CHAPTER 3. TECHNOLOGY TRANSFER

The technology transfer carried out in this project covered all the mapping processes except Aerial photography. The covered processes were:

1. Premarking of GCP (Setting of Aerial Signal)
2. GPS Survey
3. Leveling and Pricking
4. Field Identification
5. Field Completion
6. Aerial Triangulation
7. Digital Plotting
8. Digital Compilation
9. Data Structurization
10. Map Symbolization

Trainings of the former five processes were conducted in the field. The data acquired through these trainings were employed for the actual mapping in this project.
Trainings of the latter five processes were conducted indoors at DCIG with computer systems.

Table 3.1 Technology transfer sessions

Subject	Period	Contents	Number of participants (trainees)	Remarks
Premarking of GCP (Setting of Aerial signal)	1~11 May 2007	Explanation of purpose and method (materials, allocation, ground condition) Setting of aerial signals at 22 points	4	2-3 signals per day
GPS Survey	19 June ~2 July 2007	Explanation of purpose and method of GPS observation and leveling. Instruction of manipulation of GPS and leveling devices. Training of manipulation of GPS and leveling devices. Training of GPS observation	4	At CM01 & AZ001

		GPS observation at 23 points		
Leveling and Pricking	3 July ~ 16 Aug. 2007	Training of leveling (adjustment, observation) Leveling for 200km Pricking for 135 points	4	7 km per day
Field Identification	20Aug. ~26 Sept. 2007	Explanation of purpose and method of Field identification Field identification for 1,200km^2	4	
Filed Completion	8 Oct. ~ 17 Nov. 2008	Method of putting the results onto the symbolized map sheets Field completion for 1,200km2	11	
Aerial Triangulation	30 Oct. ~ 17 Nov. 2008	Creation of camera files and data files of ground control points Inner orientation Observation of pass points and tie points Observation of control points Adjustment computation	2	
Digital Plotting	1 Nov. ~ 3 Dec. 2009	Review of Aerial Triangulation Creation of Library Catalog Various settings for digital plotting	1	
Digital Compilation	1 Nov. ~ 3 Dec. 2009	Training of MicroStation Feature creating Data cleaning Creating topology	2	
Data Structurization	13 Oct. ~ 16 Nov. 2008	Understanding the concept of GIS The operation of GIS software	2	
	15 Nov. ~ 21 Dec. 2009	The methodology to prepare GIS data base from the complied plotting data.	5	
Symbolization	1 Nov. ~ 3 Dec. 2009	Training of MicroStation for symbolization	2	

3.1. Premarking of GCP (Setting of Aerial Signal)

This work was performed by technical staff members of DTC under the instruction of the Team. During the work, they learned the purpose of premarking of ground control points (GCPs), proper distribution of GCPs, suitable materials, design and color of aerial signal and use of handy GPS. All the established signals were recognized on the aerial photographs which were taken later. The trainees have attained the target level to perform future practical works.

3.2. GPS Survey

This work was performed by technical staff members of DTC under the supervision of the Team. As they did not have experience in GPS survey, they were briefly trained on operation of GPS equipment before GPS observation. Throughout the observation, they have acquired the skill. All the results of the observation were used for aerial triangulation which was done later in Japan. They have attained the target level to perform future practical works.

3.3. Leveling and Pricking

This work was performed by technical staff members of DTC under the supervision of the Team. Digital leveling method was applied to this project. As they did not have experience in digital leveling, they were trained to learn operation of digital leveling equipment before the work. During the work, they have mastered the skill. All the results of the leveling were also used for aerial triangulation which was done later in Japan. It is evaluated that they have attained the target level to perform future practical works.

3.4. Field Identification

This work was performed by technical staff members of DTC and others under the supervision of the Team. They learned stereoscopic viewing, photo-interpretation, on-site identification of topographic features comparing with aerial photographs, compilation of the results on the photographs. All of the results they made were used for digital plotting which was done later in Japan. It is evaluated that they have attained the target level to perform future practical works.

3.5. Field Completion

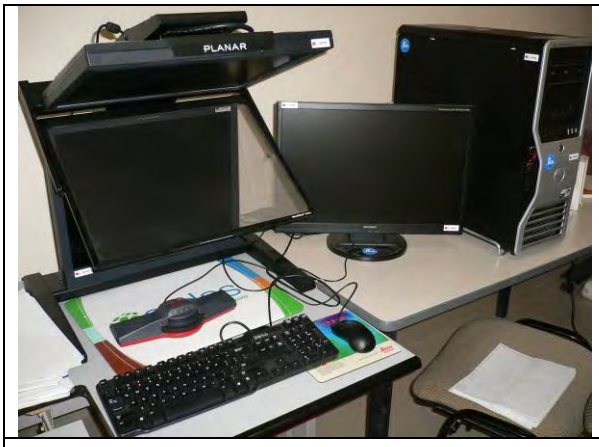
This work was performed by technical staff members of DTC and others under the supervision of the Team. They learned on-site checking of topographic features which had been plotted on the map in Japan. They also learned map compilation of the features which they corrected on-site. All the results they made were used for digital compilation and map symbolization which were done later in Japan. It is evaluated that they have attained the target level to

perform future practical works.

3.6. Aerial Triangulation

The training on aerial triangulation was conducted at DCIG in November 2008. Two (2) trainees from DCIG participated in this session.

The target level to attain is that they can do voluntary training. Before the start of training, the Team investigated their skills and knowledge on the aerial **t**riangulation with a questionnaire in order to meet their needs for the technology transfer.



Equipment used for the training

Aspect of training

Figure 3.1 Aspect of technology transfer for the aerial triangulation

The training material such as images was not from the aerial photos taken in this project. The photos used were prepared from other places because the photos taken in this project were unsuitable for trainees to look the ground relief by 3D visualization due to the flat landform of the Study area.

Evaluation

The team evaluated trainees through the training and the result of the training. The evaluation was done from the following aspects.

Table 3.2 The aspects of evaluation for the Aerial Triangulation

	Aspects	Contents
1	Basic Knowledge	Basic knowledge about Photogrammetry, Cartography, Software and this project at start of this training.
2	Motivation	Motivation to understand this training and to apply the result of this training.
3	Understanding	Understanding about the contents of the training
4	Mathematical theory	Understanding about the mathematical theory of aerial triangulation.
5	LPS	Well understanding and manipulation about LPS.
6	Improvement	The improvement of understanding and motivation through this training.
7	Future	The possibility for future application of this training and the data

Conclusion and future task

The training was planned in consideration of period, skills and knowledge of trainees. The Team decided that training should be started from software operation not theoretical explanation. The aim of the Team was that trainees studied the theory by themselves after they learned the work steps through the way of software operation.

As current situation, the Team evaluated that the trainees can operate the software. On the other hand, it is expected that the trainees would study and practice more about 3D viewing and measuring by using the material of the training by themselves continuously.

The Team gives the following items for their future task.

- ✧ Practicing using the material of training whenever they have a time.
- ✧ Trying to change the value of parameters in each step and understand their difference.
- ✧ Appreciating the theory of aerial triangulation and its mathematical theory.
- ✧ Having occasions to learn about ground control survey because its knowledge is involved to the aerial triangulation.
- ✧ Improving capacity for map reading.
- ✧ Improving their English skill because language in software is English.

3.7. Digital Plotting

The training on Digital Plotting was conducted at DCIG through November to the beginning of December 2009. One trainee from the Direction of Land Development and Regional Action (DATAR) participated in this session.

The target level to attain is that he can do voluntary training. Before the start of training, the Team investigated his skills and knowledge on digital plotting with a questionnaire in order to meet his needs for the technology transfer.

In practical work, aerial triangulation must have been completed in order to perform the next process of digital plotting. Otherwise, digital plotting is impossible because stereo models established by aerial triangulation are indispensible for data acquisition in 3D visualization. The trainee did not take the session of Aerial Triangulation conducted in 2008. Therefore, a brief training of aerial triangulation was given to him before starting the session of Digital Plotting.

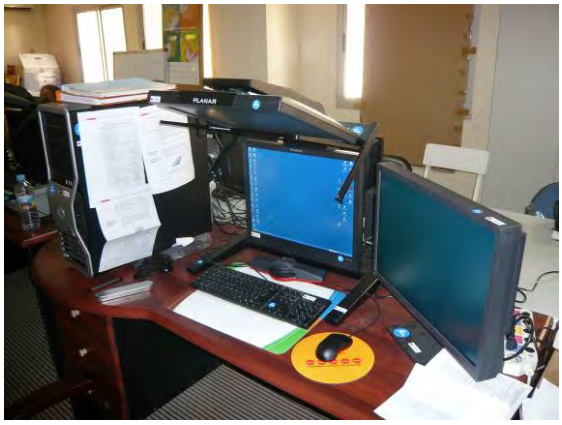
	
Digital photogrammetric system used (LPS and MicroStation are installed)	Instruction

Figure 3.2 Aspect of technology transfer for digital plotting

Aerial triangulation in the project was carried out for about 2,000 km^2 using approximately 450 photos. However, the Team used only 3 photos in the training so that trainees could learn easily the contents of digital plotting and aerial triangulation.

Evaluation

The Team evaluated trainees through the training and as the result of the training.

The evaluation was done from the following aspects.

Table 3.3 The aspects of evaluation for the Digital Plotting

	Aspects	Contents
1	Basic Knowledge	Basic knowledge about Photogrammetry, Cartography, Software and this project at start of this training.
2	Motivation	Motivation to understand this training and to apply the result of this training.
3	Understanding	Understanding about the contents of the trainning
4	LPS	Well understanding and manipulation about LPS.
5	Pro600	Well understanding and manipulation about Pro600.
6	MicroStation	Well understanding and manipulation about MicroStation.
7	TopoMouse	Manipulation of TopoMouse
8	Data acquisition	Well understanding and manipulation about Data acquisition.
9	Improvement	The improvement of understanding and motivation through this training.
10	Future	The possibility for future application of this training and the data

Conclusion and future task

This trainee had experienced in manipulating ERDAS IMAGINE, which is base software of LPS. Therefore, he could easily understand the manipulation of LPS and could operate it without trouble.

He participated in the training session in a positive manner, precisely taking notes of explanations given by the Team. His level of skill in manipulation of TopoMouse is still low because this manipulation is rather complicated for a beginner. He will be able to make rapid progress in data acquisition of planimetric features if he continues a little more exercise, but, as for terrain features such as contour lines, he is required to do much more and intensive exercise in data acquisition with 3D view.

The Team gives the following items as his future tasks to become independent.

- ✧ Improving knowledge and skills of feature measurement on 3D view.
- ✧ Improving knowledge and skills of photo interpretation.
- ✧ Improving knowledge and skills of geographic features acquisition with 3D photo viewing corresponding map scale.

3.8. Digital Compilation

The training on Digital Compilation was conducted at DCIG through November to the beginning of December 2009. Two (2) trainees from the Société Nationale de l'Eau (SNDE) participated in this training session.

The target level to attain is that they can do voluntary training. Before the start of training, the Team investigated their skills and knowledge on digital compilation with a questionnaire in order to meet his needs for the technology transfer.

On the first day, the Team gave a lecture to the trainees to explain the purpose of Digital Compilation and its relation to Digital Plotting and Symbolization.

Figure 3.3 Explanation about the session

From the response to the Questionnaire, the situation that all trainees have never touched to any CAD software (MicroStation, AutoCAD, etc) was confirmed, therefore the Team planned the program to start from the basic manipulation of MicroStation.

In this lecture, the Team lectured and practiced for the basic manipulation of MicroStation and the method of making manuals by themselves.

Evaluation

The team evaluated trainees through the training and as the result of the training.
The evaluation was done from the following aspects.

Table 3.4 The aspects of evaluation for the Digital Compilation

	Aspects	Contents
1	Basic Knowledge	Basic knowledge about Photogrammetry, Cartography, Software and this project at start of this training.
2	Motivation	Motivation to understand this training and to apply the result of this training.
3	Theory	Well understanding and good motivation for the acquisition toward theory.
4	Manipulation	Well understanding and good motivation for the acquisition toward manipulation of software.
5	MicroStation	Well understanding and manipulation about MicroStation.
6	Data Cleaning	Well understanding and manipulation about Data Cleaning.
7	Creating Topology	Well understanding and manipulation about Creating Topology.
8	Improvement	The improvement of understanding and motivation through this training.
9	Future	The possibility for future application of this training and the data

Conclusion and future task

One of trainees had little experience in software except “Microsoft Office” at the start of this training, so that she needed to start from the training of a basic level. However, she tried hard to understand the manipulation of software making her own manuals, and showed remarkable improvement in some practices with slow and steady progress referring her manual.
It is expected that the results (knowledge, technique) of this training and the data of this project would be utilized in some new fields (ex: The planning of water pipes, Land development) by the trainee.

Another trainee has already had some experience in AutoCAD, although not so familiar, but her experience was sometimes helpful for understanding the theory and manipulation, and for exercising the software by comparing with the same cases in AutoCAD throughout the training.

It is expected that the results (knowledge, technique) of this training and the data of this project would be utilized in some new fields (ex: The planning of water pipes, Land development) by the trainee.

3.9. Data Structurization

Overall objective of the training on data structurization was to transfer skills for creating GIS data from the compiled plotting data (CAD format) prepared under this project, and further creating some samples of GIS application using the converted data. This training was conducted at DCIG in both the second (2008) and third (2009) phases of the Study. It is expected that this technology transfer would encourage the related organizations for extensive use of data of this project in decision making process.

3.9.1. The Second Phase (2008)

Two (2) trainees from the Direction of Cartography and Geographic Information (DCIG) participated in this training. Thus, the number of trainees was good enough to conduct person to person operation support.

Before the start of training, the Team investigated their knowledge and experience of data structurization with a questionnaire in order to meet their needs for the technology transfer.

The questionnaire survey revealed that, both of the trainees had Good to Fair knowledge of GIS data. They had working experience on MapInfo software and some experience on ArcGIS software, too. However, this was the first training on ArcGIS software for them. Thus, the training was focused mainly on operations of ArcGIS software.

The training was designed to be practical as much as possible. Each session (except the first and review sessions) was divided into two parts: lecture/demonstration, and practice. The practices were designed for immediate practice for the trainees on personal computer. Figure 3.4 shows the environment of a training session.

Figure 3.4 A session of training in the second phase

Challenges and Resolution

This training being conducted first time for the Trainees, there were some challenges, which were resolved with the optimum efforts. These are listed below:

Challenge: The trainees' level of English understating was not sufficient to quick grasping of operations of ArcGIS software, which is in English.

Resolutions: Communicating through translator; repeating the demonstration; watching their practice activity intensively; promoting them to take note of operations.

Challenge: In addition to attend this training course, the attended trainees had also to do their regular task. Thus, despite the willingness, sometimes they remained unable to join some of the training sessions as scheduled.

Resolutions: Re-arranging the schedule, providing time even for individual trainee to make up the missed session.

Evaluation

The trainees involved in the GIS Data Structurization in this phase were evaluated considering the aspects presented in Table 3.5.

Table 3.5 Aspects for evaluating trainees in the second phase (2008)

	Aspects	Contents
1	Basic Knowledge	Basic knowledge about GIS data and ArcGIS at start of this training.
2	Motivation	Motivation to understand this training and to apply the result of this training.
3	Improvement	Overall improvement of understanding regarding operating ArcGIS, and structurization and analysis of GIS data through this Training.
4	Components of ArcGIS	Improvement of understanding of components of ArcGIS; ArcCatalog, ArcMap, Tables, and ArcToolBox and also about 3D and Spatial Analyst, etc.
5	Input and Edit GIS Data	Improvement of understanding regarding Input and Edit of GIS data.
6	GIS Data Analysis	Improvement of understanding regarding Spatial Analysis of GIS data.
7	Map Composition	Improvement of understanding regarding composing, and printing or exporting map.
8	Future	The possibility of applying the acquired training knowledge in future.

The level of both trainees, with respect to various aspects mentioned in Table 3.5, was conducted. In conclusion, both trainees showed very good motivation to learn about contents of the training. Despite being busy in other works, they tried their best to attend the sessions. It is expected that they would continue to exercise the operations by themselves.

3.9.2. The Third Phase (2009)

Structure and Schedule

Considering that the last training (conducted in the second phase) focused on functions of ArcGIS Software, the training on the third phase emphasized on structurization of GIS data from the compiled plotting data (CAD format) and preparation of sample application using mainly the converted GIS data. However, out of 6 (six) trainees attended this time, 5 (five) had not attended the last training and also a trainee (Mr. Maleck Vall) who attended last time wished to repeat some of lessons carried out last time. Thus, this training

composed of three main components with numbers of sessions for each one:

- Introduction of functions of ArcGIS software
- Conversion of the project CAD data to GIS data base.
- Creation of GIS application using mainly converted GIS data

Numbers of sessions were conducted for each of the above components.

Trainees:

This training was attended by six (6) trainees. They were grouped into three in order to conduct individual training using a restricted number of equipment.

In order to determine an effective means of technology transfer, questionnaire survey was conducted to understand the experiences and knowledge of trainees who attended for the first time in training of this Project. This revealed that, most of them had Good to Fair knowledge of GIS data and coordinate systems. Some of them had occasional experience of operating GIS software, too.

Figure 3.5 A Session of training in the third phase

- **Creation of GIS Model by Trainees**

After practice of the above sample GIS model, each trainee was asked to formulate and prepare a GIS model basically using the converted GIS data of this project. Necessary one to one discussions were held during formulation step and supervision was carried out during the preparation state. Thus, this not only provided them opportunity to put their idea into practice, but also got first hand practice for application use of this project GIS data. Also, this provided to express their understanding about whatever they have learnt in this training. The Title of GIS model created by trainees is listed.

- Suitable site for building the Central Bus Station in Nouakchott
- Creation of a GIS model to identify inundated zones in a districts of Nouakchott
- The plan of restructuring of the precarious districts of Dar Naim Commune
- Plan of installation of an Esplanade
- Identification of suitable areas for building a new school

Challenges and Resolution

During this training also, there were some challenges, which were resolved with the optimum efforts. As in 2nd phase, the trainees attended in this phase had busy schedule, and different levels of understanding of English language. These two problems were resolved in same way as mentioned in sub-heading "Challenges and Resolution" of "Training on Data Structurization in 2nd Phase"; that is, by re-arranging their schedule and communicating through translator, respectively. Besides these, the 3rd one is listed below:

Challenge: Six trainees were from four different organizations. Also their level of understanding regarding GIS was different.

Resolutions: During demonstration, encouraging them to ask questions immediately if not understood, checking their understanding regarding particular covered point. During practices, encouraging one to one discussion and repeating wherever needed.

Evaluation

The trainees involved in the GIS Data Structurization were evaluated considering the aspects presented in Table 3.6.

Table 3.6 Aspects for Evaluating Trainees on Data Structurization in 3rd Phase

	Aspects	Contents
1	Basic Knowledge	Basic knowledge about GIS data and ArcGIS at start of this training.
2	Motivation	Motivation to understand this training and to apply the result of this training.
3	Improvement	Overall improvement of understanding regarding operating ArcGIS, and structurization and analysis of GIS data through this Training.
4	Components of ArcGIS	Improvement of understanding of components of ArcGIS; ArcCatalog, ArcMap, Tables, and ArcToolBox and also about 3D and Spatial Analyst, etc.
5	Input and Edit GIS Data	Improvement of understanding regarding Input and Edit of GIS data.
6	GIS Data Analysis	Improvement of understanding regarding Spatial Analysis of GIS data.
7	Map Composition	Improvement of understanding regarding composing, and printing or exporting map.
8	Converting CAD to Shape	Improvement of understanding regarding converting CAD data to GIS Data.
9	Creating GIS Model	Improvement of understanding for using this Project data in creating GIS application Model and extracting information to be used by decision maker.
10	Future	The possibility of applying the acquired training knowledge in future.

The same criteria used in evaluating trainees on Data Structurization in 2nd phase were used in this phase.

In conclusion, all the trainees showed very good motivation to learn about contents of the training. Despite being busy in own works, they tried their best to attend the sessions. In case of missing some sessions, they tried to cover during the next sessions. With their level of improvement achieved through this training, it is strongly hoped that they will be able to increase it further with practice in future.

3.10. Map Symbolization

The training on Symbolization was conducted at DCIG through November to the beginning of December 2009. Two (2) technical staffs from the Société Nationale de l'Eau (SNDE) participated in this session.

The target level to attain is that they can do voluntary training. Before the start of training, the Team investigated on their knowledge and experience in map symbolization with a questionnaire in order to meet their needs for the technology transfer. Then, the Team explained the purpose of Symbolization and the relation to Digital Plotting and Digital Compilation to the trainees.

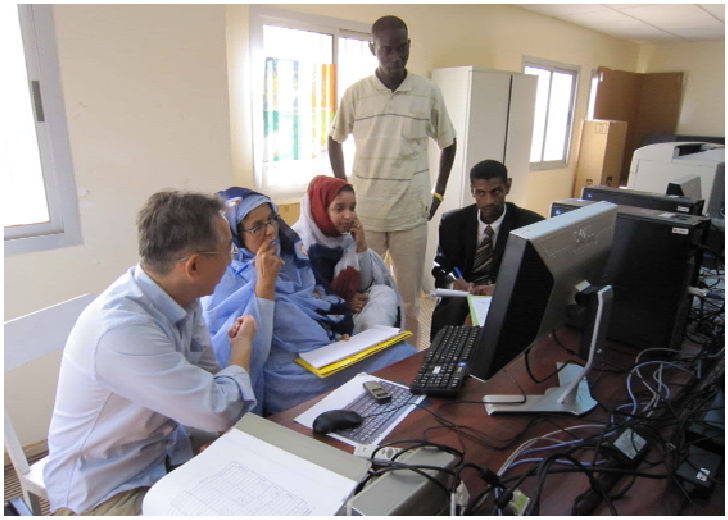


Figure 3.6 Session of map symbolization

The software used for the symbolization was MicroStation. Although the MicroStation is CAD software, it is possible to use for the symbolization in case of large scale map. In the case of small scale map, other software is normally used for the symbolization.

Therefore, the contents of training were how to use MicroStation and lecture about symbolization and practice by them.

Evaluation

The Team evaluates the trainees through the training and from the result of the training.

The evaluation was done from the following aspects.

Table 3.7 The aspects of evaluation for the Symbolization

	Aspects	Contents
1	Basic Knowledge	Basic knowledge about Photogrammetry, Cartography, Software and this project at start of this training.
2	Motivation	Motivation to understand this training and to apply the result of this training.
3	Theory	Well understanding and good motivation for the acquisition toward theory.
4	Manipulation	Well understanding and good motivation for the acquisition toward manipulation of software.
5	MicroStation	Well understanding and manipulation about MicroStation.
6	Symbolization	Well understanding and manipulation about symbolization.
7	Creating Table	Well understanding and manipulation about Creating Table.
8	Improvement	The improvement of understanding and motivation through this training.
9	Future	The possibility for future application of this training and the data

Conclusion and future task

The trainees had some experiences of CAD software but poor knowledge about topographic maps. They, however, got interested in map symbolization during the sessions.

It is normally difficult to realize and understand the attribute of each data in simple plotted data. But the attribute of the data can be realized and understood easily after symbolization.

As they made their own symbol in the practice 2, whenever they have new idea of design for symbol, they should make their own symbol by themselves through a trial and error process.

In spite of little knowledge about Symbolization, they were keen on this subject aiming to apply this technique to water supply designing. They are expected in future to apply their experience and the data supplied by this project to designing the water supply network and developing the land concerned to the network.

It is expected that they would continue to exercise the operations themselves.

3.11. Conclusion

All the planned subjects of technology transfer have been achieved in spite of some schedule modifications due to the political situation. At the beginning, most of the

trainees had no experience in theses technologies. At present, they have acquired basic knowledge and skills. They need more exercise without instructors for acquiring the ability to perform practical works. In other words, they have attained the level where they can start the exercises by themselves.

The level of achievement varies from subject to subject. Concerning the five subjects of field work, they have acquired the ability to perform the practical works because they contributed toward this mapping project. with reliable data they produced.

As for the indoor subjects, they need more voluntary exercises because these works need them to manipulate a variety of software and the software permits a variety of applications depending on their own purposes and original ideas.

Among others, Aerial triangulation and Digital plotting require them to exercise intensively for a definite period, because these subjects require them to get a skill with 3D viewing and measuring as well as to be familiarized to the software.

On the other hand, each session of technology transfer was, however, given to a few of technical staffs. Therefore, it is expected that they would try to spread the technologies to other staffs.

CHAPTER 4. DIFFUSION OF THE USE OF DIGITAL MAP DATA

For diffusing any digital map data, including the data produced under this Study project, a circulation mechanism shown in Figure below must be put into practice.

This circulation includes three phases, that is, Data creation and maintenance, Data distribution, and Data application.

In the first phase, the publisher creates his digital map data under a plan, rules and specifications, aiming to develop a spatial database. In this Study project, creation of the digital map data for the Nouakchott area has been done. After creation of data, the publisher establishes a distribution system for effective diffusion. This system must be effective so as to enable the end users easily to obtain the data they want. The publisher also prepares a user support system. Then, he announces the publication and necessary conditions.

Through the distribution system, in the second phase, the publisher distributes the data to users.

In the third phase, the users apply the data to anything to meet their purposes and intentions. For this, the users acquire necessary skill and human resources if necessary, and form an application system. They also collect or make additional data if necessary.

On the other hand, the data must be maintained for sustainable use in another first phase. Data maintenance means not only data updating but also data improvement and development. Therefore, the maintenance must be done keeping up with the user's demands. In order to make an appropriate maintenance, the publisher tries to collect the demands and opinions from the users who have applied the data.

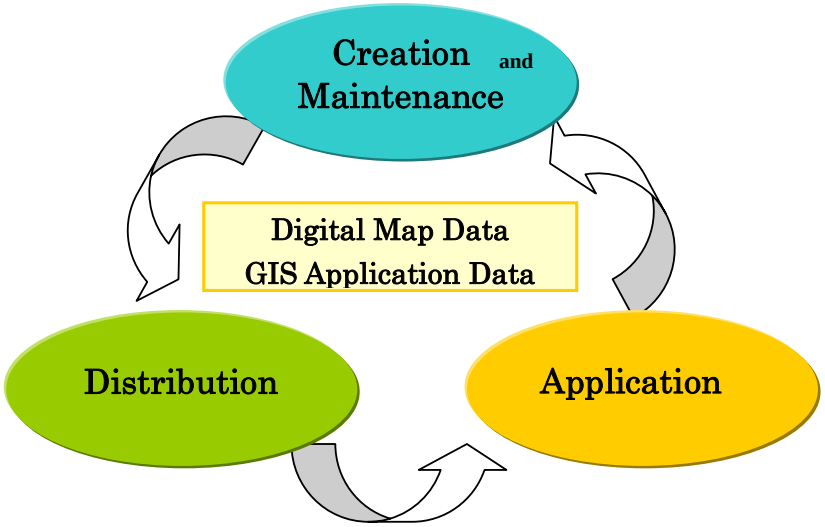


Figure 4.1 Circulation mechanism of digital map data

The wider the field of data application is, the more effective and stable diffusion of the data is expected. These various applications of digital map data and more advanced ones need a stable technical support.

4.1. The user of digital map and GIS

Before a new development of digital map data, a demand analysis of the data needs to be conducted. The result will shows the type of user and the effective way how to distribute the data.

The following conceptual diagram shows an example of structure of user group in digital map use. In addition to the three existing (or expected to be existence) user groups, it should be considered that there is a potential user group behind the group of light user.

To realize diffusion of the use of digital map data, first of all the enhancement of function of existing user group to carry out their own role and then the development of new light-user from the potential user will be necessary.

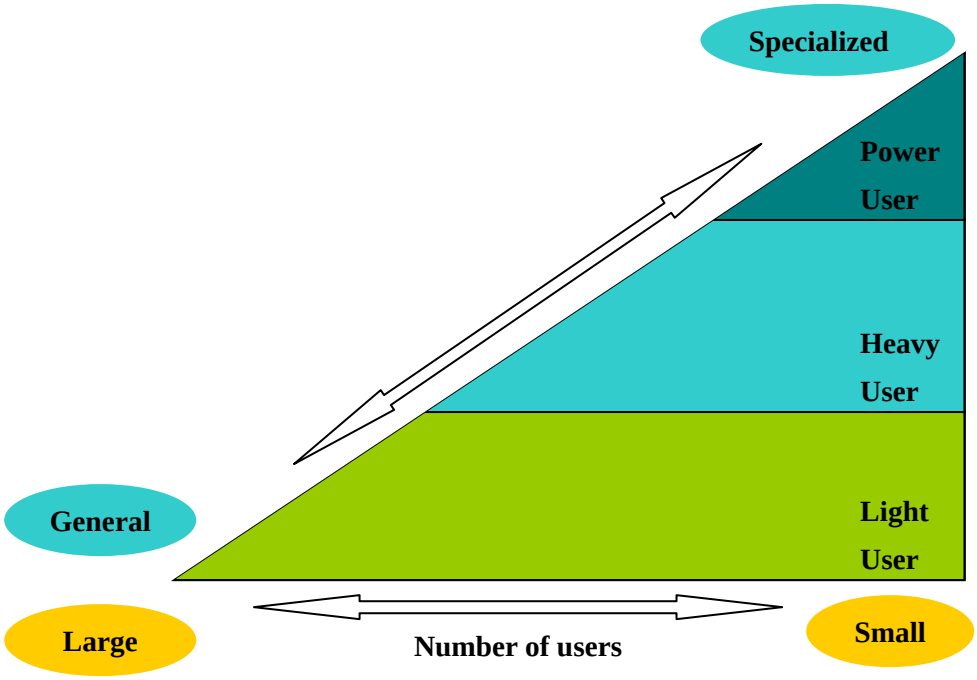


Figure 4.2 Conceptual diagram of users of digital map and GIS

4.1.1. Digital map data and GIS user

1). Power User Group

This group is expected to play an important role in all-purpose services concerning GIS

including IT support. In the case of Mauritania, the DCIG should be expected to take it. Enhancement of human resource, technical advancement, and better system environment will be necessary for DCIG to play the role.

2). Heavy User Group

This group is expected to play a role to deal with GIS including IT support for individual purpose. In the case of Mauritania, some of the existing GIS users should be supported so as to formulate this group which takes the role as advanced user of GIS, GIS analysis, etc.

3). Light User Group

Most of users who refer the digital map data mainly are generally classified in this group. In the case of Mauritania, most of the existing GIS users are included in this group.

4). Potential User Group

This group is placed behind the light user group waiting the chance to use GIS whenever the surrounding environment favors the use.

4.1.2. Digital Map Data & GIS User in Mauritania

For the diffusion of digital map and GIS, the Study team and DCIG had some discussions about the current state of usage of digital map and GIS in Mauritania and listed up the existing and potential users. Then, the Team and DCIG visited the listed organizations and introduced the digital map data which were under preparation in this Study.

1). Current condition of potential users of digital map and GIS

The following table shows the existing users and potential users of the digital map who were found through this Study and listed up.

Table 4.1 Potential users of digital map data

(Y: Yes, N: No)

Name of organ	Relevant field	Current status of map & GIS use
DCIG (Ministry of Habitat Urbanism and Development of Territory)	Development and distribution of cartographic map	Paper map: Y Digital map: N GIS: Stand-alone type
DU (Ministry of Habitat Urbanism and Development of Territory)	Urban planning, Urban development	Paper map: Y Digital map: Y GIS: Stand-alone type

DARTAR (Ministry of Habitat Urbanism and Development of Territory)	Land development, Regional planning	Paper map: N Digital map: N GIS: Stand-alone type
DIT (Ministry of Equipment and Transport)	Transportation planning, Highway construction	Paper map: Y Digital map: Y GIS: Stand-alone type
DP (Ministry of Hydraulic and Purification)	Water drainage, Main sewage process	Paper map: N Digital map: N GIS: N
OMRG (Ministry of Industry and Mines)	Natural resource and mine development	Paper map: Y Digital map: Y GIS: Stand-alone type
DGPC (Ministry of Interior and Decentralization)	Civil security, Fire-fighting, Logistic	Paper map: N Digital map: N GIS: N
Environment (Ministry Delegate Office of Prime Minister in Charge of Environment)	Environment preservation	Paper map: Y Digital map: Y GIS: Stand-alone type
DS (Ministry of Health)	Healthcare plan and management	Paper map: N Digital map: N GIS: N
DFE (Ministry of Economic Affaires and Development)	Economic affaires and development	Paper map: N Digital map: N GIS: N
CUN	Administration of Nouakchott	Paper map: Y Digital map: Y GIS: Stand-alone type
SNDE	Water supply	Paper map: Y Digital map: Y GIS: Stand-alone type
SOMELEC	Power supply	Paper map: Y Digital map: Y GIS: Stand-alone type
EU	—	Paper map: N Digital map: N

		GIS: N
UNDP	—	Paper map: N Digital map: N GIS: N
UNICEF	—	Paper Map: N Digital Map: N GIS: N
WFP	—	Paper Map: N Digital Map: N GIS: N
WHO	—	Paper Map: N Digital Map: N GIS: N
FAO	—	Paper Map: N Digital Map: N GIS: N
UNHCR	—	Paper Map: N Digital Map: N GIS: N
World Bank	—	Paper Map: N Digital Map: N GIS: N
AFD	—	Paper Map: N Digital Map: N GIS: N
French Embassy	—	Paper Map: N Digital Map: N GIS: N
U.S. Embassy	—	Paper Map: N Digital Map: N GIS: N

2). Utilization Fields of Digital Map Data and Expected Role of Organizations in Mauritania

As discussed above, an expected role to the DCIG for the diffusion of digital map data will be one of the “Power User Group” considering the official field of it in Mauritania government. Expected functions for DCIG as a “Power User Group” are development, publication and distribution of data, standardization and etc.

Table 4.2 Utilization field and expected role

Name of organ	Utilization field of digital map data and GIS	User Group (Expected Role)
DCIG (Ministry of Habitat Urbanism and Development of Territory)	Data development, Publication and distribution, System administration, Standard of spatial data and technology, etc	Power User Group
DU (Ministry of Habitat Urbanism and Development of Territory)	Urban planning GIS system administrator and System User, etc	Heavy User Group
DARTAR (Ministry of Habitat Urbanism and Development of Territory)	Land development planning, Region planning, etc	Heavy User Group
DIT (Ministry of Equipment and Transport)	Transportation facility planning and management system, etc	Heavy User Group
DP (Ministry of Hydraulic and Purification)	Discharging water, Main sewer management system, etc	Heavy User Group
Ministry of Industry and Mines	Natural resource management system, etc	Heavy User Group
DGPC (Ministry of Interior and Decentralization)	Fire protection system, Crime information system, etc	Heavy User Group
Environment (Ministry Delegate Office of Prime Minister in Charge of Environment)	Environment preservation system, Flood risk mitigation system, etc	Light User Group
DS (Ministry of Health)	Healthcare facility service system, etc	Light User Group

CUN	Nouakchott city information system, etc	Heavy User Group
SNDE	Water supply management system, etc	Light User Group
SOMELEC	Electric power service management system, etc	Light User Group
EU	Community support activity, etc	Potential User
DFE (Ministry of Economic Affaires and Development)	Ditto	Potential User
UNDP	Ditto	Potential User
UNICEF	Ditto	Potential User
WFP	Ditto	Potential User
WHO	Ditto	Potential User
FAO	Ditto	Potential User
UNHCR	Ditto	Potential User
World Bank	Ditto	Potential User
AFD	Ditto	Potential User
France Embassy	Ditto	Potential User
U.S. Embassy	Ditto	Potential User

4.2. Distribution of Digital Map Data

The newly created digital topographic map data of scale 1:10,000 will expectedly contribute greatly to decision-making in administration plan on Nouakchott for all ministries. Thus, an effective and practical system for the optimum diffusion of geographic information including this and building a sharing system are very important. Data diffusion will include selling of spatial data and its promotion for extensive use to public. Similarly, the Data Sharing System shall include interactive use of spatial data among the governmental organizations, especially among the Ministries. To make these two components successful, it is recommended to establish a responsible organization named, for instance, Spatial Data Center (CDS) to act as a core for handling the spatial data.

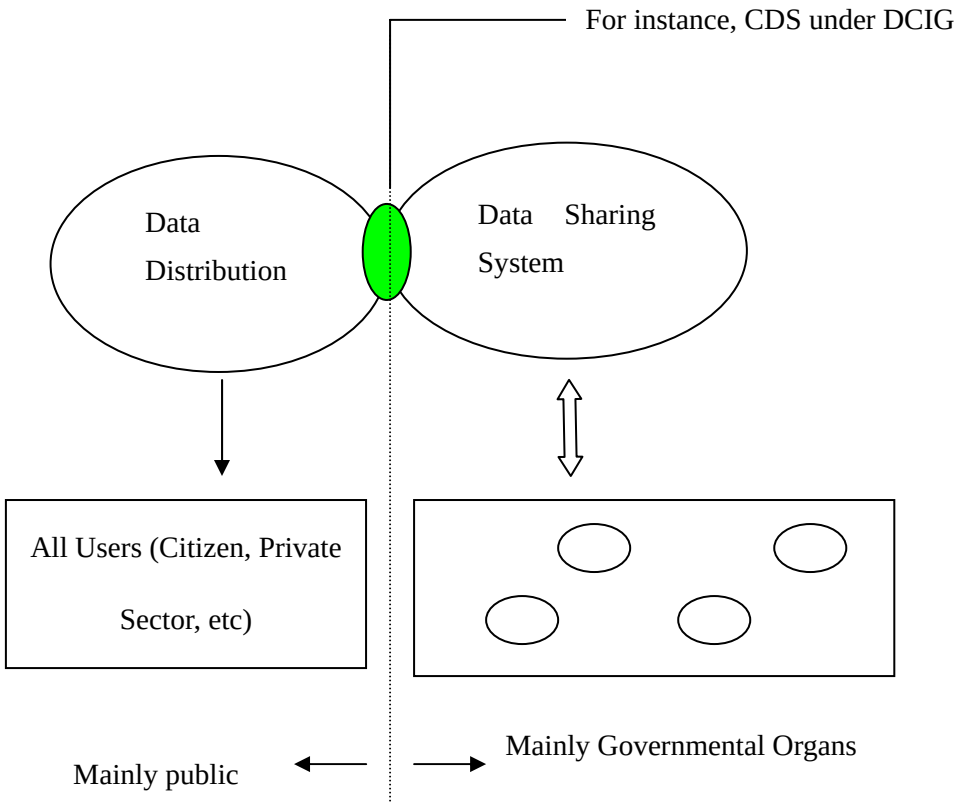


Figure 4.3 Concept of diffusion and sharing of geographic information

Thus, along with the above description of CDS, this chapter describes the two (2) main components; Distribution of Geographic Information and Data Sharing Systems.

4.2.1. Spatial Data Center

For the efficient and timely distribution of topographic data of this project as well as other spatial data available or planned to be created within the Ministry to the data users, an organization for controlling the data would be essential. This organization will also be responsible for updating all the spatial data whenever required. Thus, this will help in bringing uniformity of spatial data and will promote their diffusion. Designated organization, for instance, can be named as "Spatial Data Center (CDS)".

Throughout the realization of this Project, DCIG has been involved as the counterpart of the Study team. And also, its official coverage is development of new spatial data, publication and distribution of data, updating of data, etc. Considering this, the Study Team's proposal is to establish CDS under DCIG as shown below.

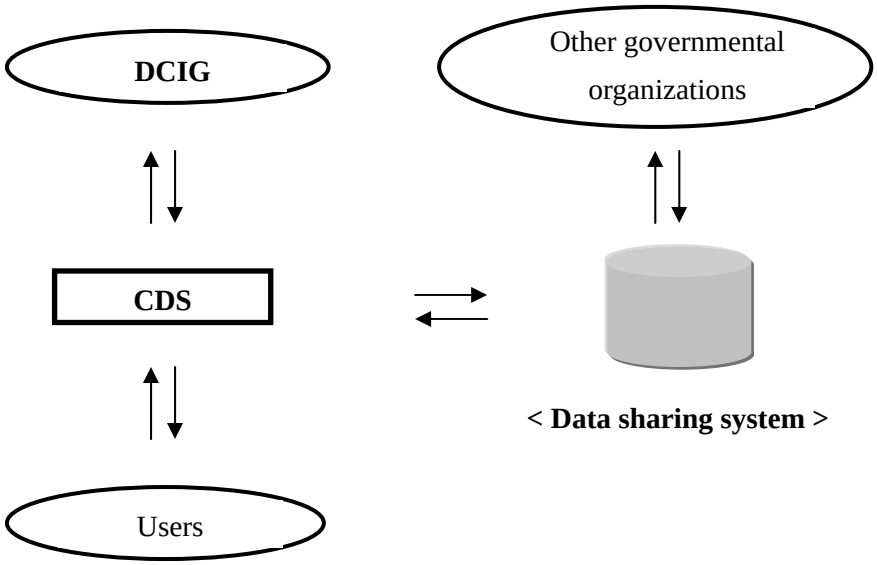


Figure 4.4 Spatial Data Center (CDS)

1). Systematizing Spatial Data Center

In order to systematize CDS, the followings need to be underlined:

a) Specific role of this center in spatial data creation and maintaining.
b) Formulation of system for updating map data.
c) Feasible infrastructure to be prepared tentatively:
   - Raising the Project team
   - Composition of hardware to work practically
   - Software to be installed.

2). Functions of Spatial Data Center

The major functions of CDS are underlined as follows:

- Promotion for data diffusion
- Facilitating for data sharing systems
- Creating, Maintaining and updating spatial data
- Setting standards for spatial data
- Others.

4.2.2. Diffusion of Topographic Data (including GIS Database)

For the wider use of spatial data including this topographic data, an organization which runs all the circulation mechanism of data creating, data distributing and service providing would be required. And also, financial resource might be necessary for the organization to operate the circulation mechanism. For this, the Study Team proposes that the spatial data should be sold. Selling of spatial data should be opened to all related organizations which want to buy the data. However, the points like types of data to be sold and clear cut pricing policy need to be clarified in advance. Similarly, need appraisal should be conducted time to time to know the demand trend of spatial data users. Moreover, promotional activities such as presenting demonstrations using the model systems created under this Project will be necessary. These all efforts will also help to maintain and to carry out activities at the CDS effectively.

For selling spatial data, two (2) cases are basically discussed; direct management by DCIG, and consignment to an agency including private enterprise.

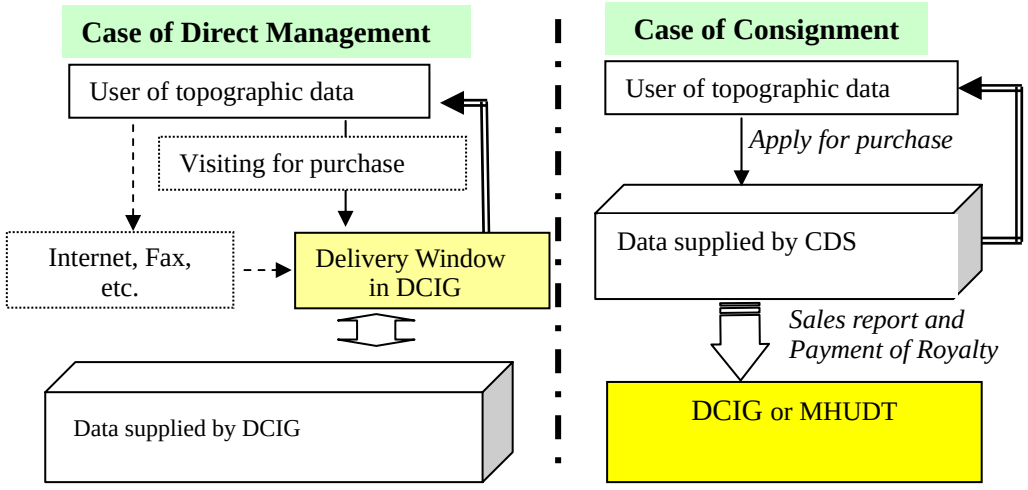


Figure 4.5 Cases of diffusion of topographic data

* MHUDT: Ministry of Habitat, Urbanism, and Development of Territory

With the case of the direct management, DCIG performs maintenance of 1:10,000 topographical maps as well as GIS database produced by the Agency as a sole organization of unifying all the geographic information. In addition, DCIG distributes the topographic data free of charge or

with payment upon the requests by playing a central role of building a system by which DCIG shall conduct distribution of the mapping products.

With the case of entrusting to the subordinate body like the agency on the other hand, the agency collectively performs data selling and supplying upon the order from a user. Then, the agency will have an obligation to submit a sales performance on a regular basis to DCIG or the Ministry. In addition, the consignee is to pay a copyright royalty, too.

Items to be sold: Even in this Project, there are different forms of data products; such as, printed maps, digital maps, GIS database, etc. And, with the concept of Spatial Data Center, various products will be piled in the future. Thus, it will be essential to decide about the product types to be diffused through selling.

4.2.3. Additional issues in the diffusion of digital map data

1). Geospatial information development plan

In this study, it was clearly understood that there is a lot of demands for the detailed maps, for example 1:2,500, 1:5,000 of scales, in order to develop water supply and sewage facility, establishing plans for drainage and to repair urban infrastructure such as, highway, green belt, disposal center, etc in the Nouakchott City.

Generally, it is expensive and time-consuming to develop a data for the new topographic maps especially at a large scale. If individual Directions of national government or local governments develop their own map data independently, overlaps of investment are likely to happen. In order to minimize the cost by avoiding the overlapping, it may be effective to set a total plan for developing a nationwide geospatial data to be named “national spatial data development plan”.

2). Collaboration of national and local governments for the development of geospatial information

There are twelve regions (wilaya) and one capital district in Mauritania. In this study, digital topographic map data (1:10,000) covering the capital district of Nouakchott was completed.

As stated above, demands for the detailed map data will be grown in the local governments. Currently, it is not a realistic situation for the Mauritanian government to prepare all data sets required by the local governments.

The digital map data prepared by local governments should be shared with the national government except some exceptional case.

3). Development of human resource

For the diffusion of geospatial data including the digital map data (1:10,000) created in this study, development of human resource is one of the important elements to be considered.

4). Utilization of geospatial information in public administration

The digital topographic map data should be utilized for public administrations in disaster mitigation, natural resource management, social security improvement, natural environment conservation, disclosure of information and others.

5). Standardization of geospatial information

The standardization of digital map data makes it easier to exchange the data among different users, organizations, social groups and others. As a result of standardization, the diffusion of digital map data can be promoted by information interchange.

6). Updating of Digital Map Data

Digital map data should be updated based on the established procedures. Without appropriate updating, the digital map data will lose connections with the spatial realities in the coming years and as a result the value of the data will be reduced.

A drastic change is taking place especially in the central area of Nouakchott and rapid expansion of human settlement to suburban area is currently in progress due to a comparatively high pressure of urban development, which makes it more important to update the data at specific interval of time.

There are forty seven map sheets (1,200 km^2) of digital map data in total and the coverage of aerial photography is 2,000 km^2. It would be recommended to update the whole digital map sheet set (47 sheets) at a single time every 3 to 5 years to preserve the freshness of the whole data set. If it is difficult to update in the above manner, it may be suggested to classify these map sheets into some classes of priority by current land use change. Moreover, map sheets which contain urban development plans or some other plans should be prioritized.

The figure below shows an example of updating cycle proposed by the Team.

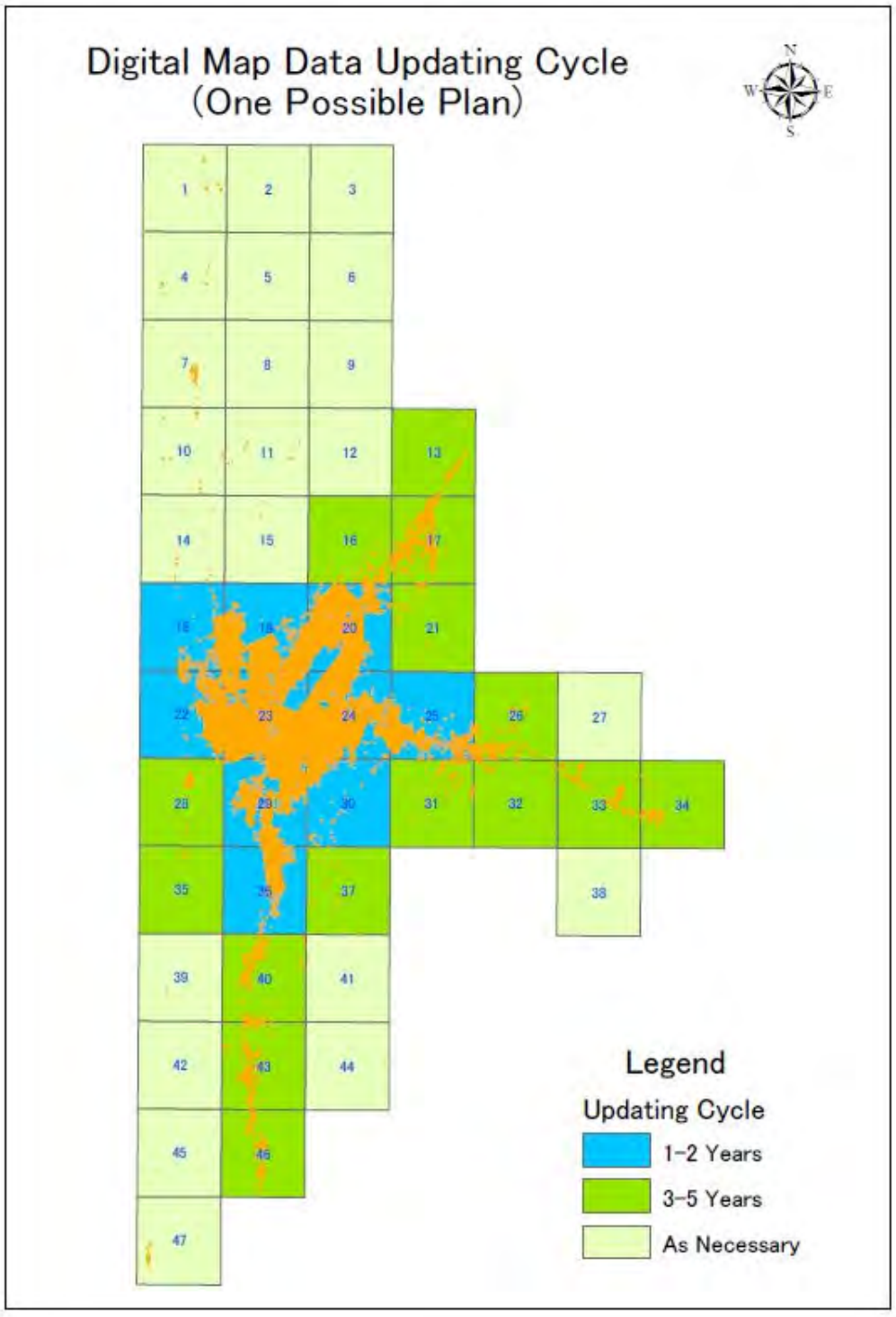


Figure 4.6 Updating cycle of digital map data (example)

4.3. GIS Model System

The newly created digital topographic map at the scale of 1:10,000 covering whole the built-up area of Nouakchott and its surroundings is expected to contribute greatly to planners and decision makers in formulating plans for managing informal settlements, improving sanitation, conserving environment and so on.

Demonstrating the usefulness of the dataset will undoubtedly help promoting their diffusion. Thus, the Team has made an attempt to prepare GIS models showing some of existing issues in Nouakchott.

4.3.1. Creation of GIS model system

The model system was designed and developed taking the following respects into consideration.

- Practical performance
- High-priority issue
- General-purpose properties
- Fast-acting properties

4.3.2. Software and hardware for GIS model systems

The following system environment was adopted in order to have beneficial effects on GIS model systems.

1). Software

One set of ArcGIS with ArcInfo license has been installed for carrying out the priority issues.

2). Hardware

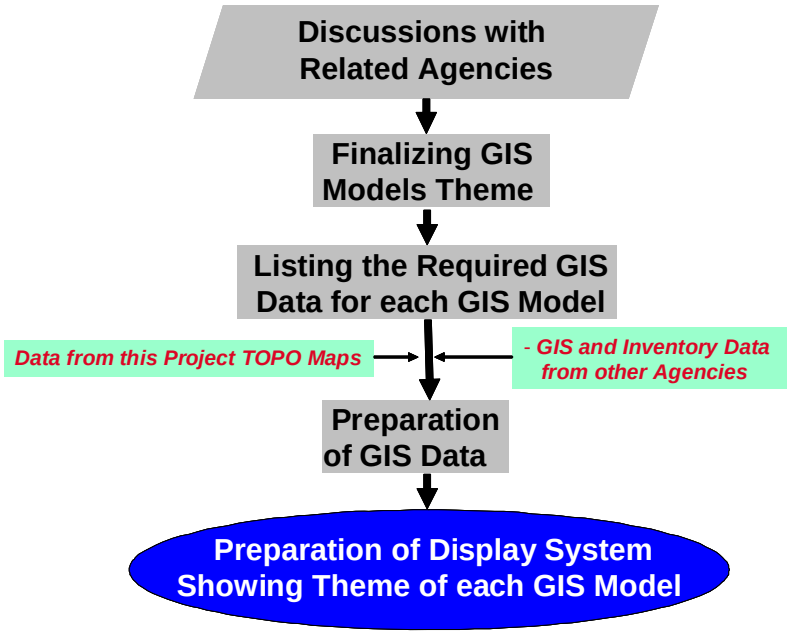
The specification of hardware installed with the GIS software (ArcGIS with ArcInfo license) and extensions of 3D analyst, Spatial analyst and Network analyst is as follows: Processor - Intel Xeon Processor 5160, 3.00GHz with 4MB L2 cache (Dual Capable) 1333MHz FSB or better.

4.3.3. GIS data and Model system

For preparing the GIS data and model system, building data, address data set, DEM, elevation class, etc were extracted from the topographic map data Those data and GIS models are applicable to the current issues of Mauritania immediately.

1). General flow of GIS model system construction

Its general flow-chart is presented below:



2). Themes for GIS Model

Discussions were held with DCIG and other related governmental and non-governmental organs to explore details about issues in the central area of Nouakchott and its surroundings. Considering the points popped up during discussion, following four themes were selected for preparation of GIS models. Related organs to each theme are given below.

Table 4.3 Themes of model system

Theme		Related organizations	GIS data used
1	GIS model for address search and display	City of Nouakchott (CUN)	See 1. in the next table
2	GIS model for potential flood risk management	Direction General of Civil Protection (DGPC)	See 2. in the next table
3	GIS model for water supply facility management	National Society of Water (SNDE)	See 3. in the next table
4	GIS model for facility management	Ministry of Health, Ministry of Fundamental Education	See 4. in the next table

The GIS data used in preparing the models for each theme were listed below.

Table 4.4 Data used in each theme

Theme	Data				
	From topographic map (1:10,000)				Other
	Roads	Buildings		Other	
		Large	Small		
1	Line data attribute of roads	Polygon data (Health center, school, Other public facilities)	Point data	Location of water point sources (*as points*)	Attribute data of roads, Attribute data of blocks
2	Line data	Polygon data	Point data	Contour lines, Leveled point, Spot heights	
3	Line data	Polygon data	Point data		Attribute data of water point sources, Photos of water point sources
4	Line data	Polygon data			Orthophoto, Attribute data of roads, Attribute data of blocks
		Schools (Junior high school, High school) (*as points*), Hospital, Health Center (*as points)*			

Then, after listing the required GIS data for each model, the Team prepared these data which include not only the data from topographic maps by this project but also those provided by other agencies. Then, the Team prepared the GIS model systems.

3). GIS Model System for Address Search / Map Display

- **Purpose**

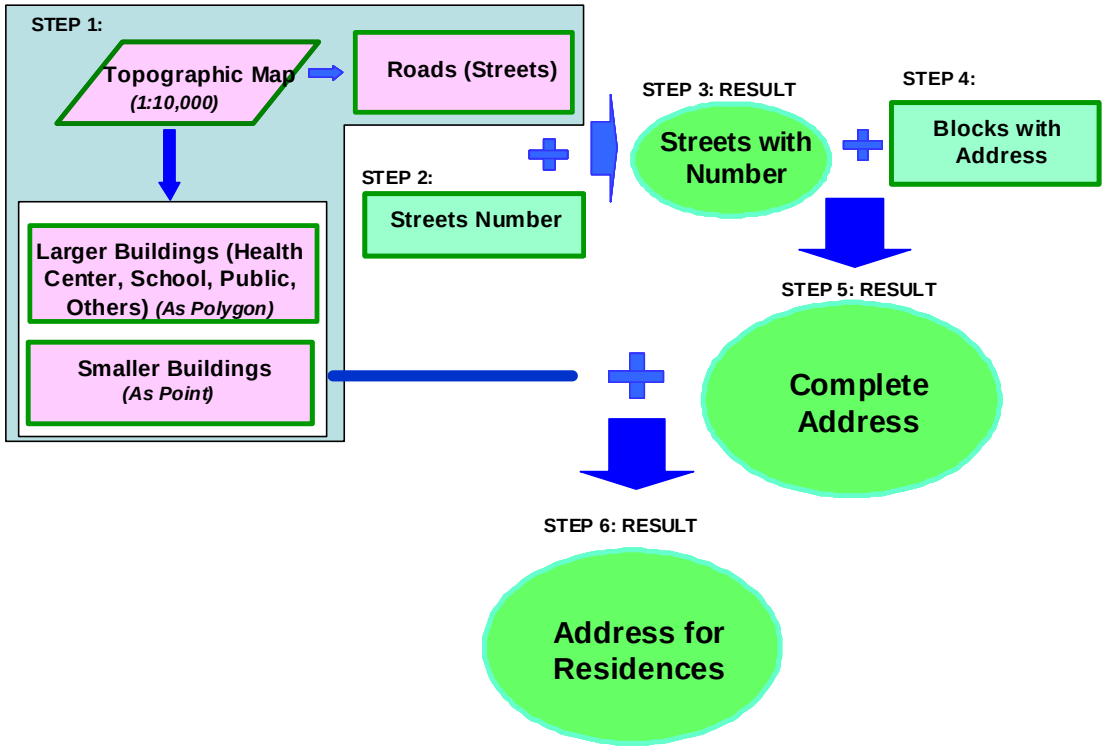
There are two ways to indicate a position on the earth. The one is direct indication with a set of coordinates and the other is indirect indication with address.

Address is used to indicate a location in human society in the most general way. For example, the location of buildings, facilities and parcels of land would be specified by their

address.

Address data of this model system can be utilized for searching a place, telling a place, managing a facility, and so on.

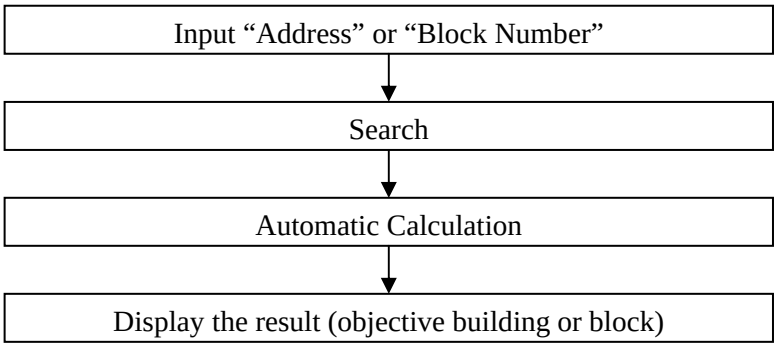
- **Items and Methodology**



The data of road number (street address) which had been provided by the counterpart, was added to the Road data extracted from 1:10,000 topographic maps. Then, they are displayed with Block having their own number. Altogether this consists of an address system of Nouakchott. Lastly, it is displayed with Buildings data (from 1:10,000 topographic map data) for address search and display.

Besides, Health center, School, and Public, all other larger buildings (polygon data) included in the 1:10,000 topographic map are categorized as other buildings. These data along with smaller buildings (as point) are displayed as background.

➢ **Procedure of using (analysis or search) in the system**



➢ **Examples of application**

Tools for address search consists of “Address Search by Street Address”, “Address Search by Block Address”, and “Address Search by Landmark”.

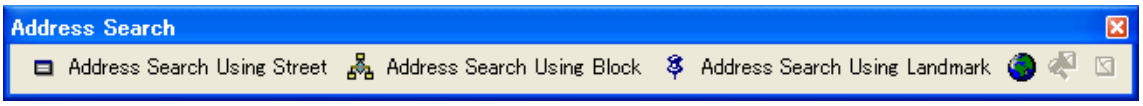


Figure 4.7 Tool-bar for address search

The following figure shows the way how to use the tools.

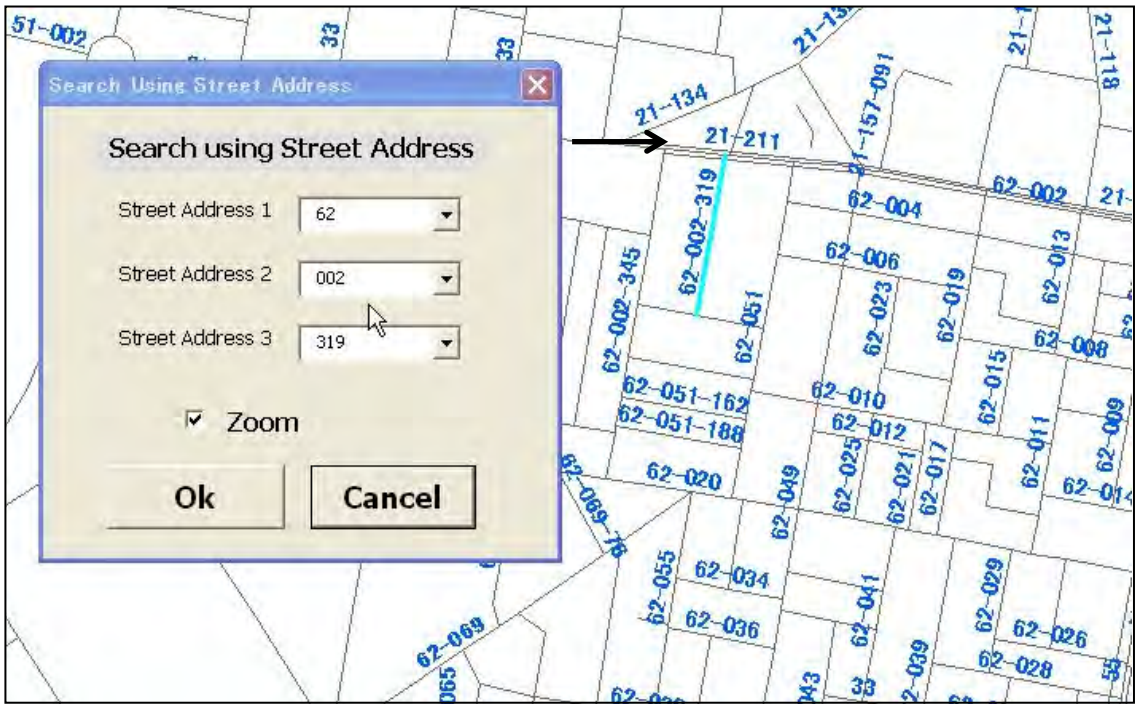


Figure 4.8 Address search tool by street address

- Address-search and map-display by street and bloc address for private use.
- Address-search and map-display by street and bloc address for public use.
- Address-search and map-display by street and bloc address for emergency use.

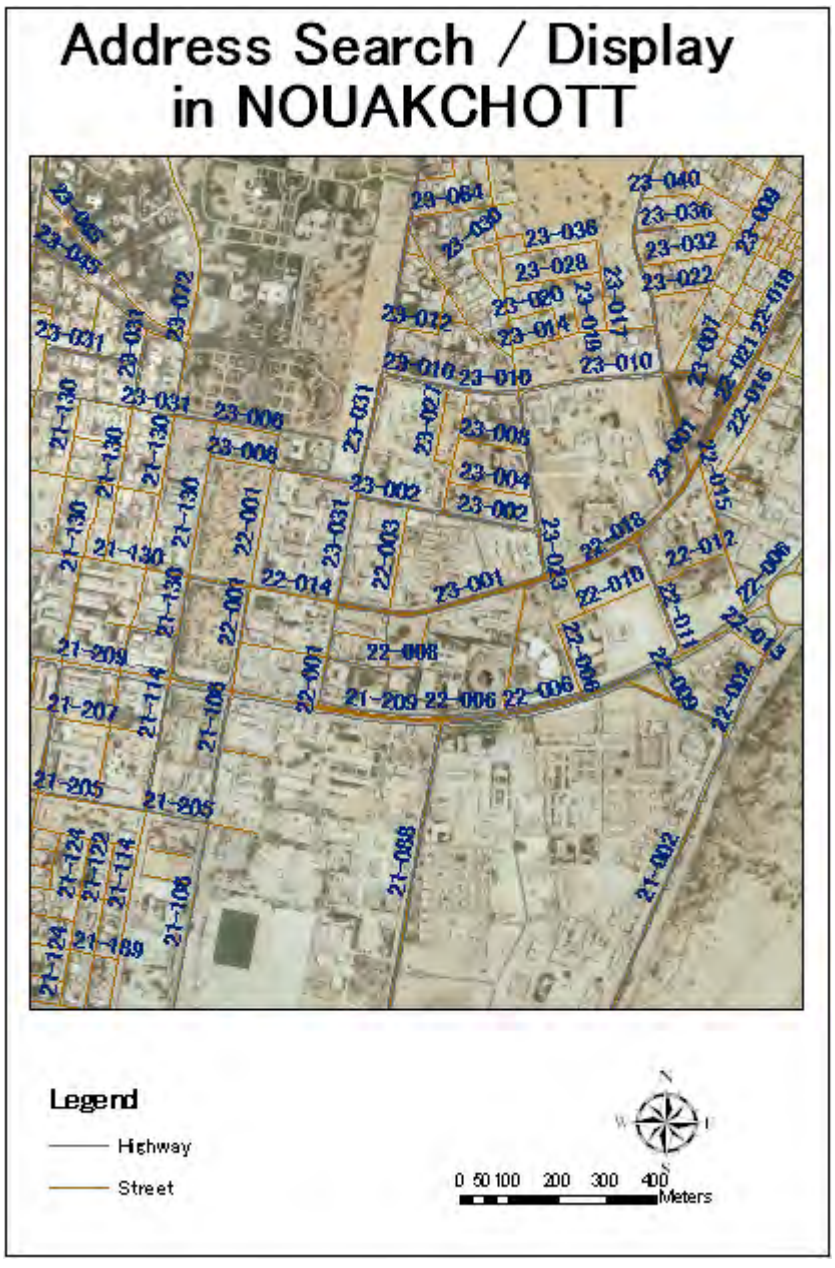


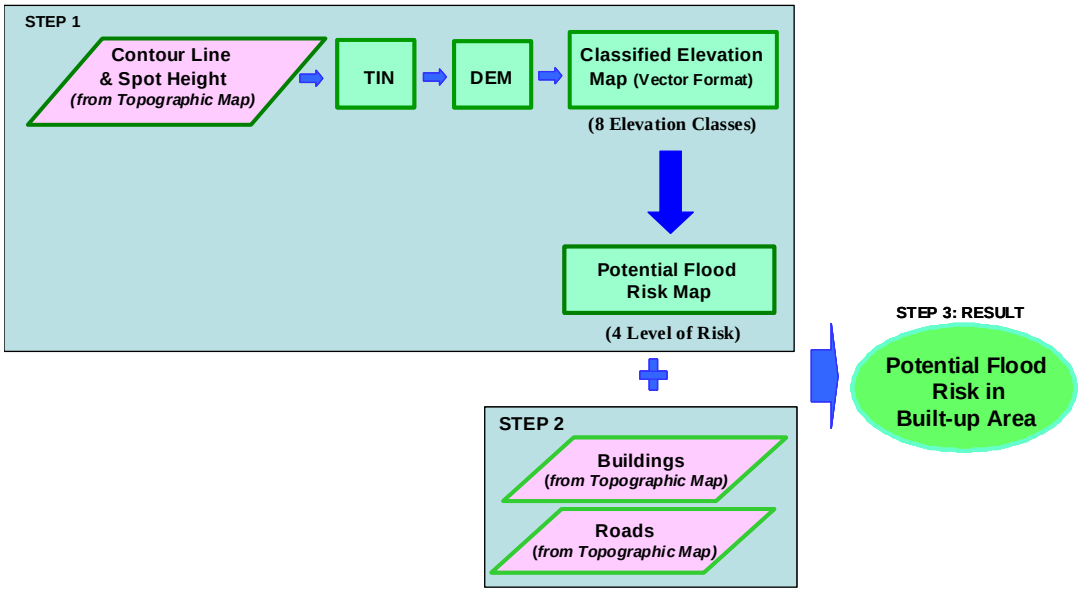
Figure 4.9 Street address in Nouakchott

4). GIS Model System for Potential Flood Risk Management

➢ **Purpose**

Nouakchott has suffered from a number of inundations in the past caused by heavy rainfall, flood of Senegal River, and beach erosion. Without protection measures, the risk of inundation by heavy rainfall will stay for the future. The risk of inundations of Senegal River-origin has been minimized. The risk of inundation caused by beach erosion will stay or increase without any countermeasures. This GIS Model was constructed by analyzing elevation around the Nouakchott for potential flooding on the built-up area, whose topography is nearly flat. This Model will greatly help in planning and implementing countermeasures in advance to minimize the damage caused by the disaster.

➢ **Items and Methodology**



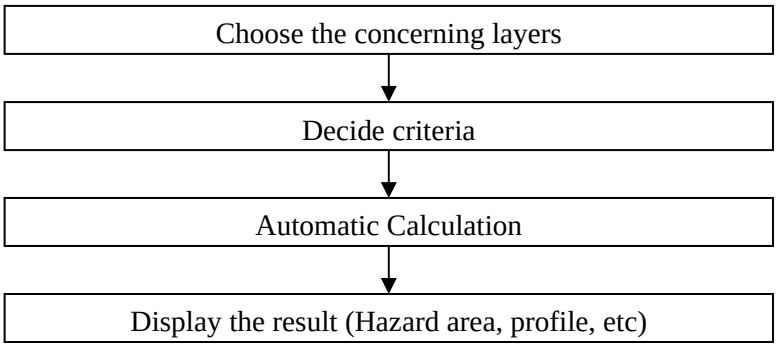
The contour lines and point data containing height information were used to create TIN (Triangulated Irregular Network), which was used to create DEM (Digital Elevation Model). The DEM, being in Raster format, represents the real world with respect to elevation as a matrix of cells or pixels. In this model, the pixel size of DEM is 20m. Considering the elevation difference from the mean sea level and further its potentiality for inundation, the elevation map is created by dividing the elevation around Nouakchott into 8 classes. This map is further classified into four potential flood risk categories, as presented below:

Table 4.5 Criteria for Elevation Map and Potential Flood Risk Map

Elevation (m)	Elevation Class	Potential Flood Risk Level
≤ -1.50	1	Serious potential risk
-1.49 to 0.00	2	
0.01 to 1.00	3	Moderate potential risk
1.01 to 2.00	4	
2.01 to 3.00	5	Less potential risk
3.01 to 5.00	6	
> 5.01	7	Low potential risk

The above Potential Flood Risk Map is displayed along with back ground data; Buildings and Roads are urban facility to show its seriousness in the built-up area of Nouakchott.

- **Procedure of using (analysis or search) in the system**



- **Examples of use application**

- Analysis of inundation hazardous area
- Hazard map
- Analysis of site location
- Disaster countermeasure planning
- Damage prediction

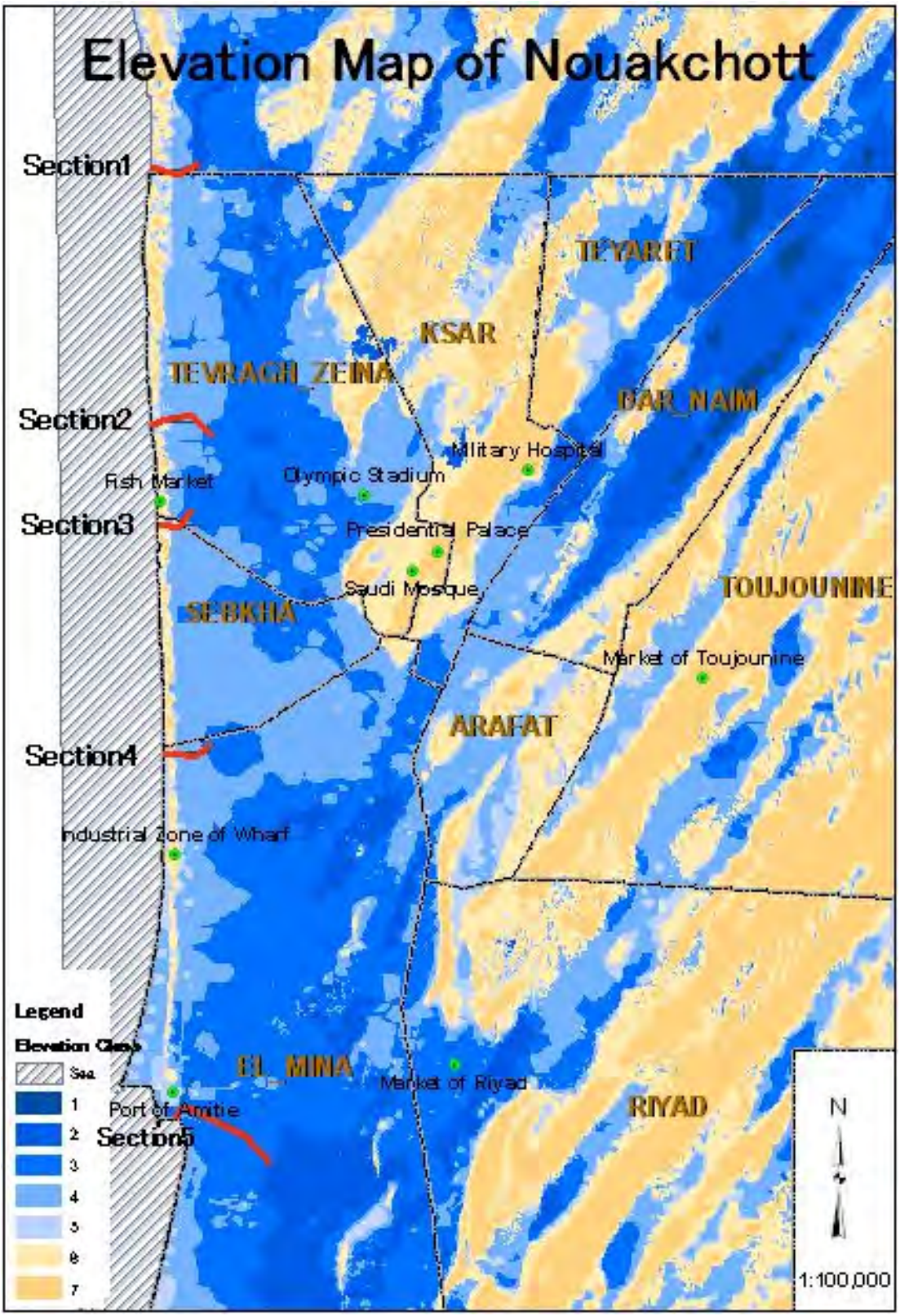
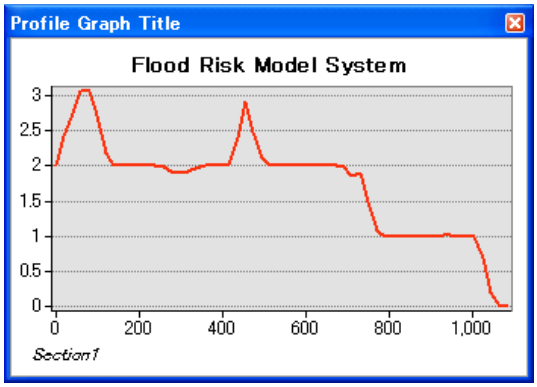
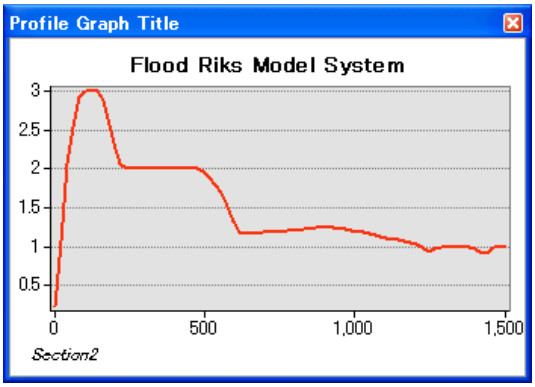


Figure 4.10 Elevation map of Nouakchott

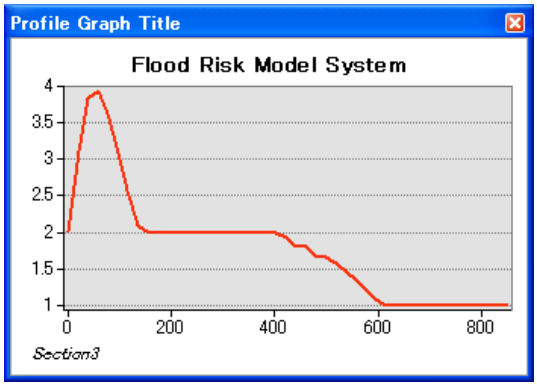
Section 1 of beach ridge



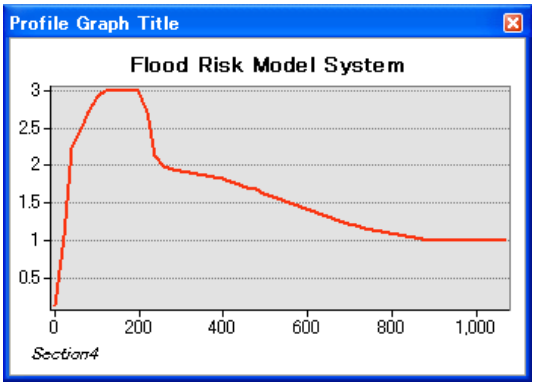
Section 2 of beach ridge



Section 3 of beach ridge



Section 4 of beach ridge



Section 5 of beach ridge

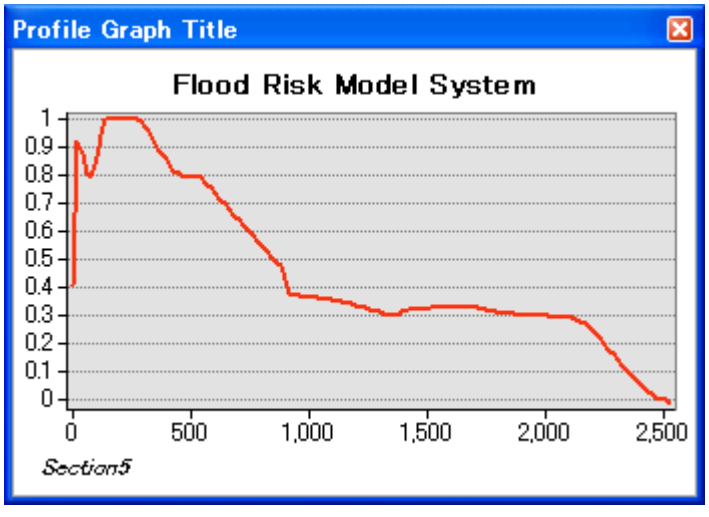


Figure 4.11 Section diagram of beach ridge

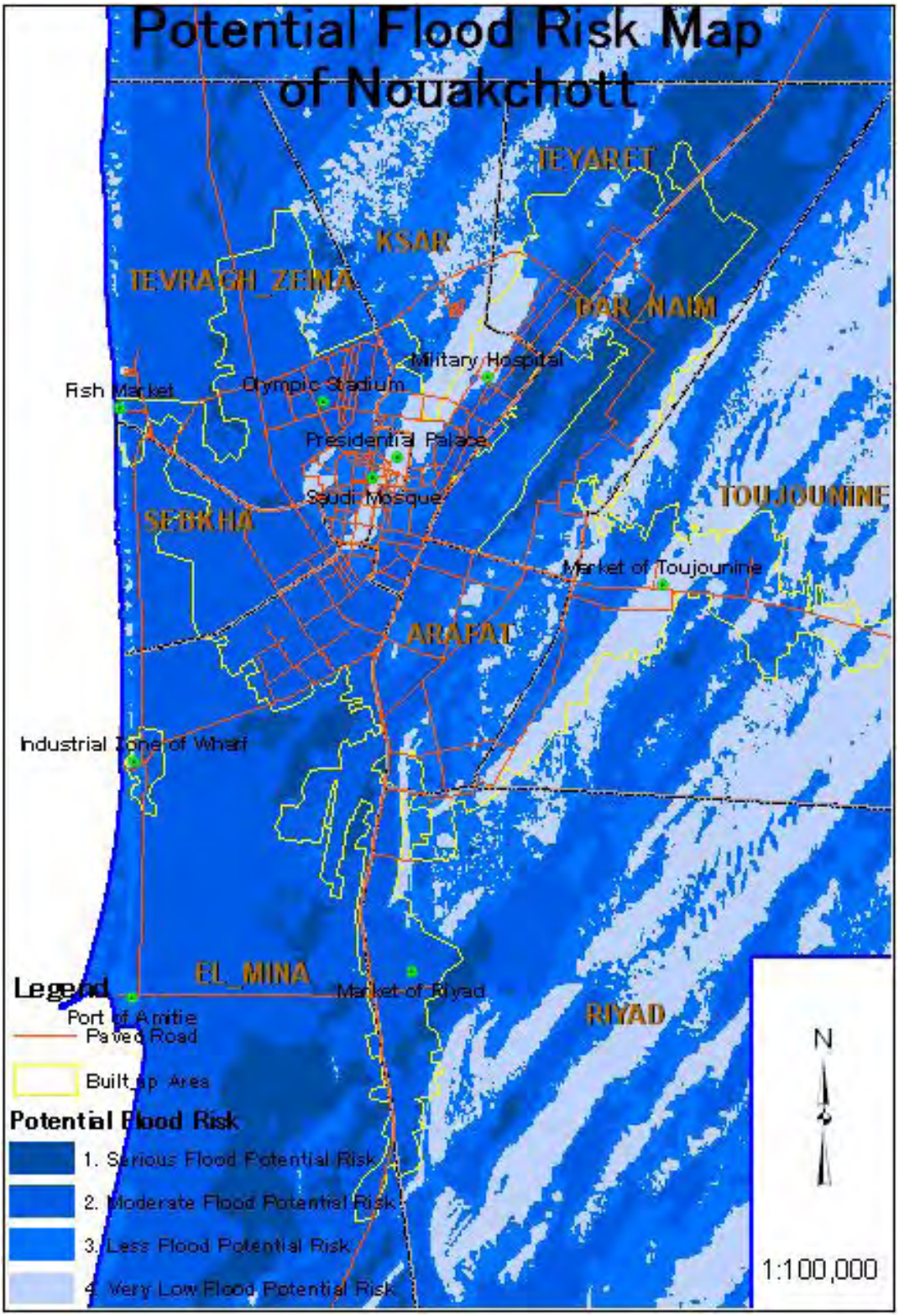


Figure 4.12 Potential flood risk of Nouakchott

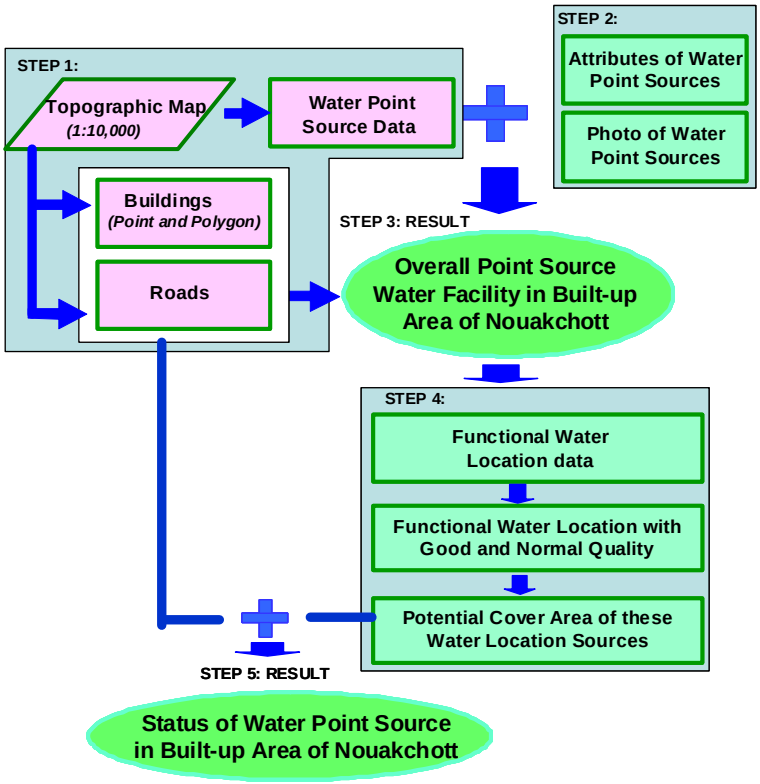
5). GIS Model for Water Supply Facility Management

➢ **Purpose**

Water supply is one of critical issues in the whole area of Nouakchott. With this essence, this GIS model was created to present the existing status of water supply facilities in the area of point source such as well, water tank, etc. Thus, this would contribute in their timely and efficient management.

➢ **Items and Methodology**

The main steps adopted for this Model are presented in the flowchart below.



Out of the GIS data of topographic map (1:10,000) prepared under this Study project, the layers related to the water point sources, small buildings, large building and roads were selected and arranged to get separate data for water sources (as points), small buildings (as points), large buildings (as polygons), and roads (as lines).

The attribute data related to the water point sources, which provided by the related agency (Nouakchott Urban Community), was combined with its spatial data. Also, the photograph

of these point sources (whatever could be taken) were linked, which can be displayed even in ArcGIS environment. After combining the attributes data and photographs, the water point source data is displayed along with buildings and roads to have better understanding of their distribution in the built-up area of Nouakchott.

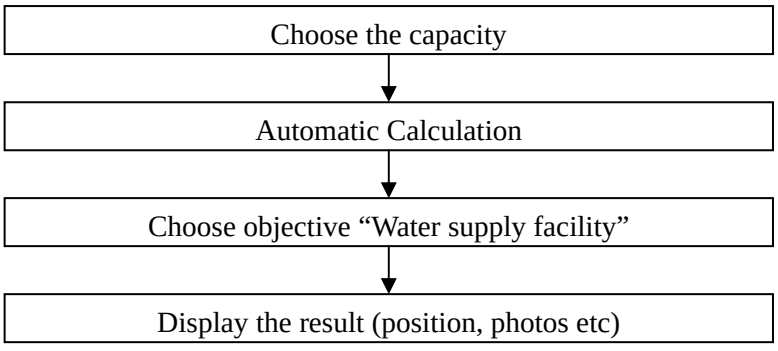
The attribute table of water point sources contains pretty large number of fields (Items). For instance, a field presents whether point source is functional or non-functional. Thus, among these water sources, many are currently not in function. Also, out of the functional ones, some have water quality as bad, which can not be used for drinking (normal and good water quality). Considering these, the functional water point sources, which have drinkable water quality, have been selected and further analyzed by buffering based on their water supply capacity with following criteria:

Criteria for buffering:

- Smaller supply capacity (approx. coverage < 50 households): buffer with 39m
- Medium supply capacity (approx. coverage 51 – 200 households): buffer with 50m
- Large supply capacity (approx. coverage > 200 households): buffer with 84m.

Finally, the status of water point sources with the above result is displayed along with background data (buildings and roads).

➢ **Procedure of using (analysis or search) in the system**



➢ **Examples of use application**

- Study current service
- Water Supply / Demand Check
- Water distribution plan

- New setting / replace / remove water facility
- Water service / quality check

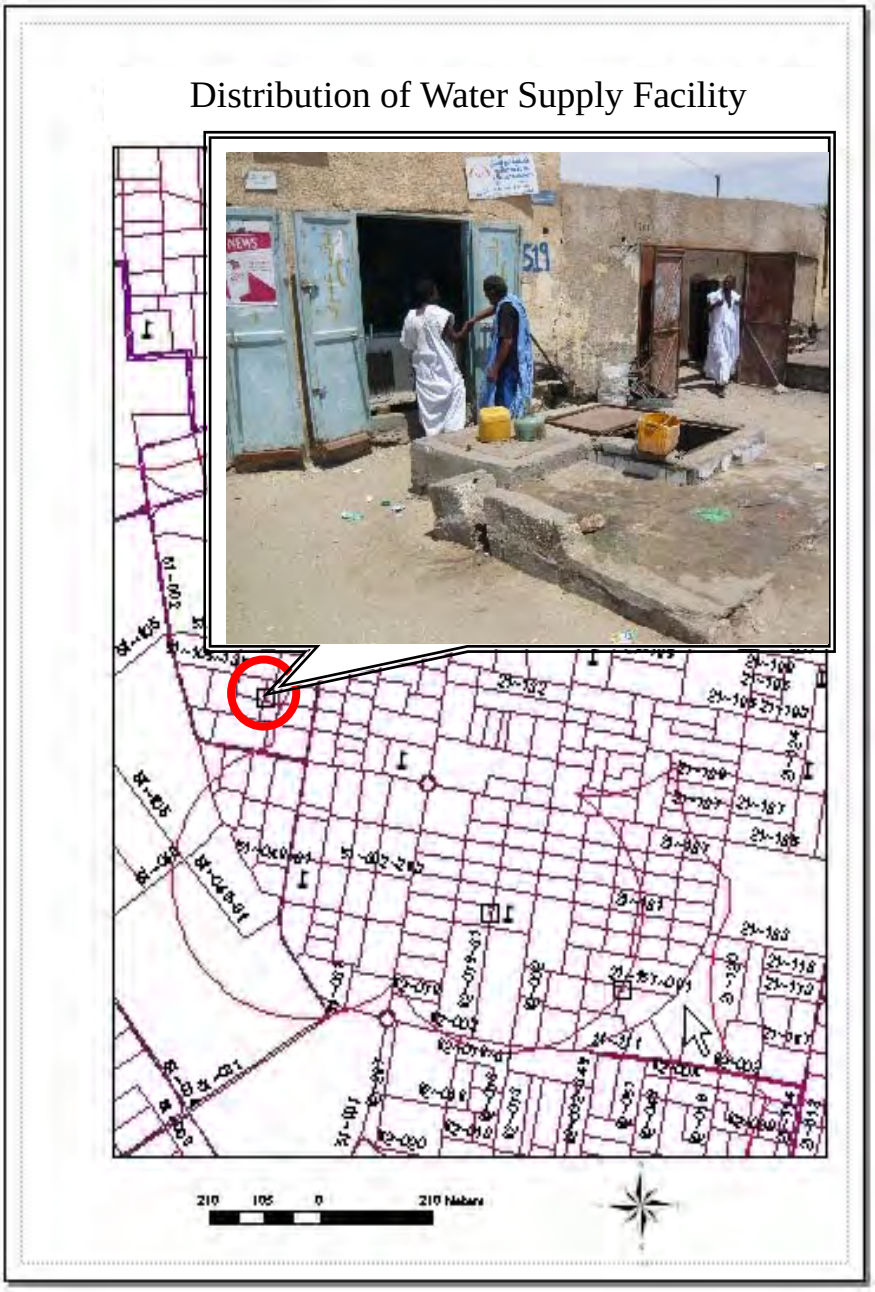


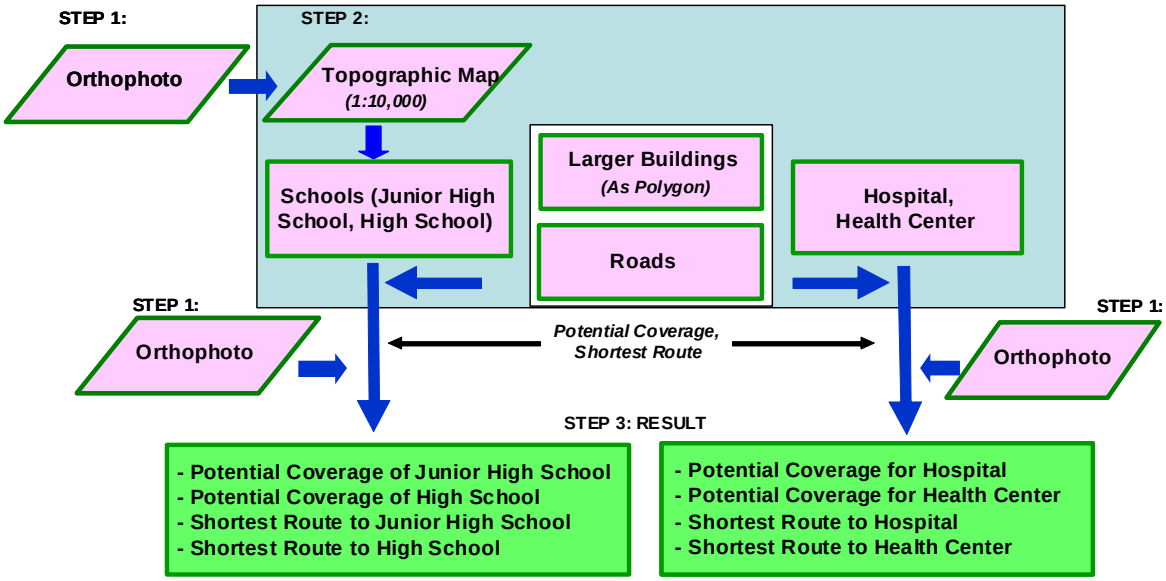
Figure 4.13 Status map of water supply facility

6). GIS Model System for Facility Management with Network

- **Purpose**

The GIS model system shows a typical example for analysis of public facility distribution, site location using buffering process. In this example, the location analysis of school, health care facilities is performed.

- **Items and Methodology**



Out of GIS layers of Topographic Map (1:10,000), Junior High School, High School, Hospital, Health Center is analyzed for its potential coverage of service by buffering with following criteria.

Criteria for buffering:

- Junior High School: 500m
- High School: 1,500m
- Hospital: 500m
- Health Center: 200m

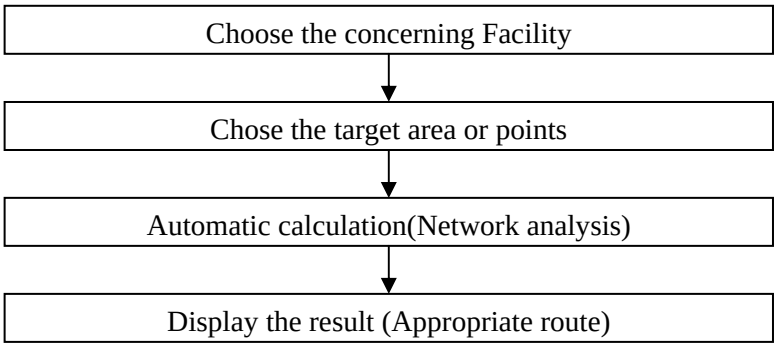
Above analysis depicts the area which is out of coverage of any school or health facility, if there is any.

Similarly, by taking few locations as sample in the built-up area, the shortest distance to reach to the school or health facility is analyzed to show its importance in case of

emergency.

All the above displays (coverage of School or health facility, shortest distance) include layers of Buildings and Roads as background.

- **Procedure of using (analysis or search) in the system**



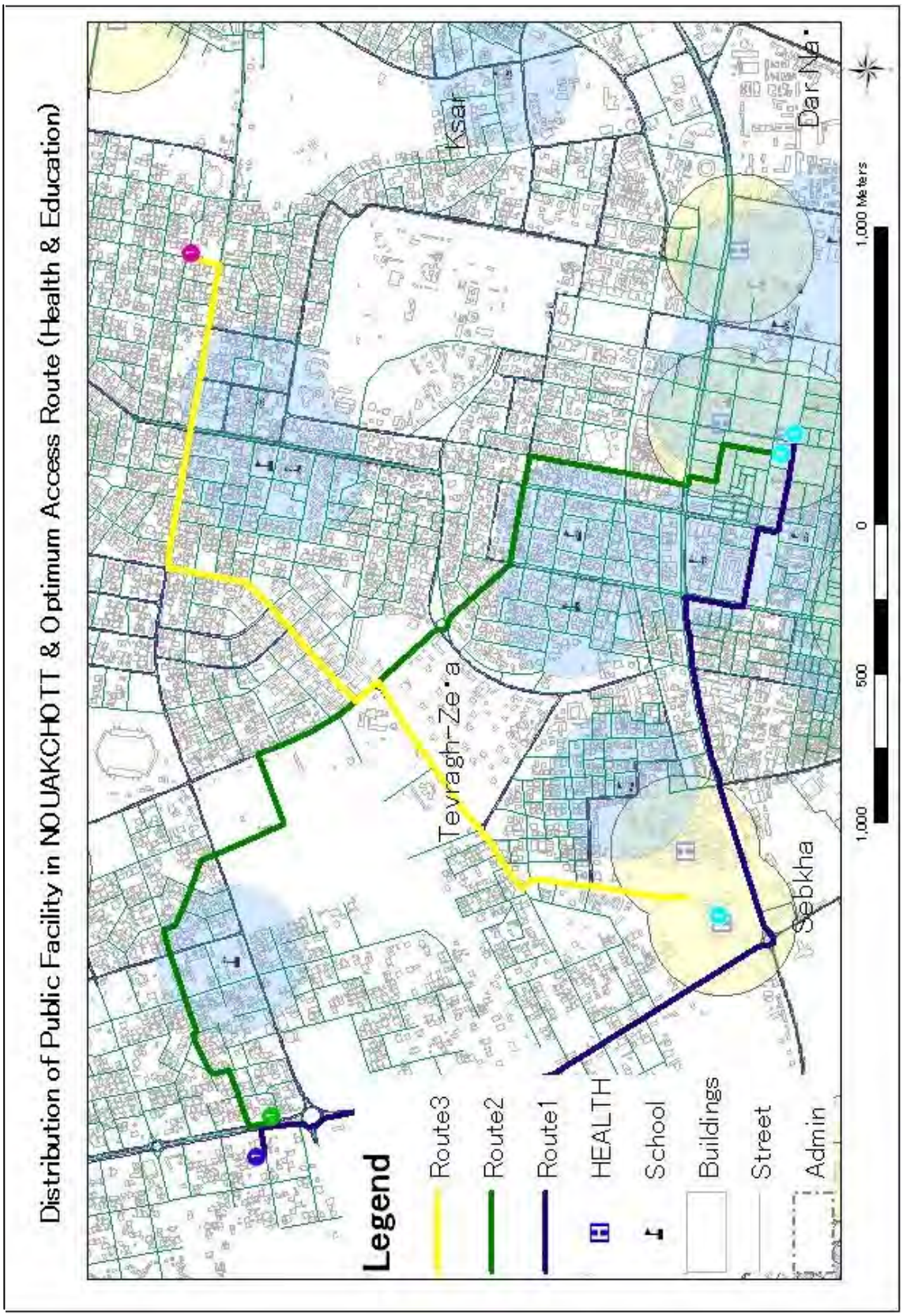


Figure 4.14 Distribution of public facility and optimum access route

CHAPTER 5. CONCLUSION

The Study started in April 2007 and completed in May 2010 with the context given in Section 1.3, that is, rapid growth of population and land use change of Nouakchott and lack of updated maps in digital form. All the planned works were carried out without a skip and achieved digital geographic database of satisfactory quality, which enables the users to make various applications of GIS. In addition, technology transfer to the technical staffs of DCIG and other relevant organs was conducted in order to enable them to perform digital mapping, data updating and data usage. The targeted levels of technologies were attained.

The geographic database of Nouakchott is a newborn national property, so it is essential for the Government of Mauritania to make every effort to promote application of the database to various fields of use and keep the database for sustainable use.

In order to keep sustainable use of the database, it is recommended that the Government would build an appropriate system for data maintenance and distribution, where data maintenance includes data updating, data improvement and data development.

DCIG, the national organ in charge of geographic information service, is required to perform its duty to maintain the database in good shape and to distribute the data to the users with efficiency. There are two approaches for building the system. One is that DCIG would directly manage the data service by equipping a laboratory exclusive for data maintenance and distribution inside of the Direction. The other is that DCIG or the Ministry would consign the data service to an agency or a private enterprise, which manages all data service under the supervision of DCIG.

In any case, it is recommended that DCIG would be technically capable for managing the data service. Technology transfer was conducted under the project and the Mauritanian staffs have attained to a level to perform practical processes of field works, but as especially for the indoor processes, they are required to make more progress by continuing voluntary trainings. At the same time, they are required to spread the technologies to other staffs in order to maintain the technical level of DCIG.

It is also recommended that the database and the new equipment should be carefully maintained for sustainable data service.

A governmental body for coordinating the needs of users and diffusing the applications should

be organized from a viewpoint of sustainable use of the database, so it is suggested that the National Commission of Geographic Information would be organized as soon as possible.