3 ASSESSMENT OF EXISTING GIS

3.1 Inventory Survey of Counterpart Organization

In order to understand the actual situation of geographic information and the GIS in the Dakar metropolitan area, an inventory survey was carried out. Firstly, the DTGC and the DUA, as the counterpart agencies in this study, were surveyed to establish the current situation of geographic information and GIS to be operated. After this, government and public organizations involved in the management and operation of geographic information were surveyed.

3.1.1 Organizational Issues

The Study aims to establish an IIMS in the DTGC and another in the DUA. This section examines issues ranging from the institutional capacity of the two agencies to future prospects in accommodating IIMS.

(1) DTGC

The DTGC is a unique survey and mapping agency in Senegal and is responsible for making topographic maps and managing them. Ten years ago, the DTGC had about 100 people on its payroll, but now it has only 30. Since 1985, no recruitment has been undertaken as a consequence of accepting IMF's recommendations. An end-result is that the average age of employees is around 40 years old and rapidly increasing.

The organization chart, as determined by the existing regulation, the ministerial decree No. 5377 of November 3, 1990, is only nominal. It is shown in Figure 3.1.1. There are two different technical divisions.

a) Division of Survey

The Division of Survey carries out land surveys and aerial surveys according to the ministerial decree. One of the major tasks is equipping Senegal with sufficient survey control points: i.e., triangulation points and level. Until now, only two series of control points were equipped along the East-West national roads.

Another task is to provide basic topographic maps of the country. The latest maps of 1:50,000 cover only the coastal zone of Senegal. Some parts of the South and inland areas are only covered by maps surveyed more than 40 years ago, and most of the country is not covered by maps of 1:50,000 but only by those of 1:200,000.

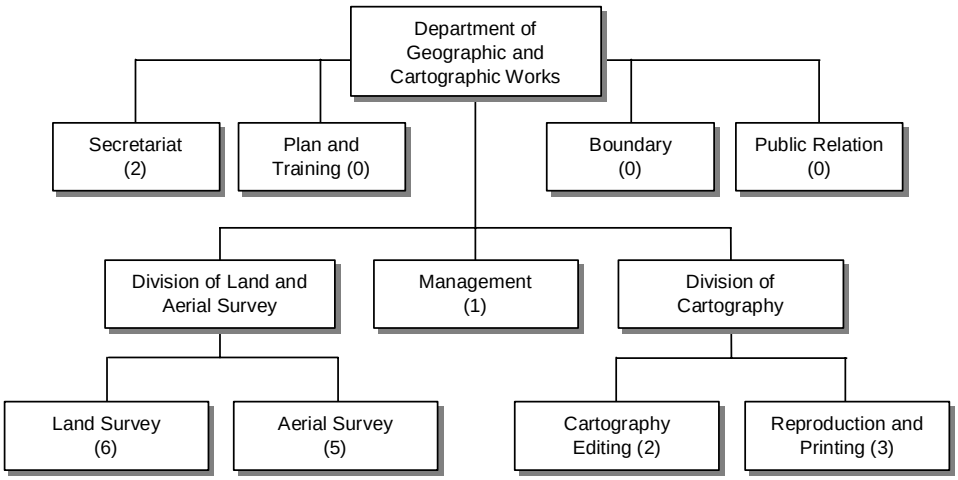
The division of Aerial Survey does not possess airplanes and cannot carry out aerial surveys independently. The division holds photo negatives taken by IGN France or other donors. Its laboratory has basic machines and materials.

b) Division of Cartography

The Division of Cartography produces maps from the surveyed data and sells them to the public. It has a conventional printing machine with two colors. Recently a new GIS was introduced to revise 1:200,000 maps of entire country as described in the following section.

Table 3.1.1 shows a list of technical personnel currently in the Department. The chart shows 31 boxes against the number of existing technical personnel of 18. Most positions are filled by doubling or tripling the functions of individuals. Out of four positions directly reporting to the director, only two are filled. The director doubles for the two vacant positions. DTGC has requested the prime minister to add personnel for almost all positions. Past experience however shows that the probability of the requests being met is small.

Figure 3.1.1 Organization Chart of DTGC



Source: DTGC

Table 3.1.1 Existing Technical Personnel of DTGC

Profession	No.
Director	1
Engineer, Cartography	1
Engineer, Photogrametry	2
Engineer, Topography	3
Senior Technician, Topography	6
Senior Technician, Phtogrametry	3
Senior Technician, Cartography	2
Total	18
Non-Technical	10
Grand Total	28

The current organization chart does not provide any specific unit for GIS (or more precisely by the current application, Digital Mapping System), although GIS in DTGC has been in operation for some time. Work involving GIS is done by three persons selected from the Division of Cartography and Division of Survey, i.e. head of Division of Land and Aerial Surveys, head of Division of Cartography, and an engineer in Division of Surveys. In addition, several persons have received GIS training at Ecological Follow-Up Center (CSE) in Dakar. Following the recent acquisition of a map data updating system utilizing satellite images donated by the French cooperation program, DTGC is planning to expand the staff for GIS to some 8 persons. If implemented, this strengthening of GIS staff would result in a department structure almost entirely devoted to GIS work, a complete departure from the official organizational structure as shown in Figure 3.1.1.

The last aerial survey was done in 1997 and no aerial survey is planned in the near future. In the meantime, work involving GIS has been increasing. Already 70 percent of work at DTGC is requested by agencies and entities outside DTGC, which can best be done utilizing GIS. DTGC is transforming itself into a GIS organization rather than a survey and map making organization as originally established. As older employees with skills in surveys and map making will retire in due course, DTGC will find it difficult to carry out survey and map making work when a new round of aerial surveys becomes necessary.

The actual work of updating maps is done on a project by project basis, i.e. when some project work requires some new geographic information in the subject project area, the base map file for the area is updated at DTGC. For example, a project sponsored by ADM requires DTGC and DUA to jointly survey certain areas, and data for the areas are being updated by DTGC.

DTGC, as its current direction goes, will probably be capable of maintaining and utilizing the proposed IIMS by its severely limited personnel in the near future. However, DTGC will find it difficult to cope with any new aerial survey and subsequent map making.

c) GIS Unit

The use of GIS at DTGC at present is limited to the following:

1 generation of geographic map data files;
2 editing of map data files; and
3 creation of output in the form of prints or digital data files.

Geographic map data files are created by analogue figure generator and a software called CADMAP by Zeiss from original aerial photos. Resultant data files are transferred to GIS with the software GeoConcept for editing and

printing as needed. Geographic figure data and associated attributes are not structured. Work is limited to simple map data management.

The primary reason for using GIS is the shortage of skilled manpower. The conventional analogue method in map making requires skills that must be acquired over many years of training. Securing of such skilled technicians has become increasingly difficult and that is one of the reasons why many countries have opted for the digital method. Senegal is no exception. The virtual ban on new recruits in government agencies for the last decade meant a severe shortage of young technicians who would carry on the skill of analogue map making. GIS therefore is viewed as a useful tool to solve the staffing problem.

d) GIS Work

Currently DTGC has a major project utilizing GIS, which is called PADDEL (“ PROJET d’APPUI a la DECENTRALISATION et au DEVELOPPMENT LOCAL”). This project started in 1997, is a part of the decentralization project sponsored by France, and is being carried out in association with many ministries and several regional agencies. An early component of the PADDEL Project was the UNICEF’s poverty eradication project and DTCG participated in the project together with DUA and other agencies. This project will continue for eight years with a budget of 1,7000,000 FF.

i) Preparation of database for Urban planning.

In this project, the digital maps of 1:5,000 and 1:10,000 were prepared to manage urban information. Since the first stage was completed, digital maps of Dakar, Pikine, Rufisque and Bargny area have been prepared in cooperation with IGN France. Two sets of PC to DTGC and four sets of PC to DUA were provided in July 2000. In the second stage, digital mapping in the suburban area will commence.

Current work by DTCG for the PADDEL project produced thematic maps based on the digital maps under their maintenance. For the UNICEF project, DTGC generated maps showing additional public facilities, inundated areas, housing types, and street lights.

ii) Updating the 1:200,000 scale map

The whole of Senegal is covered on 27 sheets of 1:200,000 topographic maps which were completed in 1981. The project will attempt to update the 1:200,000 map of the entire Senegal utilizing geographic data obtained by satellite. Counterpart training in France and installation of equipment have been completed. Two sets of GPS were introduced to

decide ground control. The actual work of map updating has commenced. Work involves the conversion of existing original maps into Geo-referenced imagery data files and the superposition of existing original maps on satellite images, thus generating updated maps and map data files. Two sheets (Dakar and Thies) have prepared in the first stage. Now another two sheets (Sokone and Kaffrine) are being updated in the second stage. This project will complete 27 sheets of 1:200,000 maps in 5 years.

e) Data and materials stored

DTGC produces 1:50,000 topographic maps as base maps, 1:200,000 topographic maps as small scale maps and some large-scale topographic maps (1:1,000 to 1:10,000) covering the Study Area. These large-scale maps were produced using photogrammetry by IGN France. Likewise, a portion of the Guédiawaye and Thiaroye areas were covered by 1:2,000 maps produced in 1995 from 1:15,000 aerial photos taken in 1992. The 1:10,000 and 1:5,000 maps were produced by digital photogrammetry from 1:20,000 aerial photos taken in 1997. Geodetic control survey and aerial triangulation were not carried out in the project, so the aerial photos were oriented from existing maps. These maps, called croquis maps, were produced digitally using a plotter and CADMAP mapping software, and the digital data is kept by DTGC. This data contains many data items, such as buildings, public facilities, roads and railroads, vegetation, water surface, topography, ground control points annotations and so on. The data set was distributed to DUA and ADM as commonly usable data.

(2) DUA

Following Law 96-07 of March 22, 1996 concerning the transfer of competence to regional, municipal, and rural authorities, and its implementation decree of No. 96-1138 of December 27, 1996, the DUA is now assigned the following:

- support to local communities for the devising and implementation of their urban planning;
- preparation of general urban guidelines for local communities;
- preparation of urban laws and regulations;
- monitoring of the implementation of laws and regulations as well as master plans; and
- technical assistance to local communities when studying urban planning issues.

The statutory organization chart of DUA as determined by the existing regulation, the ministerial decree No. 96-1138 of December 27, 1996 is shown in Figure 3.1.2. Existing technical personnel of DUA are shown in Table 3.1.2.

Figure 3.1.2 Organization Chart of DUA

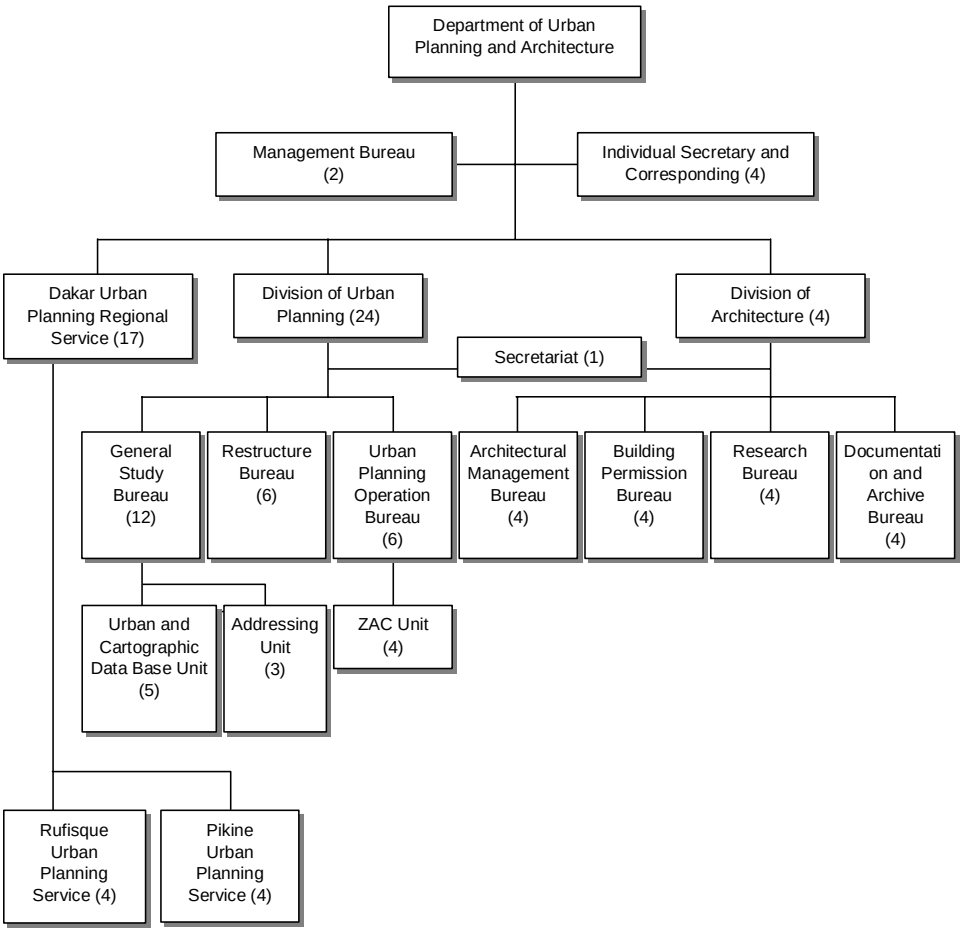


Table 3.1.2 Existing Technical Personnel of DUA

Profession	No.
Director	1
Civil Engineer	1
Architect	2
Urban Planner	10
Urban geography	1
Senior Technician, Urban Planning	2
Senior Technician, Architect	2
Sr. Technician, Transport	1
Engineer, Urban Management	1
Planner	4
Draftsman	1
Total	26
Non-technical	8
Grand Total	34

Source: DUA

As shown above, there are two different technical divisions and an independent regional service for the Dakar metropolitan area.

a) Division of Urban Planning

The Division of Urban Planning supports the urban planning in the whole country in collaboration with the urban planning regional offices which belong to the Ministry of Urban Planning and Housing but independently work for their regions following the decentralization policy of the Government.

The most important task of this division is to formulate various levels of urban planning including:

- Urban Planning Master Plan (PDU): a master plan of which the target year is usually 20 to 25 years ahead;
- Urban and Regional Development Plan (SDAU): a master plan for the smaller cities;
- District Plan (PUD): an implementation plan for the specific zones in the master plan; and
- Urban Planning Reference Plan: an action plan of the master plan targeting 5 years ahead.

The site condition in terms of urban planning is often a concern among people who want to develop or manage the land for a particular purpose. Its clarification in response to such requests is therefore related to this task.

Another important task is to review the national policy for urban planning taking into account the existing situation of urbanization, and to make necessary amendment of laws and regulations.

There are also operational bureaus and units which carry out implementation work such as the restructuring of spontaneous and non-planned settlements in the Dakar metropolitan area, and the addressing operations in several municipalities, etc. in close collaboration with other agencies and municipalities.

b) Division of Architecture

This division examines building permission applications submitted to the mayors responsible for each project site. However, applications are received and examined at the regional or prefecture urban planning offices and only the applications in the sensitive zones (the Plateau, les Almadies, etc.) are examined in the weekly joint meetings in DUA.

This division also assists public agencies in elaborating their architectural plans and terms of reference by request.

c) GIS Unit

As stated above, the DUA provides technical support to the Municipal Development Agency (ADM) for the creation of an urban database and addressing operations. The DUA acts as the project owner for local communities in urban planning studies. Thus, an Urban and Cartography Data Base Unit (CBDUC) was set up at the DUA within the framework of the PADDEL (" PROJET d'APPUI a la DECENTRALISATION et au DEVELOPPMENT LOCAL") in 1997.

The Unit aims at:

- providing the Ministry of Urban Planning and Housing (MUH) with technical data on human settlement in order to improve the urban development and extension policy in the Dakar metropolitan area, e.g. the restructuring of "Pikine Irrégulier"
- supporting other project components, such as reference urban plans, addressing, the road network maintenance, the management of municipality owned buildings, etc.

The first task of the unit was the creation of a reference base map. An area of 70 square kilometers between the municipalities of Pikine and Rufisque was covered to build a base map for use with GeoConcept, a GIS software that for technical reasons replaced the initial GIS software of PREFIX. The map production was carried out by means of photogrammetric output by the National Geographic Institute (IGN) France, and by digitalization of plans supplemented by the DTGC. Addition of the urban sketch maps (croquis), from the aerial photos of January 1997 over 60 Senegalese towns, to the base map is part of the Third Urban Project. The topologic data is available in DXF format.

At present five persons, of whom two are inexperienced, are assigned to the GIS Unit of DUA.

d) GIS works

DUA was provided with GIS together with GeoConcept software by the PADDUS project in 1997 for the first time. It was intended to be a planning tool to produce thematic maps by extracting map data from existing maps, editing the data, and printing maps.

However, its use today is limited and little effort has been made to take advantage of the analytical functions of GIS for the purposes of urban planning. One reason for this non-performance is that statistical data held by the administrative unit has not been prepared after the changes in boundaries from Quartier to Commune d'Arondissement.

DUA first utilized GIS in a project financed by GTZ for restructuring an area of spontaneous settlement called Thiaroye in 1997. Various thematic maps were produced. Since October 1998, DUA in association with ADM has been working on an urban location address identification program using GIS. The project is expected to continue till October 2003. Output from this project will be address maps.

e) Data and materials stored

DUA has digital maps of 1:5,000 and 1:10,000 in 1997 (Croquis, same as DTGC's) and the related maps are paper maps in "the PDU of Dakar 2001" in 1982, and "the White Paper 2000" in 1981. These maps contain many data items, such as existing land use, soil condition, land use plan, zoning, district plans, population of each quartier, trends of urbanization, public facilities, distribution of squatters, and others.

3.2 Inventory Survey for Other Organizations

The Study Team carried out a thorough inventory survey of data and information owned and utilized in various agencies to determine the applicability of their GIS data to the IIMS. Survey subjects were limited to those collectable during the study period in Senegal and 11 organizations, as shown in Table 3.2.1, were selected for survey, including government organizations and public utility companies. Consideration was given to the topographic map, at a scale of 1:5,000, which is likely to be used in the IIMS as the base map for spatial data.

(1) Inventory survey for existing GIS data sources

An inventory survey in the relevant agencies was carried out to find the available data source for the production of GIS data. Survey items included:

1 name or title of the existing data set;
2 year generated or compiled;
3 data form recorded (reports, resister notes, statistic table);
4 quality and condition;
5 ownership;
6 method of distribution;
7 period of maintenance; and
8 type of media (paper, electronic file, etc.).

In the case of electronic file or GIS data, the following items were added:

9 data format;
10 format for data exchange; and
11 type of storage media.

Details of the resulting data inventory are shown in Volume II: Appendices as "Inventory of Existing Data and Information".

(2) Inventory survey for existing GIS

The existing Geographic Information System (GIS) in Dakar was surveyed to investigate system condition, data condition for data exchange, and system environment. The GIS inventory survey included the following items:

1 Title of GIS;
2 Software: software name and version;
3 Purpose of use;
4 Frequency of use;
5 Database contents and updated dates;
6 Data structure and specification of GIS data format;

7 Number and composition of GIS staff;
8 Maintenance conditions of software and hardware;
9 Maintenance budget;
10 System configuration of GIS, etc.

Table 3.2.1 Summary of Inventory of Existing Data and Information

Spatial Data Infrastructure	Organizations
1 Public facilities	DTGC-MET, DUA-MUH, ADM, DID-MEFP, Municipalities
2 Administrative boundaries	DAT-MEFP, DUA-MUH, DPS-MEFP, ADM
3 Utilities (electricity, water supply, sewage etc.)	SELELEC, SDE, ONAS, ADM
4 Road and railroad	DTGC-MET, DUA-MUH, DTP-MET
5 Vegetation	DTGC-MET, CSE
6 Water surface	DTGC-MET, DAT-MEFP
7 Topography	DTGC-MET
GIS Data	Organizations
1 Existing land use	DUA-MUH, CSE
2 Soil condition	DUA-MUH, DAT-MEFP, SGPRE-MH, DSA-MA, DGR-MH, IEF-MEPN, DEFCCS-MEPN, DEEC-MEPN, CSE
3 Land use plans	DUA-MUH, DAT-MEFP
4 Zoning plans	DUA-MUH
5 District plans	DUA-MUH
6 Population of each commune d'arrondissement	DUA-MUH, DAT-MEFP, DPS-MEFP, DAT-MEFP
7 Trends of urbanization	DUA-MUH
8 Disaster records	DUA-MUH, ADM, SGPR-MH, IEF-MEPN, DEFCCS-MEPN, DEEC-MEPN
9 Public facilities	DSA-MA ,CSE, DUA-MUH, DTP-MET, ADM, Municipalities
10 Distribution of illegal settlements	DUA-MUH, ADM
11 Others	DSS-MS, DE-MTE, DCES-MEN, others

Source: JICA Study Team

3.2.1 Results of Inventory Survey for Existing GIS Data Sources

Usable data source and GIS data in this regard were surveyed for the purpose of assessing their possible use in the IIMS. The following summarizes the results

agency by agency. A detailed GIS inventory in Dakar is shown in Volume II: Appendixes as "Inventory of Existing GIS".

(1) DAT-MEFP (Department of Land Development; Ministry of Economy, Finance and Planning)

DAT manages administrative boundaries. Boundaries of Commune d'arrondissement were found on maps in the report of "Land management Report" (Natural condition and soil condition), "Synthese du Rapport d'Avant-Project du Schema Regional d'Amenagement du Territoire de Dakar" in 1994. DAT is using their GIS: PAMAP and MapINFO for the purpose of urban planning and management.

Although the study team collected the administrative boundary data of MapInfo, the polygon data structure and the map projection was incomplete. The demographic data component of the data was insufficient within the database. It is expected to include results of the next census survey in 2000.

(2) DPS-MEFP (Department of Forecast and Statistics; Ministry of Economy, Finance and Planning)

DPS manages the national census. A tract map of the census in 1988 was produced, which contains census tract boundaries and population data such as number of houses, households and population.

However it was very difficult to find the district unit of the last census survey in 1988.

(3) DID-MEFP (Department of Tax and Domain, Ministry of Economy, Finance and Planning)

DID prepares cadastre maps digitally using MicroStation software from 1994. Thirteen maps in the local area of Dakar Plateau have been prepared. The parcel map includes parcels, buildings, public facilities, and roads.

GIS data does not cover the study area.

(4) DTT-MET (Department of Land Transport, Ministry of Equipment and Transport)

DTT manages the car-rapides service using route map.

The service map was copied from the figure in the report. The Study team was not able to obtain a route map.

(5) DTP-MET (Department of Public Works; Ministry of Equipment and Transport)

DTP manages roads in the whole of Senegal. They produced the GIS data of road inventory for digital management, updated in 1999. The data contains the road

network and its attributes including status of road, road name, condition of pavement and distance.

The Study team collected AutoCAD data and the attribution data of road conditions stored in the tabular database of road management. AutoCAD data does not use map coordinates but local coordinates. The attribute of road is only the code name as text mapped in the data.

(6) SOTRAC-MET (Cap-Vert Mass Transit Company; Ministry of Equipment and Transport)

SOTRAC produces the bus route maps to manage public transport services. Although the Study team could not obtain the 1984 map publication, the present bus route has been significantly reduced due to financial issues within bus services.

(7) SGPRE-MH (Water Resource Management and Planning Company; Ministry of Hydraulic Engineering)

SGPRE uses its GIS for water resource management and reference for planning. They possess soil condition and disaster record data, which are the result of a GIS inventory for water resources studies. However, it was difficult for the Study team to use the GIS data directly.

(8) DGR-MH (Department of Rural Engineering; Ministry of Hydraulic Engineering)

DGR produces the agricultural map of 1:50,000, whose classification was not confirmed as map, such as agricultural land, niaye (swamp area) and protected area.

(9) DSA-MA (Department of Agricultural Statistics; Ministry of Agriculture)

DSA manages statistical data for crop products in the region. They produced the agriculture map of 1:50,000, which cannot be confirmed as map.

(10) IEF-MEPN (Water and Forest Inspection; Ministry of Environment and Natural Protection)

IEF produces forest map of 1:50,000, whose classification was not confirmed as map, such as forest, niaye (swamp area) and protected area.

(11) DEFCCS-MEPN (Department of Water, Forest, Hunting and Soil Conservation; Ministry of Environment and Natural Protection)

DEFCCS uses its GIS for the management of forestry and natural resources. They also produce a vegetation map digitally. The data contains information on vegetation and soil condition.

However, it was difficult to compile GIS data as project data because of the precise map scale of less than 500,000 for the reconnaissance survey. The map projection of the data is local, it does not correspond to the topographic maps in DTGC.

(12) DEEC-MEPN (Department of Environment and Historical Building; Ministry of Environment and Natural Protection)

DEEC produces an environmental map of 1:50,000, but the detailed information could not be confirmed.

(13) ADM (Municipal Development Agency)

ADM is using AutoCAD, MapINFO and GeoConcept software. They use their GIS for the purpose of regional planning and management. The base map of the digital map in Rufisque was supplied by DTGC. The data contains public facilities, such as utility network, roads and railroads, inundation area and land use plan. ADM produces GIS data individually with the survey activities.

There are different data formats in the study area. The map coordinate data does not coincide with the map in DTGC. There is a data issue in not being able to compile all data into one base map. The population data is surveyed by ADM.

(14) CSE (Ecological Monitoring Center)

CSE is an independent organization established by the USAID assistance. CSE provides various ecological research and assistance to the governmental and non-governmental organizations including international NGOs by using its GIS and selling satellite images captured. CSE also organizes training and seminars of GIS and remote sensing for the interest of concerned personnel.

CSE produced 1:50,000 land cover maps, whose data is digitally processed satellite images by Erdas and ArcINFO software.

The Study team could not use the time series data of the land cover from Satellite imagery in the study area.

(15) Dakar Urban Community (CUD)

CUD produced a distribution map of public facilities, which contain primary schools, health centers, public markets. All the map is paper based.

(16) Guediawaye Municipality

Guediawaye Municipality has produced an urban audit report with GIS data using MapInfo. The data contains existing land use, land use plan, zoning, district plans, disaster records, public facilities, spontaneous settlements.

GIS data is kept by the local consultant.

(17) Senegal Electricity Company (SENELEC)

SENELEC produced 9 sheets of map at 1:5,000 to manage electric power lines. These maps were converted to digital data using Auto CAD software. However the Study team was not able to locate them. The data contains high voltage and middle voltage power lines and facilities.

(18) Senegal Water Distribution Company (SDE)

SDE produces map digitally to manage water supply network using MicroStation software. The data contains information on water supply line, community tap locations, community fountains, consumption meter and customer. However, it is very difficult for the study team to utilize this data.

(19) Senegal National Sewage Company (ONAS)

ONAS produced maps at scale 1:5,000 to manage urban sewer and sewerage facilities. These maps are not in digital data form.

3.2.2 Current Situation of the Data Sources

The current situation of the surveyed data sources was identified as follows:

(1) Majority is Paper Map

An overwhelming majority uses blue prints for maps and drawings of various plans. Preservation of polyester base originals is generally unsatisfactory. Due to the high cost of paper as consumables in Dakar, there seems to be a tendency toward keeping thematic maps or drawings in electronic files using GIS software.

(2) Dispersion of Data Information

The existence of the conventional administrative boundary and the new one introduced by the decentralization has caused dispersion of information and data, and it is difficult to collect accurately updated information. It takes an inordinate length of time to assemble authorized correct information.

For example, a system of new administrative boundaries was introduced following the decentralization policy adopted by the Senegalese government. However, there has been confusion concerning boundaries as the delineation of the boundary is slightly different in each agency. Also, there is presently a border definition problem along Rufisque and Bargny. DAT cannot determine this boundary. The population statistics in DAT is absent and DAT awaits results of the next census survey in 2000.

Some agencies dealing with statistics do not manage data collection by maps, requiring linkage to maps and unified data management. ADM and CETUDE surveyed the population data and the related census data individually.

(3) Confusion in Map Coordinates

Data management has been indirectly affected by the confusion in the mapping coordinates. Each agency uses different coordinates. There is no established standard in Senegal.

GIS data should be managed via the proper set up of map projection in each client GIS software.

In addition, it is difficult to accurately locate buildings as address management has not been properly introduced in the Dakar metropolitan area, although ADM has started organizing an address system in collaboration with DUA and DTGC.

An occasional lack of accuracy management on maps, such as indicating control points, causes difficulty in the direct application of map data to GIS.

(4) Updating of Map Information

The extremely tight budget of each agency makes it difficult to update information on maps under their possession. The still prevalent use of blue prints and other paper media makes the task of updating even more difficult.

(5) Maps for Urban Planning

At present, data management for urban planning is done by paper media except for a few existing digitized GIS maps. Much data is waiting to be digitized for GIS application while some thematic maps for urban planning are being prepared using GIS. There is a shortage of spatial data in the existing map and data sources for urban planning at the scale of 1:5,000 to 1:50,000, which is most useful for urban planning in Dakar.

(6) Problem of Existing Electronic Files and GIS Data Compatibility

Existing map files created by CAD software may cause the structural error of figures when processed as GIS data. AutoCAD is not the mapping software for GIS data, so the data structure must be considered in treating GIS when users digitize a map. The understanding of data structure is called “Topology” in general, and is a very important factor in building GIS data. If ARCs cross, each ARC must be broken at the intersected point. The duplicated arc along the boundary of polygon is avoided. The attributes in figure data are managed as a different layer. Electronic files created by AutoCAD, replacing ordinary paper maps, cannot be directly placed under file structure processing. The existing AutoCAD files might

need pre-processing and file restructuring. Although the properties of the AutoCAD data file are confirmed as data, these attributes cannot be exported as GIS data.

3.3 Results of Inventory Survey for Existing GIS

3.3.1 Survey Results

Results of the inventory survey for existing GIS are shown in Table 3.3.1, which summarizes usage, availability, and the data exchange method. A detailed GIS inventory in Dakar is shown in Volume II: Appendices as "Inventory of Existing GIS".

Table 3.3.1 Summary of Existing GIS in Dakar

Organization	GIS Software	Purpose of GIS Use	Data Exchange Format of GIS
DTGC-MET	Geo Concept 3.6	Digital mapping	DXF
DUA-MUH	Geo Concept 3.6	Urban planning	DXF
DAT-MEFP	PAMAP 4.2, Map Info 4.5	Regional Planning	DXF, other GIS format
DID-MEFP	Micro Station V5	Administration	DXF
SDE	Micro Station 95	Facility management for water supply	DXF
DTP-MET	VISSAGE 1.21	Facility management for roads	DXF
SGPRE-MH	PC Arc Info, Arc View 3	Water resources management	DXF, other GIS format
ADM	Geo Concept 3.6, Auto CAD, Map Info 5.0	Urban planning	DXF, other GIS format
DEFCCS-MEPN	PC Arc Info, Arc View	Forestry management	DXF, Other GIS format
CSE	PC Arc Info, Arc View 3, Map Info, Erdas Imagine8.0, CHIPS	Ecological resources and environmental information management	DXF, Raster format, Other GIS format

Source: JICA Study Team

These are the current GIS users who use widely known software such as GeoConcept, ArcINFO, MapINFO or AutoCAD within each organization. The study team should consider familiar software to avoid repeating the learning operation. The study team classified GIS use as follows.

(1) Purpose of Use

a) Digital Mapping

DTGC uses the GIS for the digital map preparation and revision. Details of DTGC work is described in previous section.

b) Urban Planning and Regional Planning

DUA, ADM and DAT use the GIS for the purpose of urban or regional planning and management. The base digital map in DUA is supplied by DTGC and close collaboration among them is observed.

c) Natural Resource Management

DEFCCS uses the GIS for the management of forestry and natural resources by comparing progressive satellite images.

SGPRE uses the GIS for the water resource management and reference for the planning.

There is substantial small scale GIS data at a scale less than 1:200,000.

d) Administrative Management

A very limited attempt to use GIS is being undertaken by the Department of Tax and Domain under the Ministry of Economy. DID is trying to manage the property in the Plateau district efficiently and securely by using GIS.

However, due to the malfunction of the system, it is still under preparation and of no practical use for the moment.

e) Facility Management

Some agencies and utility companies use the GIS for their facility management.

DTP-MET manages the major roads of the entire county by using its GIS.

SDE uses its advanced GIS for their water distribution network management. The system includes all the detailed data including pipe material, size, and each subscriber’s connection.

(2) GIS Data Format

The Study team can view existing GIS data in the respective agencies. Electronic files of AutoCAD and GIS data are available. DXF files and text files are generally used as the low level format for importing and exporting. However, it is difficult for this data to be imported directly as GIS data because of the incomplete data

structure of GIS. Some GIS software provides wide adaptability for data importing and exporting. MIF-file of MapINFO and SHAPE file of ArcView are most useful in exchanging GIS software.

(3) Frequency of GIS Use

The systems are generally used frequently within each agency. Among the agencies interviewed, SDE and CSE are the heaviest users of GIS in Dakar in terms of frequency.

3.3.2 Operational Assessment

In this section the utilization and environment of existing GIS systems in Dakar are evaluated as follows:

(1) Utilization of GIS

Many agencies are in a phase limited to the individual preparation of thematic maps. In this phase it is not easy to carry out spatial data analysis because there is not much spatial data available in a separate database by itself.

It is proposed that the spatial data infrastructure should be shared commonly among different agencies. The lack of funds limits data preparation. The production of GIS data is limited in the project activities. However as a result, the agencies tend to share valuable digital data with each other. This is a suitable situation for the usage of GIS.

(2) GIS Data Management

GIS data management is primarily constrained by the respective software formats in each agency. There are many cases in which no record is kept on the content of databases, data volume of figures, and so on. It will be necessary to prepare a document on data structure and contents as the meta data when building the IIMS.

(3) Issues on GIS Data Production

There is substantial confusion about map coordinates among agencies in Senegal. Also, there is a problem of dispersion of accurate data sources and information. The document file as a meta data is needed to manage GIS data.

The figure data processing method depends on the software owned by the agency. Some data sets are weak in topology and cannot be directly used as GIS data. When electronic files of AutoCAD are simply produced by the scanning of paper maps without due attention to coordinates, they cannot be directly used as GIS data. When using such electronic files, it is necessary to make a frame work for the data

management and quality control in order to accumulate digital data suitable for GIS.

(4) Data Exchange

DXF files and text files are commonly used for data exchange to import and export figures and the associated attributes. But there is no rule for data exchange on the specification of data information. Diskette is commonly used for data exchange and there is certain limitation about the data size. Some agencies use the mediums of ZIP and CD-ROM for data exchange.

(5) System Environment

As for the environment of the machine room for GIS, there are many agencies who set aside an air-conditioned computer room to prevent dust entering from the outside. Some agencies suffer from a dust problem when using plotters.

Old and new operating systems of MS-DOS, Windows 3.1, Windows 95 and 98 and Windows NT are being used. Users of MS-DOS based software under Windows 95 encounter a limitation because of the difference in operating systems.

Many software applications cannot attain the intended performance in Dakar due to the hardware limitation of memory shortage. Many machines still have the standard size memory and additional RAM memory is needed to attain good performance.

ZIP and CD-ROM are used to back up the data. Tape drive lacks reliability. There are some users utilizing LAPLINK via the cable of RC232C in data transfer.

Most personal computers in use in Dakar are provided with a networking board, but most are not connected to any network. There are not many users who use a database server with a relational database management system. The environment should be changed from the present situation of stand-alone to networking.

There is an information network among Senegalese government agencies, but this environment is mainly used only for e-mail by modem with dial up connection method. The Local Area Network (LAN) is not common in many governmental agencies. It is necessary to make a plan to install a special network line for Wide Area Network (WAN), to establish the information technology infrastructure to be featured.

(6) Maintenance

General version upgrading of software has been done by agencies who managed to secure the budget, but most agencies do not upgrade due to the unfavorable financial situation. Hardware maintenance is also inadequate. In most cases an improvement is only undertaken when machine trouble occurs.

Because of the expensive consumables of ink and paper, stock is insufficient. The budget is not sufficient to adequately maintain the GIS. Few agencies keep a log about system troubles. At DTGC the Study Team demonstrated how to keep records of trouble shooting.

3.4 Selection of Usable Data for the IIMS

A list of the usable digital data (as opposed to merely available) was prepared for study team according to the survey result of data sources and existing GIS in Dakar. Data list is shown in Table 3.4.1. Several fields of data were selected for specific agencies.

Table 3.4.1 Collected Usable Data

Organization	Data contents	Data format
DTGC-MET	Digital map of 1:50,000 and 1:10,000 so called Croquis	Geo Concept
DUA-MUH	Digital map of 1:50,000 and 1:10,000 so called Croquis	Geo Concept
ADM	Regional planning supporting map in Dakar area - Advantages and site constraints - Drainage - Water supply network - Land use - Solid waste management - Extension tendency - Major penetrating axis in Dakar - Boundaries of cities - Boundaries of communes d'arrondissement - Power supply network - Sewage network - Public facilities - Markets - Roads	AutoCAD release 14
	Regional planning supporting map in Pikine area	Auto CAD release 14
	Regional planning supporting map in Guediawaye area	Map Info
	Regional planning supporting map in Rufisque area	Geo Concept 3.6
DTP-MET	Road management data	Auto CAD release 14

Source: JICA Study Team

All the layers of AutoCAD data are divided into several data items to be compiled to data sources for thematic maps. GIS data of GeoConcept and MapInfo are used to compile to thematic maps.

In order to compile GIS data in IIMS, each category of GIS data was prepared for the arrangement of data sources, while taking into consideration the application of urban planning in the project. Selected fields are:

- administrative boundary to treat statistic data
- statistics of tabulation data in the collective unit,
- present land use,
- planned land use,
- public facilities,
- public services,
- infrastructure (roads, utilities), and
- natural and socio-economic conditions (topography, agriculture, forestry, water resources, disaster, and environment).

This data was collected by the Study Team to be incorporated in the initial IIMS. Selected Geographic features and their Data source and preparation method is shown in Table 3.4.2. Table 3.4.3 indicates the utilization of data source, the approached methods for GIS data and how it will be integrated into the initial IIMS. There are still many paper maps even though there are some inaccurate limitations according to the data structure and the attribute of digital data. In fact much of the available digital data will require substantial work to make it fit in to the IIMS. Simply limiting the data to be included in the initial system to only that which is readily transferable would not make the system useful.

Available spatial information varies from those with a large scale of 1:5,000 used in infrastructure planning and management, those with a medium scale of 1:50,000 such as topographic maps, to those with a small scale of 1:200,000 used in regional planning. There are also some enclosed in reports and not available in the original form. All this makes it difficult to handle their GIS data in the same dimension.

Table 3.4.2 Summary of Inventory of Existing Data and Information[1]

Layer of geographical feature	Data Source	Import from Digital file	Conversion to Digital form	Field Survey By Study team
Built up area (Settlement)	DTGC,DUA	Yes		Yes
Built up area (Industry)	DTGC,DUA	Yes		Yes
Administration in 1999	DAT		Yes	
Administration in 1981	DAT		Yes	Yes
Electricity	DTGC,SENELEC	Yes	Yes	
Water supply	ADM	Yes		
Sewerage	ONAS,ADM	Yes	Yes	
Drainage	ADM,DTGC	Yes		Yes
Road	DTGC,DTP	Yes		Yes
Railway	DTGC	Yes		
Bus Route				Yes
Garbage Route	ADM	Yes		Yes
Vegetation	DTGC		Yes	Yes
Water surface	ADM		Yes	
Topography (10m DTM)				Yes
Triangulation Point	DTGC		Yes	Yes
Bench Mark	DTGC		Yes	Yes
Public Facilities	DUA,ADM		Yes	Yes
Orthphoto				Yes
Present land use map 1999				Yes
Urban Activity	DUA		Yes	
Type of settlement	DUA		Yes	
Spatial Structure	DUA		Yes	
Past project and feature project	DUA		Yes	
Potential of Site	DUA		Yes	
Urban Equipment in Dakar, Pikine,Rufisque-Bargny	DUA		Yes	
Present land use map 1987	DUA		Yes	
Urban Equipment	DUA		Yes	
Spatial development history	DUA		Yes	
Land use	DUA		Yes	
Zoning of flight control area	DUA		Yes	
Zoning map for building control	DUA		Yes	
DTM(100m)	DUA		Yes	
Slope map			Yes	
Relief map			Yes	
Depression			Yes	
Land form map	DAT		Yes	
Soil map for Agriculture potential	DAT		Yes	
Morphological map	DAT		Yes	
Soil degradation map (Degradation du Sol)	DAT		Yes	
Water resource map (Resources en Eau)	DAT		Yes	
Inondation	ADM		Yes	Yes
Protection area map	DUA		Yes	
Tourist information map	DUA		Yes	
Population data in 1996	DUA		Yes	
Population data in 1981	DUA		Yes	Yes
Statistic of Employment	DUA		Yes	
Statistic of level of comfort utilities	DUA		Yes	
Statistic of construction methods	DUA		Yes	
Statistic of density of housing per ha and per habitat	DUA		Yes	
Statistic of enrolment ration in schools	DUA		Yes	
Statistic of public and private primary schools	DUA		Yes	
Statistic of public and private secondary schools	DUA		Yes	
Statistic of primary health centers and clinics	DUA		Yes	
Stat. of security, fire station, courthouse	DUA		Yes	
Stat. of movie theater, sports facilities	DUA		Yes	
Stat. of tourism facilities	DUA		Yes	
Stat. of information facilities	DUA		Yes	
Land price in 1989	DUA		Yes	

[1] see Section 4.2.2 for application of existing data to IIMS.

Note

Table 3.4.3 Selected Data and Associated Work for IIMS Integration

I. ADMINISTRATIVE BOUNDARY MAP

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Existing Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Input	GIS Data Structure
1 Administrative boundary map of Communes d'Aarrondissement in 1997 (DAT-MEFP, ADM)	polygon	1:5,000-1:50,000	Map of Communes d'Arrondissement in 1997	Administrative boundary map	Map Info data (DAT-MEFP) Auto CAD data and GIS data of Map Info and Geo Concept (ADM)	- Map projection method of GIS data unknown (differs from one used for 1:5,000 maps). - Only Commune d'Arrondissement names available as attributes. - Other attributes fields are left blank (supposedly to be filled by the next national census survey in 2000). - The Rifisque-Bargny boundary is undefined. - Boundary differs between DAT data and ADM data for certain areas. Coordinates differ from those of 1:5,000 maps. - Data format and items differ by areas.	- Data is not readily usable because of incomplete topological structure, necessity of topological processing of figures and fragmentation of line data. - Map projection of GIS data unknown. - Original map scale is likely to be less than 1:50,000. - Necessity to transform map coordinates to 1:5,000 map because of the different map coordinates system. - Necessity to edit data to complete polygon features because of incomplete polygon structure of figures.	- Boundaries to be traced on 1:5,000 map by referring existing administrative boundary data. - A completely new data input.	- Boundary input for map digitization. - Figure identification by sequential database number is linked with data base records. - Available database items are name of Communes d'Arrondissement and population data in the newspaper "le Soleil" in 1996.
2 Administrative boundary in 1988 corresponding to the tracts in the last national census 1988 (DPS-MEFP)	polygon	1:5,000-1:50,000	Tract map in the national census 1988	Tract map	- none	- none	- Difficulty to collect census tract map because most original maps were lost. - Collected data do not match the existing administrative boundaries. - No map for Rufisque.	- Census tract boundaries are to be traced on 1:5,000 map by using reference map and census tract booklet. - New data input. - It is recommended to update the data later by DTGC and DUA when the next census is conducted.	- Map digitization of census tract. - Figure identification will use census tract number in the item II1 below. - Available database items are tract name, number of houses, number of households, and population.
3 Administrative boundary map in PDU of Dakar 2001 in 1980 (DUA-MUH)	polygon	1:5,000-1:50,000	Administrative boundary map of PDU of Dakar 2001	Referenced Maps included in the report (1:50,000)	- none	- none	- Estimated at less than 1:50,000.	- Tracing of boundaries on 1 :5,000 map by using reference map. - New data input.	- Map digitization of boundaries. figure identification will use the sequential number in the table. - Available database items are shown in the item II.2 below.

Table 3.4.3 Selected Data and Associated Work for IIMS Integration (2)

II. STATISTICS DATA Statistics data (Socio-economic data will be applied for the attributes of administrative area.)

Data Item	Feature of Figure	Contents of Data	Existing Map	Existing Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Input	GIS Data Structure
1 National census in 1988 (DPS-MEFP) house, household and population in National census 1988			- Census Report	- none	- none	- Incompatibility of district boundary between district maps and census tracts. (See I. 2)	- New data input of Census data into the database as attributes.	- Statistics data is linked with the tract data in the map file as the above I.2.
2 PDU of Dakar 2001 in 1982 (DUA-MUH) - Population data (distribution of population in 1980) - Population by zone (household survey in August 1980) - employment (population by employment, number of employee) - level of comfort utilities - construction methods - density of housing per ha and per habitant - enrolment ratio in schools - public and private primary schools - public and private secondary schools - primary health centers and clinics - security, fire station, courthouse - movie theater, sports facilities - tourism facilities - information facilities			- Tables and Figures in the report	- none	- none		- New data input of tables data into the database as attributes.	- Statistics data is linked with the tract data in the map as the above I.3.
3 Land Price in the official gazette in December 1989 (MEFP)			- none	- none			- New table data input.	- Official land prices.

III. PRESENT LANDUSE MAP

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Existing Digital Data	Condition of Digital data	Issues in Utilization	Method of Data Entry	GIS Data Structure
1 Present land use map in 1997 created by aerial photos (DTGC-METT)	polygon	1:5,000	- village settlement, regular pattern settlement, irregular pattern settlement, planned settlement - public facilities - industrial zone, commercial zone, green area, vacant land - infrastructure (national roads, regional roads, departmental roads, railroads, other transport facilities) - agriculture, nature, water surface, forest, wetland, afforestation, beach.	- none	- none	- not applicable	- No map available for the present or recent land use.	- Generation of a present land use map on 1:5,000 map by photo interpretation method using aerial photos taken in 1997. - New data input of the results of the photo interpretation.	- Digitized map of land use boundaries. - Attributes are the present land use classification.

Table 3.4.3 Selected Data and Associated Work for IIMS Integration (3)

IV. LAND USE PLANNING MAP

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Existing Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Entry	GIS Data Structure
1 Activities in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than. 1:50,000	- Commerce, industry, transport, tourism, handicraft, free zone	- Map included in the report	- none	- not applicable	- Based on a map of 1:50,000 and questionable accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Digitized map - Database attributes correspond to the legend.
2 Type of Settlement in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Building, villa, planned settlement, regular pattern settlement, irregular settlement, village type	- Map included in the report	- none	- not applicable	- Based on a map of 1:50,000 and questionable accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Digitized map - Database attributes correspond to the legend.
3 Spatial Structure in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Transport nodes, commercial nodes, industry, university, administration center, complex center	- Map in the report	- none	- not applicable	- Based on a map of 1:50,000 and questionable accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Digitized map - Database attributes correspond to the legend.
4 Past Projects and Future in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Settlement, industry, utilities, schools (Point), sports facilities (Point), leisure (Point), tourism (Point), religion (Point), health (Point), information (Point)	- Map included in the report	- none	- not applicable	- Based on a map of 1:50,000 and questionable accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Digitized map - Database attributes correspond to the legend.
5 Site Potentiality in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Occupied area, reserved area for projects, airport, afforestation, depression, lakes, marl, dune, coast, urbanize potential area	- Map included in the report	- none	- not applicable	- Based on a map of 1:50,000 and questionable accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Digitized map - Database attributes correspond to the legend.
6 Cities of Dakar, Pikine, Rufisque in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Large roads (line), VDN, Auto route (line), major activity zones, market (point), railroads (line), stadium (polygon), transport nodes, airport, university	- Map included in the report	- none	- not applicable	- Based on a map of 1:50,000 and questionable accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Digitized map - Database attributes correspond to the legend.
7 Land Use Plan in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon, line	1:50,000	- infrastructure (line), settlement, facilities, administrative boundaries (line)	- Map included in the report	- none	- not applicable	- The study area not covered with any large scale map.	- Preparation of land use plan at 1:5,000 from collected maps. - New data input	- Map digitization will utilize commonly used legend.
8 Land Development Framework for 2021 (DAT-MEFP)	polygon	less than 1:50,000	- metropolis (point), secondary nodes (point), technopolis (point), community nodes (point), rural nodes (point) - auto route (line), existing roads (line), railroads (line), existing ports (point), project ports (point), airport (point) - residential zone, coastal protection zone, protected forest, afforestation, agricultural zone, depression, industrial zone, lake, salty	- Map included in the report	- none	- not applicable	- Based on a map of 1:200,000 and low accuracy.	- New data input of map as the reference data on 1:50,000 map.	- Map digitization of map item Database attributes are taken from the legend.

Table 3.4.3 Selected Data and Associated Work for IIMS Integration (4)

IV. LAND USE PLANNING MAP (Continued)

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Entry	GIS Data Structure
9 Flight Control Area in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Zone A in the flight path area, - Zone B in the flight path area	- Map in the report	- none	- not applicable	- Using 1:50,000 map. - Low accuracy as map scale less than 1:50,000.	- Creation of data file as the thematic map concerning the restriction of building construction. - New data input.	- Map digitization of map item Database attributes are taken from the legend.
10 Spatial Development History in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- Dakar urban areas of before 1923, 1924-1953, 1954-1967, 1968-1976, 1977-1980, and 1981-1985	- Map in the report	- none	- not applicable	- Using 1:50,000 map. - Low accuracy as map scale less than 1:50,000	- New data input of map file as the reference data on 1:50,000 map.	- Map digitization of map item Database attributes are taken from the legend.

V. PUBLIC FACILITY MAP

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Input	GIS Data Structure
1 Public Facility Map in the Urban Audit Reports (ADM)	polygon, point	1:5,000	- Public buildings: (administrative office, embassy, international organization, municipal office, police, etc.) - Education facility: (primary schools, secondary schools, university, etc.) - Primary health facility: (health center, hospital, etc.) - Market - Sports facility - Parks, etc.	- Existing map and reference maps in the reports.	- Auto CAD data and GIS data (Auto CAD data in Dakar and Pinkine, Map Info data in Guédiawaye and Geo Concept data in Rufisque)	- Different map coordinates from 1:5,000 map. - Different data format and data item. - Specified data items in each area vary.	- Obsolete information in existing reference maps. - Auto CAD data can not be directly used in GIS. - No attributes is assigned to figure data in Auto CAD. - Necessity for new data input of the figure attributes. - Necessity to transform map coordinates to 1:5,000 map.	- Preparation of public facilities data on 1:5,000 map from existing maps and field survey . - New data input.	- Map digitization of the compiled map. - Database attributes are the kinds of public facility.

VI. PUBLIC SERVICE MAP

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Input	GIS Data Structure
1 Garbage Collection Service Map in the Urban Audit Reports (ADM)	line, point	1:5,000	- Position map of garbage containers (point), Garbage collection routes (line), Damping site map (area)	- Map	- Auto CAD data and GIS data (Auto CAD data in Dakar and Geo Concept data in Rufisque)	- Different map coordinates system from the 1:5,000 map. - Data format and items are not same in different areas.	- Map coordinates are to be transformed the 1:5,000 map. - Auto CAD data can not be directly used in GIS. - Survey is needed for the garbage collection routes.	- Compilation and editing of the existing usable data on 1:5,000 map. - New data input of survey results of garbage collection routes.	- Digitized map containing collection points and service routs.
2 Public Transportation Map (CETUD)	line, point	1:5,000 -less than 1:50,000	- railroad (line), public bus route service (line), private bus route service (line), terminal and station (point) bus stop (point) etc.	- existing maps and reference maps in the report	- none	- not applicable	- Low accuracy of map. - Survey is needed for the present route of public buses and private buses. - Unspecified service route of private buses.	- New data input of existing route map. - New data input of survey results of public and private bus service routes.	- Map digitization of service route on the center line of road network. - Attributes are type of public transportation, terminal, and bus stop.

Table 3.4.3 Selected Data and Associated Work for IIMS Integration (5)

VII. INFRASTRUCTURE

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Input	GIS Data Structure
1 Road (DTP-METT, Photo interpretation)	line	1:5,000	- national roads - departmental roads	- Maps and reference data in the report of the road inventory study.	- Auto CAD data and attributes data of road of GIS data. - Digital maps in DTGC and DUA by Geo Concept	- Unknown map coordinates system of AutoCAD data. - Attributes data is not directly usable.	- Difficulty in identifying the road boundary by the photo interpretation method and field survey. - Necessity to transform map coordinates. - Lack of attributes in Auto CAD data. - A few road data in digital maps of DTGC and DUA.	- Compilation of available road data on 1 :5,000 map by using reference data. - New data input of the compiled map and existing GIS database.	- Map digitization of center lines of roads. - Attributes of figures were taken from the existing list of road data.
2 Railroad (Photo interpretation)	line	1:5,000	- railroad (line) - station (point)	- Existing maps	- Digital maps in DTGC and DUA by Geo Concept	- Incomplete topology of figure data. - Different map coordinates system from the 1:5,000 map.	- Necessity of data edit to remove unnecessary figures and fragmentation of lines.	- Compilation and editing of available data on 1 :5,000 map by using reference data.	- Editing of available data on railroad and station with database attributes.
3 Water supply network in the Urban Audit Reports (ADM)	line	1:5,000	- water supply network - community fountains (point) - pumping station (point, polygon), etc.		- Auto CAD data and GIS data. - Auto CAD data in Dakar and Pikine - Map Info data in Guédiawaye - Geo Concept data in Rufisque	- Lack of data compatibility between ADM and SDE. - Uncovered area in the whole study area. - Different data format and data items.	- Difficulty of acquisition of SDE's GIS data. - Topological errors of ADM figure data. - Different map coordinates system from the 1:5,000 map.	- Compilation and editing of available data on 1:5,000 map. - New data input of database attributes on figure.	- Available data of water supply facility from existing maps such as water pipe line and the other facilities. - Database attributes are the kinds of facilities.
4 Sewerage and drainage network in the Urban Audit Reports (ADM) Sewerage map in Dakar and Pikine (ONAS)	line	1:5,000	- Sewerage network (line) - pumping processing station (point, polygon) - drainage network (line)	- Sewerage map in Dakar and Pikine	- Auto CAD data and GIS data. - Auto CAD data in Dakar - Map Info data in Guédiawaye - Geo Concept data in Rufisque	- Sewerage and drainage are available in Dakar and Rufisque. - Different data format and data items.	- Topological error of figure data in ADM data. - Auto CAD data can not be used directly. - Different map coordinates system from the std 1:5,000 map.	- New data input of the existing map. - Compilation and editing of available data on 1:5,000.	- Map digitization. - Database attributes are kinds of sewerage. - Editing of available digital data of sewerage.
5 Electricity Transmission network in the Urban Audit Reports (ADM) Transmission maps (SENELEC)	line, point	1:5,000	- high tension (line) - middle tension (line) - electric power plant (polygon, point) - other electricity facilities (polygon, point)	- Topographic map of 1:5,000 map and 1:50,000 map. - Map in the report	- none	- not applicable	- not applicable	- Preparation of high tension electric power lines data on 1:5,000 map by tracing the line on 1:50,000 map. - New data input.	- Map digitization of high tension electric power line. - Database attributes are kinds of facility.

Table 3.4.3 Selected Data and Associated Work for IIMS Integration (6)

VIII. NATURAL CONDITION AND ENVIRONMENT MAP

Data Item	Feature of Figure	Original Scale	Contents of Data	Existing Map	Digital Data	Condition of Digital Data	Issues in Utilization	Method of Data Input	GIS Data Structure
1 Elevation map (DTM)	grid	1:5,000	- DTM	- Maps in the report	- not applicable	- not applicable		- DTM data on 1:5,000	- Leveling of DTM data directly.
2 Slope map (DTM)	grid	1:5,000	- slope map from DTM	- none		- not applicable		- Calculation of DTM data.	- Calculation of slope angle.
3 Relief map (DTM)	grid	1:5,000	- relief map from DTM	- none		- not applicable		- Calculation of DTM data.	- Calculation of relief.
4 Topographic zoning map in PDU of Dakar 2001 in 1982 (DUA-MUH)	polygon	less than 1:50,000	- dunes - plateau - limestone - hill, etc.	- Maps in the report		- not applicable	- Low accuracy of existing map. - The whole study area is not covered.	- New data input as reference data on 1:50,000 map.	- Map digitization. - Database attribution refers to the legend.
5 Agricultural potential map (DAT-MEFP)	polygon	1:50,000	- agricultural classification	- Maps in the report	- none	- not applicable	- Low accuracy of existing map.	- New data input as reference data on 1:50,000 map.	- Map digitization. - Database attributes are taken from the legend.
6 Geological feature map (DAT-MEFP)	polygon	less than 1:50,000	- Types of geographical features						
7 Soil degradation map (DAT-MEFP)	polygon	less than 1:50,000	- degradation classification						
8 Water resource (DAT-MEFP)	polygon	less than 1:50,000	- under ground water, dune, depression, lake, etc.	- Existing map	- none	- Need of reference index of code and legend.	- Low accuracy of existing map.	- New data input as the reference data on 1:50,000 map.	- Digitization of map. - Legend is available as the attributes.
9 Flooding map in the Urban Audit Reports (ADM)	polygon	1:5,000-1:50,000	- flooded area	- Existing map	- Digital maps by Auto CAD	- Only Dakar area is available.	- Auto CAD data can not be used directly. - Necessity to edit figure data with topology processing. - The whole study area is not covered. - Different map coordinates from the 1:5,000 map.	- Compilation and editing of available data on 1:5,000 map with the identified flooded areas. - New data input of field survey results on 1:5,000 map.	- Editing of existing data - Map digitization of field survey results. - Database attributes are the existence of the inundation.
10 Protection area map (DTGC-METT, DUA-MUH, ADM)	polygon	1:50,000	- natural park, - heritage - protection area, etc	- none	- none	- not applicable	- No compiled maps regarding protection area, environmental area and conservation area.	- Compilation of information on 1:5,000 map with the available information of 1:50,000 map. - New data input of the compiled map.	- Map digitization. - Attributes are kinds of information.

3.5 Summary of Inventory of Existing Data

The geographic feature items to be included in IIMS were summarized with the data source organizations. The Study team will build GIS data for the project based on this data. Also these conditions must be considered for the system design of the IIMS. The following is a summary of this chapter.

- There are many paper maps that must be digitized to a thematic map of IIMS.
- Figure data of AutoCAD data is not directly available as GIS data and some data must be edited. Considering the polygon structure of GIS data, this data must be edited.
- AutoCAD attribute is not available for the property of GIS data although the property is confirmed on figure data.
- AutoCAD data includes unnecessary figures to create the hatching for data drawing. GIS data does not need to use that data.
- Map coordinates in AutoCAD is managed on a local coordinate basis in many cases. These coordinates must be corresponded to map coordinates in the existing topographic maps (ADM, DTP-MET).
- Map coordinates of GIS data do not correspond to the existing topographic maps in DTGC because the map projection of GIS data is not set up properly. ADM cannot compile GIS data with different formats among AutoCAD, MapInfo and GeoConcept because of the dispersion of data format to that processed by local consultant.
- The above-mentioned data condition must contribute to the system design of IIMS for data exchange for the current GIS user.