

GIS Implementation Strategy in Oman: Past, Present and Future

Abstract

This paper addressed the Geographical Information Systems (GIS) in the Sultanate Oman; its implementation strategy and process constraints. It also suggested ways of enhancing its current strategy in the Sultanate of Oman.

GIS was initiated in the Sultanate of Oman in late 1980s. The initial GIS implementation strategy was introduced to define the public originations requirements and then to plan and introduce a National Land Information System (NLIS). Several efforts and works have been done since the initiative strategy particularly by the Supreme Committee of Town Planning (SCTP). The implementation progress has fluctuated due to several reasons. To maximise the value of GIS in Oman, the implementation strategy needs to be reviewed and modified in order to meet the old and new objectives of GIS; and to go with the new trend of the technology. Therefore, this research aims to: (i) review the current strategy of GIS implementation; (ii) identify the implementation process constraints; and (iii) enhance the current strategy of GIS implementation in Oman.

1. Introduction

Geographical Information Systems (GIS), in their automated form, began in the 1960s by a Canadian group. The definition of GIS is not only a computer system, capable of input, storage, manipulation, analyzing and output of geographical data but also, in its widest definition, is a data system to manage the environment for sustainable development for the analyzing of data for planning, decision support and implementation of decision making. Prior to achieving that, GIS is a spatial database.

Accordingly, choosing GIS is not a simple task to perform, therefore, GIS implementation is not only purchasing hardware, software and collecting data, but it is the all procedures of combining the technology with people and method. Therefore, the environment of GIS consists of four main components: hardware, software, liveware and data. The difficulties of these procedures lie in how to combine these four components together with the same deliberations.

Currently, using GIS in the world has increased rapidly especially in Western countries. The government of Oman released the importance of GIS in the second half of 1980s. Since then significant works have been done to implement the GIS technology in Oman. The project is at the end of the project scheme therefore there is a need to evaluate the system implementation within various participant organizations as well as those throughout the country. The aspects discussed in this paper are not only to indicate or make a review of the criticism areas of GIS implementation in Oman but, the main objective of the paper, of course, is to make an attempt to investigate the GIS strategy and approach for successful implementation.

The research is divided into six sections: the abstract that outlines the work. The introduction section that briefly presents the processes of implementing GIS in Oman, The discussion section that addresses in detail the GIS implementation constraints in

Oman. The evaluation section that provides GIS assessment and the future of GIS in Oman. The final section summaries the paper.

2. The Processes of Implementing GIS in Oman

Ever since Oman decided to become a modern country in 1970, the government has looked forward to using a new technology which could introduce Oman to the twenty first century. There has also been a desire to exchange geographic data between ministries. Therefore, the system requirements were to be capable of supporting and providing maps and manipulating data related to the earth. Therefore, the suggestion, which came from international consultants, was to use Land Information Systems (LIS) or Geographical Information Systems (GIS) to fulfill these tasks. At the early stages of GIS implementation in Oman, it was seen as substantial technology, that aims:

- To provide data for decision making support
- To facilitate all digital maps and geographical data between project participants
- To increase the productivity with more efficient spatial and aspatial data
- To reduce repetition of data collection and storing between project participants
- To reduce demands on the government resources by avoiding duplication of staff and computing resources
- To produce updatable and reliable data more accurately in a shorter time.
 - To establish harmony between the various project participants

The Supreme Committee of Town Planning (SCTP) has been appointed to be responsible for choosing the right systems and designing implementation strategies of GIS. Several meetings have been held since the 22nd March 1987 to discuss the development of the system. In October 1988 SCTP entrusted ESRI with cooperation with Al Khatib & Alami Corporation to produce a comprehensive proposal for GIS implementation,

- Identification of GIS implementation strategy phases
- Identification of GIS requirements from the hardware, software, staff....etc.
- Establishing a new network to facility geographic data between participants
 - Developing new methods to update maps and related information

The implementation was designed in three phases which were supposed to progress over ten years as follows,

- **Phase One:** Its duration was fifteen months. In this phase a pilot project was designed for seven ministries to test implementation processes. Two ministries also joined the project. The pilot project was pursued in five testing areas (Sohar, Al-Rastaq, Al-Buraim, Khasiab & Governorate of Dofar). The main objective of this phase was to identify the outline requirements for the system as part of a longer program of investment in assisting management system and supporting decision. The identification of GIS requirements from the hardware and software for each GIS implementation participant has been completed in this phase.
- **Phase Two:** Its duration was three years. The objectives of this phase were to review the implementation processes and to concentrate on developing and expanding the pilot project to include further areas; and to encourage other potential ministries to join GIS implementation project.

- **Phase Three:** It is planned to take five years. At the end of which all participant ministries are supposed to be ready to join GIS network. Other objectives were expected to continue maintaining the database and to improve the facilities of hardware and software to meet the complexity of advanced GIS applications.

3. Implementation Process Constraints

The successful GIS implementation is not only to purchase computer devices and some GIS software and to place them at any corner of the organization with some GIS knowledgeable staff and then expect immediate operation. A serious commitment to GIS implies a major impact on the whole organization. However, even with this consideration there are always threats to successful using of technology. In Oman there are several constraints which could harm the GIS technology. SCTP has grouped GIS implementation constraints into four main groups. Each group contains several issues which need to be addressed.

3.1 Map Production

GIS cannot operate without a digital map. Lack of the digital map was the main concern at the early stages of the GIS implementation. Currently, most maps available in the country are relatively old. Additionally, there is some delay in producing new maps.

3.2 Sufficiency and Appropriateness of Budget

GIS is very expensive technology especially at the early stages of its implementation.

At the establishment meeting, all project participants were advised to request an adequate budget to support the implementation process. After the first phase, SCTP has requested around 10 million US Dollars to continue implementation processes. In the recent years, due to fact that GIS project output did not meet the expectations, the budget of GIS project has been cut down in most ministries. On the other hand, some GIS participants such as Muscat Municipality has increased GIS implementation budget.

3.3 Qualified Staff

To operate GIS sufficiently, highly qualified staff are required. At the early stages of GIS implementation, most participant ministries hired international professional staff in GIS field to run the system. Other tasks were given to these specialized staff such as preparing comprehensive training programs for Omani staff. Another issue that might have affected the plan is the movement of staff between various positions within their organizations. This matter necessitated preparing another training program.

3.4 Data Sources

In Oman, the National Survey Authority is responsible for map production, whilst other ministries are responsible for the preparation and conversion of their spatial and aspatial data into digital format. Repetition in data production has lead to another problem i.e. the difficulty in exchanging data between participants.

3.5 Other Constraints

The above four groups are not the only GIS implementation constraints in Oman, but several pitfalls have been identified by the researcher (from both the interviews of staff and parties concerned and close observation of implementation progress). These pitfalls are as follows,

- **Failure to identify and involve all users**

GIS hierarchy consists of operations, management, and policy levels of the organization. All three levels were not obvious from the beginning of implementation processes.

- **Failure to match capability and needs of the systems**

The first GIS implementation strategy has just presented the general needs of GIS and did not go in detail in how to match between GIS capability and users' requests. Recently, the GIS technology and application have changed dramatically and now GIS moved into another direction. All these matters have not been considered at the pilot project. There are different hardware and software alternatives in the market recently. Choosing the right hardware and software will help to implement the system successfully.

- **Failure to identify total costs, scales and schedule**

Budget identification of GIS implementation is not a straightforward process. Some GIS cost is simple to identify specialized hardware and software. Other implementation of GIS elements are restively difficult to identify particularly maintenance, data conversion and updating, long term training, systems administration, and consulting fees. All these costs were not identified clearly from the beginning.

GIS implementation especially on the national scale takes long terms until it reaches satisfactory stages. Precise schedule is fundamental for successful implementation of any technology. In Oman the plan was to implement GIS in ten years. The problem with scheduling in Oman was due to some postponements to execute some part of the plan probably due to lack of the budget

4. GIS Implementation Assessment

There are several GIS models to evaluate and choose the system. GIS has been developed world wide. Clarke (1991) for example, presents models which are based on 14 steps grouped into four main stages: analysis of requirements; specifications of requirements; evaluation of alternatives; and implementation of a system. In reality, there are many similarities between Clarke's model and GIS implementation processes in Oman especially at the stage of feasibility study when the theoretical specification and requirements of the system were designed.

The main problem of GIS implementations process lies in the fact that the implementation strategy came from outside of Oman. The strategy has not taken into consideration Oman's societies and particularities. This means that there was evidence of potential failure of the strategy from the beginning. In Oman it was agreed to share international experience in this domain, but on other hand, we need to consider our cultural issues and our data structure. For example, the data structure between Oman and other advanced countries are different in availability, reliability and accuracy. In 1980s the data structure in Oman was not well designed and was scattered between

different government sectors. At that time, there were also lacks of accurate and consistent geographic data. Unfortunately, all these matters have not been taken to consideration from the beginning.

It is vital for the assessment of GIS implementations to look at several areas of implementation such as the feasibility study, the phases of implementation, the technology, data availability, GIS output...etc. The feasibility study, for example, looked at several implementation domains. It also considered the main key questions of the implementations such as

- What are the business requirements for GIS?
- What is the most appropriate technical solution?
 - How data can be captured and converted?
 - What is the timescales of implementation?
- How will they get benefits from the implementation?
 - What is the cost?

All key questions had been answered in the initial feasibility study pilot project. The beginning of implementation was successful and the SCTP was responsible for providing and supporting GIS implementation in Oman. When further GIS development of implementation took place, some GIS participants realized that the cost of GIS was high and the incomes from the systems were not yet received. Compare to the initial strategy plan, the implementation processes no further than the second phase of implementation. Two groups of GIS users can be distinguished in Oman:

- A good level of using GIS, in particular Muscat Municipality (MM), Ministry of Regional Municipalities, Environments & Water Resources (MRMEWR), and Petroleum Development Oman (PDO)
- An average level of using GIS such as Sohar Development Office (SDO)

As a result of researching, the most important issues obstructing GIS implementation in Oman are:

- Failure to imply the technology throughout the organization.
 - The availability and updating of digital maps and data.
- The awareness of using technology including management encouragement.

5. The Future of GIS Implementation Processes

According to the initial feasibility study and the master GIS plan, the performance of distributed database which was linked to all participant organizations by a wide area network (WAN) supposed to be the final stage of implementation processes. Before adopting that, each participant organization is responsible for collecting their spatial and aspatial data to join the final stage of the project. From close observation, unfortunately, most participant organizations have not yet arrived at this stage. The processes are still no further than the second phase. However, there are executive works that have been done from SCTP, MM & MRMEWR to adopt this stage.

For more efficient GIS implementation in Oman, the main GIS implementation strategy has to be reviewed and modified. The modification is not always the best alternative and is not easy to perform. In Oman cases, there are several evidences that mean, this strategy now has to be modified. The implementation consideration now needs to looks into specific domains of implementation as follows,

- Awareness and technical support
 - Data Quality
 - Output evaluation
- Trends of GIS Technology

Other ministries have prepared to adopt GIS technology such as Ministry of Education and Ministry of the Interior. Currently, GIS also has spread into private sectors as well. According to Al-Ghazali and Mclay (2002) PDO have progressed well on the implementation of geospatial information strategy. Other private sectors also use GIS to assist in decision making. This progress is vital to improve GIS trend and to develop an advanced application.

6. Conclusion

The success of technology implementation is particularly sensitive to the right plan from the beginning. However, the mere existence of an implementation plan does not guarantee success. It is not true that the approach which was used to implement GIS in Oman is not well designed, but there were several internal and external factors that made a massive impact on the implementation of the schedule and plan objectives as discussed in section three. Unfortunately, most GIS implementation participants thought that the GIS is only a matter of purchasing computer devices and some GIS software and to placing them at any corner of the organization with some GIS knowledgeable staff and then expecting immediate results proceeds. They forgot to take into account the structure of the organization and how GIS can fit to the process of decision making rather than producing maps. Recently, there is conviction to progress GIS by paying more support to the technology.

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GIS Implementation in the Ministry of Water Resources in Oman

Hussain Jama Ismail Bait-Ishaq

and

Philip Burden

GIS Section, Technical Services Department

Directorate of Water Resources Assessment

Ministry of Water Resources

P.O.Box 2575 Ruwi, Postal Code 112

Sultanate of Oman

| [Abstract Of The Paper & The Profile of The Speaker](#) | [Speaker Index](#) | [Paper Title Index](#) |

1. Introduction:

The importance of water as a source of life is indisputable. Water has become more important in this century due to the great technological advancements which have brought about comprehensive development in the various aspects of life. The Ministry of Water Resources (MWR) has implemented different kinds of information technology in order to assist in the effective management and monitoring of the Sultanate of Oman's water resources. One of the information technologies implemented in MWR is Geographic Information System (GIS). To guide its implementation, an implementation plan has been written which sets out the resources and tasks required to realize the objectives of establishing an operational GIS for priority applications at 1:100,000 scale, and other scales, with Ministry wide access for an effective trained GIS user community.

This paper outlines experience learned from Implementing GIS in the Ministry of Water Resources in Oman and the impact that had on helping MWR to better manage water resources in Oman. This will be presented by discussing the benefits of GIS within the MWR, the GIS implementation strategy in MWR, GIS applications identified within MWR and constraints in GIS implementation.

2. Benefits of GIS within the Ministry of Water Resources:

The Ministry of Water Resources (MWR) Geographic Information Systems Section became operational in July 1991 with the primary aim of:

establishing and maintaining a computerized geographic information system (GIS) to assist in the effective assessment, planning and management of Oman's water resources.

In order to carry out its duties the GIS Section has been divided into two Units, the CAD and GIS Unit.

CAD Unit:

The CAD Unit is primarily concerned with the capturing of thematic map data for various Ministry reports and publications. It also provides digital graphic map data to the GIS Unit.

GIS Unit:

The GIS Unit collects, stores, integrates geographically related (both graphic and textual) information. It also provides results of various requested analysis and thematic map products for inclusion in Ministry reports and publications.

In implementing GIS technology within MWR there were certain benefits to be gained. However, it is well documented in the proceedings of many a GIS conference, that the benefits of introducing GIS technology to an organization will not be immediately realized. It is only after several years of slow and painstaking implementation that the benefits will begin to be realized (Burden and Parker, 1994).

Given this, GIS implementation within MWR is seen as providing both tangible and intangible benefits, including:

- increased productivity with more efficient map updating and the ability to compile and report information more rapidly;
- more up-to-date, accurate and reliable information resulting from standardization and integration of data used throughout the Ministry;
- reduced duplication of effort as more readily accessible data will avoid duplication of data collection and analysis;
- all map data will be integrated into a single shared, distributed database;
- improved coordination between departments and Ministries facilitating the storing of data and maps;
- new geoprocessing techniques will be available for problem solving;
- better service to Government users will result from more efficient information processing;
- higher quality products will be produced from more reliable, more accurate data in a more timely, efficient and cost effective manner;
- better use of Government resources by reducing duplication of effort in manpower and computing resources.

Apart from these significant benefits, Omani Nationals are being training in the use of this highly complex technology. Although initially heavily dependent upon expatriate staff training has been of maj or importance within the GIS Section. Training has taken the form of in-house courses, vender training in hardware and software, on-the-job training, and formal training such as University Degrees. Recently, four Omani staff finished training courses abroad:- three MSc and one HND. This training is theoretically based and supplements the practical in-house training that staff receive. With job hand-over now occurring, expatriates are beginning to be released (Hussain and Burden, 1996).

3. GIS Implementation Strategy and Planning in MWR:

It is a well documented fact that GIS in any organization, takes anything from 3 to 10 years to implement. The actual time taken largely depends upon the degree of GIS functionality required in the implementation, the availability of skilled personnel in GIS matters, availability of digital data, the ease of access to an organization's data, its accuracy, and management's long term support for the introduction of a complex

technology.

In order to meet the objectives set out for MWR's GIS Section and realize the benefits identified, the implementation of GIS required a structured system design and implementation approach. The Ministry's GIS Implementation Plan was thus written. This plan documents:

- the system design approach for identification of user needs, GIS functional requirements, software and hardware specifications to meet these requirements and the personnel and data resources necessary to implement the design, maintain and operate the system.
- the system implementation, outlining the tasks required to implement GIS in MWR. These tasks are grouped into four tracks:
 - Organization and Staff Development,
 - Software and Hardware Development,
 - Database Development, and
 - Applications Development.

These tasks assisted MWR in ensuring that:

- the right hardware I software solution was selected to address the needs of the Ministry's GIS;
- data required for the GIS was identified, including its source, current digital *I* accuracy status, and the effort required to convert data into a functional GIS format;
- suitable personnel were recruited to GIS, and that adequate training programs were in place;
- potential applications were identified, for both short term and long term development;
- the long term implementation was kept on track via annual business plan reviews.

The Implementation Plan recognizes three development phases;

- Phase I: Startup - hardware and software installation, recruitment, initial training and database development, pilot project initiation.
- Phase II: Completion of pilot projects, advanced training, database design, data capture, integration of GIS with MWR databases and remote sensing library.
- Phase III: Further database development, systems operation and maintenance, training and equipping an expanding GIS user community with MWR and on-line linkage nationally.

The Ministry is currently between completing phase II and starting phase III.

It is recognized that GIS changes the way an organization collects, stores and manipulates its data. It is extremely important therefore, that if this is to be achieved successfully with minimal impact on the way an organization operates, GIS must have a champion who is fully supportive of GIS and is high enough in the organization to be a part of the decision making processes. GIS should also work closely with the other information technology sectors:- Computer Section, Database Section.

4. GIS Applications Identified within MWR:

After initial user surveys, several areas for GIS application were identified within MWR. Noteworthy GIS

applications which have been / are being developed in MWR to-date, include:

Application 1: National Well Inventory Project (NWIP):

The *NWIP* was carried out in MWR to assist in identifying the distribution and quality of groundwater resources, evaluate their present use and demand, and to ensure all wells are registered. All data from the NWI Field Forms has been entered into PARADOX tables. This information will provide a basis for future water supply planning and management for municipal, agricultural and industrial uses.

The NWI and other users of NWI data need to integrate this data with other layers of information for a variety of assessment, planning and management purposes throughout the Ministry. A mechanism for integrating the NWI data with spatial data for rapid display of database queries was required.

As part of a pilot project, GIS has been used to integrate NWI well and property data for several catchments with other data layers such as land use, salinity contours, ground water levels, soils, solid geology, drainage patterns, catchment boundaries, and satellite imagery, etc. This GIS pilot was able to:

- derive composite map layers which will, for example, delineate areas where salinity is high and ground water levels low;
- graphically display the results of database queries;
- contour salinity and ground water levels or water demand; and
- display scanned documents and photographs associated with wells, to assist with registration inquiries.

ArcView was used as the tool to provide query and display access to this NWIP data in a user-friendly Windows environment. ArcView was able to allow users with no GIS experience to use the NWI GIS database, retrieve, display, map and report the results of any queries that they may generate.

The NWI GIS pilot project has now been completed and well received by Ministry personnel. A schedule for making other NWIP catchment data available in a GIS format has now been commenced (Parker, etc, 1995).

Application 2: Wadi Day qah - Dam Site Planning:

In the absence of suitable large scale mapping, GIS functionality has been used to derive large scale digital terrain models (DTM) from coordinate and elevation information. GIS functionality was then used to automatically calculate area and storage volume for given evaluations and to generate cross sections between any points of interest for the investigation teams. The digital terrain provided the base for detailed geological maps which were also produced using GIS. The DTM also provides a means of visualizing various dam site possibilities with other map features overlain on the model for planning and environmental impact assessment purposes. Using GIS functionality, geology and the DTM could be combined to derive areas of unstable slopes, faults, and potential flooded areas for example.

Once the Wadi Dayqah DTM had been generated it could be used in a number of ways using GIS functionality. One application is to use the grid cell modeling functions of GIS or DTM data to provide and

delineate watershed boundaries and stream orders within the watershed. This was undertaken for the small area delineated by Wadi Dayqah.

Application 3: Flood Risk Mapping Project:

Before GIS was available within the Ministry, Flood Risk Atlases were published using primitive manual techniques for the preparation of the printer's color masks. The masks were often prepared by the contracted printing firm, who employed staff to trace flood risk zone boundaries onto several opaque films before hand painting the zones in solid black. This, thus formed the required masks for the printing process. Quite often the tracing was not accurately performed, nor the painting of the zones uniform. The result was a sub-standard printed flood atlas, of low cartographic quality.

With the introduction of GIS however, the preparation of printer's masks could be undertaken digitally and more accurately. In the preparation of masks for a recent flood risk atlas, the manipulation of digital data proved invaluable as the area of concern covered two map datums / spheroids. Some 375 1:2,000 map sheets had to be transformed to one common map datum / spheroid, before masks were produced at a scale of 1:10,000. Such manipulation of a large amount of data such as this could not have been attempted manually.

In all, twelve flood risk assessment areas have completed and are in various stages at final printing.

As a by-product of having the flood risk zonal information in a GIS format, GIS Flood Risk Atlases with an ArcView modified user interface are in the process of being developed. Such atlases when developed, will enable queries to be made through the Windows ArcView 2 interface. Queries such as, *My property is identified by property number P292342X I wish to build on this property. What is the flood risk assessment of this property?* The results of such a query could either be shown to the customer on-screen, or a hard copy map could be provided. If also linked to property valuation data, the digital flood atlases could prove valuable in helping to determine the value of insurance premiums on properties against flood damage.

After the successful completion of the above applications, we are currently working to develop further applications such as Using GIS in Well Permitting, Aflaj Inventory GIS Development and Using GIS in Groundwater Application Development.

5. Constraints in GIS Implementation:

Any organization implementing a new and complex technology such as GIS, will face difficulties. MWR was no exception to this. Key points any organization wishing to implement GIS in the Middle East should consider, include:

5.1 Adequate funding is available

Always ensure that there is sufficient funding for implementing GIS within an organization. Funds are required for:

- the procurement and on-going maintenance of hardware and software,
- consultants to undertake GIS development activities where appropriate,

- purchase of digital data,
- short and long term training programs, and
- attendance at international GIS conferences.

It should be recognized that the first years of GIS implementation are quite cost intensive. However, the pay back will be made in reducing the overall cost in the storage and access to Ministry information as compared with the continued use of conventional means. Also, more up-to-date, accurate and reliable information as a result of the use of automated up-dating procedures and the standardization of data used by Ministries will also see a return on investment for which it is hard to place a monetary value.

5.2 Availability of digital map data

Without a complementary and efficient program of digital map production and conversion, GIS will not operate. In Oman's case, the National Survey Authority is responsible for the preparation and GIS conversion of all base map data, whilst other Ministries are responsible for the conversion of their own data into a GIS format. The Nation's base data is still in the process of being converted into a GIS format.

Also, in order to take full advantage of GIS functionality, it is necessary to ensure that the positional accuracy of map features is adequate for the nature of the spatial analytical tasks being carried out. This is because, quite often not enough attention is paid to the positional accuracy of data when it is being gathered.

5.3 Corporate attribute databases are well structured

Within MWR there has been a rapid development of attribute databases created on standalone PC's. To take advantage of the networking technology that has been introduced into the Ministry, there is now a need to integrate these databases. For this reason, a Ministry-wide database review of all its current digital and paper records has been undertaken. Successful corporate-wide GIS implementation in MWR will be dependent upon the recommendations of this database review being undertaken. Without it, GIS data will not reflect changes made to the corporate databases as and when they occur. A well structured corporate database will also eliminate duplication and erroneous data.

5.4 Adequate training

Within the Ministry three types of GIS users are recognized;

1. Those who will use GIS through a Windows type interface and will not need to know GIS to use much of its functionality;
2. Those who will use GIS through ARC/INFO directly either at the command line or through an interface,
3. Those whose main application software may need to interface with the GIS.

In order to cater for these different levels of users, training has to be pitched at the correct level so as not to confuse the user. Adopting a phased approach, staff of the GIS Section have first received comprehensive training, both in-house and via overseas tertiary studies. With this complete, and as the GIS databases are

being developed, training is now being given by GIS staff to the users of GIS data.

Sufficient time should be allowed to enable training to be effective. If the time allowed for training is too short or is not pitched at the correct level to suit the user, adequate comprehension of this complex technology will not be attained.

5.5 Arabization

MWR has implemented a policy that all of its databases and application programs must be bilingual (Arabic / English). Yet problems abound as there is currently no one Arabic computer standard which is used on all the computer platforms. There is clearly a need for this issue to be resolved. For data to be transferred between applications these standards must be in place. For this reason, GIS implementation within MWR has primarily been in English, with only printed maps having Arabic text.

Organizations need to carefully consider their existing databases, the language and standards used, and this will impact the transfer / utilization of database data to GIS applications.

6. Conclusion:

Has MWR been successful in implementing its GIS? With the actual delivery of GIS hardware and software in mid 1992, GIS has helped to bring to the attention of senior management the need for better control and management of the data the Ministry collects. In spite of several GIS applications having been successfully developed, overall implementation of GIS within the Ministry has fallen behind schedule and needs to be further accelerated. There are several reasons for this, including:

- being a service provider at the same time as trying to implement GIS. This has directly impacted upon and resulted in the slow capture / conversion of graphic data;
- not spending enough time on producing quick GIS applications which could be useful to selected Ministry personnel, rather than giving a great deal of attention to the overall corporate GIS / data issues;
- spending too much time on training, and not enough on fast application development;
- the slow speed of addressing the corporate data issues raised by GIS in the early stages of its implementation.

Faced with these difficulties, the situation is slowly changing for the better. Given the slower than expected implementation, MWR is still considered to be the lead agency in implementing GIS in the Sultanate and is often called upon to provide advise to other organizations to assist them in implementing their GIS systems. In this regard, GIS in MWR has been successful, for it has helped to make personnel, both within MWR, and external to the organization, more aware of the powerful tool GIS is in managing and querying an organization's spatial / attribute data.

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| [Abstract Of The Paper & The Profile of The Speaker](#) | [Speaker Index](#) | [Paper Title Index](#) |



[CGIS](#)
[HOME](#)
[PAGE](#)



[CONTENTS](#)