophoto was generated by stereo matching method.

5.5.2 Orthophoto projection and mosaicing

Orthophoto was produced by using digital image of aerial photos, aerial triangulation results and DTM. Orthophoto was made for each model. Orthophoto was used to determine the areas of maps produced in this study, to compile the results of field identification survey and also to check if every necessary geographic feature is checked in field identification survey.

5.6 Digital mapping

Digital mapping was carried out in Japan by using the results of field surveys conducted in Colombia.

5.6.1 System and data used

(1) System

- Zuka meijin (System developed by Asia Air Survey)
- SocetSet (BAE systems)
- Summit Evolution (INPHO)
- MicroStation V.8 (Bentley)

(2) Data

- Digital image of aerial photos
- Aerial triangulation results
- Description of ground control points

(3) Reference material

- CAD data file of annotation
- Map symbol and map style of IGAC (Version 2.0)

5.6.2 Results of digital restitution

Result of digital mapping were made in MicroStation DGN file format.

5.6.3 Identification of unclear items

The following items were listed to make material to be used in field identification survey.

- Items difficult to identify on aerial photo image during digital mapping process
- Geographic features which are not defined by IGAC's map symbol and map style

5.7 Field identification survey

Field identification survey was carried out in three steps.

5.7.1 Confirmation of IGAC's specifications and method

(1) Specifications

There are three technical specifications of IGAC on field identification survey

Anexo 2: Field identification survey

Anexo 6: Unico de model

Anexo 7: Map symbol

There are some inconsistencies among these three types of documents IGAC and the JICA Study Team agreed to carry out the field identification survey for the Study following Anexo 2.

(2) Procedures

IGAC's standard method for field identification survey is as described below.

1) Preparatory work

2) Field work

3) Provided material

5.7.2 Inventory survey

In inventory survey the following information was collected. With this inventory work, the volume of field work is estimated.

- Existing maps and statistical data
- Name of administrative area and location of administrative boundaries
- Name and type of road and rivers
- Name and type of public facilities and major buildings
- Other relevant data

5.7.3 Field survey

Actual field identification survey was carried out by IGAC staff. Code numbers were used to show the results of field identification survey so that Japanese map editing staff can understand the kind of geographic features identified in the field. As for the annotation information, the JICA Study Team and IGAC agreed that IGAC makes complete dataset so that the JICA Study Team can use it without any further checking or modification.

(1) Inspection

Orthophoto with the result of field identification were inspected by the JICA Study Team members to check to see if any modification or improvement is required in survey method. Data collected by RECON were downloaded to PC for each map sheet and the JICA Study Team member checked the accuracy of location data.

(2) Data compilation

Collected annotation data were converted into Shape File format for each map sheet. Then the data were displayed on monitor screen to make corrections. For the area where RECON was not used, location of annotation points marked on orthophotos were digitized and compiled as Shape File format.

(3) Output

Results of the field identification survey for each municipality are summarized on a Table 5-1.

Table 5-1 Output (Barranquilla, Cartagena, Santa Marta)

Output	Barranquilla	Cartagena	Santa Marta
Orthophoto with survey results	196 sheets	120 sheets	103 sheets
Annotation data (Shape file)	196 files	120 files	103 files

5.8 Digital editing

Original data made by digital mapping were editing according to Map Symbol rules.

5.8.1 System and data used

(1) System used: MicroStation J

(2) Data used:

- List of geographic features
- Orthophoto with field identification survey results
- Digital mapping results

5.8.2 Digital editing procedures

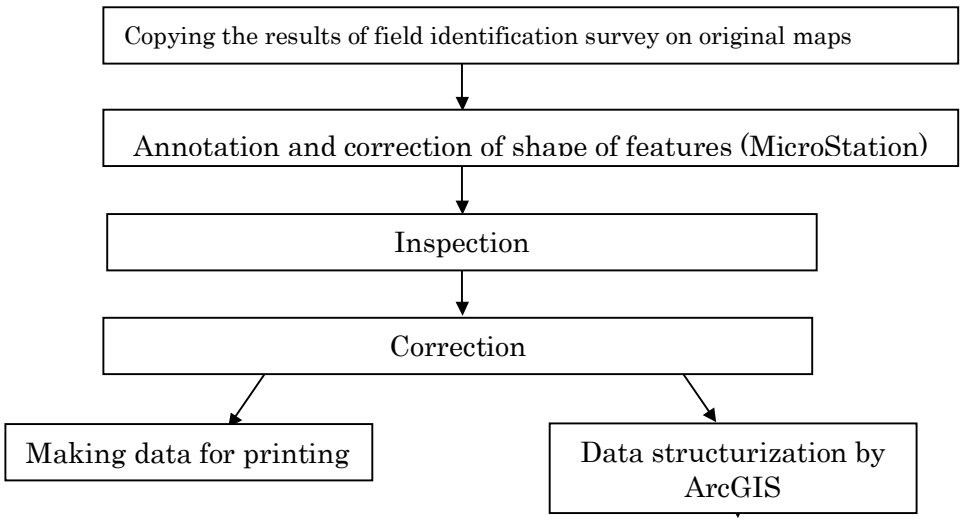


Figure 5-2 Map editing procedures

5.8.3 Quality control

Edited map data were plotted out on paper sheet and the following factors were checked.

(1) Completeness: All the geographic features are drawn according to map feature catalogue.

(2) Data acquisition rules: Data are captured according to the rules specified in the specifications.

(3) Accuracy of location: Positional accuracy of features drawn on the map is high

(4) Accuracy of classification: Correct classification of road and geographic features.

5.8.4 Output

Map data file. MicroStation DGN file format

5.9 Field completion survey

IGAC does not carry out Field Completion survey. In the Study, the JICA Study Team proposed IGAC to add this process in order to introduce a Japanese method to IGAC.

The results of the field completion survey were directly drawn on paper maps and brought back to Japan. As for annotation information, the JICA Study Team asked IGAC to review the spelling.

5.10 Editing after field completion survey

Second map editing work was carried out from late October 2006 based on the results of the field completion survey. Two major elements of the second editing were:

- Correction of geographic features and map symbols
- Correction of features which were not clear during digital restitution process
- Correction of marginal information whose contents were changed

5.10.1 Systems and data used in the editing

(1) System: MicroStation J

(2) Data

- List of geographic features (result of field completion survey)
- Results of field completion survey compiled on orthophoto
- Digital map data

5.10.2 Quality Control

It was checked if all the unclear parts were clarified and all the necessary corrections were made. If uncorrected items were found they were corrected during the inspection process.

5.11 Symbolization

After the digital edit was completed, topographic map data were compiled by modifying the position of place names and annotations to make map data for printing.

5.11.1 Systems and data used

(1) System: MicroStation

(2) Data: Edited map data

(3) Specifications: Map Symbol and Map Style (IGAC Version 2.0)

5.11.2 Quality Control

After modification for making map data for printing map, each sheet was inspected. Any mistakes found in the inspection were sent back to digital mapping or digital editing process and corrected.

5.11.3 Output

- Data file for map printing
- MicroStation DGN file and its plot file in Adobe Portable Document （AcrobatPDF） format

5.12 Issues and solutions

During the process of the Study some issues were found. The JICA Study Team provided solutions or advice to IGAC. And by the end of the Study, IGAC changed or improved its production method or process to avoid such problems.

5.12.1 Incomplete models

Some of the photos covering water areas in Cartagena and Santa Marta areas were found not to be correlated. In other words, there were some incomplete models. For example, sand bars in Cartagena were not covered by single course. For “Incomplete Models”, elevation of the water body were estimated from the elevation of nearby land area.

5.12.2 Numbering of photos

It was found that numbers of photos which were generated automatically by aerial camera, point number of airborne GPS data and file number of digitized aerial photos were not co-related. This caused much confusion in preparatory stage for aerial triangulation. It is recommended to review numbering rules or at least make some relational table.

5.12.3 Position of cross strips

IGAC flew cross strips which connect main flight courses. However, the position of cross strips were not in designed in a way to reduce the number of ground control points.

5.12.4 Quality of the image of aerial photos

(1) Contents of the problem

After the JICA Study Team started aerial triangulation in Japan, it was found that color tone in some digital image was not continuous. Details are as follows:

- By enlarging the image up to pixel level, it was found that color tone of neighboring pixel is not continuous.
- In areas such as roof of buildings or surface of roads where color tone should be almost the same, color one of neighboring pixel changes randomly.

Because of these problems, it was very difficult to measure the elevation of flat surface such as rooftop and road surface during stereoscopic restitution process. Incidentally, this problem was not caused by shifting or scanning line usually caused by vibration during scanning process. After carefully examining the image, the JICA Study Team concluded that it would be possible to continue aerial triangulation and digital mapping with the scanned aerial photos provided by IGAC.

(2) Inspection of scanning process at IGAC

During the period the JICA Study Team stayed in Colombia between January and February 2006, the JICA Study Team checked IGAC film scanning process. The result was as described below:

- Vexel UltraScan 5000 was introduced by EU but IGAC staff did not receive sufficient training to use the machine.
- Aerial photo image scanned by IGAC for other project also had similar image problem

CHAPTER 6. INSTRUMENTS AND EQUIPMENT PROCURED BY JICA

JICA donated to IGAC the following instruments and equipment including software required for technology transfer.

- Aerial triangulation system (Software)
- Digital mapping system (Software)
- Digital editing system (Software)
- Data structurization system (GIS Software))
- Networking equipment
- Printing
- Plotter

6.1 Procurement process

Donated systems and equipment were procured by JICA Colombia office by tendering. The JICA Study Team prepared a draft technical specification for the instruments and equipment. The preparation of the draft was done in three steps:

- Investigation of equipment of IGAC as well as its modernization plan
- Survey of price, method of procurement and possibility of maintenance of instruments and equipment listed as candidates
- Preparation of final specification sheet

6.1.1 Preparation of draft specifications for JICA

It was the best if systems IGAC had already chosen were procured. The JICA Study Team asked IGAC about the selection of systems. However, as for photogrammetric mapping work IGAC was still in the process of evaluating various different systems in the year 2005. Therefore, the JICA Study Team decided not to specify any particular system except for small parts of the system.

The name of the brand the JICA Study Team judged to specify and the reason for the selection is explained below.

(1) CAD software: Bentley MicroStation

(2) Word Processing, Spread Sheet、Database and Presentation software : Microsoft Office Professional Edition

(3) Software for editing and viewing raster image file：Adobe Photoshop CS 2

(4) Software for editing and viewing large size graphic file (Drawing software) : Adobe Illustrator CS

(5) GIS software: ESRI ArcInfo ver.9

As the results of tender by JICA Colombia office, the following systems and instruments were procured and installed in IGAC.

- Aerial triangulation system: One set
  - ・LPS Stereo
  - ・LPS Core
  - ・LPS ATE
  - ・LPS TE
  - ・ORIMA TE GPS for LPS
  - ・Hardware HP Workstation XW6200
- Digital mapping system: One set
  - ・LPS Stereo
  - ・LPS Core
  - ・PRO600 FOR LPS/DPW
  - ・MicroStation
  - ・Hardware HP Workstation XW6200
- Digital map editing system:　One set
  - ・MicroStation
  - ・Hardware HP Workstation XW4300

- GIS
  - ・ArcINFO9.2
  - ・Hardware HP Workstation XW4300

- Printing devices
  - ➢ Large formst (A0 size) Color Plotter
    - ・HP DESIGNJET 1055CM PLUS

- Laser printer（Mono chrome laser printer）
  - Epson Laser Printer 2420DN

Other image processing software

- Microsoft Office Professional Edition
- Adobe Photoshop CS 2
- Adobe Illustrator CS

CHAPTER 7 TECHNOLOGY TRANSFER

Basic objective of this Study is to transfer technology for digital mapping and basic GIS data construction from the JICA Study Team to IGAC. However, being quite different from other survey and mapping organizations, IGAC staff already had experience and basic skills in operating digital photogrammetric instruments and software. Therefore, the JICA Study Team decided to provide advice mainly on the improvement in the efficiency of production.

As for survey and mapping work which IGAC carried out in Colombia for the Study, the JICA Study Team provided technical advice while working together with IGAC staff in Colombia. And for some elements of map production which the JICA Study Team implemented in Japan, the JICA Study team members in charge of each process visited IGAC to review IGAC's method and to provide necessary advices.

7.1 Aerial triangulation and digital mapping

During the first field work in Colombia in 2005, the JICA Study Team explained the ground control point allocation plan for bundle block adjustment method before the start of ground control point survey.

The JICA Study Team member in charge of digital mapping visited IGAC from October 2006 for one month. And the member in charge of digital mapping reviewed IGAC's aerial triangulation and digital mapping process and found that IGAC operators had no problem in digital mapping. As for aerial triangulation, the member in charge of digital mapping concluded that by using automatic correlation function of software IGAC could carry out aerial triangulation without problem. Therefore, the member in charge of digital mapping taught IGAC staff a method to carry out aerial triangulation with manual correlation to deal with cases where automatic correlation is difficult.

7.2 Digital editing and symbolization

IGAC can carry out digital editing without any problem. So the JICA Study Team member in charge of digital editing and symbolization spent his time mostly in the discussion with IGAC on defining symbols for the 1/2,000 scale mapping for the three municipalities. The details of the discussion on the specifications for symbolization are summarized in Chapter 8.

7.3 Data structurization and making plot files

The JICA Study Team member in charge of data structurization and plot file production visited IGAC for one month from October 2006. A JICA Study Team member analyzed IGAC's structurization and plot file making processes and proposed data structurization plan. IGAC and the JICA Study Team had a series of discussion on the subject and decided the data structurization rule for the study. The specifications for data structurization is described in Chapter 8.

CHAPTER 8 DISCUSSION ON IMPORTANT TECHNICAL SUBJECTS

The JICA Study Team spent most of the time in discussion with IGAC on very fundamental rules of survey and mapping as well as on technical specifications. This chapter describes the discussion on important technical subjects.

8.1 Coordinate system employed by IGAC

The JICA Study Team understood IGAC's coordinate system as follows.

8.1.1 IGAC's local coordinate system

(1) Almost all of the 1099 municipalities have each own origin of coordinates.

(2) Previously, coordinates of these origins were unique to each coordinate system. But now, values of the coordinates of these local origins are set to the same VALUE of the coordinate system for smaller scale survey and mapping. This is confusing because it is difficult to tell if a set of coordinates of a point is of local coordinate system or that of small scale coordinate system.

(3) Basically earth surface is projected to a plane which touches the earth surface at one point. However, considering large difference in altitude in some areas, a plane is LIFTED from the earth surface.

(4) IGAC set a scale factor as 1.0000. Therefore, this local coordinate system can use within an area about 10km by 10km. This implies that in large cities, more than one local coordinate system is required.

8.1.2 Issues

The JICA Study Team assumes that this local coordinate system cause the following inconveniences.

(1) If many local coordinate systems exist for one area, ordinary users of geographic information will be confused.

(2) If many local coordinate systems exist, GIS software manufactures hesitate to make conversion program. Or, does IGAC has a plan to distribute conversion software to general public?

(3) After checking some GIS data made by IGAC, it was found that parameters of ellipsoid used were different from that of GRS80. It seems that change of the size of ellipsoid is used as a substitute to the vertical shifting of planes. For ordinary GIS users, this kind of solution may be difficult to understand.

(4) In the future, geodetic control point network will be established in many municipalities. If coordinates changes over a short period time due to the move of origin, management of survey data will be very complicated.

(5) Coordinate value of origin of local coordinate system are the same with the coordinate value of the coordinate system for small scale mapping. Coordinate values of both coordinate systems are identical at the origin of local coordinate system. Although coordinate values of the two coordinate systems are identical only at the origin of the local coordinate systems, this system is quite confusing for ordinary map users because it is difficult to identify the type of coordinate system only from coordinate values of points on maps.

8.2 Use of GPS installed data recorder (RECON)

IGAC used GPS installed data recorder for the first time in field identification survey. In future field identification survey it will be necessary to make work plan by taking considerations of both advantages and disadvantages of the recorder.

Good point of the recorder is that coordinates and text information on collected data stored in digital form and therefore can be transferred to mapping system with further digitization.

Disadvantage is that the system does not support Cartesian projection. Also, since GPS installed in the recorder measure the location of the receiver only by single positioning mode, positional accuracy is not so high.

By considering above discussion, the JICA Study Team recommends IGAC to use the recorder in the following manner.

- Type of work suitable for using the recorder: National Census in which the quantity of data collection is large and also every building or household must be visited.
- Type of work not suitable for using the recorder: Identifying and drawing items which are not clearly visible on aerial photos.

8.3 Data Catalogue

IGAC published various catalogues on geographic features. However, after worked with IGAC counterparts, the JICA Study Team realized that actual survey and mapping work had not been implemented according to existing catalogue and specifications.

8.3.1 Type of Catalogues

Since the start of the project the JICA Study Team collected the following data catalogue available at IGAC.

(1) Modelo de datos Catalogo de Objetos CO-25 ver2(1995)..... A
This is a catalogue of geographic information and map symbols basically for 1/25,000 mapping.

(2) Modelo de datos urbano catalog de objectos CO-U y Catlogo de simbolos CS-2000 (1996) ..... B
This catalogue was published by Subdireccion Catrografia.（In this report, we call this catalogue as CO-U catalogue and CS-2000 symbol data.）

3) PROYECTO DE NORMA TÉCNICA NTC COLOMBIANA 2001-04-11
CATÁLOGO DE OBJETOS GEOGRÁFICOS BÁSICOS C
Este proyecto de norma técnica será sometido a consulta pública en el primer semestre de 2001.

4) Unico de modelo ..... D

5) GEODATABASE catalogue made in April 2006 ..... E

8.3.2 Purpose and characteristics of these catalogues

The JICA Study Team analyzed the characteristics of these catalogues. As the result of our analysis the JICA Study Team thinks that the characteristics of each catalogue is as follows..

- A and B has a characteristic of Inventory Catalogue which covers geographic information made or possessed and managed by four sub directorates of IGAC.
- A and B do not have any explanation on how to handle data on a specific software to be used in data production. These documents are made based on ATOKIS of Germany.
- C was made in the movement of standardization of geographic information based on ISO.TC211. For the production of this catalogue C, organizations other than IGAC also

participated.

- D and E looks like catalogues used in IGAC for data production.

- As for catalogue D , the JICA Study Team thinks that D was made based on B. That is, D extracted only mapping items and attributes of B for the purpose of map production.

8.3.3 Suggestion of the JICA Study Team

- As for A and B, they are already obsolete and therefore the team feels it not necessary to improve them.
- However, from a point of view of utilization of geographic data, it will be necessary or at least useful for IGAC to make a catalogue like A or B. The reason to suggest such an activity is that discussions participated by various sub-directions and divisions of IGAC will give IGAC staff a good opportunity to think about the concept of basic GIS data which contribute to the efficient and reliable territorial planning.

- Catalogue E specifies data structure for only one type of GIS software – ArcGIS. And the catalogue E seems to be made to be used in map symbol editing work. It is possible for users outside IGAC use the catalogue. But the JICA Study Team feels that catalogue E may not be the most convenient model of geographic data to be used by many different types of users outside IGAC.

- Basic GIS data or Spatial Data Framework proposed by the JICA Study Team in October 2006 has data structure which is easily used by users of various different purposes.

- Catalogues D and E do not have the definition of geographic features. No documents which explain the definition of geographic feature were found. Clear definition of geographic features is necessary to make high quality data efficiently. If the mapping work proceeds with unclear definition of geographic features, much confusion occurs. Actually, the JICA Study Team was also annoyed by the unclear definition of geographic features made by IGAC. If IGAC plans to subcontract out mapping to local contractors, it is the responsibility of IGAC to provide contractors with very clear mapping specifications.

Incidentally, there are following two types of specifications in the technical specifications IGAC uses for the work subcontracted out to local private firms.

Anexo No.6	Modelo de datos
Anexo No.7	Symobologia

8.4 Data Structurization

The JICA Study Team and IGAC spent long time to discuss on the data structure of GIS data.

8.4.1 Structure of data structurization implemented by IGAC

IGAC's method of data structurization changed after the Study was started in 2005.
The difference is summarized on Table 8-1.

Table 8-1 Change in IGAC's Data Structurization Method

	Digital Mapping Software	Software for data editing and structurization	Data output format
After Autumn of 2006	INPHO, LPS, DVP, All with CAD MicroStation	ArcGIS V9.1	Geodatabase, Shape File, Dxf
Before Autumn of 2006	INPHO,LPS,DVP,LPS, SocetSet with interposes to MicroStation	ArcGIS, ArcInfo,Workstation and occasionally MicroStation	Geodatabase, ArcInfo coverage, Shape File, Dxf

(1) Contents of the data structurization

The JICA Study Team assumed that Basic GIS Data would be as follows:
1) Purpose
Purpose of making Basic GIS Data is the provision of accurate and reliable geographic data which can be used as the standard in overlaying more than one type of spatial information.

2) Contents
Framework information such as road, water line and building, which can be used as positional reference when thematic data are added.

3) Data structure
Basic GIS data have universal data format and structure which are not dependent on specific software and therefore can be used by a wide variety of users. On the contrary, IGAC wanted to include every feature drawn on the map in Basic GIS Data.

For the topographic mapping in the Study, every feature which can be identified on aerial photos is to be drawn.

As the result of discussions mentioned above, IGAC and the JICA Study Team agreed as

follows on the data strucutrization.

1) Every data except for annotation and symbols are included in Basic GIS Data. Road names, river names and elevation height are included.

2) Feature class

Basically the data are classified into 5 groups and then each group is divided into point, line and polygon data.

- Datos Basicos (Consisting of 12 feature classes)
- Elemento Divisorio (Consisting of 2 feature classes)
- Urbano (Consisting of 4 feature classes)
- Relive (Consisting of 2 feature class)
- Infraestructura (Consisting of three feature classes)

3) Attribute information

Road names, river names, spot heights and elevation value of contour lines are registered as attribute information. If there are both official name and common name for roads and rivers, both of them are registered.

4) Method of grouping

Geographic features of 1/2,000 scale topographic maps are re-classified into feature models of basic GIS data. If necessary, geometry is also changed in this process. Result of re-classification is expressed using UML Class diagram. Each geographic feature is expressed as CLASS and each theme is expressed as PACKAGE which combines classes.

CHAPTER 9 PROMOTION OF THE USE OF GEOGRAPHIC INFORMATION

It is necessary to understand the current situation of users of geographic information in order to promote the use of geographic information made and supplied by IGAC. For this purpose, municipalities of Cartagena, Barranquilla and Santa Marta were visited and various types of thematic maps used in POT making were collected. The collected maps and material were analyzed to understand the quality and accuracy of the information. Further, answers to questionnaire were also collected from 48 municipalities listed in the 100 municipalities. Municipalities of Cali, Manizales and Perelia were also visited to collect information on the current use of geographic information.

9.1 Current situation of the use of geographic information

In Colombia each municipality is responsible to make its own POT. This means there is a clear need for reliable geographic information.

However, answers from the 48 municipalities indicates that municipalities which do not have human resources or equipment to make thematic maps to be used to make POT are naturally still in a very primitive stage as far as the use of geographic information. And most of the municipalities do not have any resources to handle geographic information.

9.1.1 Thematic mapping for POT

Municipalities are trying to make various maps because by LAW388 each municipality has to make its own POT.

Cities which are the target of the mapping in this study, namely, Cartagena, Barranquilla and Santa Marta, are well ahead of other majority of municipalities in terms of mapping and POT making.

9.1.2 Thematic maps to make POT

Each municipality has its own development program and therefore types of maps to be used in POT making are different. In general maps required for making POT can be divided into the following categories.

- Public administration maps: Administrative boundaries, etc.

- Land use management maps: Current land use; land use plan for various sectors; zoning plan which consists of master plan
- Social infrastructure maps: Road, water, sewerage, electricity, gas and other utilities
- Environment management maps: Conservation areas; nature ecosystem protection areas, etc.
- Hazard prevention maps: Inundation areas; areas of high possibility of landslides; steep slope areas, etc.

Maps collected from Cartagena, Barranquilla and Santa Marta are as listed on Figure 9-1. Most of them are based on IGAC or DANE maps. However, they have problems such as different scale, difference in production year, and changes over time, inaccuracy in positions. If these maps are to be used in urban or regional planning, their compatibility with new data or maps should be carefully examined.

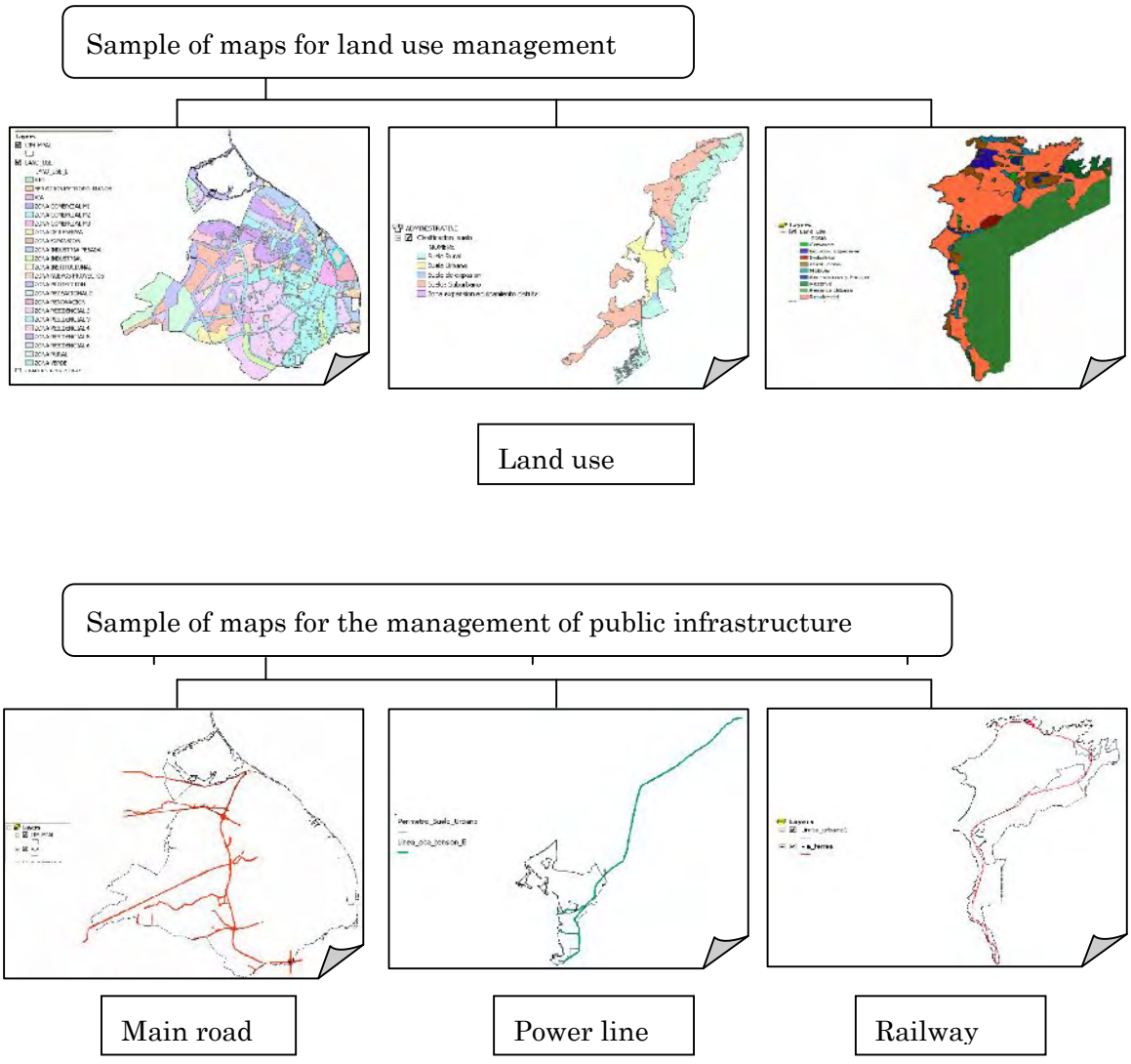


Figure 9-1 Sample of collected maps

9.1.3 Issues in POT

The main objective of geographic data supplied by IGAC is to promote the making or updating of POT. However, some problems have to be solved before IGAC data are widely used.

(1) Making standard for POT maps

Most of the thematic maps used in making POT use IGAC or DANE topographic maps as their base. However, both maps are different in scale, production year and accuracy. Therefore, if they are overlaid, geographic features such as roads and buildings do not match. The maximum difference was 20 meters in Barranquilla and 15 meters in Satan Marta (Figure 9-2). Some maps cannot overlaid because they are twisted.

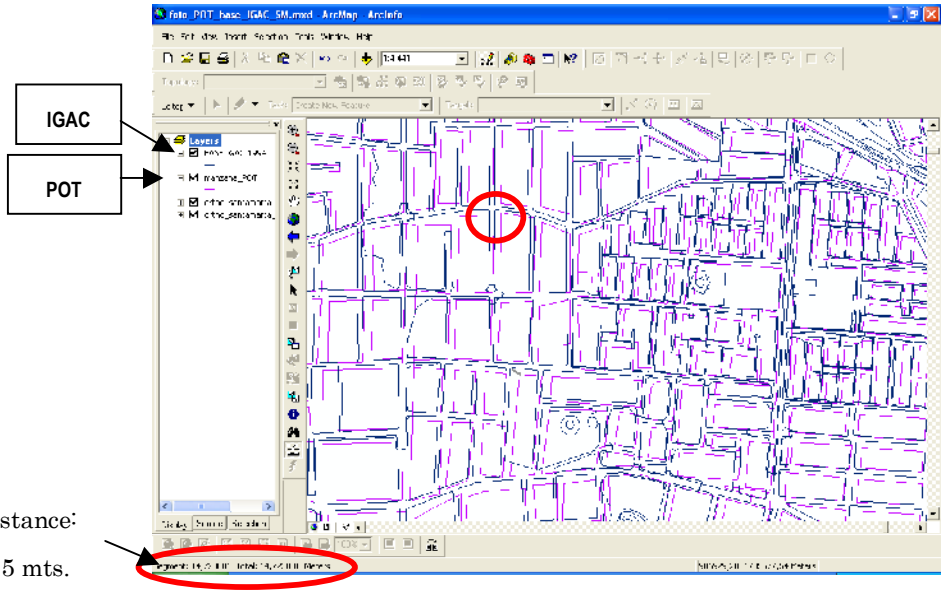


Figure 9-2 Overlaid of new and old (1994) maps of Santa Marta

(2) Management of POT maps

Once maps are produced they have to be updated constantly because geographic features changes over time. However, POT maps are not updated due to the shortage of budget or because municipality staff are not well aware of the fact that geographic features on maps changes over time.

(3) Standardization of POT making method

Various types of thematic maps are required to make POT. Although IGAC has a guideline to make thematic maps, details of the map making have not yet been standardized.

9.2 Technical problem in the promotion of geographic information and GIS

Small local municipalities do not have human resources, organization and budget to use GIS. The problems associated with the promotion of the use of GIS are summarized as follows:

(1) Review of geographic feature catalogues

Geographic feature catalogue which defines geographic features to be mapped and their code is very important document in making a GIS database. However, current catalogue of IGAC is mainly aimed at the management of cadastral data and not suitable for general purpose GIS database. It is necessary to redefine geographic features and their attributes for GIS database which is used as basic framework for various types of thematic map production.

On the other hand, IGAC has urban data model CO-U and symbol catalogue CS-2000 to manage urban land and cadastral data. They are made by referring to geographic information standard but they are not related to POT.

(2) Making guidelines

As a base map for POT maps, maps of IGAC or DANE are used. However, mixing use of more than one type of base map causes troubles because of difference in scale, map legends and accuracy. These problems prevent ordinary planners or GIS users from using maps or geographic information more extensively. It is necessary to make a guideline for the production of basic geographic data.

(3) Budget

Under the Law 388, municipalities have to make POT. However, most of the municipalities do not have enough budget to make good quality POT. However, if reliable geographic data are provided, preparation of thematic maps and POT will become much easier than now. In order to avoid redundant investment in geographic data production, it is recommended to use high quality maps and geographic information to be supplied by IGAC.

(4) Institutions

IGAC makes map by receiving orders from municipalities. However, IGAC does manage maps made by municipalities. On the other hand, municipalities cannot have their own organization to handle geographic information particular GIS data. Some municipalities hire temporary staff to operate GIS but after the contract is terminated they leave the organization and the municipality cannot keep the know how in using geographic information and GIS. It will be beneficial for

municipality to utilize the capacity of IGAC territorial offices to fill the shortage in technical capacity.

CHAPTER 10 GIS MODEL SYSTEM

10.1 Purpose of the development of a model system

The purpose of GIS model system development is to make a tool which can be used in making various development plans including but not limited to POT and which can also be used in introducing the merit of GIS to potential users.

10.2 Policy in the development of a GIS model system

10.2.1 GIS model system to support POT making

GIS model to be made in the study needs to support thematic map production for POT and the promotion of the use of geographic information. For this reason, it was determined to use only basic functions of ArcGIS without adding any software. Data format is Geodatabase and operation manual was made in Spanish.

10.2.2 Functions of the GIS model system

GIS model system is designed to run on ArcGIS9.1.

For the purpose of the promotion of the use of GIS, the following functions were developed. With these functions a manual was made to experience the following things:

- Thematic mapping and updating
- Coordinate conversion (convert to Cartesian coordinate)
- Data editing
- Thematic map viewing
- Thematic map printing

(1) Thematic mapping and updating function

Editing point, line and polygon features for making thematic maps. Also, data record of geographic features are managed and updated.

- Management of road name and attribute related to road network
- Data management related to map annotation
- Data management related to geodetic control points
- Management of other type of information

(2) Coordinate transformation function

Map data existing in the three cities use special coordinate system and not easy to use for ordinary GIS users. Therefore, a command to carry out coordinate conversion with simple operation was made.

(3) Data editing and viewing function

Displaying and editing function was prepared. By using this function you can overlay the thematic maps on the screen and edit the data.

(4) Thematic map printing

After creating layout on the screen you can print them on a paper. You can select layout which is store as a template also.

10.3 Contents of GIS model system

IGAC should lead activities to promote the use of GIS in various fields.
As the use of GIS increase, the necessities of the GIS from municipalities and from the private company will become more sophisticated.

And interest will expand not only for POT but applications such as the prevention of disaster or for the planning purpose using standard specifications.

Content of GIS model system and the use of SIG are shown in Figure10-1, 10-2, 10-3.

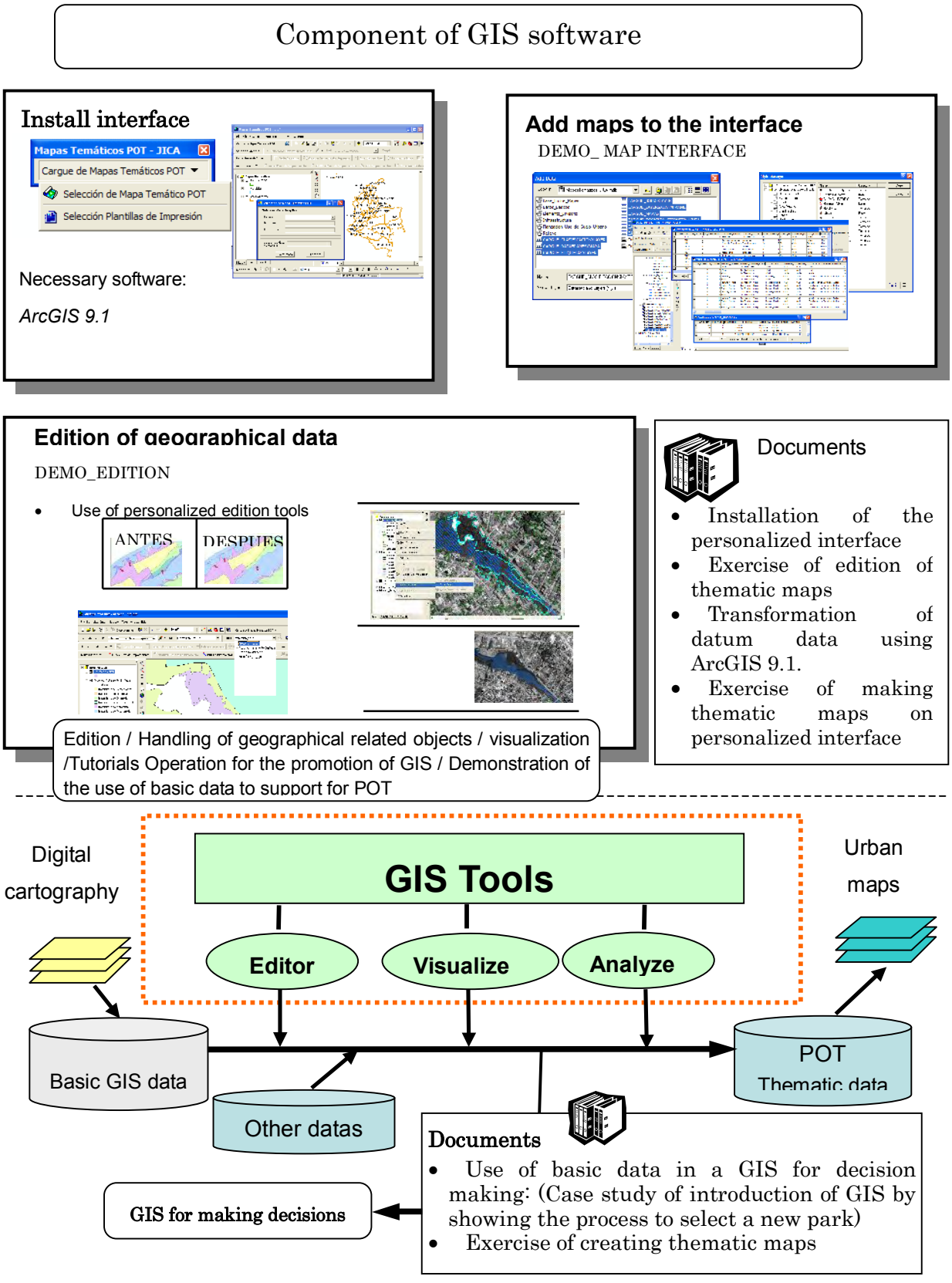


Figure 10-1 Components of GIS software

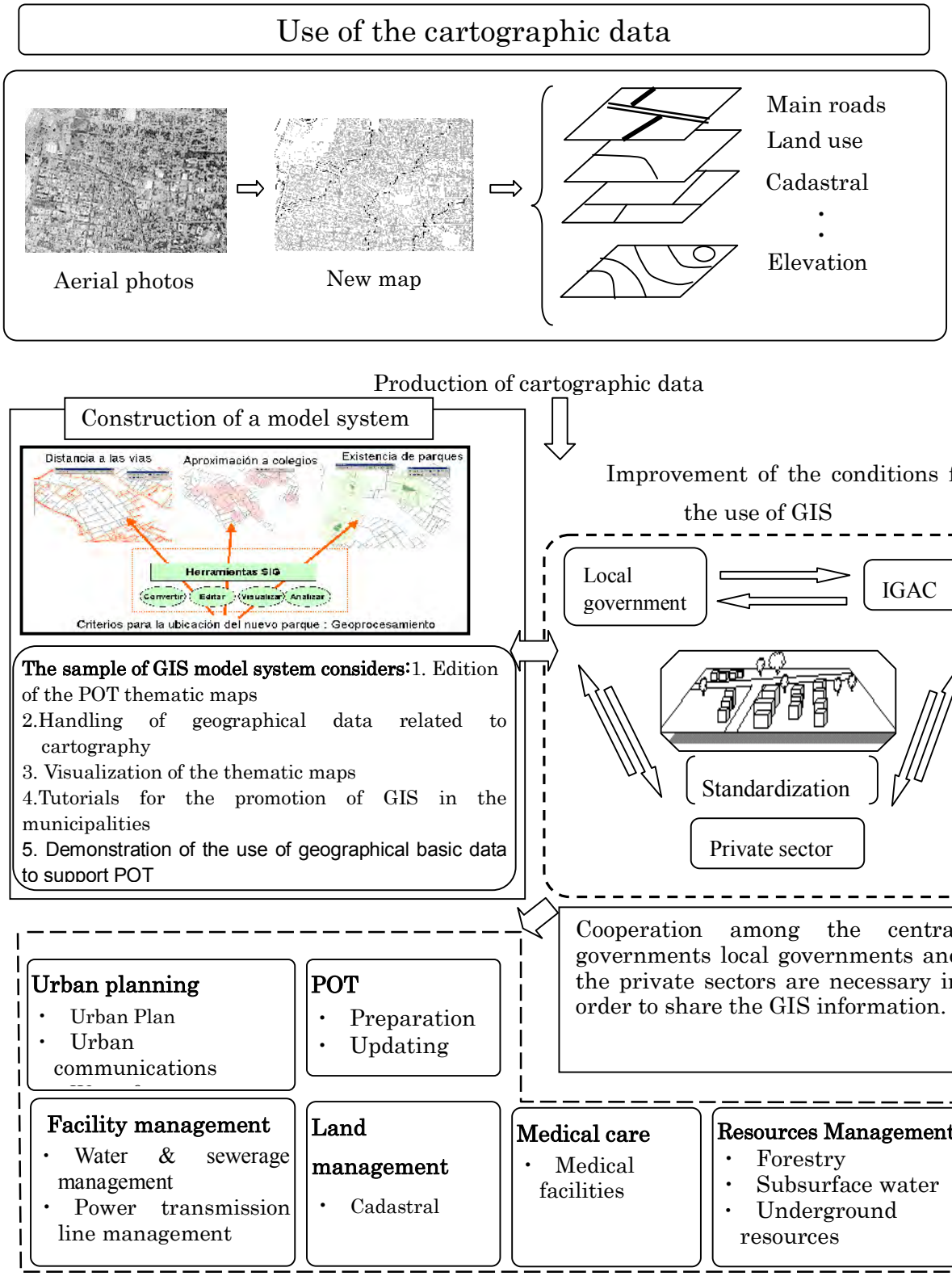


Figure 10-2 Data processing with special information

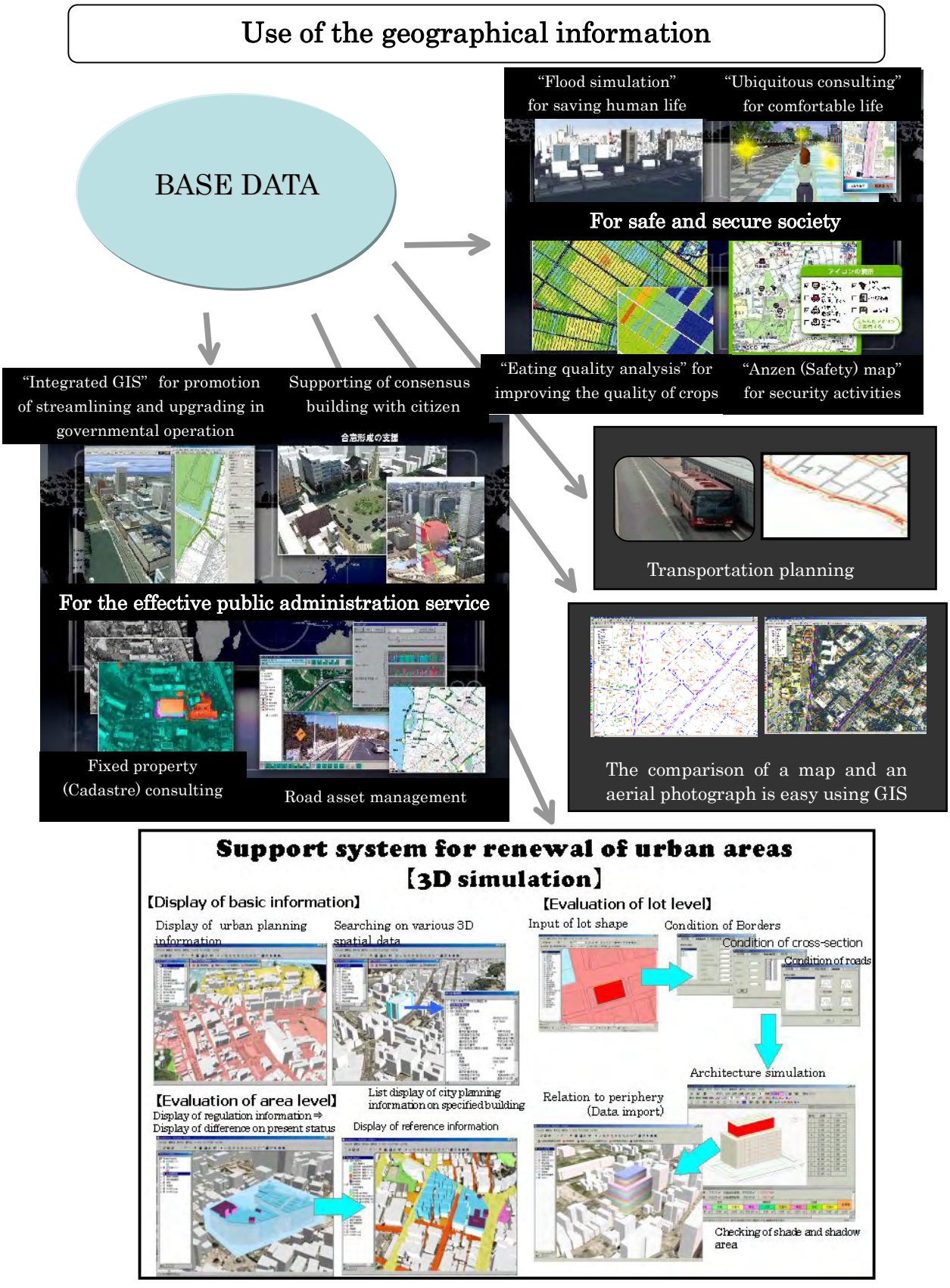


Figure 10-3 Use of the geographical information

CHAPTER 11 SELF SUSTAINABILITY ANALYSIS

11.1 Purpose and method

11.1.1 Purpose

The purpose of the analysis is to examine if IGAC can produce 1/2,000 digital maps and basic GIS data of 100 municipalities based on its technical capacity and also utilizing technologies transferred through the study.

11.1.2 Method of Analysis

The subject of self-sustainability analysis is the IGAC's program to make 1/2,000 scale digital maps and basic GIS data of the 100 municipalities. Three factors determine the level of the self-sustainability after the completion of the JICA project.

- Combined production capacity of IGAC and private sector
- Budget to make basic GIS data of the 100 municipalities
- Results of the technical transfer program of JICA

11.1.3 Data Collection

Information on IGAC was collected by the interview with IGAC staff, questionnaire, observation of production processes and analysis of existing documents. IGAC regional offices in Santa Marta and Cali were visited.

As for the survey of the situation of 100 municipalities, a questionnaire was prepared and distributed to the 100 municipalities through IGAC regional offices and collected by the same IGAC offices.

11.2 Chronological record of activities

11.2.1 Work in Colombia (January – March 2006)

(1) Explanation of the purpose of the study as well as the contents of self-sustainability analysis to IGAC

(2) Analysis of IGAC's current conditions and issues

(3) Collection of basic data to make tentative work and cost plans

(4) Selection of the 100 municipalities

11.2.2 Work in Colombia (June – July 2006)

(1) Recovery of the answers to the questionnaire

(2) Analysis of collected answers

(3) Calculation of the volume of GIS data production

(4) Analysis of the role of IGAC territorial offices

11.2.3 Work in Japan (August 2006)

(1) Recovery of answers

(2) Pre-processing of collected answers

(3) Calculation of work volume of 1/2,000 scale digital mapping of the 100 municipalities

(4) Collection and analysis of additional information

11.2.4 Second Work in Colombia of the 2nd year (Sept – Nov, 2006)

(1) Planning of the 100 municipalities mapping

(2) Collection of additional information on IGAC's situation and working procedures.

(3) Visit to IGAC territorial offices

(4) Confirmation of the results of technical transfer and provision of recommendations

11.3 Results

11.3.1 100 municipalities survey

(1) Outline of the 100 municipalities

In the 100 municipalities, five large cities, namely, Cali, Ibague, Villavicencio, Popayan and Florencia are included. Since their area size and population are both far larger than those of the remaining 95 cities, the analysis of characteristics of "the 100 municipalities" was made on "95" municipalities.

Total size of 95 municipalities is 21,610ha and average size of the one municipality is 227.39ha. Average population is 530.000 and average population density is 2.86 person per ha.

99 of the 100 municipalities are already covered by aerial photos. Sample aerial photos of four municipalities are shown on Figure 11-1. As these sample photos shows, urban areas of most municipalities can be covered by a few models of aerial photos.

Figure 11-1 Existing aerial photos of Santa Catalina, Bolivar

Since only 48 of the 100 municipalities sent their answer back to the JICA Study Team, it was necessary to examine if these 48 municipalities can represent the 100 municipalities. Actually, five municipalities, namely, Cali, Ibague, Villavicencio, Popayan and Florencia, are different from other 95 municipalities in terms of its size. Therefore, in this examination the five municipalities were excluded.

The JICA Study Team concluded that area size and population of the 43 municipalities which sent back answer are practically almost equal to that of 95 municipalities. Therefore, the team judged that the 43 municipalities could be regarded as representative of the 100 municipalities.

(2) Summary of the survey of the 48 municipalities

The following is the summary of the replies from 48 cities.

- Major industries are agriculture and cattle breeding in most municipalities. This implies that land use pattern is also almost identical.
- Majority of the 48 cities listed "old and inaccurate map" as the problem for POT making.
- Many cities think that making standard for POT is important.
- Only three cities have special section in charge of survey or GIS. However, even such cities number of technical staff is between one and three. This means most of the 48 cities do not have capability to handle survey data, maps and GIS data.

11.3.2 Costs to make maps and basic GIS data for 100 municipalities

Cost estimation was made in order to compare the total cost of the 100 municipalities mapping with ordinary budget of IGAC.

Two estimations were made. One estimation was based on unit prices IGAC uses in estimating budget for contracts with private firms.

The other estimate was based on the contract amount of 65 municipalities mapping project undertaken by private firms in 2006.

(1) Cost estimation by using IGAC unit price

Grouping was made based on their location. And for each group, time and costs for ground control point survey, field identification survey, aerial triangulation and photogrammetric mapping were estimated.

1) Work volume of 100 municipalities mapping

- Mapping Area size: 56,210 ha
- Models: 646 models
- Control points: 723 points

2) Work speed

- Ground control point survey: 4 points/day/team
- Field identification survey: 130 ha/day/team
- Aerial triangulation: 10 model/man/day
- Digital mapping: 200 ha/man/month
- Digital editing: 600 ha/man/month

Total length of work is 25 months.

3) Costs

a）	Ground control point survey：	CO$549,480,000
b）	Field identification survey：	CO$224,840,000
c）	Aerial triangulation：	CO$81,719,000
d）	Digital mapping and editing：	CO$2,810,500,000
e）	Field completion survey：	CO$56,210,000
	Total：	CO$3,694,766,000

These costs are calculated based on the assumption that all the work is sub-contracted out to local private firms. IGAC often uses local survey firms for their mapping work if its own capacity is not sufficient. Costs estimated on this assumption are the maximum costs IGAC will need to make topographic maps of 100 municipalities.

(2) Cost estimation by referring to 65 municipalities mapping project

Contract amount of the 65 municipalities mapping with a total area of 65,000ha which IGAC contracted out to Colombian private firms is CO$4,500,000,000. On the other hand total size of the 100 municipalities mapping is 56,210ha.

By using these data of the mapping work already carried out, costs for the mapping of 100 municipalities were estimated.

Two calculations were made. In one case it was assumed that no fixed cost exists. In the other case, percentage of fixed cost and percentage of variable costs were assumed 10% and 90%.

If 10% of the contract amount is the fixed cost, total cost for the 100 municipalities mapping can be estimated by the following formula.

（CO$4,500,000,000×10%）＋（CO$4,500,000,000×90%）/65,000ha×56,210ha

＝CO$3,952,315,385

And if the percentage of the fixed cost is 0$ the total price will be CO$3,891,461,538.

Since it is unlikely that all the contract price consist of variable cost, for the purpose of this approximation, the price estimated with 10% fixed cost, that is, CO$3,952,315,385, is used

(3) Evaluation of the two estimations

Costs estimated by two methods are as follows:

IGAC estimation : CO$3,694,766,000

Estimation from previous contract: CO$3,952,315,385

The difference is 7%. Judging from the fact that both calculation were not made based on exact number of control points or the shape of mapping areas, the JICA Study Team regard this 7% difference not significant. Conclusion of these estimations is that 100 municipalities mapping will be able to be done if approximately CO$4,000 million budget is available.

It should be noted that these figures are based on the assumption that existing aerial photos are used for the mapping.

In the Table 11-1, the estimated cost could be compared with IGAC budget. IGAC's budget directly related to mapping is as follows.

Table 11-1 Estimated mapping cost compared with IGAC budget

Cost Item	2005	2006	2007
1. Production and updating of general maps	300,000,000	300,000,000	4,108,000,000
2. DANE	10,987,569,206	0	0
3. Contract with other institutions	0	0	4,280,000,000

The Amount of mapping budget changes drastically from one year to the other. Basically the mapping budget for the year 2007 is for the production of 1/25,000 maps. But if this size of budget is allocated for the 1/2,000 scale mapping, total cost of mapping CO$3,952,315,385 can be easily covered.

11.4 Capacity of IGAC in map and GIS data production

11.4.1 IGAC's own resources and capability

Type and number of instruments and number of technical staff of the division of photogrammetry and division of geodesy are described in Chapter 6.

Overall resources of IGAC in the production of 1/2,000 scale digital maps and basic GIS data can be summarized as follows:

(1) Instruments and technical staff

As of July 2007, the Division of Photogrammetry has total 21 digital plotting systems and 25 digital map editing systems. As for the number of operators, it is possible for IGAC to hire contractors if the needs to increase production capacity arise. Therefore, IGAC has sufficient number of technical staff for photogrammetric mapping.

As for ground control point survey, Division of Geodesy has enough number of GPS and levels and operators to carry out field works.

(2) Operational skill of photogrammetric mapping systems:

IGAC has no problem in the operations of individual mapping and editing system.

(3) Experience in photogrammetric mapping

IGAC has enough experience in stereo restitution and editing. The same is also true for aerial triangulation, ground control point survey and field identification survey.

(4) Capability to make basic GIS data

The JICA Study Team and IGAC had a series of discussion on the definition and contents of basic GIS data, the JICA Study Team judges that IGAC has capability to produce GIS data from topographic map data.

(5) Issues and technology transfer

The JICA Study Team identified some issues in IGAC's map production method or rules. Particular concern was that communication between each technical group seems not be sufficient. Shortage in communication appeared in various process by taking different forms.

Other minor issues include, but not limited to, map sheet layout which changes with the expansion of the size of each municipality.

All these issues identified by the JICA Study Team were checked and reviewed by IGAC. And some of the suggestions made by the JICA Study Team have already been accepted by IGAC and IGAC changed its previous method. Particular importance is IGAC is now trying to improve communication between different technical groups.

11.4.2 Capacity of Colombian private mapping firms

In 2006, IGAC made a contract with Colombian private mapping firms to make 1/2,000 scale digital maps of 65 municipalities. Capacity of private sector will be important in making 1/2,000 scale digital maps and basic GIS data in a short period of time. 4 major private mapping firms were visited to know their capacity

- FAL LTDA
- GEOVITAL
- GEOSISTEMAS
- ATLAS INGENIERIA

All of the four firms have some relation with IGAC. For example, former IGAC staff is working as top management in some firms. Although photogrammetric instruments of most of the firms are not as new as those of IGAC, all of them have sufficient capability to produce digital maps.

11.5 Results of the self sustainability analysis

Self sustainability of IGAC's 1/2,000 scale maps and basic GIS data production program is judged by three factors as follows:

- Combined production capacity of IGAC and private sector
- Budget to make basic GIS data of the 100 municipalities
- Results of the technology transfer program of JICA

11.5.1 Combined production capacity of IGAC and private sector

By July 2007 IGAC has almost completed to equip itself with full digital photogrammetric production line. Operators of old analytical plotting machines were all trained to use softcopy restitution and editing instruments. On the contrary private firms are still using analytical plotters in addition to modern digital mapping instruments. But their final products comply with IGAC specifications.

By combining both capacities, it will not be difficult to make maps of 100 municipalities.

11.5.2 Budget to make basic GIS data of the 100 municipalities

IGAC's annual budget is CO$ 72.823 Million in the fiscal year of 2007. Total budget to be used for general mapping is CO$8.388 Million. On the other hand, budget required to make 1/2,000 scale maps and basic GIS data for 100 municipalities is approximately CO$3.694 Million. Therefore, if all of mapping budget is used for the 100 municipalities mapping, it can be completed in almost two years.

11.5.3 Results of the technology transfer program of JICA

As already mentioned in Chapter 7, the JICA Study Team contributed in reviewing and modifying IGAC's production methods for better results. The modification contributes to improve efficiency in 1/2,000 scale photogrammetric map production.

11.5.4 Overall evaluation of self sustainability

By combining all the factors mentioned above the JICA Study Team concludes as follows:

(1) IGAC has enough resources to produce 1/2,000 scale digital photogrammetric maps and basic GIS data of the 100 municipalities in reasonable timeframe. If IGAC'S own production resources are occupied with other mapping projects, then Colombian mapping firms can fulfill the shortage in resources.

(2) However, IGAC has gone through very drastic modernization process in the past three years and the process has just been completed. Many new methods were introduced. Although IGAC has acquired enough skill in the operation of each production system, such as soft copy mapping system, there still is uncertainty in combining all the new systems into one unit of digital map production.

(3) Furthermore, there are still some items which need further examination as to whether modification or improvement is required or not. One example is the local coordinate system now being used by IGAC for the mapping of local municipalities. As recorded in Chapter 8, the JICA Study Team argued that current Cartesian coordinate system of IGAC was not easy to understand for ordinary GIS users. While the JICA Study Team understands that the system has long been used in Colombia and was chosen over other method because of certain advantages of the system, the team thinks it is worthwhile for IGAC to review the coordinate system again from the point of view of the promotion of GIS data. One of the most difficult parts of using GIS for ordinary GIS users is the conversion of coordinate system or projection system. If each municipality has its own coordinate system, the chance that ordinary GIS users are confused.

Another example of items which has potential needs for review and improvement is the technical specifications for geographic features which should be interpreted and drawn on maps. IGAC has published data catalogues but the JICA Study Team thinks that definition of geographic features is not necessarily clear enough. Unclear definition of geographic features is potential cause of confusion in restitution and field identification.

(4) By combining above arguments, the JICA Study Team judges that IGAC is basically self sustainable in the production of 1/2,000 scale digital maps and basic GIS data of the 100 municipalities if sufficient budget is allocated. However, further technical review and improvement will be required to eradicate potential causes of confusions such as local coordinate systems and data catalogues.

Chapter 12 Proposal to IGAC

The JICA Study Team has summarized its recommendations to IGAC as described below from the implementation of the study.

12.1 IGAC's own resources and capability

(1) Instruments and technical staff

As of July 2007, the Division of Photogrammetry has total 21 digital plotting systems and 25 digital map editing systems. As for the number of operators, it is possible for IGAC to hire contractors if the needs to increase production capacity arise. Therefore, IGAC has sufficient number of technical staff for photogrammetric mapping.

As for ground control point survey, Division of Geodesy has enough number of GPS and levels and operators to carry out field works.

(2) Operational skill of photogrammetric mapping systems:

Full scale conversion from analytical plotters to soft copy mapping systems started almost two years ago. And by July 2007, all the operators of conventional analytical plotters had been trained to use soft copy machines. So, IGAC has no problem in the operations of individual mapping and editing system.

(3) Experience in photogrammetric mapping

IGAC has enough experience in stereo restitution and editing. The same is also true for aerial triangulation, ground control point survey and field identification survey.

(4) Capability to make basic GIS data

Since 2005 IGAC was studying the use of ArcGIS for map data editing and in 2006 a new data model was announced. Although the JICA Study Team and IGAC had a series of discussion on the definition and contents of basic GIS data, the JICA Study Team judges that IGAC has capability to produce GIS data from topographic map data.

12.2 Evaluation of self sustainability

(1) IGAC has enough resources to produce 1/2,000 scale digital photogrammetric maps and basic GIS data of the 100 municipalities in reasonable timeframe. If IGAC's own production resources are occupied with other mapping projects, then Colombian mapping firms can fulfill the shortage in resources.

(2) IGAC has gone through very drastic modernization process in the past three years and the process has just been completed. Many new methods were introduced. Although IGAC has acquired enough skill in the operation of each production system, such as soft copy mapping system, there still is uncertainty in combining all the new systems into one unit of digital map production.

(3) The current Cartesian coordinate system of IGAC was not easy to understand for ordinary GIS users. While the JICA Study Team understands that the system has long been used in Colombia and was chosen over other method because of certain advantages of the system, the team thinks it is worthwhile for IGAC to review the coordinate system again from the point of view of the promotion of GIS data.

12.3 Mapping Technique and Specification of IGAC

The JICA Study Team judged that the mapping technique and specification of IGAC had some problem.

The contents of discrepancy were explained and it has advised by the JICA Study Team..

(1) Incomplete model

Some of the photos covering water areas in Cartagena and Santa Marta areas were found not to be correlated. In other words, there were some incomplete models. For example, sand bars in Cartagena were not covered by single course.

For “Incomplete Models”, elevation of the water body was estimated from the elevation of nearby land area.

Although the height of the water surface was deduced from the height of nearby land on the model and it corresponded by giving height in the incomplete model.

The JICA Study Team guessed that IGAC was almost inexperienced in 1/2,000 topographical mapping near coast, so the JICA Study Team guided IGAC for the future photography method.

(2) The numbering rule of a photograph

It was found that numbers of photos which were generated automatically by aerial camera, point number of airborne GPS data and file number of digitized aerial photos were not co-related. This caused much confusion in preparatory stage for aerial triangulation. It is recommended to review numbering rules or at least make some relational table.

(3) Position of cross strips

IGAC flew cross strips which connect main flight courses. However, the position of cross strips was not in designed in a way to reduce the number of ground control points.

The purpose of the cross strips was explained and the correspondence to a future photography plan was guided.

(4) Quality of the image of aerial photos

1) Contents of the problem

Color tone in some digital image which IGAC created was not continuous.

- By enlarging the image up to pixel level, it was found that color tone of neighboring pixel is not continuous.
- In areas such as roof of buildings or surface of roads where color tone should be almost the same, color one of neighboring pixel changes randomly.

2) Inspection of scanning process at IGAC

Usually it is not recommended to manipulate image resolution by interpolation method. Also after some experiment it was confirmed that best quality image could not be obtained if scanning speed was set at maximum level. The JICA Study Team advised to find the most suitable level of scanning speed by considering both image quality and scanning time.

12.4 Subject about improvement in staff technologic abilities

(1) Management of a topographical map and a GIS data base .

One of the requests from a municipality was the necessity of updated maps. Because there is no updated maps and they feel inconvenience for planning purpose.

But when the data of three cities is completed IGAC will offer a set of data to three cities. These data is expected to be used effectively in various scenes.

However, update of data will become a big problem in future. So it is necessary to find a way to perform data update. Utilize the staff of IGAC regional office for data update is recommended.

(2) IGAC regional office training

IGAC is the national survey and mapping organization of Colombia and a leading geographic institute in Central and South America.

For staff education various training courses about a survey, photogrammetry, remote sensing for mapping are available at CIAF.

However, these kinds of training opportunities are not fully available to the staff of regional offices. While IGAC headquarters send its technical staff to local offices as instructors for training, regional offices seem to desire more frequent or longer training programs.

Currently, their involvement in topographic mapping is limited but IGAC is trying to train regional office staff in field surveys for topographic mapping. Therefore it is important to think about their training in this field positively

12.5 Review IGAC's production process

(1) A production process and specification review from a different viewpoint from IGAC.
IGAC is a survey department with more than 70 years of history.

Therefore some production process has changed and it is necessary to review a work process, but in some case review is not performed.

The JICA Study Team was able to review specifications from the viewpoint that was different from IGAC in a production process and reported the result.

However, the JICA Study Team thinks it is necessary to increase opportunities of information exchange between sections in order to handle mass production in future. In addition, it is necessary to bring up the manager who can look around the whole process.

(2) Advice to IGAC from an investigating commission

- Aerial triangulation and digital mapping
  IGAC operators had no problem in digital mapping. As for aerial triangulation the JICA Study Team concluded that by using automatic correlation function of software IGAC could carry out aerial triangulation without problem. Therefore, the JICA Study Team taught IGAC staff a method to carry out aerial triangulation with manual correlation to deal with cases where automatic correlation is difficult.

- The contents and the subject of a coordinate system employed by IGAC
  Almost all of the 1099 municipalities have each own origin of coordinates.
  As a result, coordinate system of Colombia causes the following inconveniences.

1) If many local coordinate systems exist for one area, ordinary users of geographic information will be confused.

2) If many local coordinate systems exist, GIS software manufactures hesitate to make conversion program. Or, does IGAC has a plan to distribute conversion software to general public?

3) In the future, geodetic control point network will be established in many municipalities. If coordinates changes over a short period time due to the move of origin, management of survey data will be very complicated.

One of the purposes of making GIS data and using GIS is to share geographical information by using the same coordinate system. Existence of multiple coordinate systems in small areas will make the use of geographic information difficult.

4) Coordinate value of origin of local coordinate system are the same with the coordinate value of the coordinate system for small scale mapping. Coordinate values of both coordinate systems are identical at the origin of local coordinate system. But coordinate values of the two coordinate systems are identical only at the origin of the local coordinate systems, this system is quite confusing for ordinary map users because it is difficult to identify the type of coordinate system only from coordinate values of points on maps.

12.6 Verify Specification of IGAC in the Same Position as Subcontract

The survey and a field survey were performed without carrying the survey technique of Japan, but by respecting the specification of IGAC. So the JICA Study Team had to confirm specifications of IGAC in detail, and as a result the JICA Study Team was able to point out a reexamine point to IGAC. It will be important to explain the reexamine result to the people in IGAC.

(1) Data catalog

IGAC has published various catalogs on geographic features.

There are following two types of specifications in the technical specifications IGAC uses for the work subcontracted out to local private firms.

Anexo No.6 Modelo de datos

Anexo No.7 Symobologia

Items checked during field identification survey were listed based on the data model rules specified in Anexo 6. However, there are some geographic features which are not covered by

this data model. Also, symbolization rule is specified in Anexo 7 but some of them do not match with data model described in Anexo 6. Further, some parts of the feature classification rule of this Anexo 6 found to be not so logical.
It is understandable that this kind of confusion occurs because IGAC was in the process of constructing data model. It is recommended to review the structure of data model and also make data model and symbols consistent with each other.

12.7 Proposal of New Technique to Field Survey Method which IGAC is Performing

IGAC is now shifting from analog method to digital method.
Therefore, the contents expected to be helpful in the future have a strong posture taken in positively.

Introduction of RECON and orthophotograph is a concrete example, and it also considers it to be an important subject to connect to the mass production organization which is less experienced by IGAC.

(1) Use of a data recorder (RECON) with GPS
IGAC proposed to used GPS installed data recorder in field identification survey. Advantages and disadvantage of the use of the recorder were clarified during the field identification survey. In future field identification survey it will be necessary to make work plan by taking considerations of both advantages and disadvantages of the recorder.

Good point of the recorder is that coordinates and text information on collected data stored in digital form and therefore can be transferred to mapping system with further digitization.

Disadvantage is that the system does not support Cartesian projection. Also, since GPS installed in the recorder measure the location of the receiver only by single positioning mode, positional accuracy is not so high.

By considering above discussion, the JICA Study Team recommends IGAC to use the recorder in the following manner.

- Type of work suitable for using the recorder: National Census in which the quantity of data collection is large and also every building or household must be visited.
- Type of work not suitable for using the recorder: Identifying and drawing items which are not clearly visible on aerial photos.

CHAPTER 13 Recommendations for the Use and Application of digital data created by the Project

The recommendations for the use and application of digital data created by this project are summarized below.

13.1 Role of IGAC on the use of GIS

The potential role of the digital data created by this project can be used for updating of POT. But once the digital data are created, these data need maintenance. So IGAC should act more as a top manager in dissemination of information.

(1) Conceptualization of some of the tasks

Conceptualization of some of the tasks is documented below.

- IGAC should be responsible for coordinating, integrating, and monitoring GIS activities in the Colombia.
- IGAC should provide technical assistance and training at various stages of the project execution using GIS, and also act as an information center.
- IGAC should play a central role in advising government and municipality on issues of geographic information policy, such as standards, exchange formats, data charging and data collection units, legal issues.
- Until the municipalities are able to fully undertake the job themselves, IGAC should be responsible for the update and integration of the digital data.
- Provide functional standards and guide line for:
    1) Data collection methods and survey protocol
    2) Validation of data
    3) Documentation and quality assurance
    4) Analysis and modeling
    5) Reporting and product development
    6) Data audits

Figure 13-1 show a type of GIS user and a role of IGAC as data provider.

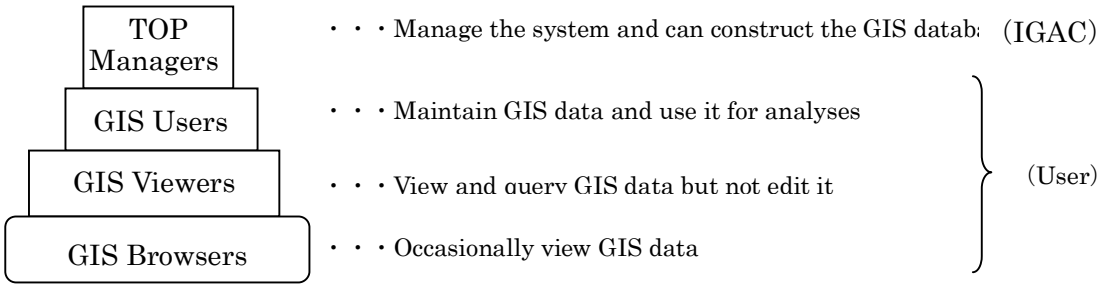


Fig. 13-1 Type of GIS User and their role

(2) Training specially for mapping purpose

1) Train the GIS user
2) Training for operations personal (i.e. data collection and entry)
3) Training for viewers
4) Training Users ((i.e. decision makers)

13.2 GIS data base User

Basic GIS Data is the provision of accurate and reliable geographic data which can be used as the standard in overlaying more than one type of spatial information, such as road, water line and building.

Many GIS users use existing basic GIS data from IGAC etc. And add other type of data if required for actual use. Therefore reliability of GIS data base is important.
Actually the following user exists in Bogotá (Table 13-1).

Table 13-1 GIS data base User

No	Name	Comments	Jurisdiction
1	DANE - Departamento Adminstrativo Nacional de Estadistica	Statistical data producer	National
2	Ministerio de Ambiente, Vivienda y Desarrollo Territorial	Ministry of the Environment, Housing and territorial development	National
3	ECOGAS - Empresa Colombiana de Gas	Gas company	National
4	IDEAM - Instituto de Hidrología, Meteorología y Estudios Ambientales	Institute for hidrology, meteorology and environmental studies	National
5	DNP - Departamento Nacional de Planeacion	National Planning Department	National
6	Bogota Municipality - Alcaldia de Bogota	(*) In general, institutions of Bogota do not use IGAC-produced data for their tasks.	Local (Bogota)
6.1	DAPD Departamento Administrativo de Planeacion Distrital	Planning Office	Local (Bogota)
6.2	IDRD Instituto Distrital de Recreacion y Deporte	Recreation - Sports	Local (Bogota)
6.3	IDU Instituto de desarrollo urbano	Urban development	Local (Bogota)
6.4	DACD Departamento Administrativo del Catastro Distrital	Cadaster	Local (Bogota)
6.5	CVP- Caja de vivienda popular	Popular Housing	Local (Bogota)
6.6	DABS- Departamento Administrativo de bienestar social del distrito	Social welfare	Local (Bogota)
6.7	DADEP - Departamento administrativo defensoria de espacio publico	Public spaces	Local (Bogota)
6.8	DAMA - Departamento administrativo del Medio Ambiente	Environment	Local (Bogota)
6.9	Empresa de renovacion urbana	Urban renewal	Local (Bogota)
6.10	ETB - Empresa de telecomunicaciones de Bogota	Telecomunicactions	Local (Bogota)
6.11	BSH - Bogota sin hambre		Local (Bogota)
6.12	Canal Capital	Television channel	Local (Bogota)
6.13	FAVIDI - Fondo de ahorro y vivienda distrital	Housing fund	Local (Bogota)
6.14	DPAE - Departamento Administrativo La Dirección de Prevención y Atención de Emergencias de Bogota	Emergencies prevention & attention	Local (Bogota)
6.15	Metrovivienda	Social housing	Local (Bogota)
6.16	Secretaria de educacion	Secretary of Education	Local (Bogota)
6.17	Secretaria de hacienda	Secretary of	Local (Bogota)
6.18	Secreatria de gobierno	Secretary of government	Local (Bogota)
6.19	Secretaria de obras	Secretary of public infrastructure	Local (Bogota)
6.20	Secretaria de salud	Secretary of health	Local (Bogota)
6.21	Secretaria de transito y transporte	Secretary of transportation	Local (Bogota)
6.22	Transmilenio	Transmilenio Transportation system	Local (Bogota)
6.23	Empresa de Acueducto de Bogota	Aqueduct	Local (Bogota)
7	Corporación Autónoma Regional de Cundinamarca (CAR)	Cundinamarca environmental regional office	Regional (Cundinamarca)

13.3 Specific use of GIS data

(1) Preparation of basic GIS data and special data

The JICA Study Team assumed that there are two types of GIS data required for project. Spatial data which is a basic GIS data commonly necessary for formulation of various projects and other types of data required for actual projects (Table 13-2).

Table 13-2 Specific use of GIS data

		Road construction	Agriculture	industry	Fisheries	Housing	Tourism	Disaster	Environmental preservation
Spatial data	Road, railroad	○				○	○	○	○
	Coastline	○		○	○				○
	Water area (river, lake)	○	○				○	○	
	Geographical feature (elevation, contour line)	○	○	○		○			
	Control point	○				○		○	
	Vegetation						○		○
	Public facility					○		○	
	Name of a place						○	○	
Other	land use	○	○	○		○		○	○
	Soil		○						
	Geology	○		○				○	
	Disaster history	○				○	○	○	

(2) Use of GIS according to a purpose

The GIS data base created by covers all the contents indicated to "spatial data." However, the information above including land use , soil, geology, a disaster history, etc., raised to "others" will be collected if required.

Table 13-3 shows the data for main project arranged.

Table 13-3 Use of GIS data according to a purpose

Field	Summary	Data to use
Urban Planning	City planning decision, Urban planning control	Road, River, Boundary (administration boundary), Contour line, Control point Land use, Educational facilities
Facility management	Sewer pipe management Power transmission	Drainage canals, such as a pipeline, water supply plant information, a pump place,

		and beneficiary information
Land management	Land ownership management tax property evaluation	Lot number, a house, present condition classification of land, structure, etc.
Resources management	Agriculture, agricultural management soil diagnostic Underground resources (groundwater, various ores, etc.)	Farming person, area, crop inclination soil, slope, geology

Urban Planning .. The information necessary for city planning decision, urban planning control and city planning support, etc includes road, river, boundary and facilities etc.. Also statistical information such as population etc. is necessary.

Facility management .. Many information's to be collect and requires lot of time for data construction. Especially the accuracy of position of piping network data is a big key to a success and quantity of work will become huge.

Land management .. IGAC is already using computer for cadastral. To prepare the necessary data cadastral survey is necessary. Also the boundary of the land and the name of the land owner as a annotation information. For this 1/2,000 scale information are adequate to indicate each house definitely

Resource management .. For farming project topographic map scale of 1/2,000 are adequate to indicate each crops. Attribute data of land owners should be attached as a annotation.

CHAPTER 14 Conclusion

The study was implemented in July 2005 when The JICA Study Team started its preparatory work in Japan. And the study was completed in December 2007 when the JICA Study Team delivered the final output to JICA Tokyo office.
In Colombia, aerial photography, film scanning, ground control point survey and field identification survey were planned and implemented by IGAC. The JICA Study Team provided various advices on aerial photography, film scanning, ground control point survey and field identification survey.

Since IGAC technical staff already had knowledge in the operation of digital mapping instruments, technology transfer was made mainly as a form of technical discussions rather than giving instructions on the operation of instruments. A series of discussions were made to check problems of current production process and exchange opinion on production techniques. These discussions are aimed for the strengthening the production capacity in IGAC.

The production of 1/2,000 scale digital maps are being handled by the headquarters of IGAC. If territorial offices can take over some part of the field work carried out by the IGAC headquarters, cost saving is possible. But currently main role of regional staff is the management of cadastral data including data updating. So most of the regional offices do not have experience in photogrammetric mapping. Therefore, if regional office staff is going to involved in topographic mapping process, training and education will be required in this field.

If territorial offices can take over some part of the fieldwork, not only cost saving but also the involvement of territorial office will be a big benefit for the mapping work.

The mapping budget for the year 2007 is mainly for the production of 1/25,000 maps rather than 1/2,000. But the JICA Study Team judges that IGAC is basically self sustainable in the production of 1/2,000 maps for the 100 municipalities. If production resources are occupied for the production of 1/25,000 maps, Colombian mapping firms can fulfill the shortage in resources.

Finally, the JICA Study Team wishes to express sincere appreciation for the great support and cooperation rendered, during the period of implementation of the Study, by the Director General of IGAC, IGAC counterparts, the Japanese Embassy in Colombia and the JICA Colombia office.

Appendix 1

SCOPE OF WORK FOR THE STUDY ON THE FORMULATION OF GEOGRAPHIC DATA BASE OF THE PRINCIPAL CITIES IN THE ATLANTIC COAST IN REPUBLIC OF COLOMBIA

SCOPE OF WORK
FOR
THE STUDY ON THE FORMULATION OF GEOGRAPHIC DATA BASE OF THE PRINCIPAL CITIES IN THE ATLANTIC COAST IN REPUBLIC OF COLOMBIA

AGREED UPON BETWEEN

INSTITUTO GEOGRAFICO AGUSTIN CODAZZI (IGAC)
AND
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Bogota D.C., 22nd March, 2005

Mr. Nobutetsu ENOSHITA
Leader
Preparatory Study Team
Japan International Cooperation Agency (JICA)

Mr. Iván Darío Gómez Guzmán
Director General
Instituto Geografico Agustin Codazzi (IGAC)

Mr. Luis Alfonso Hoyos Aristizabal
Director
Agencia Colombiana de Cooperacion Internacional
(ACCI)

as witness

Mr. Pedro Jose Fernandez Ayala
Deputy Director
Departamento Administrativo Nacional de Estadística
(DANE)

I. INTRODUCTION

In response to a request of the Government of Republic of Colombia (hereinafter referred to as "the GRC"), the Government of Japan decided to conduct "The Study on the Formulation of Geographic Data Base of the Principal Cities in the Atlantic Coast in Republic of Colombia" (hereinafter referred to as "the Study"), in accordance with the relevant laws and regulations in force in Japan.

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

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

II. OBJECTIVES OF THE STUDY

The objectives of the Study are:

1) to formulate new digital topographic maps covering as shown in Appendix-1-1, 1-2 and 1-3(hereinafter referred to as "the Mapping Area"),at the scale of 1:2,000, including taking new aerial photographs (Approximately 400 square kilometers) ;
2) to conduct the feasibility study for the formulation of geographic data base in the other 100 municipalities.
3) to pursue technology transfer in the course of implementation of the Study.

III. SCOPE OF THE STUDY

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

1. Review of Existing Conditions

   Existing conditions relevant to the Study including organization set-up, mapping system, facilities management and control points shall be reviewed.

2. Aerial Photography

   Black and white aerial photographs at the scale of 1:10,000 covering shall be taken.
   (Approximately 400 square kilometers)

3. Map Production for covering as the Mapping Area.
   1) Control Point Survey, Leveling and Pricking

      Control point survey, leveling and pricking shall be carried out.
   2) Aerial Triangulation

      Aerial triangulation shall be carried out.
   3) Field Identification

      Topographic information shall be interpreted mainly using the aerial photographs. The field identification shall be conducted in case that the information on the aerial photographs is difficult to be interpreted.
   4) Digital Plotting

      Digital topographic data shall be plotted.

5) Editing and Symbolization

The digital topographic data shall be edited and symbolized to print topographic line maps at the scale of 1:2,000.

6) Field Completion

Field completion shall be carried out.

7) CD-ROM production

The digital topographic data shall be compiled into CD-ROM.

4. Conduct of Feasibility Study

1) Review of Existing Data

Existing digital topographic data in the other 100 municipalities shall be reviewed. 100 municipalities are listed as shown in Appendix 2.

2) Supplementary Survey

Necessary data for cost-benefit analysis shall be collected.

3) Cost Estimation

Cost for the formulation of geographic data base in the other 100 municipalities shall be estimated.

4) Economic and Financial Analysis

Benefits which are supposed to be created by the Projects, shall be analyzed.

5. Utilization of GIS data

GIS data formulated in the Study shall be utilized for the various purposes of land use plan, cadastral information, public service networks and so on.

6. Establishment of Coordinating Committee and Technical Team

Instituto Geografico Agustin Codazzi (hereinafter referred to as the "IGAC") is encouraged to establish a Coordinating Committee and Technical Team. The Coordinating Committee is responsible for the management of the Study. The Technical Committee shall conduct the Study based on the direction of the Coordinating Committee.

7. Technology Transfer

In order to facilitate technology transfer to the counterpart personnel, part of the above-mentioned items shall be undertaken by the counterpart personnel under the technical supervision of the members of the Study.

8. Dissemination of the Final Products

Recommendations for the wide and effective use of the topographic data produced under the Study shall be prepared.

IV. STUDY SCHEDULE

The Study will be implemented in accordance with the tentative schedule as shown in Appendix-3. The schedule, including dispatch schedule of the full-scale study team (hereinafter referred to as "the Study Team") and report submission dates stated in the next clause (V), is tentative and subject to be modified when both sides agree

upon because of any necessity that arises in the course of the Study.

V. REPORTS AND FINAL PRODUCTS

JICA will prepare and submit the following reports and the final products of topographic mapping works to the GRC.

1. Inception Report
   Twenty (20) copies (ten (10) copies in English and ten (10) copies in Spanish) at the commencement of the Study
2. Interim Report
   Twenty (20) copies (ten (10) copies in English and ten (10) copies in Spanish) within fifteen (15) months after the beginning of the Study
3. Draft Final Report
   Twenty (20) copies (ten (10) copies in English and ten (10) copies in Spanish) within twenty-six (26) months after the beginning of the Study
   IGAC will submit its comments within thirty (30) days after the receipt of the Draft Final report.
4. Final Report
   Twenty (20) copies (ten (10) copies in English and ten (10) copies in Spanish) within thirty (30) days after the receipt of the comments on the Draft Final Report.
5. Final products of topographic mapping
   1) One (1) set of negative films of aerial photographs
   2) One (1) set of contact prints of aerial photographs
   3) One (1) set of digital data of aerial photographs
   4) One (1) copy of result of ground control point survey for map production of the Mapping Area
   5) One (1) copy of result of aerial triangulation for map production of the Mapping Area.
   6) Five (5) sets of 1:2,000 scale digital topographic data of the Mapping Area
   7) Two(2) sets of 1:2,000 scale topographic maps plotted on polyester base of the Mapping Area

VI. UNDERTAKING OF THE GRC

1. To facilitate the smooth conduct of the Study, the Technical Cooperation Agreement signed between the GRC and the Government of Japan on 22nd of December, 1976, and the Note Verbals issued by the Government of Japan on 17th of September, 2001 and confirmed by the GRC on the 21st of January, 2002 will be applied:
   1) to secure the safety of the Study Team ;
   2) to permit the members of the Study Team to enter, leave and sojourn in Colombia for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees;
   3) to exempt the members of the Study Team from taxes, duties and other charges on equipment, machinery and other materials brought into Colombia for the implementation of the Study ;
   4) to exempt the members of the Study Team from income tax and charges of any kind imposed on or in connection with any emoluments or allowance paid to the members of the Study Team for their service in connection with the implementation of the Study ;
   5) to provide the necessary facilities to the Study Team for the remittance as well as utilization of the funds introduced into Colombia from Japan in connection with the implementation of the Study and

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

2. IGAC: To facilitate the smooth conduct of the Study, IGAC shall take the following necessary measures:
   1) to secure necessary permission to use aircraft for aerial photography in connection with the implementation of the Study ;
   2) to facilitate legal entry with permission into private properties and restricted areas for the implementation of the Study ; and
   3) to secure permission for the Study Team to take all data (including topographic maps, negative films, contact prints and digital data of aerial photographs) related to the Study out of Colombia.

3. The IGAC shall act as counterpart agency to the Study team and also as coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

4. The IGAC shall, at its own expense, provide the Study Team with the following :
   1) available data and information related to the Study ;
   2) security-related information ;
   3) information on as well as support in obtaining medical service ;
   4) counterpart personnel ;
   5) suitable office space with necessary office equipment and furniture ;
   6) credentials or identification cards ; and
   7) vehicles with drivers.

   Note: The IGAC shall have cooperation with other organizations concerned for above 1), 2) and 3).

5. The IGAC shall, at its own expense, take aerial photographs mentioned in the article 2. of "Ⅲ. SCOPE OF THE STUDY". Likewise the IGAC shall, at its own expense, scan those photographs and provide them the Study Team at the beginning stage of the Study

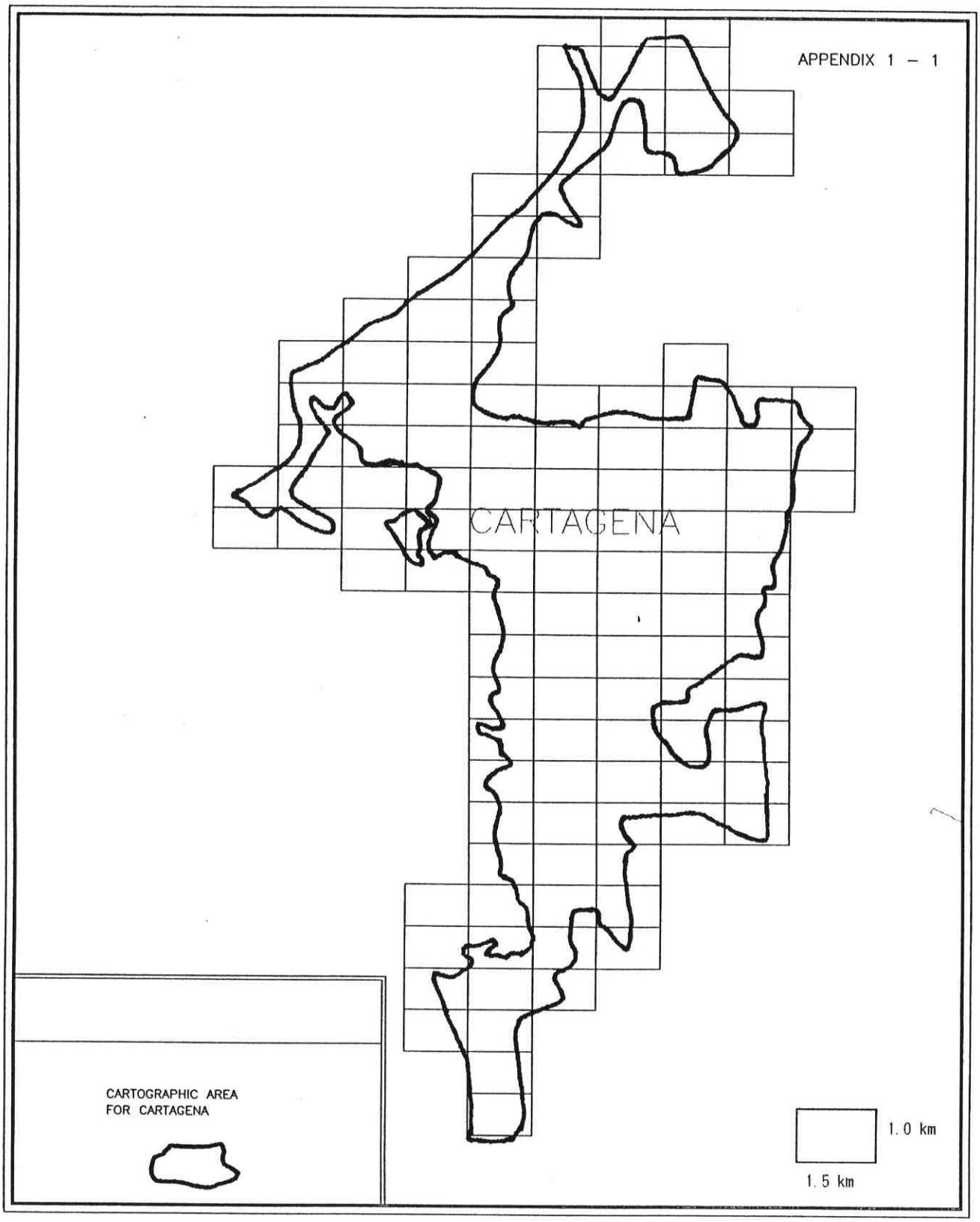
VII. UNDERTAKING OF JICA

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

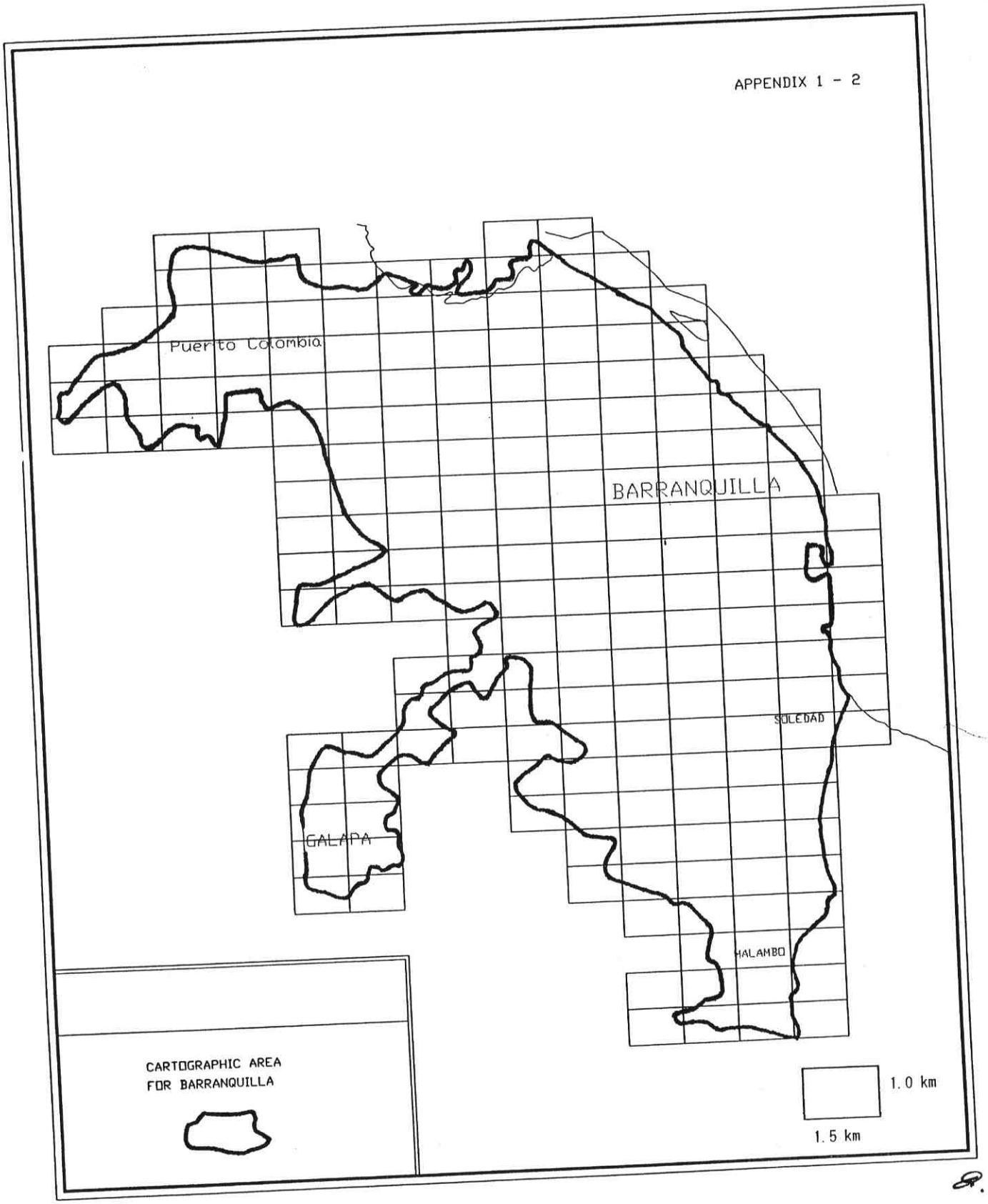
VIII. OTHERS

1. JICA and the IGAC shall consult with each other in respect of any matter that may arise from or in connection with the Study.
2. The Scope of Work is prepared in English and Spanish, and both versions are signed by the both partners. In case any doubt arises in interpretation, the English text shall prevail.
3. Minutes of Meeting dated on 22nd of March, 2005 complements the Scope of Work.

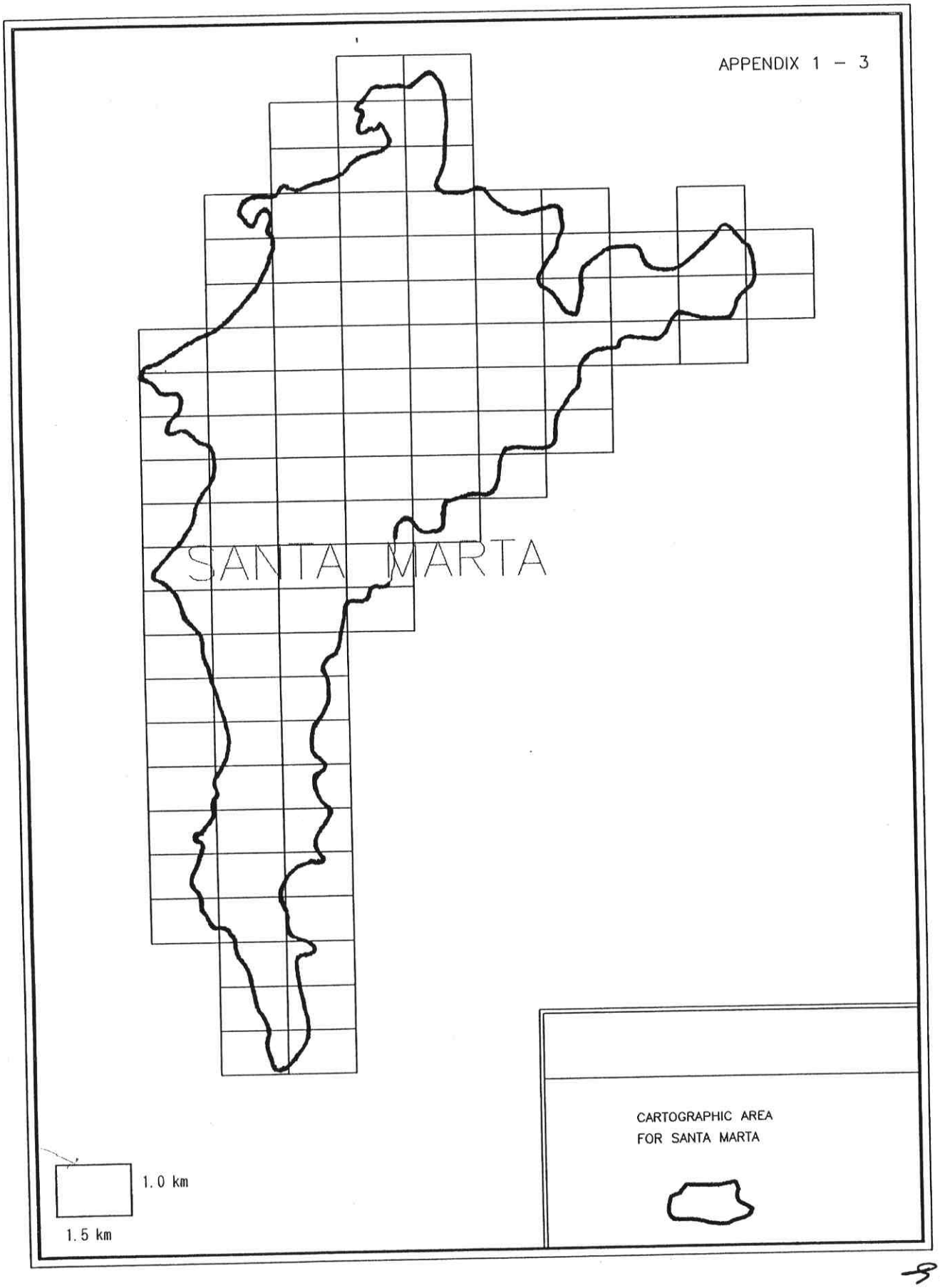
APPENDIX 1 – 1



APPENDIX 1 - 2


Puerto Colombia
BARRANQUILLA
SOLEDAD
GALAPA
HALAMBO
CARTOGRAPHIC AREA
FOR BARRANQUILLA
1.0 km
1.5 km

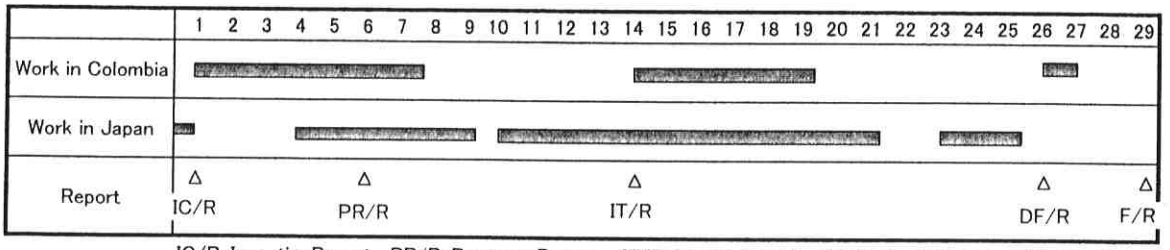
APPENDIX 1 – 3



100 Municipalities in Colombia

No.	Province	Municipality
1	SANTANDER	BUCARAMANGA
2	TOLIMA	IBAGUE
3	CUNDINAMARCA	SOACHA
4	SANTANDER	FLORIDABLANCA
5	RISARALDA	DOS QUEBRADAS
6	BOYACA	SOGAMOSO
7	BOYACA	DUITAMA
8	BOLIVAR	MAGANGUE
9	NORTE DE SANTANDER	OCANA
10	SANTANDER	GIRON
11	NORTE DE SANTANDER	VILLA ROSARIO
12	VALLE	YUMBO
13	CALDAS	LA DORADA
14	SANTANDER	PIEDECUESTA
15	NARINO	IPIALES
16	HUILA	PITALITO
17	TOLIMA	ESPINAL
18	CUNDINAMARCA	FACATATIVA
19	VALLE	JAMUNDI
20	NORTE DE SANTANDER	LOS PATIOS
21	META	ACACIAS
22	QUINDIO	CALARCA
23	CESAR	AGUACHICA
24	META	GRANADA
25	MAGDALENA	CIENAGA
26	CUNDINAMARCA	CHIA
27	BOLIVAR	TURBACO
28	CUNDINAMARCA	MOSQUERA
29	CORDOBA	LORICA
30	CAUCA	SANTANDER DE QUILICHAO
31	CORDOBA	CERETE
32	RSARALDA	SANTA ROSA DE CABAL
33	SANTANDER	SAN GIL
34	CORDOBA	SAHAGUN
35	TOLIMA	MELGAR
36	BOYACA	CHIQUINQUIRA
37	MAGDALENA	EL BANCO
38	MAGDALENA	FUNDACION
39	GUAJIRA	SAN JUAN DEL CESAR
40	SUCRE	COROZAL
41	CESAR	AGUSTIN CODAZZI
42	BOLIVAR	ARJONA
43	VALLE	FLORIDA
44	ARAUCA	SARAVENA
45	NORTE DE SANTANDER	PAMPLONA
46	TOLIMA	HONDA
47	VALLE	SEVILLA
48	CORDOBA	PLANETA RICA
49	CALDAS	CHINCHINA
50	VALLE	EL CERRITO
51	TOLIMA	CHAPARRAL
52	PUTUMAYO	PUERTO ASIS
53	VALLE	PRADERA
54	HUILA	GARZON
55	TOLIMA	MARIQUITA
56	SAN ANDRES	SAN ANDRES
57	ATLANTICO	BARANOA
58	ARAUCA	TAME
59	CUNDINAMARCA	FUNZA
60	CAUCA	PUERTO TEJADA
61	VALLE	CANDELARIA
62	TOLIMA	FLANDES
63	GUAVIARE	SAN JOSE DEL GUAVIARE
64	VALLE	ROLDANILLO
65	ARAUCA	ARAUQUITA
66	NORTE DE SANTANDER	TIBU
67	VALLE	ZARZAL
68	BOYACA	PUERTO BOYACA
69	BOLIVAR	MOMPOS
70	CORDOBA	MONTELIBANO
71	CUNDINAMARCA	MADRID
72	CALDAS	VILLAMARIA
73	TOLIMA	LIBANO
74	GUAJRA	FONSECA
75	CORDOBA	TIERRALTA
76	QUINDIO	LA TEBAIDA
77	QUINDIO	MONTENEGRO
78	CASANARE	AGUAZUL
79	SUCRE	SAN ONOFRE
80	MAGDALENA	PLATO
81	META	PUERTO LOPEZ
82	MAGDALENA	ZONA BANANERA
83	SUCRE	SAN MARCOS
84	HUILA	CAMPO ALEGRE
85	SUCRE	TOLU
86	MAGDALENA	PIVIJAY
87	SANTANDER	PUERTO WILCHES
88	TOLIMA	GUAMO
89	QUINDIO	QUIMBAYA
90	TOLIMA	LERIDA
91	HUILA	LA PLATA
92	SANTANDER	SOCORRO
93	META	SAN MARTIN
94	GUAJIRA	BARRANCAS
95	VALLE	CAICEDONIA
96	CASANARE	PAZ DE ARIPORO
97	VALLE	LA UNION
98	CAQUETA	PUERTO RICO
99	CESAR	CURUMANI
100	CALDAS	RIOSUCIO

Tentative Schedule of The Study



IC/R: InceptionReport PR/R: Progress Report IT/R: Interim Report DR/R: Draft Report F/R: Final Report