THE STUDY
FOR
ESTABLISHMENT OF DIGITAL TOPOGRAPHIC MAPS IN GEORGIA

Final Report

Summary

PASCO CORPORATION

March 2008

CURRENCY EQUIVALENTS

Currency Unit = Georgian Lari (GEL)

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PREFACE

In response to a request from the Government of Georgia, the Government of Japan decided to conduct a study on The Study for Establishment of Digital Topographic Maps in Georgia and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Hisashi MORI of PASCO Corporation and consists of PASCO Corporation between April, 2005 and February, 2008.

The team held discussions with the officials concerned of the Government of Georgia, 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 Georgia for their close cooperation extended to the study.

March 2008

Eiji HASHIMOTO,
Deputy Vice President
Japan International Cooperation Agency

Mr. Eiji HASHIMOTO
Vice President for
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Mr. Hashimoto,

We are greatly honored to submit to you the final report on “The Study for Establishment of Digital Topographic Maps in Georgia” that was implemented based on the contract with your Agency.

This report summarized the progress of the study and results of the works over the three years from fiscal year 2005. Pasco Corporation carried out this study from April,2005 to March, 2008, and the outcomes from the works include aerial photographs on the scale of 1/40,000, topographic maps on the scale of 1/50,000 , the digital topographic data with GIS database and GIS model systems.
In this report, we also elaborate on approaches to effective use of the topographic data in various fields of decision-making and are convinced that it will contribute to the promising socio-economic development of Georgia.

On behalf of the study team in Pasco Corporation, I would like to express my deepest gratitude to the Geology-Cartography and Geodesy Service and the organizations concerned in the Government of Georgia for their close cooperation extended to the Study Team.

Finally, I wish to convey my sincere appreciation to the officials in JICA, Geographical Survey Institute, the Ministry of Land Infrastructure and Transport, the Ministry of Foreign Affairs and the Embassy of Japan in the republic of Azerbaijan for providing us with suggestive advices and appropriate directions that have been given to us during the implementation of the project.

March, 2008

The Study for Establishment of Digital Topographic Maps in Georgia
Leader of the Study Team Hisashi Mori

Contents

List of Figures

List of Tables

List of Abbreviations

CAD	Computer-Aided Design
DEM	Digital Elevation Model
DGC	Department of Geodesy and Cartography
DTM	Digital Terrain Model
EPNR	Environment Protection and Natural Resources (The name of the ministry)
GCGS	Geology-Cartography and Geodesy Services
GCP	Ground Control Point
GIS	Geographic Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
MSL	Mean Sea level
MST	Multi-sensor Triangulation
NGO	Non-Governmental Organization
OJT	On-the-Job Training
SGC	Service of Geodesy and Cartography
SIA	Spatial Information Agency
TIN	Triangulated Irregular Network
UNDP	United Nations Development Program
UTM	Universal Transverse Mercator
WGS 84	World Geodetic System 1984

Chapter 1. Introduction

1.1. Background and progress of the Study

Necessity for the Project

Georgia is currently carrying forward national development and democratization, and the country is in absolute need for foreign assistance in shifting to a market-based economy, developing social infrastructure and environmental protection, supporting refugees, etc. through land reform. More concretely, accurate ascertainment of geographical information which underlies the national land is among top priority issues. However, in the aspect of national basic map, there has been no revision conducted so as to keep the topographic maps up to date since 1980s during the former Soviet era, and the obsolete geographical information has been one of the hindrances to planning and formation of national development programs and smooth implementation of relevant projects.

Therefore, it is a common understanding that immediate construction of national spatial basic data (geographical information) reflecting the most recent situation and digitization of map data for easy use are vital for smooth realization of all sorts of national development plans. Accordingly, the government of Georgia submitted an official request to the government of Japan in January 2004, which has successfully led to the implementation of the Project.

Progress of the new National Development Plan and promotion of shift to the market-based economy by the reformed government

Georgia underwent a drastic political change in November 2003, when the people's culminated frustration toward the stagnant economy and the then government's rampant corruption ousted the former president Eduard Shevardnadze. In consequence, Mikheil Saakashvili, one of the key figures of the reform group, was selected as a new president, initiating a new administration in January 2004. Today, the new president is carrying forward reorganization of the government structure along with formulation of a new National Development Plan. The Policy Framework 1998-2000 formulated by the Ministry of Finance of Georgia posts the following as the nation's economic policy goals: promotion of shift to the market-based economy, strengthening of the fiscal infrastructure, privatization of large state-owned companies or non-agricultural land, land reform, tax reform, etc.

Meantime, the Georgian government underwent a ministrial reshuffle in October 2005, immediately after the initiation of the Project, and the former counterpart, i.e. the

Department of Geography and Cartography (hereinafter referred to as "DGC"), was drastically restructured and downsized. The counterpart, the former DGC, was taken over to the SGC (Service of Geodesy and Cartography) in 2006,and moreover the SGC affiliated with the Geology Service that belongs the same ministry as the SGC in the end of 2007. As a result, the counterpart again changed the name to GCGS (Geology-Cartography and Geodesy Service) from SGC and widen the function of its service with the increase in staff member.

1.2. Objectives and Study area

Under the above mentioned background, the study was implemented to prepare the latest topographic data, which contributes to planning of medium-long term national development strategy of Georgia, and to create GIS model systems for promoting the effective use of geographic information. The study also aimed the establishment systems for dissemination of data and sharing the geographic information.

The targeted area is 24,000km^2 as shown in figure 1.2.1 ,where the areas are densely populated and major economic activities are operated.

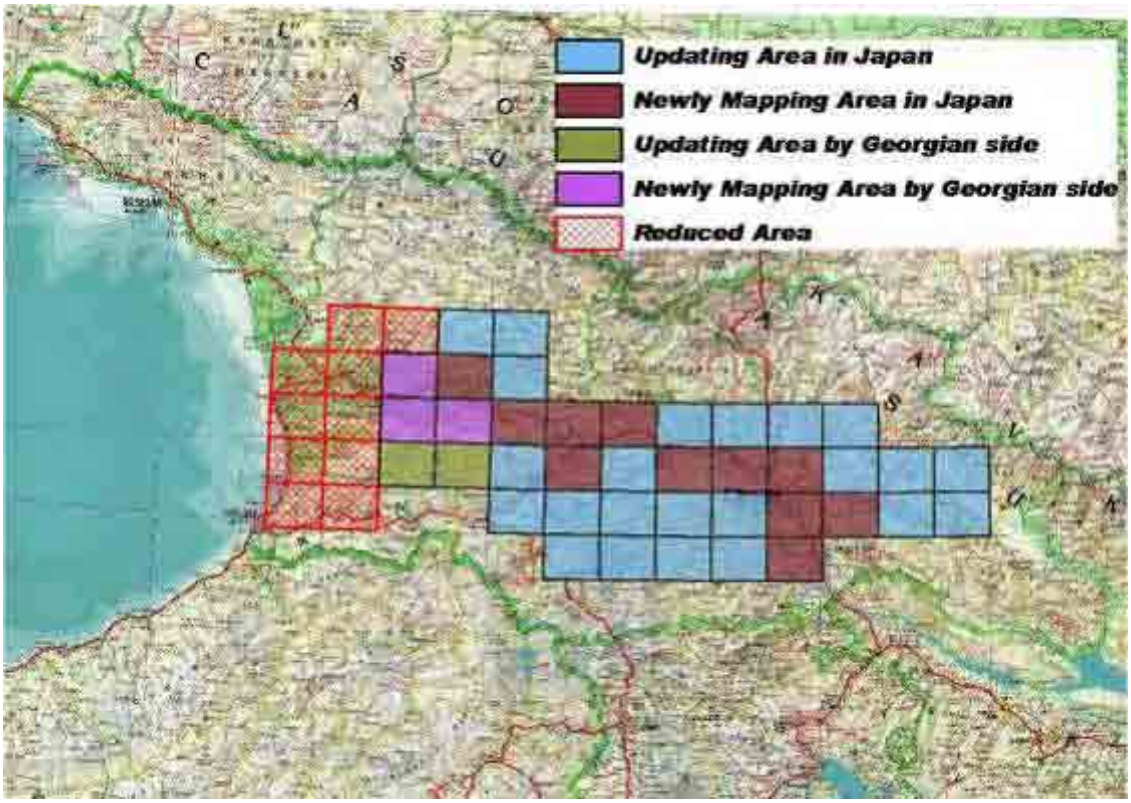


Figure 1.2.1 Study Area

1.3. Outline of the Study and Outcomes

1.3.1. Contents of the study

Contents of the Study are as following table.

Table 1.3.1 Items of the work in the Study

Item	Quantity	Specification	Remarks
Aerial photography	Covering 30,000 km^2	Scale 1/40,000 B/W panchromatic film Lateral Overlap：60±5% Adjacent Overlap:30±5%	Mapping area is for 24,000 km^2 only
Acquiring digital image	1,447 images	Scanning of aerial photographs	
Ground control point survey	33 GCP	UTM, WGS84	GPS observation
Levelling	920km		Pricking for 63 points
Digital mapping	Updating：15,000 km^2	Digitizing existing maps and updating chronological changes	1/50,000 for 24,000 km^2
	Plotting newly: 9,000 km^2	Creating new maps by Stereo Digital Plotter	OJT was done for 3000 km^2
Map symbolization	39 map sheets	155 new items were decided on the basis of on the existing map symbols of Georgia	Symbolizing topographic data using Illustrator.
Creation of GIS database	24,000 km^2	Design and creation of GIS data from digital topographic data.	ArcGIS’s Geodatabase format

GIS Model database	6 fields; Urban development, Forest management, Environmental protection, Tourism promotion, Agricultural land use, Educational facility	Creating Databases from each thematic map
GIS Model systems	GIS Model for Urban Development	GIS analysis models :1 set each GIS Model data base :1 set each Manual for operating models
	GIS Model for Forest Management and Reforestation	
	GIS Model for Facilitating Environmental Protection	
	GIS Model for Facilitating Environmental Protection	
	GIS Model for Optimization of Agricultural Land Use	
	GIS Model for Contribution to Information of Educational Improvement	

1.3.2. Outcomes of the Study

Table below shows final products from the Study.

Table 1.3.2 Outcomes of the Study from the Study

Item	Quantity	Remarks
Negative films of aerial photographs	1 set	Covering 30,000 km^2
Scanned images of aerial photographs	1 set	
Contact prints of aerial photographs	1 set	Panchromatic films
Flight index sheet of aerial photographs	1 set	
Result of field survey	1 set	Ground Control Points
Result of aerial triangulation	2 blocks	1,441 models
Films for printing maps	1 set	Scale: 1:50,000
Digital data file of topographic maps	5 sets	
Topographic maps	500 copies	Scale: 1:50,000 250 copies in English 250 copies in Georgian
GIS model system	1 set	6 models for Coordinating Committee

Inception report	10 copies of English 10 copies of Russian	
Interim report	10 copies of English 10 copies of Georgian	As per request of the counterpart, Report in Georgian was prepared instead of Russian
Progress report	10 copies of English 10 copies of Georgian	
Draft final report : Main report : Summary	10 copies of English 10 copies of Georgian 10 copies of English 10 copies of Georgian	
Final report : Main report : Summary	10 copies of English 10 copies of Georgian 10 copies of English 10 copies of Georgian	

1.4. Composition of the Study Team Members

The members of the Study Team and their dispatch from Japan to Georgia for the Study are as follows;

Table 1.4.1 Members of the Study Team

TITLE	NAME
Team Leader	Fujio ITO
Team Leader , Deputy Leader , Project Adviser	Hisashi MORI
Supervisor for aerial Photography	Timo JARVINEN
Supervisor for control Survey	Yutaka NAKADA
Supervisor for field verification 1	Sadao MATSUMOTO
Supervisor for field verification2 , Supervisor for map symbolization	Toshinori OTSU
Supervisor for revision of existing map Supervisor for field verification 2 Supervisor for construction GIS model system	Akihiro SUGITA
Supervisor for construction GIS model system	Hidetoshi KAKIUCHI
Supervisor for map symbolization	Takashi SHIMONO
Supervisor for digital plotting and compilation	Minori ONAKA
Supervisor for GIS Database	Awadh Kishor SAH
Interpreter	Makiko UEHARA
Coordinator	Kensuke KIMURA

Chapter 2. Basic policy of the Study

2.1. Overall Policy

- Support the body that acts as a coordinator in cooperation with related organizations.
- Pay a careful attention to transfer the technologies in view of promotion for disseminating topographic data and of construction of data sharing.
- Make an effort to promote the wider use of geographic information.

2.2. Basic Policy in Technical Aspects

- Adopt a new survey standard and coordinate system
- Bring a innovated methods in conducting the field verification
- Attach great importance to efficient creation of digital data in mapping
- Attach importance to the technical transfer in creating GIS database
- Construct GIS model systems for encouraging positive use of geographic information

2.3. Basic Policy of Technology Transfer

Main emphasis was placed on establishment of firm skills in producing digital topographic data and on methods of data sharing and dissemination to widen the GIS users.

Items of technology transfer through the OJT and points stressed are as follows (Table2.3.1).

Table 2.3.1 List of crucial items in the OJT and its aim

Items	Contents	Point stressed	Effects on skill building for the counterpart
Ground ControlPoint Survey and analysis	Selection of GCP' And GPS observation Analysis of GPS data	Practice of systematic observation	・Reconstruction of the geodetic control point network, and promotion of use of GPS data in digital photogrammetry
Digitization of existing map	Geometric correction and Geo-referencing Skill for digitizing	Knowledge on tolerable error in geometric correction	・ Effective utilization of equipment and apparatus of the Department of Geography and Cartography, and revitalization of engineers
Aerial triangulation	Methods of aerial triangulation	・Operation of software for digital aerial ・Evaluation on the results from aerial triangulation	・ Improvement of productivity through application of digital technology
Stereo digital plotting and compilation	Stereo plotting Compilation of digital data	・ Practical operation of digital plotting ・Method for cleaning of digital data	・ Improvement of productivity and cost reduction through application of digital technology
Symbolization and Preparation of printing film	Map symbolization Creation of digital printing data	・Operation of publishing software ・Displacement of symbol and discontinuity of featuring lines	・Realization of producing printed 1/50,000 maps
Creation of GIS databases	Design of structure of database Creating GIS data	・ Understanding GIS ・ Operation of GIS software	・Popularization and promotion of GIS in assisting formulation of priority projects in the national development plan, and establishment of viability of the GCGS
Application for GIS	Preparation of thematic data and Applying GIS model	・Choosing necessary data ・Creation of GIS models and practical use	・ Elevation of the degree of contribution of GCGS and improvement of its position through practical application of GIS to priority fields

Chapter 3. Outline of the Study

3.1. Overall component of the Study and its flow

The flow chart below shows the component of the work in the Study and work flow.

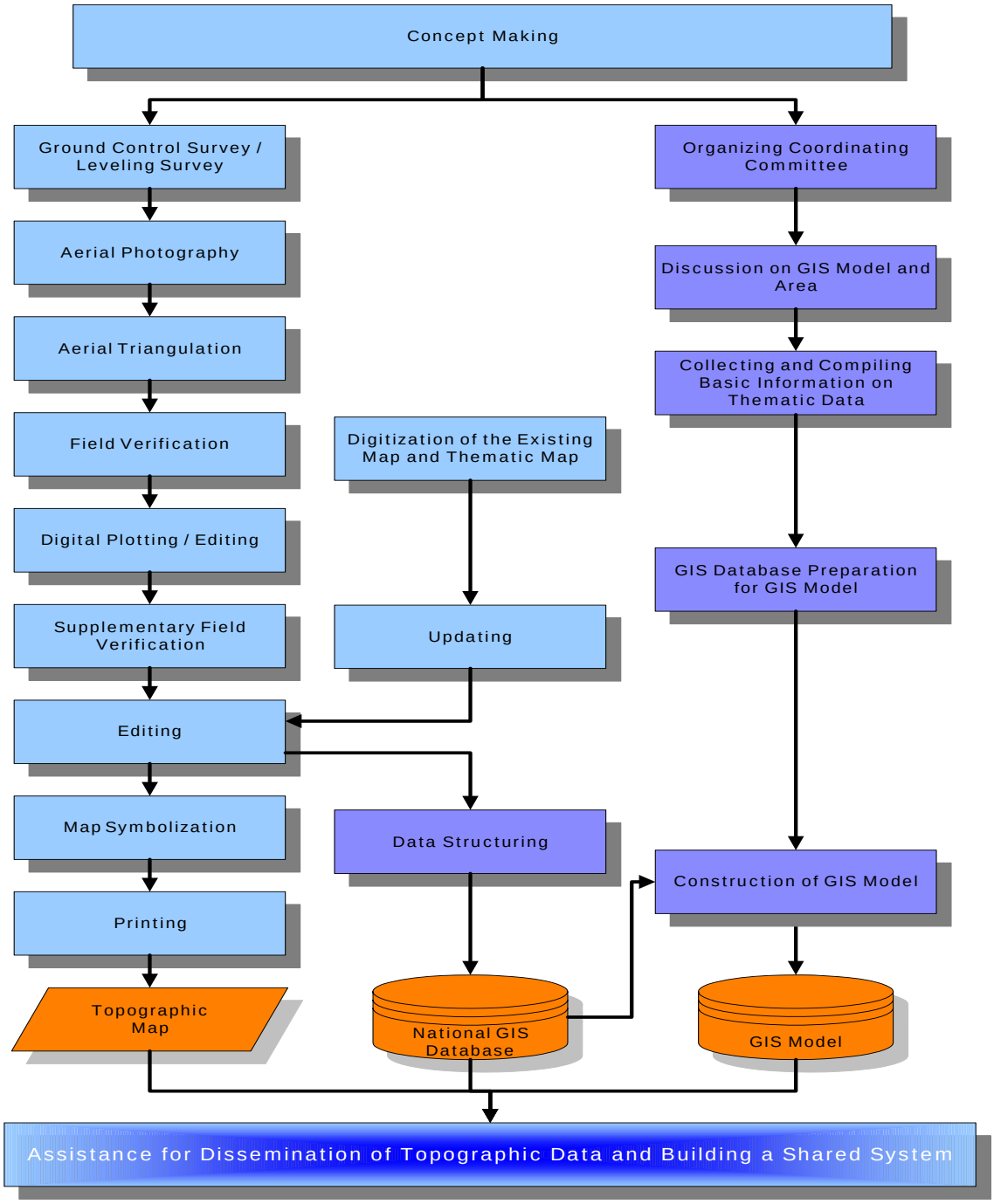


Figure 3.1.1 Conceptual diagram of the Study and flow

3.2. Work items and process in each year

The following table shows process of the Study in each year.

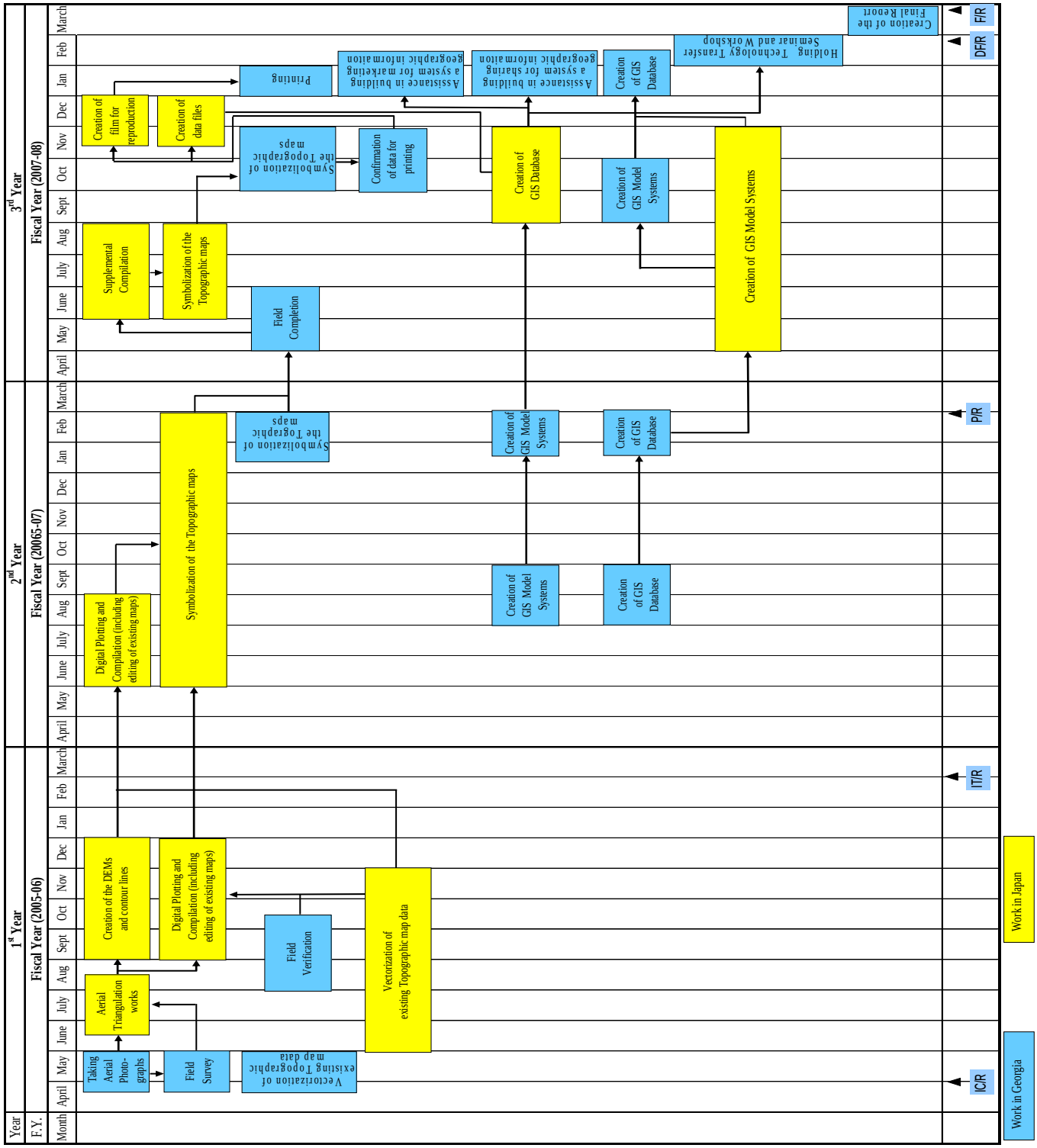


Figure 3.2.1 Work items and process in each year

3.3. Study items and their results in three years

3.3.1. Survey standards and map specifications

The first work in Georgia included discussion with the former DGC held on the surveying standards, map specifications and map symbols. The discussions throughout the 3 years are summarized as follows:

(1) Survey standards

Reference spheroid	:	WGS84
Map projection	:	UTM
Precision of map	:	Planimetry 0.5 mm on the map Altitude 1/3 of contour interval Contour line 1/2 of contour interval

(2) Map specifications

Map sheet size	:	0°20'(longitude) x 0°12'(latitude)
Contour interval	:	In mountainous areas intermediate contour intervals should be 20 m for the maps to be newly created, and in flattish and/or hilly areas supplementary contour lines should principally be added.
Conversion of zone	:	To generate and keep seamless data between zones 37 and 38, the data located in zone 37 should be converted into zone 38 during digitization.

(3) Map symbols

Map symbolization was carried out after finishing correction of the final topographic data in accordance with the specification of map symbols that had been prepared previously. This work was done with the use of software "Illustrator" which excels its efficiency in graphic function. The table 3.3.1 outlines the basic structure of symbolization.

Table 3.3.1 Basic structure of symbolization

No	Major lassification	Sub classification	Remarks
1	Control point	3 items	
2	Buildings and other structures	34 items	Note 1: One item was brought back. Note 3: Three items were added
3	Infrastructures	9 items	
4	Railways	7 items	
5	Roads	12 items	
6	Hydrography and its structures	39 items	Note 2: The name and expression of an item was changed. Note 4: Two items were brought back
7	Topography	18 items	
8	Vegetation	16 items	
9	Ground	4 items	
10	Mixed vegetation	10 items	
11	Boundaries	3 items	
	Total	155 items	Refer to New Symbols in the symbolization
Annotations		19 types	

(Individual symbols are classified into 227 codes (classified by symbolized expression, realistic features, index/intermediate/supplementary lines, large/medium/small, etc.)

The map sheets with both English and Georgian annotation were to be prepared according to the mutual consent.

Figure 3.3.1 Sheet design of new printed map

3.3.2. Aerial photography

Aerial photography was done with a scale of 1/40,000 covering 30,000km2 and resulted in obtaining 1,447 images of effective photographs. The specification of the photography are shown below. The coordinates of the principal points are measured automatically using DGPS.

Table 3.3.2 Specification of the aircraft and aerial camera

Aircraft	Camera type	Lens type
Piper PA31-T N700RG	ZEISS RMK TOP 15	PLEOGON- A3

All the frames of aerial film were scanned using *Vexcel Ultrascan5000* according to the following conditions for preparing digital images.

Table 3.3.3 Specification of the film scanning

Mode	:	Grayscale
Resolution	:	20 micrometer
File format	:	Tiff (un-tiled, uncompressed)

3.3.3. Ground control point survey

A geodetic control network survey using GPS was conducted on the entire landmark centers that had been installed previously. Existing national geodetic control points were dominantly utilized in selecting GCP's. The following datum was employed in the Study.

Table 3.3.4 Specification of the film scanning

Coordinate system:	UTM Zone 37 and/or Zone 38
Vertical datum	WGS 84
Vertical datum:	The Baltic mean sea level in the system of 1977
Measurement unit	Metric system

Figure 3.3.2 Observation of GCP in the field

3.3.4. Aerial triangulation

The triangulation was done based on WGS84 and coordinate system UTM , Zone 38 scanned images of aerial photographs.

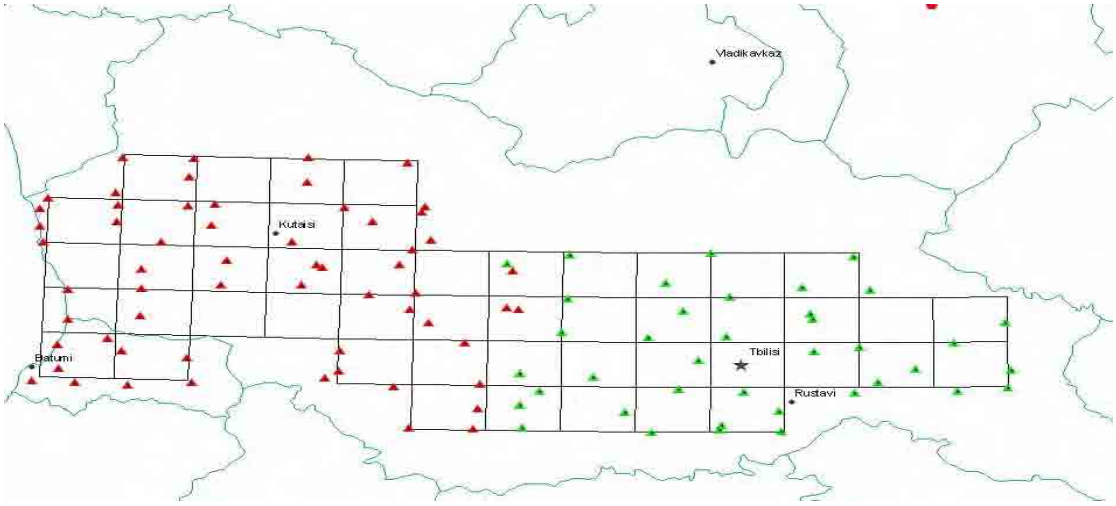


Figure 3.3.3 Allocation of control points in each block

In the horizontal and vertical directions, the resulted standard deviation of residual errors computed as "RMS" and maximum residual errors of the control points are presented in Table 3.3.4 below :

Table 3.3.5 Specification of the film scanning

Block No.	X (Longitude)		Y (Latitude)		Z (Elevation)	
	Standard deviation	Max.	Standard deviation	Max.	Standard deviation	Max.
B1	0.237	+0.846	0.213	-0.643	0.088	-0.340
B2	0.358	+1.327	0.293	-0.866	0.047	+0.124

The above adjustment computation results could be deemed as a satisfactory level of accuracy.

Accuracy standards for standard deviation of residual errors

X: less than 1.2 m ("altitude above ground level" x 0.02 %)
Y: less than 1.2 m ("altitude above ground level" x 0.02 %)
Z: less than 1.2 m ("altitude above ground level" x 0.02 %)

Accuracy standards for maximum of residual errors

X: less than 2.4 m ("altitude above ground level" x 0.04 %)
Y: less than 2.4 m ("altitude above ground level" x 0.04 %)
Z: less than 2.4 m ("altitude above ground level" x 0.04 %)

3.3.5. Field Completion

(1) Preparation of Orthophotograph

To facilitate an easier recognition of location in the field, orthophotographs with coordinates which handy GPS guides accordingly were prepared.

Figure 3.3.4 Output files cutting off into the format of newly designed map sheet

(2) Verification of ground features

Carrying the existing topographic maps and orthophotographs with the remarks by preliminary photo interpretation, necessary information for the maps were verified and sorted out onto the orthophotographs for the next process of plotting.

Figure 3.3.5 Scene in preliminary photo-interpretation

3.3.6. Updating of the existing maps

For the areas with relatively few chronological changes (apporoximately 15,000 k ㎡), ground features except for contour lines, rivers and forests were updated with a help of aerial photographs taken in this project.

Updated digital topographic data (roads, railways, power lines and pipe lines) were compiled using CAD and GIS software's**.**

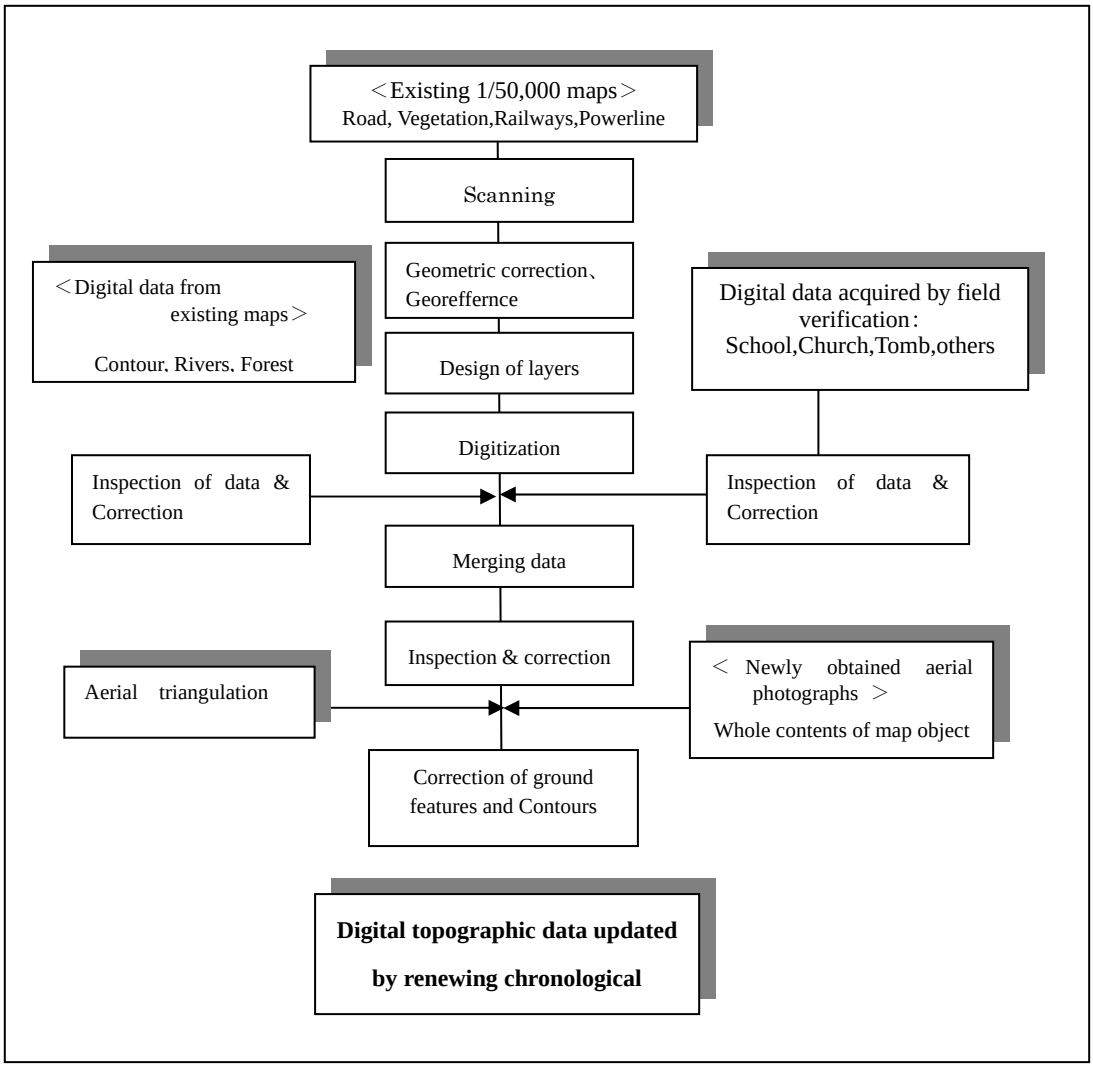


Figure 3.3.6 Updating existing maps using digitized existing map data

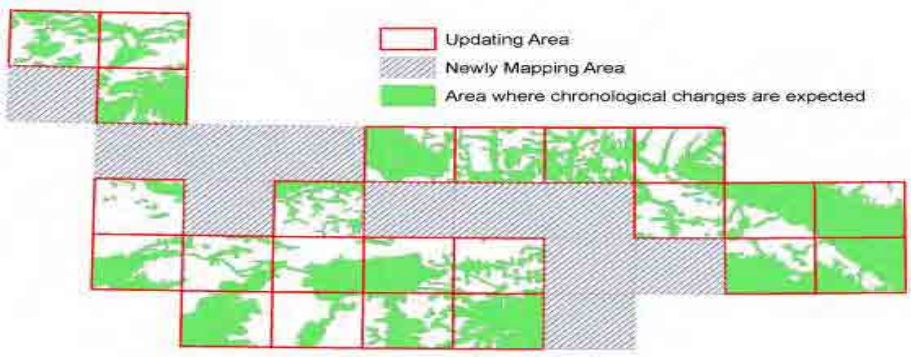


Figure 3.3.7 Areas for updating the existing maps

3.3.7. Digital plotting for newly created maps

Digital plotting for newly maps was carried out by measuring and plotting geographic features and contour lines necessary for a 1:50,000 topography through stereoscopic observation of 3D models.

In acquiring data, particular attention was paid to seamless and consistent matching to the adjacent map sheets, considering that digitization was conducted per map sheet. The following methods were taken as a means to acquire the data.

- Digitization of geographical features was performed using the superimpose function and referring to photos taken during the field surveys and existing maps, so as to prevent any plotting omission and misinterpretation.
- The intervals between intermediate contours and index contours were set at 20m and 100m respectively, and supplementary contours were inserted every 10m in areas with wider contour intervals.
- Summits, cols, and critical points, intersections of trunk roads, confluences of rivers, and change points of gradients were selected as elevation control points so as to make it easy to interpret heights and topography.

Figure 3.3.8 Summit Evolution for digital plotting

3.3.8. Field completion

Field completion was made carrying the draft maps prepared from digital plotting and compilation for the purpose of confirming ground features, geographical names and other descriptions on the map to be corrected when needed.

Figure 3.3.9 Sample of draft map with descriptions about corrections

3.3.9. Map symbolization

Map symbolization was carried out after finishing correction of the final topographic data in accordance with the specification of map symbols that had been prepared previously. This work was done with the use of software " Illustrator" which excels a function in graphical operation.

3.3.10. Creation of GIS database

After the digital map data had been structurized, the GIS data base was made. In creating this database, ArcGIS's Geodatabase format was adopted. Data were sorted out according to data properties so that each dataset formed one feature dataset. Each dataset was assigned with a code number and classified depending on the data type.

To use it as a national spatial basic data, the GIS data base was classified into traffic, geographical features, the boundary, the water system, vegetation, the building, and seven kinds of other object.

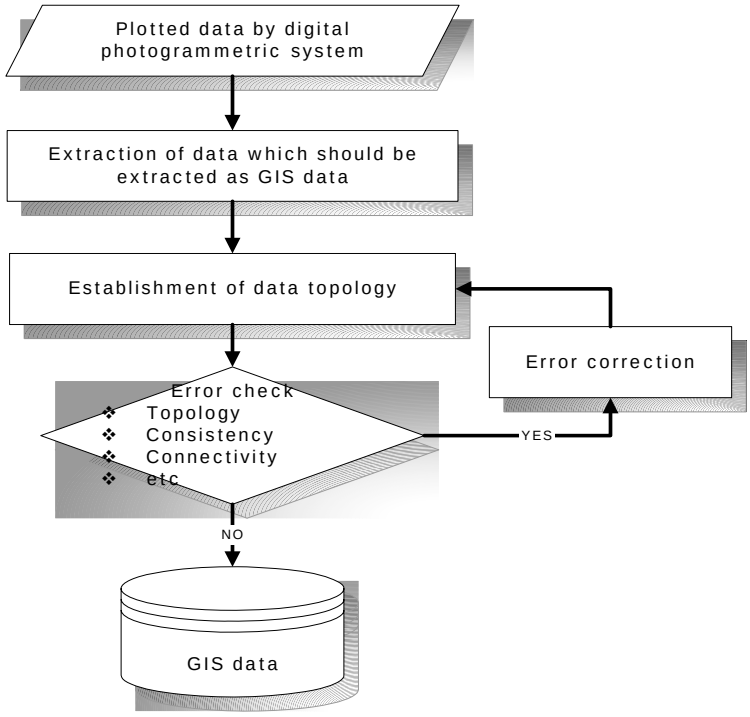


Figure 3.3.10 Work Flow of GIS data Creation

The database for a map sheet consists of 7 kinds of feature data sets as below:

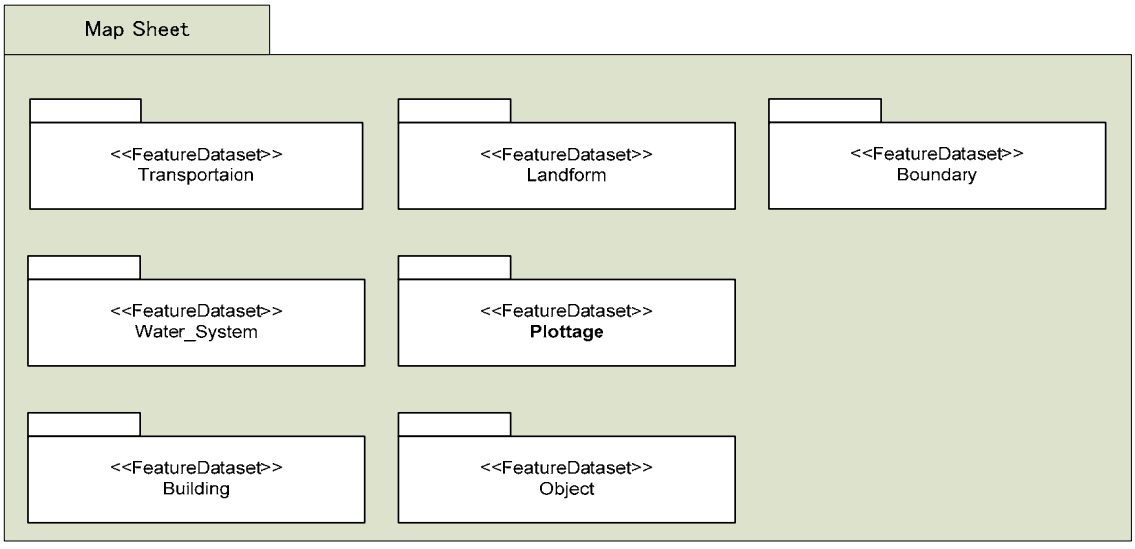


Figure 3.3.11 7 Kinds of Data set composition

3.3.11. Creation of GIS MODEL Systems

(1) Selecting and analyzing themes of model area

A Coordinating Committee comprising of six closely related counterpart governmental organizations was organized whereupon the theme with purpose, target area, and the required basic data for creating the GIS Model Systems were decided.

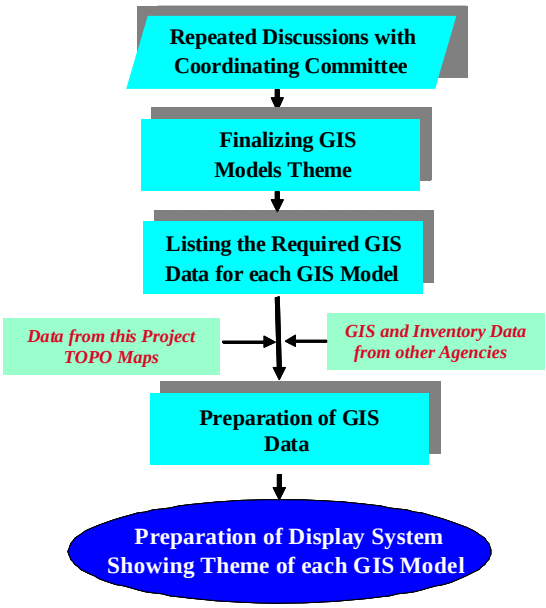


Figure 3.3.12 Participation of Coordinating Committee Members and Creation of GIS Model Systems

Table 3.3.6 GIS Model Area and Theme for each GIS Model

GIS Model	Selected Area	Main Theme
GIS Model for Urban Development	Greater Tblisi	Fundamental information to be used for urban planning
GIS Model for Forest Management and Reforestation	Zestaphoni	Forest management for conservation and reforestation
GIS Model for Facilitating Environmental Protection	Kutaisi north	Prevention from human disturbance
GIS Model for Enhancing Possibility of Developing Tourism	Borjomi / Bakuriani	Developing cultural resources for promoting tourism
GIS Model for Optimization of Agricultural Land Use	Mtskheta	Appropriate land use allocation after land privatization
GIS Model for Contribution to Information of Educational Improvement	Tbilisi	Offering useful information on educational facilities including human resources

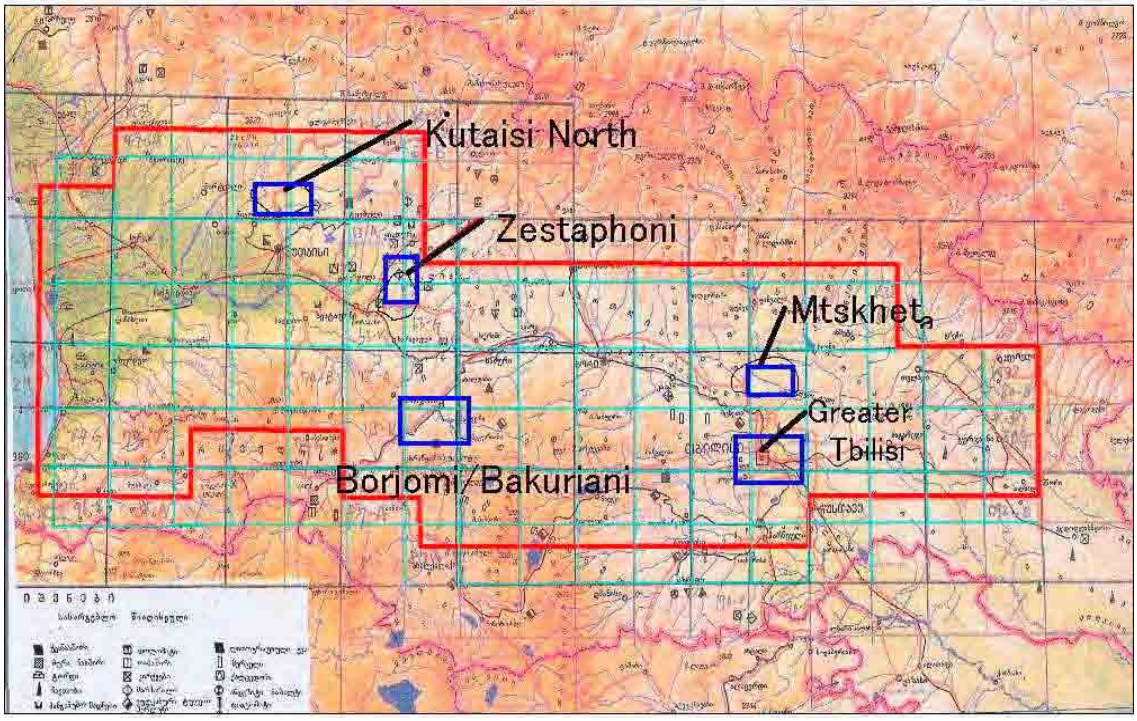


Figure 3.3.13 Location and Guide Areas of Each GIS Model

(2) Creation of GIS Model Systems

Utilizing the geographical data of the newly created Topographic map in the best way, six kinds of GIS model systems were made. Each GIS model system is equipped with three (3) sub-models. Analytical outline of each Model is as follows:

① GIS Model for Urban Development (Greater Tbilisi)

➢ Organization In-charge	Department of Urbanization and Construction, Ministry of Economy Development
➢ Purpose	To serve as guidelines for formulating master plans of different land use types such as Reallocation of settlements New development avoiding areas prone to disaster.
➢ Analysis summary	This model has evaluated the land use suitability that is conducible to restriction and guidance for future urban developments.

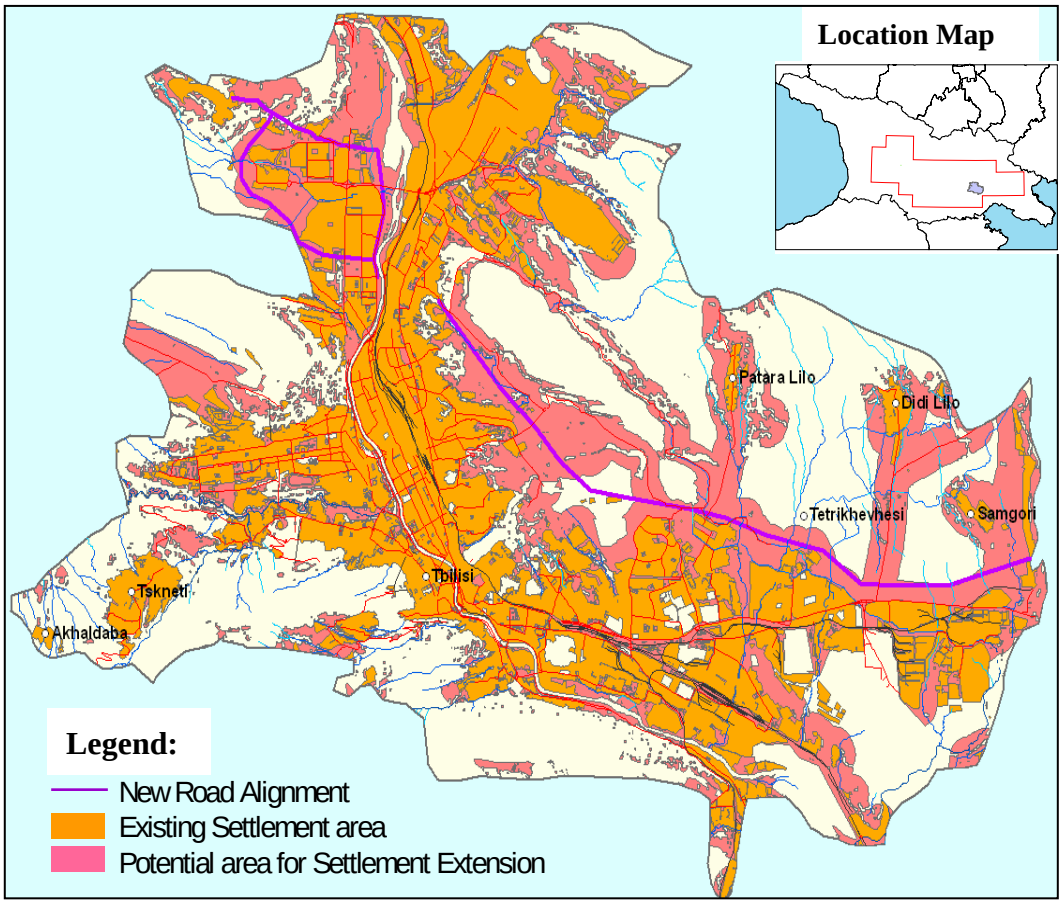


Figure 3.3.14 Potential Area for Settlement Expansion and Alignment for New Road Development

② GIS Model for Forest Management and Reforestation (Zestaphoni)

- Organization In-charge: Department of Forest Management, Ministry of Environment Protection & Natural Resources
- Purpose: To serve as guidelines for generating forest management programs with consideration given to ecology and potentiality of land use, including topographic features, for the purposes of planned and scientific forest conservation and reforestation.
- Analysis summary: It has analyzed forest vegetation types by indexing its preciousness, ease of reforestation, accessibility, danger of deforestation, etc.

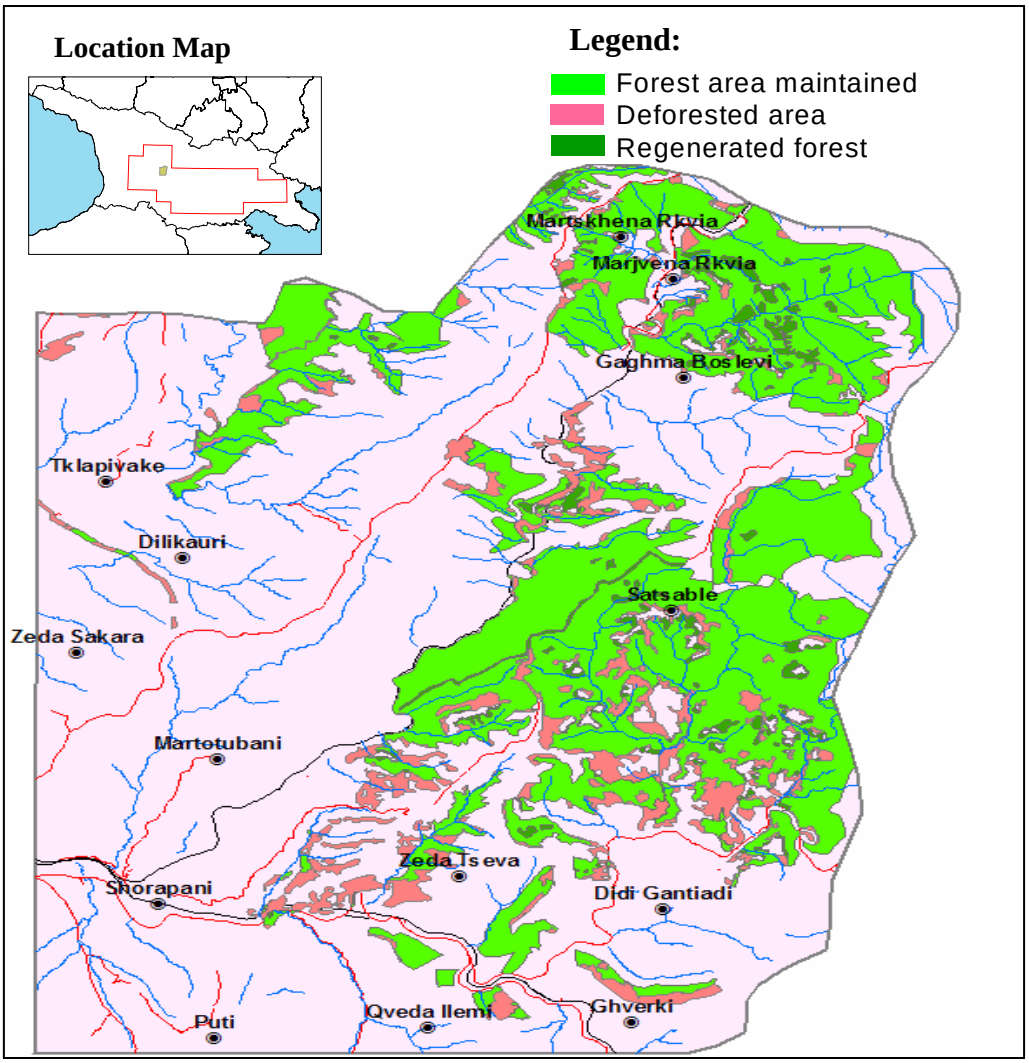


Figure 3.3.15 Forest Conservation Status between 1993 and 2005

③ GIS Model for Facilitating Environmental Protection (Kutaisi North)

- ➢ Organization In-charge — Department of Conserved Territories, Ministry of Environment Protection & Natural Resources.
- ➢ Purpose — To identify areas to be protected for conserving the ecosystem and valuable nature for drawing boundaries such as natural park zone conserved areas, etc.
- ➢ Analysis summary — It has classified the forest vegetation and then overlapping with human and natural factors to which they are susceptible.

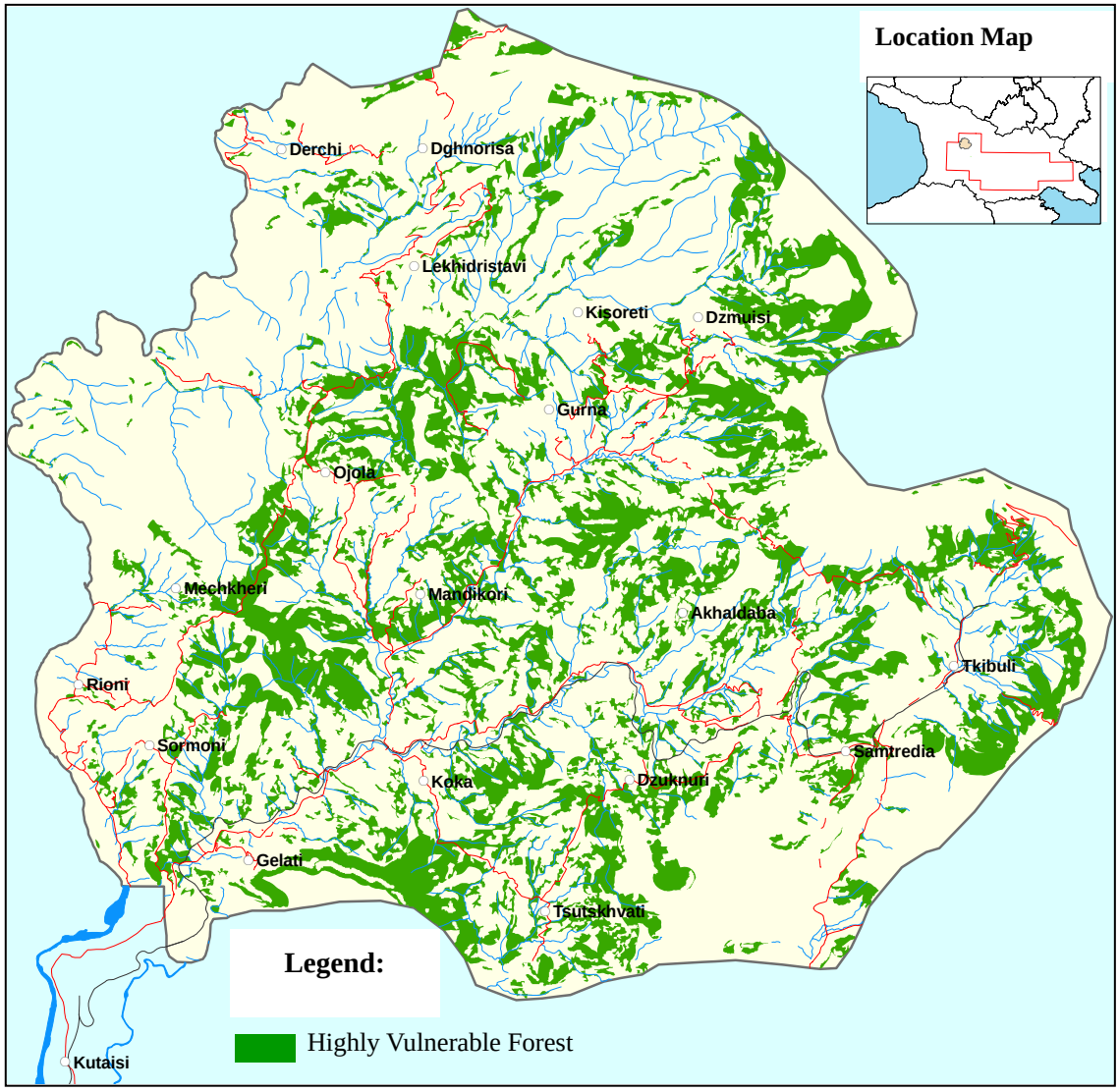


Figure 3.3.16 Highly Vulnerable Forest in the Model Area

④ GIS Model for Enhancing the Possibility of Developing Tourism(Borjomi)

- Organization In-charge: i) Department of Tourism and Resorts, Ministry of Environment Protection & Natural Resources.
  ii) Department of Cultural Heritage, Ministry of Culture, Monument Protection and Sport.
- Purpose: to serve as guidelines for development of tourism resources in order to facilitate utilization of cultural heritage, historical sites and natural treasures for tourism and utilization of natural landscapes as tourism resources.
- Analysis summary: It has assessed the use potentiality as tourism resources of relics, natural treasures and natural resources including landmarks, remarkable topographic features, and areas with attractive vegetation, by overlapping them with tourist route, accommodation, and other facilities.

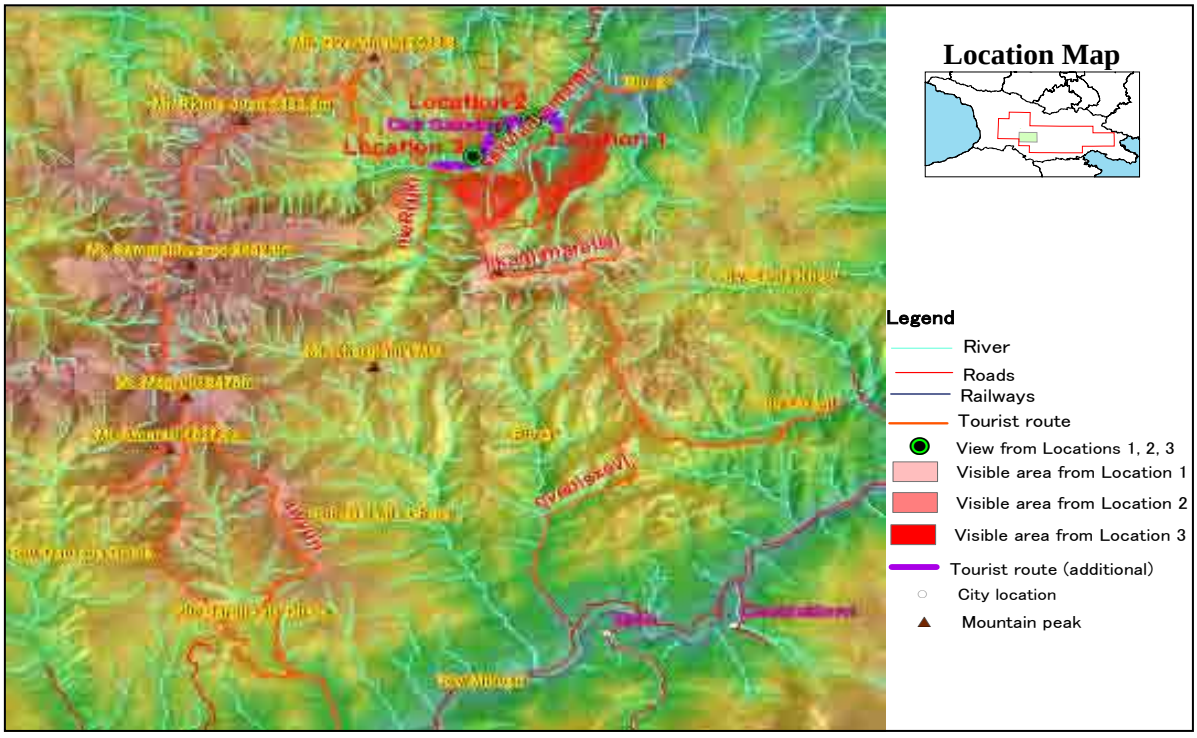


Figure 3.3.17 Possible Extension of Tourist Route

⑤ Model for Optimization of Agricultural Land Use (Mtskheta)

- ➢ Organization In-charge: Land Resources Management Service, Ministry of Environment.
- ➢ Purpose: to contribute to demarcation of preferable land use by assessing the land use potentiality for cultivated land, grass field and waste land, in order to guide proper use of privatized and as a result of land reform. Moreover, it will facilitate, such as:
  - · To find out the land to be used more extensively for agricultural yield.
  - · To chose the best crops suitable for each farm land.
  - · To avoid development of settlements in the land with high potential for agriculture.
- ➢ Analysis summary: This model has analyzed Land ownership status and terrain conditions of existing agricultural land and land suitable for potential agricultural development.

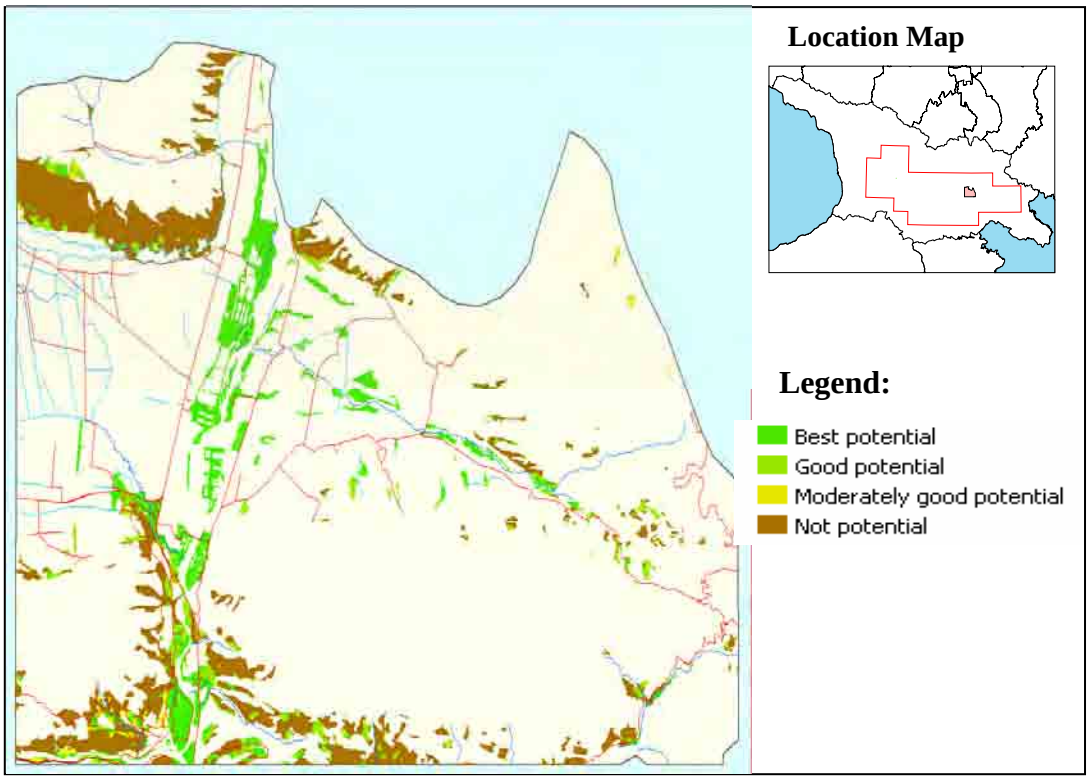


Figure 3.3.18 Potential Land for Agricultural Development

⑥ GIS Model for Contribution to Information of Educational Improvement (Tbilisi)

- Organization In-charge: Department of Policy Making and Strategy, Ministry of Education and Science.
- Purpose: to contribute to search systems for the current sufficiency of educational facilities that is conducible to improvement in regional primary educational environments.
- Analysis summary: Along with comparison of available schools and their facilities among the districts of Tblisi City, this model also includes comparative analysis for these facilities as well as accessibility between a district of Tblisi City and a district in Imereti region highlighting the current sufficiency of educational facilities.

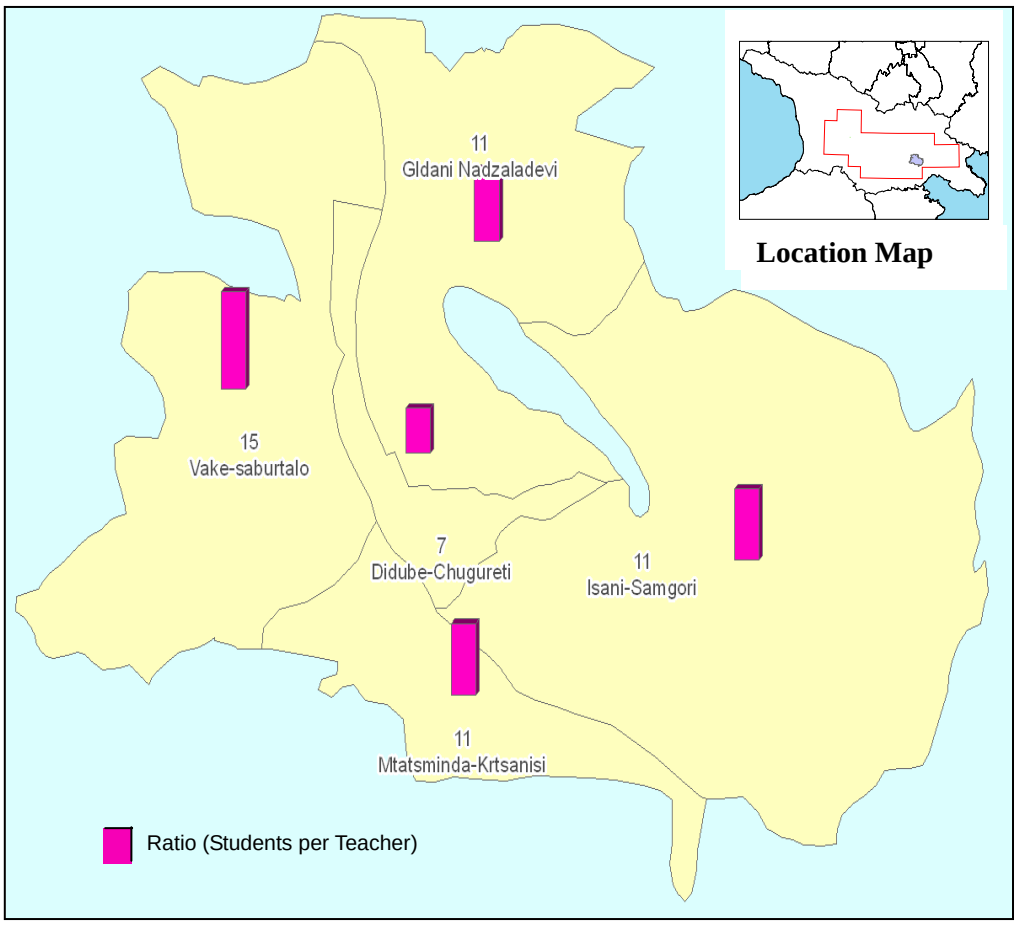


Figure 3.3.19 Ratio of Students per Teacher in each District of Tbilisi

3.3.12. Dissemination of Geographic Information and Building a Sharing System

(1) Concept of construction of spread and common system

For the widely use of new topographic data prepared under this Study, an effective and practical system for its dissemination by selling to users and building a sharing system among the governmental organizations are very important as shown in below conceptual diagram. To make these two components successful, a responsible organization, for instance, Spatial Data Center (SDC; tentative name) needs to act as a core for handling the spatial data.

The organization that has some authority regarding spatial data, for instance, SDC need to be established as a responsible organization for the spread and use activity of the geographic information whole as a nucleus with the common system of data between a spread and related organization by sales of data etc.

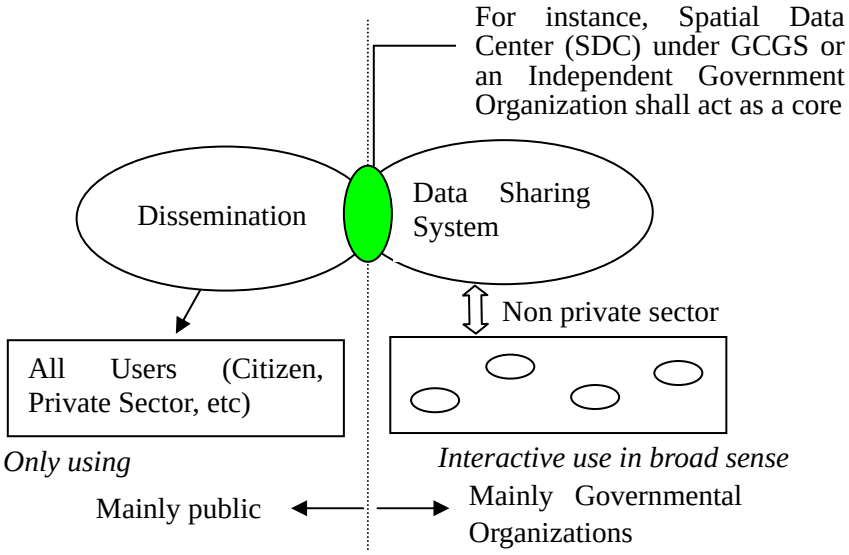


Figure 3.3.20 Concept of Dissemination and Sharing of Geographic Information

(2) Spread of Map data

To attempt a wide, positive use of the topographical map (digital map data and print chart) maintained by the main enumeration and the spread to the ordinary user, it proposes sales and the spread system. When the system of sales of the map data is established, the case by the GCGS operating directly and the case by the consignment to the third-party body including a private company are assumed.

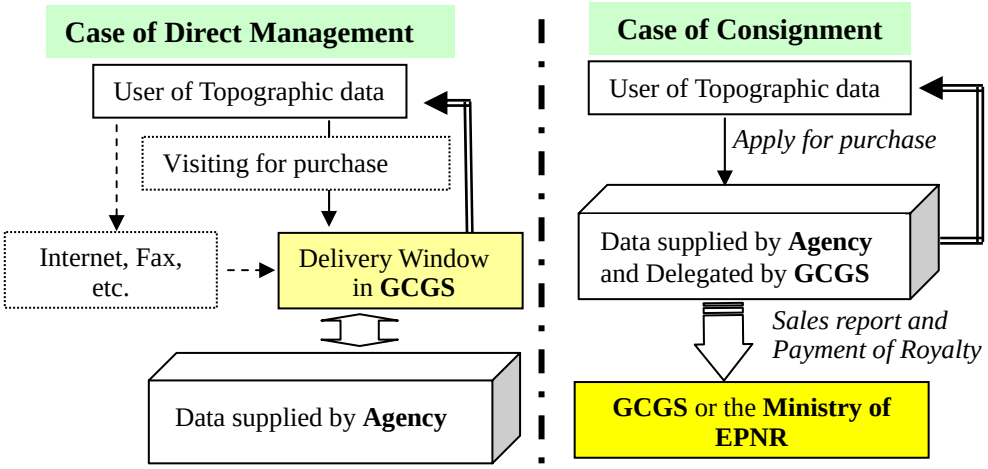


Figure 3.3.21 Cases of Dissemination of Topographic Data

① Case by Direct Management

As for GCGS, the active conduct of business of sales of the map data etc. is not admitted by the law.

However, in case the function of GCGS as an organization belonging to the ministry would be strengthen in near future and admitted to conduct selling as an enterprise, it will be useful to forecast even roughly a gain from selling the mapping data.

1) Setting the price of products

The analysis result of the questionnaire was examined about the pricing of the topographical map that was the result data of this project, and base on the consultation with counterpart, the unit price of the topographical map product was set as follows.

Table 3.3.7 Sales pricing of topographical map

	Low Unit Price	Medium Unit Price	High Unit Price
Printed map	US$ 5/ sheet	US$ 10/ sheet	US$ 20/ sheet
Digital Map	US$ 20/sheet	US$ 40/sheet	US$ 60/sheet

2) Prospect of Demands and Expected Sales Income

A) In case of Printed Map

Considering the varieties of users, three kinds of demand cases have been assumed for estimation of sales income.

Table 3.3.8 Comparison of Sales Amount in 3 Cases

User Groups	Demand Case-1 (at price US$ 5/sheet)	Demand Case-2 (at price US$ 10/sheet)	Demand Case-3 (at price US$ 20/sheet)
NGO , Foreign Donors	US$ 5 x 1,200	US$10 x 600	US$20 x 300
Private Companies	US$ 5 x 500	US$10 x 300	US$20 x 180
Citizens	US$ 5 x 5,600	US$10 x 2,800	US$20 x 1,700
Sum of amount	**US$ 36,500/year**	**US$ 37,000/year**	**US$ 43,600/year**

NGO and Foreign Donors: About 20 groups are assumed as an example.

Private companies: About 20 companies are assumed as an example.

Citizens: 1% of the Republic of Georgia people (about 5.6 million people) is assumed to be a group of users of the geographic information, and it is assumed sooner or later that about 5% is an actual data buyer.

B) In case of Digital Map

In case of Digital map, demands will be limited resulting in the single demand case. Moreover, for the user group "Citizens", use of digital maps being difficult, has not been included in the following estimate of sales (Unit price x demand):

Table 3.3.9 Comparison of Sales Amount in 3 Cases of Unit Price

User Groups	at Price US$ 20/sheet	at Medium Unit Price	at High Unit Price
NGO , Foreign Donors	US$ 20 x 300	US$ 40 x 300	US$ 60 x 300
Private Companies	US$ 20 x 200	US$ 40 x 200	US$ 60 x 200
Sum of amount	**US$ 10,000/year**	**US$ 20,000/year**	**US$ 30,000/year**

This shows the expectation of sales amount from both products printed and digital topographic maps will be altogether up to nearly US$ 73,000 in the highest case

② Case by Consignment

For the Printed Topographic maps, the case of consignment can be considered. In this case, the Agency collectively performs sale and the supply upon the order from a user. Then, the Agency will have a obligation to submit a sales report concerning numbers of distribution on a regular basis to GCGS or the ministry.

In this case, the income from sales of the printed maps will be revenue excluding

costs that comprise of a royalty and maintenance fee to GCGS. The royalty will amount 10 % of total income from the product sales, for instance and 15 to 25 % might be charged for the maintenance of data. Therefore, GCGS or the ministry will be recipient body having income of 25 –35% based on this assumption.

Thus, the following revenue as indirect sales of the printed maps will be expected roughly.

Demand Case-1

US$36,500×25%-30%=**US$ 9,125 to 10,950 /year(*Maximum Revenue)***

Demand Case-2

US$37,000×25%-30%=**US$9,250 to 11,100 /year *(Minimum Revenue)***

Demand Case-3

US$43,600×25%-30%=**US$10,900 to 13,080 /year *(Medium Revenue)***

This means that in Demand Case - 3, when the revenue will be Maximum from a kind of copyright, it will cover the wages for nearly 2.7 staff by setting US$ 400/month/peroson as a salary.

1) Data Sharing System

A sound system for sharing such data should be established among the governmental organizations to have effective control over redundant investments in spatial data creation. All data produced from this Project can be considered for sharing, however, data from other Project or possessed by other Ministry may be needed to decide case by case. Thus, some sort of deciding body will be needed and this can be named, for instance, as Council for National Spatial Data Sharing (CNSDS). This Council guide the policy and the management method of the common system as shown in the following.

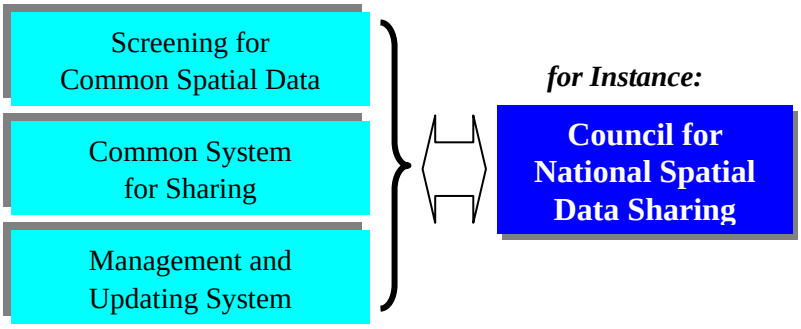


Figure 3.3.22 Tasks for Building Data Sharing System

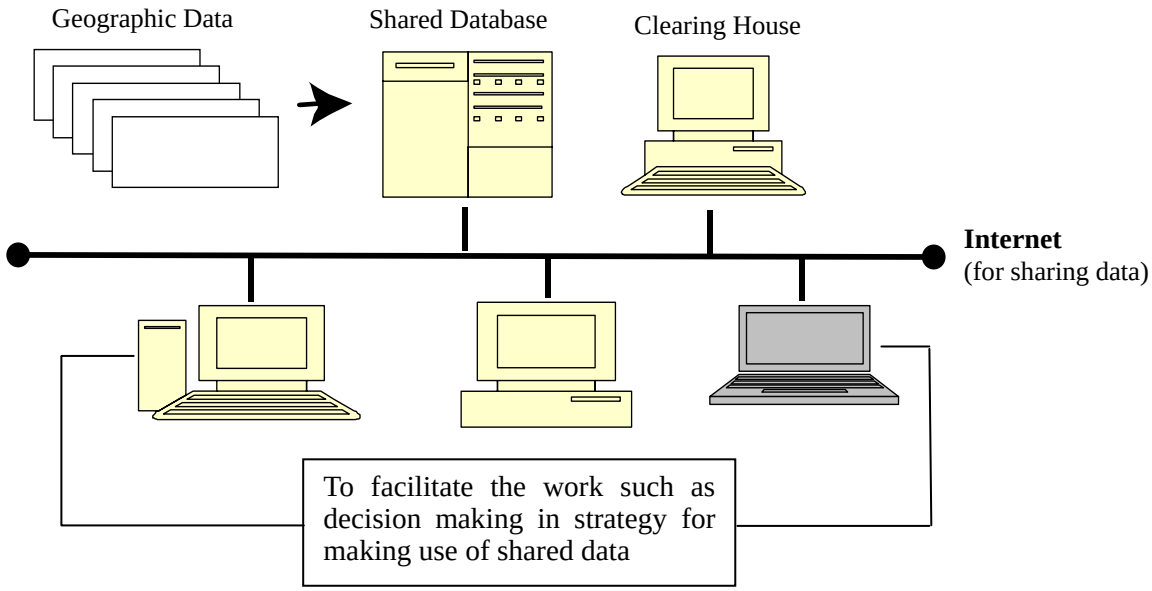


Figure 3.3.23 Concept to help figure out the System Image

The whole procedure is presented in comprehensive way by the following flow chart.

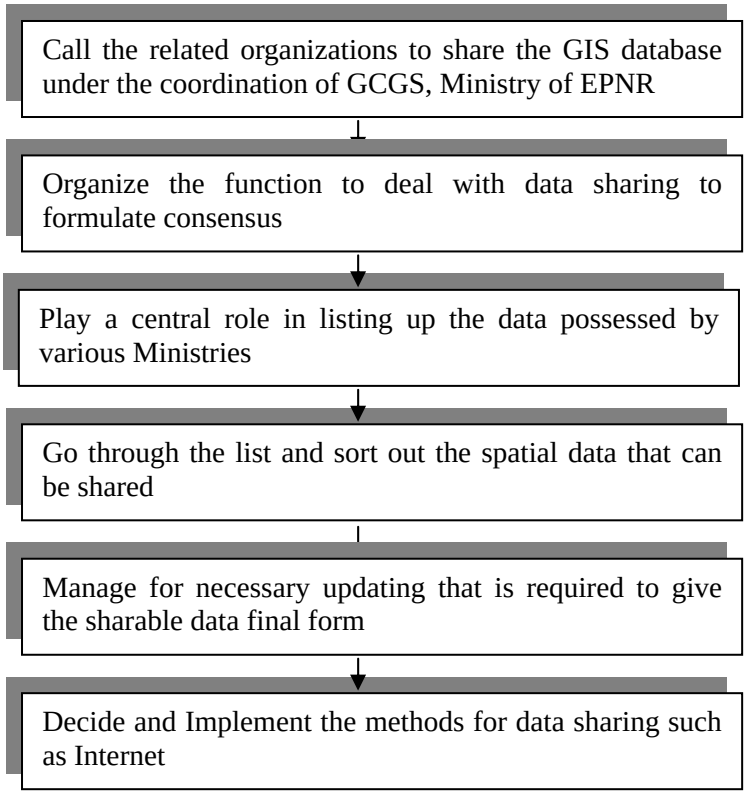


Figure 3.3.24 Ideal Steps for Realization of Data Sharing Systems

3.3.13. Workshop

With the purpose to demonstrate the understanding of the involved counterpart personnel, the Workshop was organized on 14th February 2008 prior to holding the Seminar. During this, not only the staff of GCGS and Agency got chance to present their knowledge gained during this Project period, but also the members of Task force presented their experience from this Project. All these staffs were being involved in OJTs, in other words their presentation showed the confirmation of knowledge gained during these OJTs.

The program of this Workshop was as mentioned in Table 6.4.1.

Table 3.3.10 Program of Workshop

Time	Description		Title
10:30-10:40	Opening Speech	First Deputy Minister	Vice Minister of the Ministry of Environment Protection and Natural Resources
10:40-11:00	Project Overview	Mr. Hisashi Mori	Team leader of the JICA Study Team
Coffee break (11:00 - 11:15)			
11:15-12:30	Short Introduction for Preparation of Topographic Map	Mr. Akihiro Sugita	Member of the JICA Study Team
	Creation of Digital Topographic Data	Ms. Tamar Onashvili Mr. Otar Demetrashvili	GCGS / SIA
	Vectorization	Ms. Khatuna Alasania	GCGS
	Field Verification	Mr. Irakali Gotsadze Mr. Giorgi Peradze	SIA
	Symbolization	Mr. Shalva Rukhadze Mr. Tedo Gorgodze	GCGS / SIA
12:30-12:45	Question and Discussion		
Lunch break (12:45 - 14:00)			
14:00-15:00	GIS Database Creation	Ms. Mariam Gigauri	SIA
	GIS Application 1	Ms. Nino Khidirbegishvili	GCGS
	GIS Application 2	Ms. Maka Devidze	SIA
15:00-15:10	Question and Discussion		
Coffee break (15:10 - 15:30)			
15:30-16:20	Purpose of GIS Model Systems and Expectations	Mr. Awadh Kishor Sah	Member of the JICA Study Team
	Possible use of GIS Model Forest Management and Reforestation	Mr. George Bagaturia	Department of Forest Management
	Possible use of GIS Model for Facilitating Environmental Protection	Ms. Lika Salia	Department of Protected Areas
	Possible use of GIS Model for Enhancing the Tourism Development	Mr. Kakhaber Todua	Department of Tourism and Resorts
	Possible use of GIS Model for Optimization of Agricultural Land Use	Mr. Beso Gelitashvili	Land Management Service
	Possible use of GIS Model for Developing cultural resources in need for tourism promotion	Mr. Tengiz Kodua	Department of Cultural Heritage
16:20-16:30	Question and Discussion		
16:30	Closing Speech	Mr. Irakli Lejava	Head of GCGS

3.3.14. Seminar

Beside the workshop the seminar was successfully held with more than 70 participants from various organizations. This was attempted for rising keen public awareness of the effective uses of digital topographic data under the aims of the followings;

- Explanation of this research service
- Explanation of results
- Explanation of digital technique used by main enumeration
- Introduction of uses of made digital topographical map and GIS basic data, etc.
- Construction vision of system concerning use and spread of geographic information

Therefore, main emphasis was placed on utilization of the digital data for its applications to such as GIS analysis.

5 specialist from the members of coordinating committee were involved in making their presentations for this purpose.

Table 3.3.11 Program of the Seminar

Time	Title	Speaker	Affiliation
9:30-9:40	Opening Address	Mr. Zaal Gamtsemlidze	Minister of the Ministry of Environment Protection and Natural Resources
9:40- 9:50	Acknowledgement	Mr. Mitsuhiro Kohno	First Secretary, The Embassy of Japan in Azerbaijan
9:50-10:20	Project Overview and Outputs	Mr. Hisashi Mori	Team leader of the JICA Study Team
Coffee break (10:20 - 10:40)			
Part-1: Presentation of the Results of the Study			
10:40-10:55	Preparation of Topographic Maps	Mr. Akihiro Sugita	Member of the JICA Study Team
10:55-11:10	Creation of GIS database	Mr. Akihiro Sugita	Ditto
11:10-11:30	Skills learned through the technology transfer	Ms. Maka Devidze Ms. Tamar Onashvili	GCGS / SIA
11:30-11:50	GIS Model Systems for demonstrating the effective use of digital topographic data	Mr. Awadh Kishor Sah	Member of the JICA Study Team
11:50-12:00	Question and Answer		
Lunch break (12：00 - 13:30)			
Part-2 Application and Recommendations on Dissemination of Spatial Data			
13:30-13:45	Promising uses of digital topographic data with the use of GIS Model Systems	Mr. Awadh Kishor Sah	Member of the JICA Study Team
13:45-14:00	Appraisal of effectiveness in practical use of the	Mr. Tengiz Kodua	Department of Cultural

	GIS Model System - Useful information to approach the designation of cultural tourism		Heritage, Ministry of Culture, Monument Protection and Sports
14:00-14:10	Appraisal of effectiveness in practical use of the GIS Model System - Useful information to develop natural resources for promoting tourism	Mr. Kakhaber Todua	Department. of Tourism and Resorts, Ministry of Economic Development
14:10-14:20	Appraisal of effectiveness in practical use of the GIS Model System - Possibilities to contribute to demarcation of Protected Area	Ms. Lika Salia	Department of Protected Areas, Ministry of Environment Protection and Natural Resources
14:30-14:40	Appraisal of effectiveness in practical use of the GIS Model System - Possibilities to contribute to allocating agricultural lands	Mr. Beso Gelitashvili	Land Management Service, Ministry of Environment Protection and Natural Resources
14:40-14:50	Appraisal of effectiveness in practical use of the GIS Model System - Possibilities to contribute to planning reforestation	Mr. George Bagaturia	Department of Forest Management, Ministry of Environment Protection and Natural Resources
Coffee break (14:50 - 15:10)			
15:10-15:25	Some Useful Suggestions for Dissemination of Spatial Data	Mr. Hisashi Mori	Team leader of the JICA Study Team
15:25-15:30	Vision of GCGS in Promoting Spatial Data	Mr. Irakli Lejava	Head of GCGS, Ministry of Environment Protection and Natural Resources
15:30-15:40	Question and Discussion		
15:40	Closing Remarks	Mr. Michio Kanda	Special Advisor, JICA

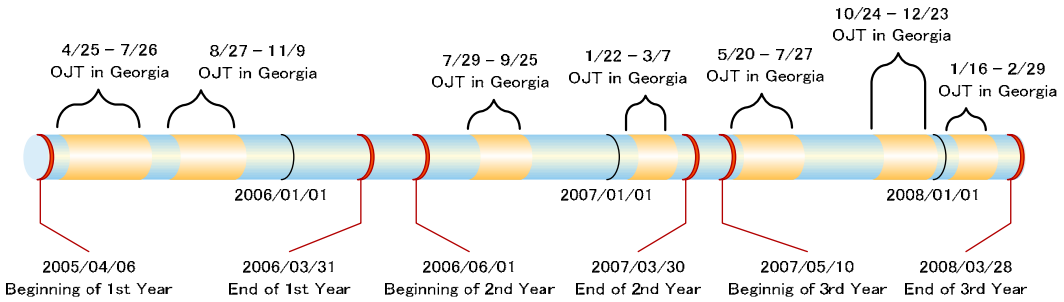
Figure 3.3.25 Presentation by the Study Team

Figure 3.3.26 Participants attended the Seminar

3.3.15. Execution of Technical Transfer

(1) Plan and execution schedule

The Study Team submitted a "Technology Transfer Detailed Plan" to the former DGC, and discussed the contents of OJT in more detail. According to the detailed plan, the technical transfer items in the form of OJT were as follows in the 1st year, the 2nd year and the 3rd year respectively.



(2) Technology transfer execution item of each annual

① OJT during the first work in Georgia (2005, 1st year)

- Ground control survey (including pricking and GPS analysis)
- Digitization of existing map
- Field verification
- Map symbolization
- Aerial triangulation
- GIS introduction

② OJT during the second work in Georgia (2006, 2nd year)

- Stereo digital mapping and compilation
- Revision of existing topographic maps
- GIS structure definition
- Creation of GIS database

③ OJT during the third work in Georgia (2007, 3rd year)

- Field completion
- Creation of GIS database
- OJT for creation and use of GIS model system

(3) Overall evaluation of technology transfer

The counterpart personnel have acquired fundamental techniques for the creation

of topographic map and GIS data processing through the OJTs.

However, they should enhance the capability in future in order to satisfy the demands for higher level of data services considering followings:

- To complete updating of remaining map sheets by themselves.
- Improving knowledge of geographic features acquisition by skillful photo interpretations so that they can produce reliable topographic map.
- Increasing knowledge of processing of photogrammetric operation and 3 dimensional plotting for new map creation.
- Reinforcing new staff having expertise in above operations and also providing trainings to the staff.

3.3.16. Equipments installed

The list of installed equipments are listed in Table 3.3.12.

Table 3.3.12 List of installed equipments

Item	Model	QTY
Scanner	HP DesignJet 4200	1
Printer	HP Color laserJet 5550n	1
Printer	HP DesignJet 4000ps	2
	HP Officejet 7313	1
Workstation (Desktop Computer)	HP xw8200	2
	HP xw4300	4
	HP dc7600	6
	HP dx2000	2
Laptop Computer	Fujitsu Siemens Celsius H230	2
	HP nx7010	2
GPS	Leica GPS System 1200	4
Digital Level	Leica Digital Level Sprinter100	4
Total Station	Leica TC805	2
SOFTWARE	Arc View 9.1 single use	6
	Arc View 3.3	1
	Arc Info 9.1	1
	Spatial Analyst	1

	3D Analyst	1
	Network Analyst	1
	ERDAS IMAGINE 8.7 Professional	1
	Virtual GIS	1
	Leica LPS DTM	1
	Leica LPS PRO600	1
	Autodesk CAD	2

Chapter 4. Issues to be considered in future

4.1. Counter part organizational Development

During the period of this Project, the counterpart has gone through organizational change two times. At present, with the inclusion of Geology staff, its name is Geology-Cartography and Geodesy Services (GCGS) and is under Ministry of Environment Protection and Natural Resources. In future, with the concept of increment in its mapping activities, more resources will be required. Thus, to develop this organization for producing and managing the map data including topographic in future, development in the following aspects will be needed, such as:

- ✓ Increment in the office infrastructure
- ✓ Addition/upgrading of Hardware and Software
- ✓ Increment in the number of staff. Also, along with In-house training, there should be provision of getting staff training at other agency or abroad wherever suitable.
- ✓ Allocation of Budgetary plan for the above points.
- ✓ Decision regarding mid/long-term geographic information maintenance plan

4.2. Strategy to maintain map of remaining area

The reform of the counterpart's organization and the resulting degradation of their skill level have inevitably trimmed down the land to be mapped in the OJT, leaving approximately 6,000 km^2 out of the originally-planned area unmapped. This area is equivalent to 10 map sheets based on the new map width. Considering that the GCGS will have to vectorize the area by themselves using the technologies transferred in the project, the following measures specifically need to be addressed in addition to the issues raised above.

A. To complete the remaining updating of the map sheets, the counterpart acquired basic skills to carry out this work by themselves.

B. However more elaborate practice will be needed in terms of improving knowledge and skills of geographic features acquisition by skillful photo interpretations so that they can produce reliable topographic maps.

C. The possibility of self-production of new maps is limited in the method by updating at this moment. It is mainly because of that their skills and knowledge

do not reach a sufficient level so as to challenge the professional process through the photogrammetric operation and 3 dimensional plotting(stereo scopic feature capturing) for new map creation.

1) Adjustment of moved technology to do update technology in map to continuous business.
2) Improvement of aerial photograph interpretation technology for accurate grasp of geographic information.
3) Not only update of the map data but also acquisition of features under three dimension environment by training of basic Photogrammetry technology.
4) Securing finance for the implementation;

Any department in the Georgian Ministry of Environment Protection and Natural Resources is financially restricted; hence it will most likely be extremely difficult to secure budgets necessary for early implementation of the above development work. Accordingly, it is a practical option to give thoughts to allocating of a part of revenues from sale of map data to the financial source of the updating work.
According to a mid-level sales forecast, the revenue from direct sales of printed maps (as mentioned in section 3.3.12.) will be approximately **US$37,000 per year.** If about 50% of the revenue is allocated to the budget for map updating for remaining sheets, approximately US$38,000 will be secured in two years, which will suffice the necessary development cost described above.

Based on the above calculation, the updating of the remaining ten map sheets will roughly require:

* 60 months/12 months → 5 years if one person is assigned.
* 30 months/12 months → 2.5 years if two persons are assigned.
* 20 months/12 months → 1.7 years if three persons are assigned.

4.3. Issues related to promotion of data use in future

4.3.1. Establishment of data sales system

Though, the provision for distribution of topographical map is shown in a basic chart in the country, up to now it is lacking in practice. Moreover, the road of the use spread of the geographic information has been shut so far. It is hoped to build up the system that the map data including the digital data maintained this time can be supplied to a wide user through the market window such as the book shops as soon as possible. The construction of the system for selling maps is hoped employing following ways with

the further verification of the economical effect, and the achievement of sales at an early chance.

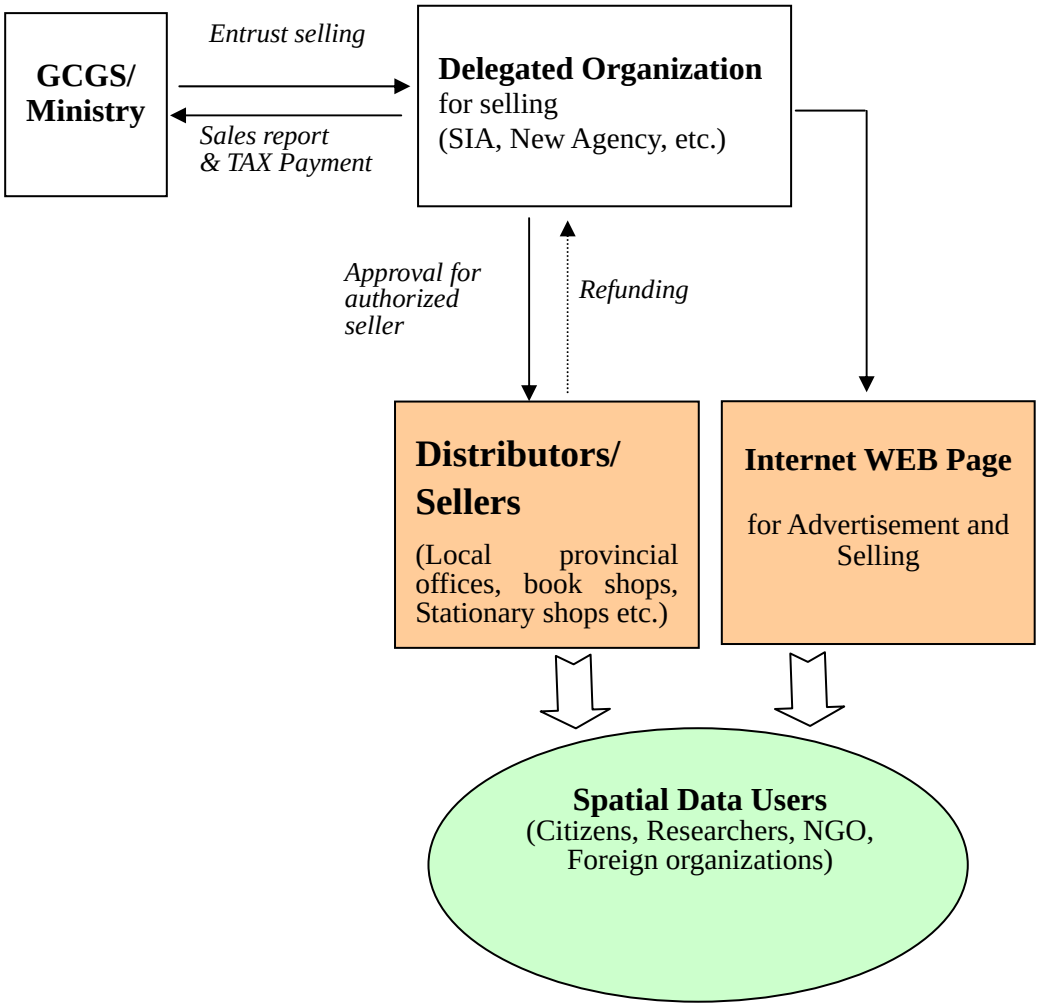


Figure 4.3.1 Diagram of a Model Showing the Scheme of Selling Mapping Data

(1) Data Sharing System

Achieving the sharing system for geographic information

For the effective use of the geographic information owned by various governmental organizations, it is preferable to achieve sound sharing among them. For this, it is necessary to set up a Council for National Spatial Data Sharing (CNSDS) (tentative name) that will make easier to maintain the rule and the standard for the following data sharing if necessary.

1) Installation of inquiry concerning data use.
2) Setting up Standard for data and its use.
3) Customizing GIS software and offer of free software.
4) Formulating plan for the addition of new data set and updating the existing ones.

4.3.2. Popularization of GIS application

(1) Basic consideration

To widen the users of GIS for variety of fields, various means of dissemination methods; such as presenting demonstration, distributing picture book, advertisement through Internet, organizing workshop, providing training, etc. need to be implemented as much as possible. This will increase demand of GIS data including that the topographic data as presented below:

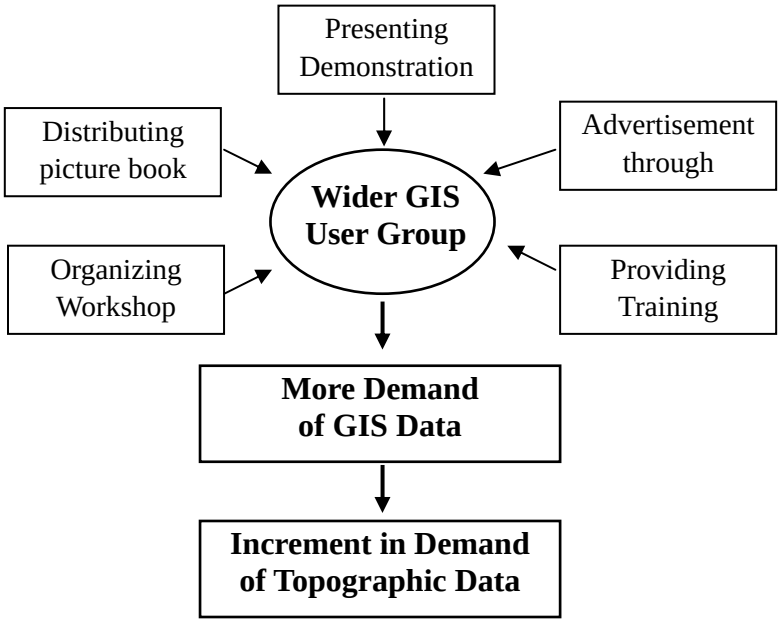


Figure 4.3.2 Dissemination methods for wider use of GIS

(2) Points to realize user- friendly extensive use of GIS

1) Some issues to be resolved

To promote the use of GIS data using the above mentioned dissemination methods, system required, especially the Software, to use the created GIS data and GIS Models need to be underlined. Regarding this, it should be noted that all the GIS data (including that for GIS Models) have been created using ArcGIS and can be opened using other GIS Software, though the display system of GIS Models comprising the customized program linked to ArcGIS can be displayed only using ArcGIS. Hopeful way to overcome this inconvenience, more simple and inexpensive alternatives should be collectively considered.

2) Encouraged to use Free software

Display and updating extent of the created GIS data using other Software will

depend upon its capability to do so. Besides ArcGIS, Software like MapInfo, Erdas Imagine are powerful to handle the updating and analysis of spatial features. In case of difficult to afford these Software, the users can try with the free Software. There are number of free Software and some are listed below:

Table 4.3.1 List of Free Software for GIS utilization

S.N.	Software Name	Main operations	WEB Home Page
1	Grass GIS	Displaying, Updating, and analysis	http://grass.itc.it/index.html
2	TNTlite	Displaying, Updating, and analysis (÷)	http://www.microimages.com/tntlite/index.htm
3	MapWindow	Displaying	http://www.mapwindow.org/mapwinapp.php
4	ArcExplorer	Displaying	http://www.esri.com/software/arcexplorer/explorer.html
5	ERDAS MapSheets Express	Displaying	http://gi.leica-geosystems.com/LGISub2x289x0.aspx
6	GeoMedia Viewer	Displaying	http://www.intergraph.com/gviewer/

(÷) - TNTlite is for small-scale projects.

3) Variation of practical use of free Software

The above mentioned Software are can be downloaded free of charge from the above WEB Home Page. Out of these Software, Grass GIS and TNTlite offer display as well as updating and analysis with the greater extents. Others Software have mainly provision for displaying the GIS data, where one or more GIS layers can be displayed at one time. Thus, the provision of displaying two or more GIS layers together will provide depth of understanding regarding how one feature is overlaying upon another; such as:

- ✧ Whether feature of a GIS layer is lying just beneath of feature of another GIS layer.
- ✧ If not, how much one is farther from another.

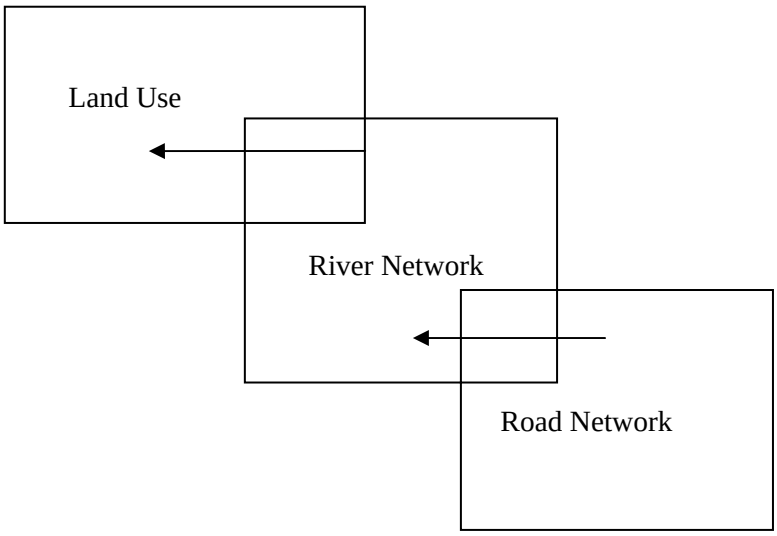


Figure 4.3.3 Examples of Thematic layers

Thus, the comparison can be made by simply overlaying several layers for extracting the useful information that can be vital in the decision making process.

4) Human resources developmen

- GCGS shall arrange training, seminar/workshop involving spatial data users time to time for the introduction of GIS application along with the use of these created six (6) models. This will not only inspire the users to include GIS more in their routine work but also interaction will increase resulting more opportunity for GCGS for collecting their feedback, which can be a good source for improving the spatial data further.

- GCGS shall supply GIS database with a brief guidance on utilization of free Software. With this, the spatial data users will have easier in using the database.