Chapter 5

GIS in Urban Planning and Infrastructure Management in Qatar
The evolution of Geographic Information System (GIS) in Qatar has come a long way. Qatar is the first country in the world to have implemented a comprehensive nationwide GIS and is internationally recognized so. This chapter will deal with the history of GIS in Qatar, organizational set-up, functioning aspects in technological terms as well as integration and operation in the different sectors of the economy.

History of GIS in Qatar

The GIS in Qatar was introduced in 1989 by Sheikh Ahmed bin Hamad Al-Thani, a member of the ruling who is popularly known as Champion of GIS in the state. Witnessing a demonstration of GIS technology in Canada and recognizing its potential to revolutionize the way information is managed, he was very much convinced about its implementation in Qatar. He persuaded some of the senior members of the government and with their cooperation a government-wide user needs study was conducted in the same year to ascertain which areas of government would clearly benefit from the implementation of GIS. The study indicated that the potential use of GIS in Qatar was enormous. Three key recommendations resulting from the study were:

- Implementation of digital mapping database for the entire country;
- Creation of a comprehensive fully integrated nationwide GIS;
- Establishment of a high level National GIS Steering Committee to set standards and oversee the implementation and development of GIS in Qatar.¹

The recommendations were translated into action by the establishment of a National GIS Steering Committee and The Centre for GIS (CGIS) in 1990. The role of the CGIS was to implement GIS in Qatar in an organized and systematic fashion and impartially serve the GIS requirements of all government agencies. One of the primary tasks of the Centre was to implement a high resolution Digital Topographic Database which is now in place providing a consistent framework for a wide range of GIS users and their applications.

Mr. Zuljiwani, a man with vision, brought by Sheikh Ahmad bin Hamad Al-Thani was the key player for implementation of GIS in Qatar, who transformed the dream into reality. Being determined to set up a GIS system in Qatar he came out with the complete directive of its implementation. He preferred the top-down approach of the implementation plan to reduce the development and operational cost in terms of manpower, hardware and software.²

Today, 17 government agencies in Qatar are using GIS in their day-to-day activities.³ Their databases are compatible and they are all integrated through high speed fibre optic network. Dozens of GIS applications have been developed and are at use benefiting government workers, private businesses and citizens alike. The agencies participating in the GIS network in Qatar are depicted in figure 5.1.

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¹ Based on a document “Qatar Geographic Information System” provided by the Centre for GIS, Doha, Qatar, May, 2004.

² As per information given by Mr. Syed Murtaza Ali, GIS Technologist, Qatar General Electricity and Water Corporation, Qatar, May 2004.

³ A Deva Kumar Verma, “Qatar: A Road Map for National GIS implementation”, GIS@ Development, November 2003, pp. 39-44.
All agencies in Qatar using GIS are connected by a high-speed fibre optic network called *GISnet*. The participating agencies share over a hundred gigabytes of spatial and non-spatial data on-line on daily basis to carry out their specified tasks. The data mainly consists of vector topographic data, raster data and satellite images maintained by CGIS, apart from specific agency data such as land parcels, utilities and services, addresses and various statistical data related to

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socio-economic issues from Planning Council census division. Through GISnet all the public data is shared which augment the inter-agency cooperation. The structure of the network is shown below.

![Qatar GIS Network](image)

**Figure 5.2: Structure of Qatar GIS Network**

**Recognising the Need for GIS Implementation**

As comprehensively explained in Chapter 3, Qatar experienced rapid urban growth during the past three decades after the discovery of oil. In order to meet the emerging requirement of the country’s development, several hundred kilometres of roads, drainage networks, telephone lines, power and water networks and other utilities have been built accompanied by a spurt in new real estate developments. The post oil era was the boom period leading to rapid development, hence, there was no time for planning or documenting. By the late 1980’s, re-building started.
for that had been constructed too hastily in the late 1960s and 70's.\textsuperscript{5} The government agencies in the country were unable to keep up-to-date records of this rapid and large-scale development. The lack of information together with inadequate inter-agency co-ordination led to poor and inefficient physical and utilities planning and management of resources.

The government agencies accountable for providing utility services to the inhabitants produced and maintained paper base maps at different scales to store and display information relevant to them. Apart from the cost of surveying and mapping exercise, there existed duplication of efforts and wastage of resources. Moreover, there was inconsistency in the results from one agency to another. There was lack of coordination between these agencies involved in physical and utilities planning that resulted in inharmonious infrastructure expansion and urban growth leading to large strain on government expenditures.

Shrinking budget and escalating expenditure on duplication of efforts led the government to realize the need for an innovative means of tapping and managing vast information resources that facilitate more constructive decision making required to sustain the developments and to maintain newly built infrastructure. The realization that eighty percent of this vast information was geographically related, prompted the government officials to choose GIS technology as viable solution. The adoption of the technology revolutionized the way information is managed in the country since the 1990s.

**Organisational Structure of Qatar GIS**

Qatar adopted the top-down approach for GIS implementation in the state. Figure 5.3 describes its organizational structure. The Cabinet is the sole authority for policy decisions at the national level. Hence it stays on the top. The proposal for every guiding principle has to be ratified from the cabinet. The National Committee for Coordination of Government Services is responsible for

\textsuperscript{5} Qassim Mohammed Ali Al Ghanim, "Qatar's GIS - A Unique Model for Next Millennium GIS", A paper presented in a unspecified conference, See www.gisqatar.org.qa
harmonization of all services provided by the different agencies to the people. Every developmental agency reports to this supreme committee about their vocation that in turn reports to the cabinet headed by HH the Emir.

The *National GIS Steering Committee* consists of top government executives from different government agencies mostly directors of ministries. The responsibilities include development of GIS policy, developing GIS standards, defining database creation priorities, devising guidelines for data sharing and work for GIS training programs.\(^6\) Apart from overseeing the development of GIS in Qatar, all specifications and data dictionaries are approved and administered by this committee to ensure that all GIS standards in the country are compatible and in harmony so that data sharing is never jeopardized.

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\(^6\) As per personal interview with Mr. Shakeel Qadri, Technical Head of CGIS, Doha, Qatar, May, 2004.
Center for GIS (CGIS) was the nodal agency for developing and maintaining GIS applications. All activity regarding the implementation was done by CGIS in the incipient stage. Later each ministry had one dedicated section of GIS application to take care of departmental needs specific to them. The placement of the GIS section within the different ministries was most critical aspect with respect to implementation and administration. All the staff were recruited by the Baladiya (Ministry of Municipal Affairs & Agriculture) and trained and retained by CGIS. Later all were transferred to the GIS sections of different ministries.

The GIS Coordination Group consists of coordinators who head their departmental GIS and are normally technical persons. The coordinators of all ministries and departments report to the head of CGIS in a meeting held every two weeks. They discuss their specific technical issues and find out solutions collectively. In this way they remain updated about all the concerned departments. Sharing of the experiences in each department helps in a big way to solve any problem in terms of system development and implementation.

The CGIS is considered the key player of GIS implementation and maintenance in the State of Qatar shouldering various responsibilities to turn the national mission a reality. Therefore, the need is recognized to describe its role and functions in detail. The following section is devoted for the same.

Centre for GIS: Role and Mission

With the motto: 'We provide the data, you make the difference', the mission of the Centre for GIS is to coordinate a systematic implementation of GIS in Qatar, which simplifies data transfer between all agencies, minimizes data redundancy, and ensures suitably trained personnel are available to operate and manage the various components of the system.7

7 www.gisqatar.org.qa
This is the mission statement of the CGIS which is achieved by developing national standards, specifications and procedures for the orderly collection, storage and retrieval of GIS data; by encouraging inter-agency cooperation; by providing a high speed fibre optic network (GISnet), accurate spatial reference bases, technical support and advice by developing special products, by hosting training programs, seminars and conferences and by publishing periodicals.

In carrying out this mission, The CGIS provides support and services in the following areas which acted as a key component of implementing nation-wide GIS in the State of Qatar 8:

- CGIS is official mapping agency for the State of Qatar, maintaining and providing on-line access to Qatar’s Digital Topographic Database. This comprehensive database comprises of highly accurate, topologically structured, Topographic Vector Maps; high-resolution ortho imagery and high precision Digital Elevation Model.
- It convenes and chairs GIS Coordinators’ Group meetings on a regular basis, normally every two weeks, with representatives from every agency. The Centre encourages cooperation, sharing and coordination of GIS activities and ensures adherence to and compatibility of all GIS standards.
- The Centre maintains the high-speed fibre optic network called GISnet, linking all of Qatar’s GIS databases and ensures it is secure and operational at all times.
- As the official geodetic agency for the State of Qatar, the Centre maintains geodetic networks and maintains an active GPS Base Station, which tracks GPS satellites 24 hours a day.
- The Centre makes these GPS signals available on-line to users and computes and broadcasts differential corrections.

8 Ibid.
• The Centre also supports and assists government agencies in setting up their GIS units, and training their personnel in data automation procedures and in the development and use of database specifications, standards and GIS applications.

• Developing products of value for a variety of GIS and GPS users is an important part of the Centre's work and is already being implemented for various government agencies and the public alike.

• The Centre also provides technical information and support to the National GIS Steering Committee of Qatar, develops and maintains relationships with international GIS organizations and participates in international cooperative agreements.9

One of the primary tasks of the CGIS was the development of digital mapping specifications and standards for the production of Qatar's Digital Topographic Database. To this end, a book titled 'National GIS Database Specifications and Data Dictionary - Topographic' was published and a highly automated digital map monitoring system was implemented both of which enabled the creation of a highly accurate, fully functional digital topographic database.10

**Digital Data Base Creation**

One of the key components of a Nation-wide GIS implementation is to ensure that everybody uses a common spatial reference or base map. The Centre for GIS has developed a countrywide Digital Topographic Database that is available digitally on-line 24 hours a day. There is only one place where this database resides. It is updated daily and it is this copy that everybody uses at all times. Digital Vector

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9 Based on the document “Qatar Geographic Information System Activities”, provided by CGIS, Doha, Qatar, 2004.

10 Based on a document provided by CGIS, Qatar, 2004.
Mapping has been carried out for whole country at different scales with the help of aerial photographs. At the scale of 1:5,000 photography all inhabited areas have been digitised by stereo-compilation with less than 0.5 meter positional accuracy. At 1:30,000 photography the whole country has been digitised by Stereo-Compilation with less than 2.0 meter positional accuracy.¹¹

Through Digital Ortho Imagery all inhabited areas has been digitised at the scale of photography: 1:4,000. The whole country has been mapped at the scale of 1:54,300. The Digital Elevation Model has been created for all inhabited areas at the 1:4,000 scale of photography with elevation accuracy of less than 10 cm. Similarly the whole country’s digital elevation model has been derived at the 1:30,000 scale of photography with elevation accuracy of less than 1.0 meter.

Today decision makers are faced with a dilemma in absence of the right information at the right time. Towards this end the CGIS has received new one-meter, high-resolution satellite images (IKONOS) of the entire country to update the country’s base map. The mosaic map, accurate imagery of 11,500 square-kilometres of country coverage, would enable the CGIS more efficiently to plan and manage high-profile infrastructure and utility projects such as roads, water, drainage, telecom and electric power distribution, natural resource inventory improvement, risk mitigation, and effective emergency response. The entire country was shot at one-meter resolution and ortho-rectified.

**Defining Data Dictionary**

Subsequently, the CGIS in concert with the National GIS Steering Committee, has worked with each agency that has implemented GIS, to provide guidance and advice on how to develop specifications and data dictionaries suitable for their respective disciplines in order to ensure they are not only suitable for each agency’s applications, but also compatible with the specifications and standards of

all other agencies. This effort has led to the development of a set of National GIS database specifications and data dictionaries consisting of 16 volumes, one for each agency.

The purpose of these data dictionaries is to clearly define, for each agency, the kind of data that is included in its database, what each data item is called, how the data is assembled and structured, how accurate it is, and so on. These are the kinds of things agencies must know if they are going to electronically exchange data with each other. And since all agencies have developed their data dictionaries in consultation with each other, and under the supervision of the CGIS, the process has ensured that every data item used by each agency is identified and that only one agency is made responsible for collecting, maintaining and sharing with others, a specific data item. This has ensured order and discipline in the collection, naming, coding and storing of data. Not only has this served to standardize and streamline data collection, data entry, data management, and other procedures but it has also minimized redundancy and its use has considerably improved quality assurance, communication, field service, inventory maintenance, programming and a variety of other associated activities.

GIS Implementation in Qatar

The five key steps of GIS technology implementation in the State of Qatar are\textsuperscript{12}

- Conduct user needs study
- Establish a National GIS Steering Committee
- Establish a Centre for GIS
- Implement a nation-wide digital mapping program
- Foster cooperation and coordination among all agencies

\textsuperscript{12} op. cit. p. 42.
To institutionalise the GIS following strategies were adopted by the government which proved out be very successful.

- Make everybody aware of GIS
- Seek support from the highest levels of government
- Seek support from every government departments
- Involve every government department in design and implementation
- Establish education and training programs
- Make GIS tools available to everybody
- Encourage competition but not at the expense of cooperation.

One striking feature of Qatar GIS was its recruitment policy. The recruitment of the staff was done very thoughtfully according to a well conceived plan to make it more interactive and social. The policy of segregated recruitment was adopted which means all staff of one ministry had some kind of association with one another in terms of state of origin, same university or same culture. For instance, telecom GIS is operated by staff from Kerala while road division is maintained by people from Mumbai. This policy increased their level of interaction and provided them a comfortable work environment. The result was higher productivity and cohesiveness within the department. That is why Qatar GIS is sometimes referred as social GIS.\(^{13}\)

Inter-ministry interaction is also high because all the staff has worked together as a team earlier and has then been transferred to other ministry. The personal relations among the staff gave them freedom to discuss technical details and problems without any inhibition or hesitation. The sharing of technical knowledge and experiences made the task easy to reach at a solution resulting in higher productivity.\(^{14}\) There is no inter-department conflict and non-cooperation as it happens in most of the countries where sharing of data is a big issue.

\(^{13}\) Ibid.

\(^{14}\) Ibid.
To sum up, things don't happen simply because they are right or good or useful rather they happen when *people believe* in them and *make commitment* to pursue them. The application of GIS in different sectors of planning is the outcome of the incessant commitment and focussed approach of the CGIS. The major application is in the field of preparation of country’s physical development plan and infrastructure planning and management that will be discussed in subsequent sections.

**GIS in Qatar's Physical Development Plan**

Due to influx of oil money in the Gulf countries in general and the State of Qatar in particular, they have started construction of residential and commercial complexes accompanied by various utilities and services. The haphazard and unplanned development process led to chaos in management visible in the form of urban sprawl, traffic congestion, and improper spatial allocation and distribution of public facilities and infrastructure. Under this backdrop the State of Qatar conceived the idea of integrated planning process that may encompass overall development of the country in general and the capital city, Doha in particular. Taking the lead the Ministry of Municipal Affairs and Agriculture (MMAA) completed preparation of a Physical Development Plan (PDP) for the country. The project was carried out by Planning Department in collaboration with American consulting firms with the aim to establish a comprehensive planning framework for the country's long-range physical development. The process would improve the government's ability to track development trends and project future development needs and explore the opportunities and impacts of alternative development scenarios. The centralisation of planning activity would enable the Planning Department to ascertain responsible and consistent development policies.

and regulations based on social values, community aspirations and fiscal realities. The control, monitoring and assessment of new development proposals and construction in consonance of government policies and priorities will be eased.

**Planning Issues**

The Planning Department is responsible for providing the guide map for the country's development through the physical development plan. Different government agencies implement the plan as per their area of operation. This centrality of planning provides an effective tool to carefully manage government expenses related to infrastructure and service provision in support of new development and ensure ease of implementation and effective co-ordination between many governmental entities that play a role in the development process. Ultimately it improves the quality of Qatar's built environment for the benefit of all its residents.

Some of the main planning issues that existed before implementation of GIS in Qatar can be summarized as follows:

- Inadequate comprehensive physical development strategy that guides the type and direction of urban growth at national and regional level.
- Absence of a coordinated plan to utilize natural and human resources productively for physical development.
- Insufficient control on urban development and disparity between direction of physical development and infrastructure expansion particularly in Doha that led to increase in land value and social costs.
- Widespread inconsistency between the land use types especially in the city centre which lead to socio-economic and environmental problems.
• Lack of provision to allocate adequate land for various urban activities such as housing, industries, commerce on the basis of population forecast and its distribution in the different part of the country.
• Disparity between capacity of transportation network in the city and type of urban development and its future expectations.
• Need to identify adequate sites for waste disposal at national level and preserve areas of high environmental value by protecting them from urban and industrial development.

The present rapid pace of physical development is likely to continue due to the recent discovery and exploitation of the country's natural gas reserves. It is in this context that the Planning Department of the Ministry of Municipal Affairs and Agriculture realized the need for GIS based physical development plan that will control and guide the country's physical development through the 21st century\textsuperscript{16}.

**Stages of PDP Development**

The holistic Physical Development Plan of Qatar comprised of mainly three fundamental tasks.\textsuperscript{17} First, being the organisation of database with the aim of maintaining social, economic, demographic and physical data that can be served as input in the planning process. On the basis of these data one can forecast its impact on development plan and develop transportation models to meet future requirements. Second task was preparation of physical planning strategies, policies and, plans with the objective of development of physical plans for the future development of the State of Qatar through the year 2020 at four levels of detail:
- National and Regional Physical Plan, State of Qatar

\textsuperscript{16} www.qatar-info.com/resources

\textsuperscript{17} Ahmed Al-Dowsari, “Qatar's Physical Development Plan”, a paper presented in an unspecified conference, See www.gisqatar.org.qa
Local Plan for Inner Doha and Al Khor
- Detailed Area Plan.

The PDP Plan hierarchy allows for handling the task at different levels of planning. Detailed planning has to be done in areas where planning issues are more complex requiring specialized polices or solutions. Moreover, through all levels of the PDP hierarchy the areas are integrated within a single, national land use planning system. This GIS-based system ensures a consistent planning approach throughout the country while allowing the flexibility necessary to meet localized planning needs.

The objectives of this phase also included evaluating the issues as identified in the description of each plan level, establishment of general planning standards for each land use designation based on population, establishment of a planning framework which can be used by the Planning Department in the future, integrating GIS in planning process as a planning tool, establishment of data requirements needed at each level in the planning process and recommending and advising MMAA in their decision to provide a data base framework for maintaining and updating the PDP in the future on GIS, recommending necessary development controls for physical development plan evaluation and implementation.

The third task included establishing physical planning framework, institutional organization, procedures and regulations with the objective of revision of the existing planning and operational framework as well as procedures in the context of implementing the PDP and comparing the existing planning and development control capability to the needs associated with the PDP's planning and control system. The tasks also included training for selected Planning Department staff in the process of utilizing, maintaining and updating the PDP.\(^\text{18}\)

The PDP GIS database now contains both spatial and non-spatial data that augments the flexibility of use. The non-spatial data consists of attributes, such as

\(^{18}\) Ibid.
the existing land use code, together with large volume of text. This text is both
descriptive as well as advisory. It explains existing conditions of land and policies
or regulations applicable such as development standards and land use control. The
GIS stores PDP data at a single location with references from each of the five PDP
plans in order to avoid duplication or inconsistencies between the five areas,
strictly following the national standards. In order to provide a consistent
representation of content and visual representation of the range of maps produced
under all levels of Physical Development Plans, a set of PDP cartographic
standards have been adopted for all mapping. In most cases the standards used are
of the national standard defined by CGIS such as the colours for representing land
use.

Technical Phases of PDP
There have been three fundamental technical areas the PDP project of Qatar has
gone through namely, Physical Planning, Application of GIS and Transportation
Modelling.

Most of the PDP policies are based on land use/ land cover that is
geographical in nature. For instance industrial and commercial areas have specific
regulation and policies. The mapping of PDP policies to specific geographic
locations is done through a series of five Policy Maps and six overlays, all of
which are linked to policy text and development regulations through the country's
GIS. The policy map of a specific area is obtained through overlaying the national
policy maps on the local area map. Once the local policy map is produced, the
detail plan is defined in consonance of national policy maps. This ensures a
consistent, integrated set of policy maps for all of Qatar's future development.
Through the application of GIS, these maps can be quickly accessed in various
combinations at all levels of geographic detail.

As a GIS based planning tool, the PDP has been formulated to maximize
the electronic search, retrieval, and analysis features of the GIS. The usability of
this data structure relies to a large degree on the GIS' ability to link and interrelate both spatial and non-spatial data within a single integrated system.

The final PDP plans are all in GIS format. This input will significantly improve the capability of MMAA/PD in particular and the Qatar government in general to establish and constantly improve development objectives, policies, and development regulations at all levels of planning framework such as the national plan level, master directive plan level, local area plan level and the detailed area plan level. In so doing, the GIS will help effectively to plan, control, monitor, and assess actual and proposed development projects and find development alternatives. This will make Qatar’s PDP an effective, rational planning tool for decision makers to use on a daily basis for the betterment of the country.

Third technical phase of the PDP project was focussed on transport planning as mentioned earlier. The purpose of the models is to predict travel demand and transport network performance in order to estimate the consequence of the transportation and land use development plan. In addition, the models provide a multi-level basis for analysis ranging from broad regional and national traffic flow models to the detailed simulation and evaluation of street flows in the Doha city centre.

One of the unique features of the transportation model of Qatar, probably the only one of its kind in the world, is its interface with the GIS. The GIS-Transportation Model interface consists of a network interface and a land use interface. All the data related to road network required by the transportation model software EMME/2 is extracted from the concerned ARC/INFO coverage for the road network using the network interface. The land use data required for calculation trip generation/attraction is also extracted from the corresponding ARC/INFO coverage using the land use interface. The network interface also transfers the network data, modified during EMME/2 sessions, back to the Arc/Info coverage.
In order to retrieve and display spatial and non-spatial data of the PDP a user-friendly application program namely, PDP Viewer has also been developed using Netscape and ArcView. Any of the PDP Plan documents including output maps, images, or text and majority of the PDP Library documents can be browsed on the screen using the Viewer.

It is hoped that this plan will provide the Ministry of Municipal Affairs and Agriculture and other government agencies with an effective tool, which is dynamic and flexible in nature due to its GIS base, that will guide and direct physical development in the country and ensure efficient utilization of available resources to achieve a healthy and sustainable physical environment for the citizens of Qatar.

As mentioned earlier, Geographic Information Network Superhighway (GIS net) of Qatar connects 17 different agencies such as agriculture, Cadastral, Water, Electricity, Land registration, Education, Environment, Planning Council, Health, Telecom, Roads, Petroleum and Gas, Building Engineering, Fisheries, Police, Drainage that use the centralized database to carryout their operations. In this section of the chapter we will look into the details of GIS functions in the relevant departments.

**GIS in Ministry of Electricity**

Utility agencies need to know where their facilities are and how they are being utilized. Asset management is an important component of utility operation. GIS provides the platform for viewing and analysing facility and customer data. With this background GIS was introduced in the Ministry of Electricity and Water. Qatar General Electricity and Water Corporation is known as KAHRAMAA. It is derived from Arabic word *Kahar* means electricity and *Maa* means water. Its main task is to provide uninterrupted supply of water and electricity to the nation.
Kahramaa is the oldest member of the CGIS. The main users of GIS within the electricity department are Electricity Planning Department, Electricity Transmission Department and Electricity Distribution Department. The present level of GIS application in the ministry has come a long way. The first step towards GIS implementation is database creation. Accuracy in the database is very critical in order to reach at practical solutions through analysis. The database creation was started way back in 1989 with the help of infrastructure provided by the nodal agency, CGIS. All the maps dealing with the planning of distribution lines with their equipment were on paper. The whole area of Doha was covered by 4000 sheets of map. Each sheet dealt with a particular area. The first step towards GIS implementation was conversion of paper maps into digital one. Some part of it was outsourced and rest was done in-house.

There cannot be only one solution for all the user departments because the requirement of each one is different. Each department therefore, encountered with its own implementation problem and devised its own solution. The conversions of data from paper to digital in Kahramaa its own limitation that guided the selection of software to be used. The electricity network is dynamic as it changes frequently. According to the demand the network has to be altered. For instance, if a new connection is requested, feeder capacity has to be changed. Due to this dynamism AutoCAD was chosen as conversion software that is transformed in Arc/Info for further applications.

One of the limitations of GIS software is its inability to accommodate dimensions that are very critical in electricity network. For example, putting graphics such as arrowheads, arcs and adding text is not easy if you have a large database of such requirement. Therefore, base data is converted and maintained using AutoCAD and later exported into coverages in Arc/Info, once a month. Once data is exported from AutoCAD to Arc/Info, the attributes are not there. So,
the solution was 'Extended Data Entity' in AutoCad which was basically a program written using LISP (the programming language of AutoCAD). The conversion of data was automated by writing another script in AML (language used in Arc/Info customisation)

The Duties of Electricity GIS Section

- To carry out user need studies and discuss with the users about their requirements and to update the same on periodical basis.
- To convert the existing geographical data in GIS format and others in vector or raster format for easy handling.
- Maintaining the detailed drawing of the electrical network.
- Checking accuracy and reliability of procured data and quality assurance.
- Defining specification of data acceptable received from contractors.
- To make data accessible to the user departments by maintaining local and public servers depending upon privilege granted to each of them.
- To provide record drawings to the staff of electricity, consultants and contractors on a daily basis.
- To provide appropriate applications to the end users and train them to use it efficiently.
- Maintaining consumer number location, where GIS technology can locate a consumer number geographically. This data is maintained and a print can be given when the need arises.

Sources of Data

The basic source of data for the electricity department has been the paper maps in their archives. Newly laid cable route or substations are updated on the basis of detailed drawings submitted by the contractors to the GIS section. Cable laying notification is issued from the Overhead line section for urban and rural areas and given to surveyors and is reported to the GIS section for update. Distribution
Control Centre gives its detailed reports on any modifications in the network. The information about connections given to new plots or removed from a plot is reported with consumer information. Schemes generated by Planning and Development sections carrying hand marked approved drawings and their details are also sent for updating. Often building permit applications carry the drawings for new proposals, and this also forms a data source.

There are few GIS based applications being developed and used for different purposes. InfoENet is the application used daily for fast display of electricity data to deal with customer affairs. Distribution and Planning departments use it frequently to see the existing situation and plan for the future. The application known as Scheme is used within the section to prepare proposal drawings. It is basically an Auto LISP based set of tools.

**Benefits of the GIS System**

With the implementation of GIS system the efficiency of the department has improved significantly. Earlier the drawings were on paper archived in the store. If any information is needed, one had to go through huge drawings and maps one by one. To locate a customer was a time consuming affair in case of any need. Now the whole network is available on screen and can be seen at once. The search is made by just entering the electricity number of the consumer and the system locates it geographically with reference to landmarks like road or lane. The electricity planning department can have a synoptic view of the whole network and use it for future proposals. The distribution department uses it to manage the supply of electricity. In case of new connections, the department just locates the plot of the consumer and checks for the availability of distribution network and its distance. It helps them to put a feeder or establish a transformer. The nearest feeder is located and its utilization level is found out online. If some lines are idle, connection is given from there. Due to online availability of GIS data the response time is greatly reduced. In case of any fault and complain about failure of power
supply the consumers are identified with their electricity number. The system locates the place geographically where disruption of supply is reported, which enables the maintenance department to respond in minimum time. Using the system they locate the feeder and transmission line to find out where the fault can be. The database correctly stores the data regarding which houses are connected to which feeder and which feeder is connected to which transformer. This helps in locating the fault in the network.

To sum up, since electricity network is said to be a dynamic network, the updating of network is very easy in comparison to a paper-based system. Using the digital database everyday work orders are printed with its location and address for accomplishment of tasks that take just a few minutes. So, the work of days has come down to hours and minutes with the application of GIS technology.

**GIS in Ministry of Water**

The Ministry of Water is under KAHRAMAA and is one of the oldest users of GIS. Water GIS was initiated by CGIS in June 1991 when a few CGIS employees were assigned the work of data dictionary preparation with the coordination of Ministry of Water and Electricity. To implement the system reliable and accurate data preparation was very crucial. Hence, Water GIS identified two teams for data collection and updating. The survey team was sent for measurements manually on ground using Tape method. All measurements were recorded in survey books which were later updated onto transparent maps by draftsmen.

Water GIS started a user need study with all departments in the Ministry of Water and Electricity in 1994. After the user need study they started a pilot project for collecting data based on GIS technology methods in Al Rayyan and Al Khor municipalities. The conversion of data started in 1996 using an Arc/Info application known as WaterDAT. The application was used for manual

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20 As per document provided by CGIS, Qatar, 2004.
digitisation of water primary mains, reservoirs, water towers, water distribution areas, water distribution network and connections to households. The input formats were in ortho images TIFF, AutoCAD DWG and DXF, Arc/Info Coverage, ESRI Shapefile and Oracle 8 formats.

In July 2000, the Ministry for Electricity and Water converted to Qatar General Electricity and Water Corporation (KAHRAMAA). The implementation process of GIS in the ministry was started with surveying total stations. All the drawings submitted by the Record Team were scanned and geo-referenced. In order to update and maintain GIS data AutoCAD software was used due to easy handling. The survey of Tanker Supply locations was also initiated along with other information on water tanker supply, to be used for optimising the supply by carrying out GIS analysis. After collection of relevant data digitisation of whole water feature was given on contract for conversion into Arc/Info data format.

So, the major sources of data were hard copy maps and survey books from the Record Team, engineering drawings related to water features, AutoCAD maps and drawings, Arc/Info format Water GIS data, CGIS topographical data and other public agency data.

**Tasks of the GIS Section**

The general task performed by Water GIS section is to provide maps and create drawings for water distribution projects for the Technical Affairs Department. It conducts surveys generating new drawings for proposed water projects requested by the Water Planning Section. Providing soft and hard copies of them to Water Distribution Network Department, Water Network Planning Department and other GIS agencies is also a responsibility of this section. The other duties include tender preparation for new projects in GIS section, quality control checking on GIS data supplied by contractors, providing GIS services required for approval of Building Permit, support applications that are deployed in Water Distribution
Network, Customer Service Department, Water Planning Section and Primary Maintenance Section, develop applications wherever needed in the department by any of their team, maintain GIS data on Unix server or NT servers, attribute data on Oracle database servers and design new data structures for the future compatible to new GIS technology.21

GIS Applications

There are many applications developed in the Water GIS section to perform different tasks. They are developed using softwares like Visual Basic/Map Objects etc. and are listed as follows.

1. **Apparatus Information System**: This system is developed to maintain water network apparatus. It keeps track of history, location and condition status information of all apparatus in the network enabling them to generate reports of the same when required. Geographical location of each component of the network can be found out by querying the database on the basis of Qatar Survey Sheet number and unique apparatus number. Apart from updating the database it also enables viewing of the information using function like Zoom In, Zoom Out and Pan in any direction.

2. **Water Maps**: This application is used for viewing and printing Water Network data in different formats like DWG, DXF, coverages and shapefiles in different paper sizes. It also helps in searching and querying the database on the basis of Qatar Survey Sheet Number, Zone number and Zone name viewing urban, planning and road data as reference.22 There is option to zoom in and zoom out and Pan the data as required.

3. **Building Permit Application**: When a new building is planned, the builder takes permission and approval from different utility departments also. This application is used for approving building permits and checks for water

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21 Ibid.

22 As told by Mr. Sanjay Shukla, Water Department, KAHRAMAA, Qatar, May, 2004.
network features availability. The search can be made by Qatar Survey Sheet number or Planning Identification Number (PIN) given by the planning department. Data entry of planning details with Building Permit Number and water network is also done by the system. Print out of all data entry details with approval and rejection information is given to the customer.

4. **WaterDat Application**: This application is primarily used as data maintenance and data automation tool for water network providing much flexibility in terms of data entry. It's a digitisation tool for 1K tiles where edge matching with other tiles is easier. Here data entry can be done either with dimension, coordinates or scan images. Points can be generated using one way, two way and three way dimensions and line can be generated using label feature. Whenever new feature is digitised the data entry form pops up. The system has four different levels of quality check controls. It lists layer attributes and prints check plots with attribute reports for final check. Urban planning, poles, manholes and road data are viewed as reference.

5. **Water Projects**: It is used for mainly displaying geographic details of project proposals which includes area and number of sheet, start date, end date, cost, contractor etc. It provides a query platform to search for project or proposal number and name of engineer.

![Figure 5.4: Structure of Water GIS](image-url)
GIS in Qatar Telecommunications

Qatar Public Telecommunications Corporation (Q-TEL) is responsible for providing high quality telecommunication services to the public, satisfying the needs of all customers in terms of coverage of areas, continuous improvement of quality and maximization of reliability by provision of world class features. Q-TEL started GIS way back in 1991 recognizing the potential benefits of the technology. At the same time the CGIS started to form a joint collaboration of various agencies consisting of municipal authorities, utility organizations and other ministries under a dynamic leadership.

The objective behind joint collaboration was to develop a mechanism thorough which all the participating agencies would follow a common set of standards to share each other’s data in future. Q-TEL recognized the long-term benefits of such technology and decided to be a part of the country’s GIS development. To make it a reality a representative from Q-TEL was appointed to the National GIS Steering Committee.

Al-Khor City was selected for the GIS pilot project for each of the eight participating agencies including Q-TEL in 1992 under the umbrella of CGIS, the parent organization. This led to development of a prototype system of GIS technology to demonstrate how the technology can be used in Q-TEL. Realizing the success of the pilot project on telecommunication, a GIS working group was formed in Q-TEL. The detailed user need study was also conducted to define the specific requirements within the department and devise a strategy to reap the maximum benefits from the GIS technology in order to raise the service standards for the customers.

When GIS was started in Qatar it was centrally managed from CGIS and later transferred to the user departments. GIS resources were finally transferred to Q-TEL in 1995 under the direction of Access Network Section. A separate GIS

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23 As per document provided by Q-Tel Corporations, "GIS in Q-Tel", 2004.
System unit was created within Q-TEL in April 1996 with the following objectives.\(^{25}\)

- Automate the entire Access Network Record management system.
- Improve efficiency and quality of Local Line and Junction Network planning execution of civil works, external network engineering and cabling operations.
- Improve inter-agency coordination for data sharing and other applications.
- Augment efficiency in geographically locating customers and the access network items serving the customer.
- Provide immediate, current and accurate network engineering data for better decision-making.
- Make Work Order processing workflow faster.
- Support and manage entire Q-TEL spatial database.

GIS Applications in Q-TEL

Q-TEL is the most successful story of implementing GIS technology to perform its tasks in an automated and efficient manner. Various projects have been implemented in the department, Telecommunication Access Management System (TEAMS) being the major one. Q-TEL has successfully completed the following applications.

1. **Q-TEL Inter-Exchange Transmission Network Model**: It was developed by creating a geographic database of all existing and planned exchanges and Remote Line Unit (RLU) and all the connections between them.
2. **QATARNET**: It is also known as Q-TEL GSM Network Model and is being developed, creating a database of all the GSM stations.
3. **Fibre Optic Network Model**: The application has all the proposed, existing and planned fibre optic links in the country.

4. Qatar Cable Vision Broadcasting Area Coverage Model: It shows the location of all the broadcasting stations and their coverage areas.

5. Digital Terrain Model: The development of this model was for line-of-sight analysis between transmission towers to determine potential sites for GSM stations with optimum performance.

6. Developed a comprehensive geographic database for all the Q-TEL Pay Phones in the country showing their locations, networks and revenue information used for its planning and marketing strategy.26

Telecommunication Access Network Management System (TEAMS)

TEAMS is the largest application in Q-Tel implemented in order to automate external plant records management, external planning, estimating and monitoring functions for civil works and cabling operations required to make changes in the Access Network to extend telephone services to new and existing customers. The application was based on customized ArcView GIS using Avenue language. TEAMS started with the version 1.0 and with the passage of time various addition of functionalities were made as per the requirement and up gradated to version 2.1 and became fully operational in the year 2000. It is anticipated that by September 2004 version 8.0 will be implemented which would enable to plan everything on GIS such as maintenance, work order or updating. In future they are planning to move on ArcGIS and geodatabase.

Apart from this Q-Tel has started Asynchronous Digital Subscriber Line (ADSL) service for Internet connections. But presently due to lack of infrastructure this facility is not given to everyone. It depends upon various factors like distance from exchange, cable infrastructure and equipment around the area. Based on these criteria, Internet connection application is approved or rejected. The GIS based system, TEAMS helps to find out all this information online within minutes and accordingly decision is made.

26 Ibid.
The TEAMS stores data on customer, manholes, exchanges, cabinet (RLU), distribution points (DPs), joint boxes, pay phones and ducks and cables. It has a locator system which can locate any feature on the network such as manhole, joint boxes, plot numbers, streets and plots based on Qatar Area Reference system. It also stores Duct Space Record (DSR) which has the cable information and its path to the customer plot. Based on this data the system is able to list all information regarding DPs, cabinet and connection addresses which is used for decision making.

The implementation of TEAMS was done in three different phases.

**Phase 1: Data conversion:** Massive data conversion was carried out in Q-Tel from paper maps to digital ones. About 3500 maps and drawings of different scales and sizes were converted into GIS format and overlaid on Qatar base map provided by CGIS. After completion of this phase all paper maps and records containing the inventory of the entire Q-Tel access networks, their physical location and attribute information about each network item both above and underground and network information from exchange to customer handset was made digital. The whole task was carried out in-house.

For the data conversion a dedicated group was created for digitisation and geo-coding the spatial data. The digitisation was done on each sub-area sheet-by-sheet basis. In order to maintain the quality a standard RMS error was maintained. The spatial data was stored in Arc/Info format and attributes were stored in Oracle. The quality check group ensured data consistency and accuracy. The huge data conversion was considered the cornerstone of the project implementation. British architecture was followed in conversion. This phase also included the development of the access network information query, display and plotting capabilities to allow users to access and use the digital information. The

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27 As told by Mr. Taha Alvi, Database Administrator, Q-Tel, Qatar in a personal interview, May 2004.

28 Ibid.

29 As told in an interview with Mr. Krishna Kumar, GIS Coordinator, Q-Tel, Qatar, May 2004.
automation took about one year, meanwhile all software, and data dictionary specifications were prepared.

**Phase 2: Application Development:** This phase involves developing specific software modules to automate planning, estimating, and monitoring functions for the civil external work and cabling operation required to make changes in the access network to extend telephone services to the subscribers. The customisation was done keeping in view the user comfort and to make it user friendly by self-expressive symbols. Gradually, the system was improved by making changes as per the user request and changing needs.

**Phase 3: Complete Automation:** Third phase involves complete automation of the entire workflow of Works Order processing. Once an application for a new telephone connection cannot be fulfilled by the nearest available distribution point, it is forwarded to network access section. A Works Order is initiated here for the work to be done to extend the existing infrastructure so that a new connection can be provided. The Work Orders folder travels online through different phases of planning, estimating, civil works, external works and cabling operation until the work is completed\(^\text{30}\). Upon completion of work order the service is restored to the subscriber. All affected permanent drawings and records are updated to reflect the new built changes to Q-Tel Access Network facilities infrastructure. The entire automation of Work Order flow also includes accessing inter-agency data and road opening coordination with other agencies for all underground work.

Another module was developed for data updating which was fully menu driven with customized icons. It was based on the server version of Arc/Info with 150 AMLs written for different tasks. The attribute data was directly updated in Oracle from Arc/Info. Each function has some validation to avoid error in the data. The module has error report generation capability validating the attributes to its spatial entity.

\(^{30}\) As per personal interview with Mr. Thomas Mammen, GIS Analyst, Q-Tel, Qatar, May, 2004.
Benefits of GIS in Q-Tel

GIS implementation has helped Q-Tel in many ways by providing useful tools for managing telecommunication facilities, inter-exchange transmission network, GSM network, fibre optic network and pay phone planning and marketing. The benefits can be better understood if we get an idea about the old manual system which was very cumbersome. In order to maximize customer satisfaction and gain efficiency all the information is required on fingertips. Q-Tel has a variety of manual records in different forms. Each information is valuable and needs to be accessed very frequently which is very difficult. The extent of the trouble can be anticipated by the fact that Q-Tel has about 30,000 records which has to be used on daily basis to retrieve information. Most of them belong to External Plant network and the staff accessing this information is spread out in the field. To meet the requirement often photocopies are taken to use it in the remote offices. These copies are used for months without any updating. The access to updated information is very difficult to get in manual system as it takes time to make changes in the database.

Another disadvantage of manual system is its maintenance. After daily use it is often misplaced or degenerates due to wear and tear and information is lost. To overcome all these difficulties Q-Tel decided to implement GIS technology.

Now with GIS implementation all information is retrieved very fast. Every customer is given a Q-Tel ID which is unique to him/her. On this basis all information regarding the customer is obtained from the system. Now both planning and maintenance is very easy. Now if somebody applies for a new connection, his/her residence and address is located geographically on the system based on adjacent telephone number supplied by the applicant. Once location is known, search is made for the nearest DP from where connection can be given. Since the system stores information about DPs, information regarding the number of connections given from that particular DP and how many are idle is found out. If some DP is found fully unutilised connection is granted from there or else they
plan for another distribution network. The work order is issued which travels through different sections from planning to engineering, which are responsible for providing the connection.\textsuperscript{31}

Hence a week's work is accomplished in a day. For maintenance of the network also the fault is located online with the block, street and plot number of the affected customers. Once all information of the affected network is retrieved with the joint box and distribution point from where connection is provided it becomes easy to locate the fault. The type of fault and location map is given to maintenance department to carry out the task. This reduces the response time of fault management and provides efficient service to the customer to raise satisfaction level.

Presently Q-Tel is going to implement Network Engineering software developed by Telcordia Corporation that will automate the entire system of telecommunication management that is also used by Britain and Bahrain. The software enables to visualize components within the exchange such as floor plan, rack, chassis, equipments, card, ports, plug-in, jumpers etc. and to plan jumpers online. The system will display everything in real-time. If any card is not working the affected area can be find out and replacement can be done sitting on the system itself\textsuperscript{32}

To sum up, Q-Tel is one of the leading users of GIS technology in Qatar. The application of GIS has transformed the way they operated. Now any information of the network with its component can be viewed with a click of the mouse and decision can be made in terms of planning a new network or its maintenance. In the future, as mentioned earlier, the whole system is going to be automated fully.

\textsuperscript{31} As per information given in an interview with Mr. Sameer Mohammad Saeed, GIS System Administrator, Q-Tel, Qatar, 2004.

\textsuperscript{32} As Told by Mr. S. Krishna Kumar, Q-Tel, Qatar in a personal interview, May, 2004.
GIS in Road Department

One of the essential functions of Ministry of Municipal Affairs and Agriculture (MMAA) is to provide basic municipal infrastructure facilities like roads and drainage network. Besides other infrastructures road department is managed under the supervision of MMAA. Optimum use of existing resources and development of well connected and better road network through proper planning, constructing and managing the same was a tedious task without use of GIS technology. Realizing the benefits of such technology the road section adopted GIS based system to serve the nation in better way by establishing a separate GIS unit in the department.

Ministry of Municipal Affairs and Agriculture has a separate department who takes care of all project management known as Project Planning Department (PPD). The Engineering Information Division (EID) is a middle unit in the organizational structure of MMAA operating as technical arm of PPD. The EID is responsible for providing GIS data management, validation, publishing, and mapping for both Road and Drainage Departments as well as Building Engineering Department. The organizational Structure is shown in the Fig. 5.5.33

As per information provided by Mr. Yasser Mustafa Mohammad Noor, Head of Engineering Information Division, Qatar, May, 2004.

Figure 5.5: Organizational Structure of Road GIS Section.
The objective of Roads GIS unit is to provide road data to the users such as managers, planners, engineers, consultants or other general users to help them in making sound decisions based on latest information for effective planning. This unit also provides various user specific GIS applications to help them in utilizing and presenting the GIS information in a meaningful manner in order to be effective in the field.

Tasks of Roads GIS Unit

The main role of this section is to provide sanitized data and GIS information in digital and hardcopy to government and private sector clients apart from following functions.\(^{34}\)

- Collection of road data
- Management of roads data by creation and updating the databases.
- Plotting of road maps and development of GIS application.
- Provision of technical support and guidelines for in-house users and consultants, contractors etc.
- Coordination with different departments.
- Attending GIS coordinators' meetings as road specialists and reporting progress and coordination issues.

Data Conversion and Quality Checks

The data is converted from hard copy paper media into digital form by using software like AutoCAD in different formats such as DXF, DWG, TIF, BMP, JPG etc. Proper data entry and geo-reference checks are done before transferring the database. Roads GIS section applies intensive in-house validations, consistency checks and revision on GIS data such as spelling check, correct data type, missing fields, and other necessary information etc. before approving it to be loaded in the central database. There are some procedural checks on data also. All the requests

\(^{34}\) As per unpublished document provided by CGIS, Doha, Qatar, 2004.
are commissioned through the head of Engineering Information Division (EID). The completed projects are reported to EID head and data is updated according to its approved format. In this way it is easy to maintain consistency in the data format. Finally the shapefiles and AutoCAD formats are converted into Arc/Info format coverage.

**GIS Application Development**

Roads GIS Section has been developing GIS application continuously in order to serve its users in a better way. All application development can be broadly classified in few groups such as data entry application, query and display application, map generating application, data updating application and project or data tracking applications. The process followed for the development includes user need study, choosing suitable tool or software, design the application, writing codes, testing the application and finally deploying the same.

The following are the major applications developed and being used in the Roads GIS section.\(^{35}\)

1. **Road Centreline Updating Application**: This application was developed to update the centreline road data based on 1K urban topographic data. It helps in retrieving engineering drawings from central repository apart from achieving and cataloguing design as built and standard drawing at one place.

2. **Road Opening Application**: The application was developed to assist users in keeping and tracking their records and files. Instead of manual search and lot of filing cabinets, it can be done electronically with greater efficiency to retrieve the information.

3. **Traffic Management System (TRAMS)**: The TRAMS application was developed to aide the traffic engineers in their work and provide inventory information of their material and equipments. It displays the road network

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\(^{35}\) Ibid.
with all traffic junctions with its detector loops that find the traffic volume\textsuperscript{36}. The red light functions in accordance with the detector loops. If detector senses no vehicle from one side of the road at intersections it turns the light green allowing other traffic to cross over.

4. **ArcWays**: It was developed for maintenance and quality division to aid the engineers in their work in determining the pavement condition and maintenance.

5. **Project Information Tracking System (PITS)**: The application stores all details of roads and help in tracking the status of a project.\textsuperscript{37}

6. **Cor-Net**: This helps the traffic engineers in analysing the present road network condition in the country and make new plans for development of the same.

7. **Spatial Index Document Encoding and Retrieval (SPIDER)**. The application was developed with the intention to store the Roads projects drawings into digital format for consultants, contractors to submit digital drawings of completed projects, for efficiency and easy retrieval of information based on project ID.

Apart from these, there are other applications also which convert DXF drawings into shapefiles or coverages and generate maps.

So, from the above section we can conclude that road development right from proper planning, tendering, contracting, construction till maintenance and further enhancement and adjustments is difficult to achieve without an efficient GIS tool accompanied by up-to-date GIS information and data on road networks to cover the whole road management cycle. Qatar has made appreciable advances in this regard.

\textsuperscript{36} Information provided by Mr. Gary Jumlani, GIS Analyst, Road Division, Engineering Information Division, Doha, Qatar, May, 2004.

\textsuperscript{37} Ibid.
The road GIS section is suffering from various problems and requires improvement in terms of high performance hardware, latest version of softwares, enough GIS qualifies technicians, well design multi purpose GIS applications that cater for a full range of every day requirements instead of many applications.

**GIS in Drainage Department**

Provision of drainage facility is one of the major tasks of the municipality. The Ministry of Municipal Affairs & Agriculture (MMAA) in Qatar is responsible for providing such facilities. Engineering Information Division (EID) is the middle unit within the organisational chart of MMAA that takes care of the Drainage Department. The EID is caretaker of up-to-date GIS data on road and sewer networks used by the planners, engineers and construction companies.

The Qatar’s drainage department is responsible for creating and maintaining a detailed Wastewater Collection, Conveyance, Treatment and Reuse database that provides useful information on all these networks. Coordinated information for all these drainage features is available with 20 cm. accuracy. The objective of Drainage GIS Unit is to provide drainage data and applications serving the purpose of engineers, managers, surveyors, contractors etc. to perform their daily activities by accessing drainage data in a more meaningful way to provide quick solution to problems enabling them to take effective decisions. The information is provided to the external user after filling-up a request form signed by the EID head.

The Drainage department has three different drainage networks.

(i) Foul Sewer Network
(ii) Surface / Ground Water Network
(iii) Treated Sewage Effluent Network

The main features of the drainage network are gravity sewers, manholes, Manhole one, pumping stations, gullies, pressure pipes, valves and septic tanks. Gravity Sewer is the part of pipe within which fluid from one or more facilities is carried by the force of
gravity. *Manhole* is a chamber through which access can be acquired to the Gravity Sewer Segment (line) for maintenance or inspection purpose. *Manhole One* is the chamber built, maintained and owned by the landlord on a gravity sewer that represents the termination of responsibility of drainage authority for the line. Access can be acquired to the line for maintenance or inspection purpose. *Pumping Station* is a facility that collects fluid delivered to it either under pressure or by gravity and forwards the fluid by mechanical means to another part of the network. A *Gully* is a chamber that functions as a surface water collector and a silt trap. *Pressure Pipe* is a pipe or culvert carrying fluid under external force. A *Valve* is a device placed within the network used to control the direction, pressure, release or admission of air to the fluid. *Septic Tank* is a foul sewage collection chamber serving one or more properties located either within the boundary walls or adjacent area found in properties that are not yet connected to a foul sewer network that are emptied by a suction tanker.

**Major Functions of Drainage GIS Unit**

The Drainage GIS Unit was established to perform the following duties and functions.

- Collection of spatial data related to drainage from the Survey Unit and other concerned departments in different formats.
- Conversion of data into GIS format as per the defined standard conforming to National database.
- Daily update of data related to various components of the sewer network and making it available by writing applications as per their daily needs.
- Development of required GIS applications to make it user-friendly.
- Creation and plotting of drainage maps for different purposes for various groups of users.
- Hardware & software upgrading and technical support to drainage department.
Customised GIS Applications

The drainage department has developed various applications to meet the day-to-day requirement for performing different tasks. The set of functions includes converting, updating, operating and managing drainage data. Some of the important applications are described below.

1. **Drainage Information System**: The application helps design engineers to decide where to construct a pumping station and to find out which direction to drain the water. The decision is made on the basis of generating contours and surface models using Digital Elevation Model (DEM) for the area of interest. This application stores all the data related to sewer network such as manhole, connections, pumping stations, wall chambers and rising main etc.

2. **Manhole Data Entry Form**: This application helps for addition, updating and modification of data related to manholes that is stored in the central database. When data is entered the system automatically generates a unique key number and updates it in Arc/Info coverage and in Oracle through Arcinfo-Oracle connectivity. Whenever system encounters two manhole positions with the same reference number, it gives error massage and stops further processing. This way redundancy in the database is avoided.

3. **Sewer Data Entry Form**: The application prompts for Upstream and Downstream manhole number and then checks for their existence. Next, it checks for invert levels of both manholes and presence of sewer lines between these two. After all these checks the system allows data entry, generating a unique key number that acts as a link between Arc Info and Oracle for update.

4. **Valve Chamber Entry Form**: It is an interface for entering conditional attribute data for valve chambers using the record sheets, which is filled by surveyors in the field while doing the conditional survey of valve chambers.

5. **House Connection Positional Data Entry**: The application is meant to enter the positional data of house connections to the manholes using different
methods, record sheets being the data source. Surveyors go to the site physically and take the offset from various points such as distance from boundary wall to manhole, distance from the corner of the building, distance from the sewer line. Deciding upon any of these methods data is recorded on the sheet in terms of exact position of the house connection that is later keyed in into the database.

6. **D**R**G** Plot: This application is designed for the purpose of producing maps of different sizes and scales as per the requirement, using topographic data, ortho-images or planning data as a base map and drainage features with the option of displaying attributes data such as pipe diameter, pipe material etc. on the map.

Apart from these applications a few more are still on the way to being implemented. The most important of them is Road Opening Application. At the road-opening unit of the drainage department numerous applications from various agencies are received on daily basis. Processing of these applications manually is a very tedious job and time consuming also, making the process slow as it involves approval from various internal sections and area engineers. This process is being automated by this customized application.

All above-mentioned applications contribute to the drainage department to accomplish its tasks efficiently. The major application is the Drainage Information System taking care of all activities of the department. Rest of them are helpful in maintaining the accurate database. GIS is more of database stored in different formats. Once we have accurate database it is very easy to handle the tasks. Hence all these small applications are of great value to make the whole system working. The modular structure of the applications makes the data base maintenance easy by appointing specialised staff to carry out the job.

The GIS not only helps in maintaining the existing drainage network or sewer network but also helps in planning the whole network. In the above section we studied the functions, responsibilities and in-house applications in the Drainage Department
for better management of the drainage network and information retrieval in the form of map. In the subsequent sections we will examine the application of GIS in planning the sewer network, taking a case study of an industrial city of Qatar called Al-Mesaieed.

**GIS in Sewer Infrastructure Management: A Case Study of Mesaieed City**

Towards a completely GIS assisted sewer systems various applications have been developed by Information Technology Department (ITD) of Qatar Petroleum, as part of the pilot project, to modify the existing workflow procedures. These applications facilitate the users to automate their routine tasks and relieve them from the manual and time-consuming data entry and Quality Assurance/Quality Control checks with very little training. For planners, the decision support application provides access to all available data in one place enabling easy manipulation, querying and integration of data from different sources, including satellite and aerial photographs, and preparation and printing of desired maps with required information.

The primary prerequisites for planning any infrastructure are the planned layout and the population forecast of the region. All the Master Plans that underline the broad land use of the area are prepared keeping in view the future requirements. Mesaieed Industrial City (MIC) expansion plans are formulated in consonance with the Master Plan envisaged for the next 25 years. Sewer infrastructure planning for this region is based on this development blue print. The GIS application allows the blue print to be viewed in the system along with other data like contour and existing facilities both under and above the ground. The contours are used to create digital elevation model to find out the slope and aspect. Armed with this wealth of information the planner is able to plan the infrastructure starting with the pumping stations, then the sewer lines and the manholes. At times aerial photographs are used in conjunction with elevation models by the planner in visualizing the topography of the area while locating

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162
pumping stations. Knowledge of existing facilities are crucial at the design stage, therefore, it should be readily available and accessible from the application, to help in selection of the appropriate design especially while designing underground sewer facilities like sewer lines, distribution chambers, gravity lines etc.

Mesaieed Industrial City a town, located 40 km south of the capital city Doha was the starting point for the planning of sewer infrastructure. Information Technology Department (ITD) of Qatar Petroleum (QP) took up the pilot project for implementing GIS in this City in 1997 in order to provide the best services to the community. MIC began to utilize GIS for the management of its sewer network with the completion of the pilot project. Timing of this transition, from traditional to GIS, assumes particular significance as the city is all posed to embark on an ambitious expansion plan. The city is expected to serve a population more than three times the current figure in the next three to five years. Rapid urbanization process in this area calls for planning and implementation of appropriate infrastructure facilities by the concerned authorities to provide consistent services to the community of the city.

Spatial Data Standards and Management Strategy: Management of spatial data is very crucial feature especially in the case of cross-platform operation of GIS. Strategies for data management are evaluated based on its ability for ease of data manipulation (edit, add or delete), adequate security, fast retrieval, and integration with other data, especially AutoCAD39 that stored most of the data prior to ESRI products.

ArcSDE, the database integration technology of ESRI, is used in MIC for integrating data between GIS and AutoCAD formats and improving network performance. All the three categories of sewer database namely Foul Sewer, Surface Sewer and Treated Sewers are independently registered with ArcSDE. AutoCAD clients can directly access spatial data stored in ArcSDE that vastly improved the

39 www.gm.unccd.org/fields/multi/arab/api
productivity and functioning of the GIS system in terms of faster application responses relieving GIS personnel from additional task of data conversion.

Data security is a vital issue for any application. In the case of MIC data security is implemented at two levels, application and ArcSDE. At the application level users are allowed data access, based on their intranet ID provided by database administrator. Intranet ID’s are captured from the network and compared against an encrypted list of authorized users stored on the network database. ArcSDE provides a combination of instance and password for data access. Authorized users are provided automatic access without the need to know the instance or password.

**Decision Support System Application:** The Decision Support System Application (DSS) developed by QP for MIC is aimed at assisting managers and senior staff in their planning and infrastructure development. Besides planning, it also permits monitoring the sewer system by providing access to images from CCTV, data manipulation and querying, and overlaying of satellite and aerial photographs together with GIS data for a better appreciation of the spatial layout of a region. The application has not only made easy the planning of sewer infrastructure systems but also facilitated keeping track of maintenance schedules and resources, preparing detailed asset inventories, carrying out inspections, creating service requests and reports, etc. Thus, management of MIC’s sewer system has been made a lot easier by the use of GIS technology.

**GIS in Land Information Centre**

One of the major functions of the Ministry of Municipal Affairs & Agriculture (MMAA) in Qatar is to maintain cadastral information that is also known as parcel
information. Maintaining the database of each parcel with its land use and other details is considered essential for better management of urban land. Land Information Centre (LIC), a sub-set of MMAA is responsible for such function. It’s a technical arm and the manager of planning data and applications serving Land Department, Planning department, and Land Acquisition Department. The General Survey Section that acts under the supervision of LIC is provider of accurate digital survey data for the whole country on parcel level. The organizational chart is depicted below in figure 5.6.

![Organizational Chart]

**Figure 5.6: Organizational Structure of MMAA’s Land Information Centre**

All the above mentioned departments work together for better management of the urban land and to ensure all the construction in the country under pre-defined policy and plans. Each construction has to seek permission from the Land and Planning Department. The customers are expected to submit their building permission application with the coordinates of the plot. The application is submitted to the Land & Planning department for approval. The processing unit of the department converts the
building permission drawing into digital format. The General Survey Section is
provided with the digital copy of the application to visit the site. After visiting the site
x, y coordinates are verified and plot number is assigned to the plot. This becomes the
reference number for further use and information. Once this task is completed the
parcel is called *live parcel*\(^40\) and becomes the property document. The printing of the
drawing is done in ArcView GIS and provisional approval is kept in the text format
making the parcel live.

The task of LIC is to convert the property document file into the *coverage*
(Arc/Info) and maintain the database on Unix server on source level. It also performs
data quality check control and validation apart from supplying digital data and maps to
government agencies. The sources of data in the LIC are, policy plans from planning
department, plot layouts from general survey section, building layouts from building
permit department and several tabular and spatial data from LIC itself. The datasets
maintained by LIC are termed Land plans, containing planning details like
subdivisions and road, cadastral plot details and administrative boundary zones; in
urban areas they contain physically existing plots and streets with its addresses like
plot number, street name and number; Plans with not-approved planning information
and Plans with attributes of all the above datasets in tables.

The Planning department of LIC is the sole authority for preparing Master plans
of the different urban centres as well as the whole country. The entire task is
accomplished by the different departments of planning unit. There are mainly seven
departments namely Urban Planning, Urban Design, Building Control (development),
Current Planning, Design Review, Rural Area Planning and Urban Management
department looking into special issues. \(^41\)

The planning section is also responsible for strategic planning, master planning,
and allocation of parcels for different land use, acquisition of land, proposing

\(^{40}\) As per information given by, Mr. Sanjay K. Parab, GIS Coordinator, Land Information Center, Doha, Qatar, May, 2004.

\(^{41}\) Information provided by Mr. Al-Wakar, Head, Planning Section, LIC, Doha, Qatar, May, 2004.
acquisition as per national interest, approving structural plans, proposing new roads at regional and national scale.

The functions of the urban planning department include preparing land use plans of the city and state, future planning for expansion of the city or redevelopment, community area development plans, future planning for highways, parking, community facilities such as parks, school, community centre, health centres etc42.

All above mentioned departments of Land Information Centre use GIS technology to carry out their daily tasks. Various application programs have been developed to automate the tasks and maintain accuracy with efficiency. Some of them are described below.

**Applications of GIS in LIC**

Land Information Centre GIS follows a well defined set of standards for in-house application development on conventions such as file naming, variable naming, programming style, application functionality and coding system i.e. Visual Basic, Avenue. The application, *Database Update program* is developed for editing of all layers in the planning database in a multi-user environment. It has a full set of editing tools that update the records after checking many constraints.

The *Survey Conversion Application* converts the survey data from general survey section into ArcInfo format and splits the coverage into different coverages zone-wise. *Plan Plot 3.0* facilitates the query on the approved policy plans and automates the process of viewing, delivering live spatial survey data with parcel identification number along with surveyed boundary dimension. This application is used by LIC, land department, Land acquisition department and Rayyan and Doha Municipalities. *Plan Map* is meant for query and display of the plan maps with easy to reference information and provides staffs of Planning and land department with quick and easy maps depicting location of planning related information. *Builder View* is the application used by Rayyan Municipality for providing appropriate planning

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42 As informed by Mr. Reyaz Ahmad, Head, Planning Section, LIC, Doha, May, Qatar, 2004.
regulations and policies applicable to a particular plot. This helps in granting permission for a particular type of construction according to the area. Using the application the municipality provides information pertaining to spatial survey data with PIN, policy plan, Qatar Area Reference System (QARS) address, surveyed boundary dimensions, existing drainage network and topographic details for a particular plot.

*Preliminary Building Permit Approval* application makes one of the very fundamental functions of Planning and Development department an easy work. It processes and updates a digital site plan to the data layer as per the standards of planning department. It also verifies proposed plans from Building permit department for conformity with planning regulation and finally converts the building drawings into ArcInfo coverage.

*Land use Information System* is being used by Planning department, for updating of approved policy plans’ coverage and its attributes with the correct proposed land use as per the final approval from competent authorities like planning and development authorities. Another significant application recently implemented is *Physical Development Management System* that enables users to display and edit selected QARS information through zone, street or plot number. This way updated information regarding city development is available for further decision-making.

**Concluding Remarks**

The State of Qatar is the pioneering country having implemented countrywide GIS successfully. The fundamental aspect of the implementation is the driving force behind the mission with greater vision and involvement of the top officials, in this case Sheikh Ahmed bin Hamad Al-Thani, a minister in the cabinet, recognised as champion of GIS in the State. To make the country GIS successful, integration of technology stands mandatory: The country data should be managed by a central authority to avoid duplicity and repetition of work. The CGIS in Qatar has played a vital role in this
direction. The entire user department follows the same symbols and data standard to make it a useful cross-platform. All the 17 participating agencies follow the same data standard defined by the CGIS. The utility agencies maintain database at two levels. The minute details of the facility specific to the departments are stored on local servers that are only used by the department internally. At the second level, the major data resources are stored in public server that can be accessed by any participating agency. The CGIS is the central authority maintaining the public data. By logging on the intranet (GISnet) any data can be accessed. For instance, to plan for new road or maintenance work the road department might need information of affected networks such as location of electricity network, sewer network, water network etc.

Each of the utility agencies has developed internal GIS applications to serve their specific needs. The strength of GIS lies in the mode of spatial and non-spatial data storage and its retrieval for prompt and realistic decision-making. The adoption of GIS technology has transformed the way they dealt with their customers and provided facilities in the country. The work of days has been accomplished in hours, as information is the key factor that is readily available on the network. This helps in planning new facilities and carrying out maintenance work efficiently.