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Research Article

Framework for enterprise GIS for Saudi municipalities

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Municipalities in Saudi Arabia are working hard to make use of rapid advances in information technology (IT), especially geographic information systems (GIS), to improve their performance and increase their effectiveness. Most initiatives in IT applications, including GIS, are limited to individual departments rather than supporting comprehensive institutional operations. This has resulted in fragmented applications with isolated databases. It is obvious that the municipalities lack an overall framework to guide them through building reliable IT solutions that care for enterprise or corporate requirements. Because the Saudi municipalities share many commonalities, especially among their business functions and organizational structures, it is believed that a general framework is necessary to help them to develop their IT solutions in general and GIS applications in particular, because the majority of municipal decisions are spatially oriented. This article attempts to provide a framework for enterprise GIS for Saudi municipalities. It starts by reviewing the important issues associated with enterprise GIS to establish the basis for building a framework that is suitable for the Saudi context. The proposed GIS framework emphasizes the enterprise requirements for municipal institutions and considers GIS as a major IT requirement that can be supported by other related technologies. The suggested framework includes three main factors: business functions, tasks and data requirements. The integration of these factors provides the basis on which the municipalities can advance their aim of automating their functions. Discussion of these factors within Saudi context is presented with reference to the Municipality of Jeddah where data were based upon interviews with key municipal officials in 2004. The main finding of this research article is the identification of municipal functions and tasks that pave the way for determining applications required for the corporate IT solution. Furthermore, this article identifies data issues related to municipal data – sources, sharing and management – and calls for establishing a unified municipal data model. Finally, this article suggests that similarities among Saudi municipalities lead us to believe that IT applications can grow reasonably well by partnership among municipalities.

Keywords: GIS; Municipal applications; Enterprise solution; Urban management

1. Introduction

Developments in information technology (IT) encourage public agencies to improve their services and make them perform more efficiently. In general, IT solutions, if used properly, can provide important tools to support the municipal administration, and therefore directly affect the management, control and development of the built

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environment. A considerable proportion of municipal information is land-related and location-oriented, thus geographic information systems (GIS) become central to any municipal information system. Practically speaking, GIS can provide municipalities with unprecedented benefits, which may lead to a reform of their work and achievements (Bails 2002). Applications of GIS in Saudi municipalities are growing steadily, but most municipalities lack a comprehensive understanding of what can be realized from GIS development, especially when considering the widely varying functions carried out by the various inter-related municipal departments.

Saudi municipalities face increasing public and institutional pressures to deal with rising urban and environmental problems within their localities. Further, the public requires decisions that will be more efficient, logically based, unbiased, and environmentally safe. Accordingly, municipal authorities are required to be responsive and able to take quick decisions based on reliable and accessible data. Though the municipalities own much spatial and attributable data, they require information from other local agencies concerned with infrastructure and community data services. In reality, the management of the flow of spatial and attributable data within the municipal departments and with other public bodies is difficult and time consuming, because the municipal departments and other agencies maintain separate digital and paper records.

The continuing developments in IT, especially in GIS, make IT a necessity for all the Saudi municipalities. Many of them have been through various automation projects, some of which have been GIS related. However, most GIS initiatives are limited to individual departments working towards their own specialized solutions. Though there has been some improvement in carrying out limited activities, this approach results in the duplication of data and fragmented automation, which makes it difficult to integrate the corporate functions.

This article argues the importance of enterprise-wide GIS for municipalities in Saudi Arabia because they need more than the automation of a few separate functions and duties especially when dealing with predominantly integrated city functions. Furthermore, this article attempts to provide a framework for an enterprise GIS approach to help municipal authorities to establish a road map for GIS development. The approach to developing municipal GIS solutions aims at instituting intrinsic changes into the municipal procedures and performance. In particular, the municipal GIS framework starts by defining the user needs, application requirements, data requests and specifications. Additional GIS components such as the system configuration of hardware and software are beyond the scope of this article. Notwithstanding the importance of establishing an enterprise GIS for municipalities that share common settings and legislation, there are differences that relate to the cultures within organizations especially the norms, values and bureaucracies that may affect GIS diffusion (Campbell 1996). It is understandable that the introduction of GIS to any organization will lead to changes and that municipalities will differ in the extent to which they welcome GIS as a tool for improvement and in their abilities to absorb the potential changes. It is therefore important to consider the institutional context of the individual municipalities when adopting any generalized framework.

In fact, the GIS framework proposed here will be useful to all municipalities in Saudi Arabia as they share largely similar tasks, comparable administrative structures and employ procedures governed by directives and regulations passed to them by the Ministry of Municipal and Rural Affairs (MOMRA). This article begins by

presenting a background section that discusses issues related to enterprise GIS, attempting to define its scope and approach in order to establish a general understanding that will help in building a framework for the enterprise GIS that is necessary for Saudi municipalities: this is discussed in Section 3, which also highlights the methodology for adopting the proposed framework. The remaining sections attempt to examine the application of the suggested framework for enterprise GIS for Saudi municipalities.

2. Background

GIS capabilities encouraged municipalities and local governments to utilize its potential to enhance decision making and effectiveness in managing city affairs. The Saudi municipalities are taking progressive steps towards using GIS; however, attempts in this respect are limited to a few unintegrated departmental applications. The literature on the Saudi experience of GIS applications in general, and on municipal GIS in particular, is scarce. The available contributions focus on specific applications such as building permits (Alterkawi 2005) and the distribution of health facilities (Murad 2004). Regionally, Qatar has developed an advanced GIS system for urban management, while the experience of Abu Dhabi is oriented towards corporate applications that involve re-engineering of all the major business processes (Kunka *et al.* 2005).

In general, the literature on GIS covers extensive practices of advanced economies, while relatively less breadth of literature is available on successful GIS applications adopted in emerging economies such as the importance of landscape information systems in Seoul Korea (Oh 2001), the experience of Durban City, South Africa (Odendaal 2003), the municipal GIS in Gorakhpur, India (Nandan 2006), in addition to many other practices. Nevertheless, contributions to enterprise GIS involve a wider perspective towards applications that are oriented to the direction of operations and management of integrated urban activities.

Corporate (or enterprise) GIS refers to the 'concept that a central service bureau or group can be more cost effective to serve an entire organization' (Municipality of Anchorage 2004, p. 1). Enterprise GIS is concerned with breaking down data barriers to corporate GIS that serves various departments to increase the appropriation of spatial data (Bails 2002). The objectives of enterprise GIS include the provision of a reliable, accessible database that supports the needs of municipal users and simultaneously the public in a cost-efficient way. Accordingly, the benefits of enterprise GIS include the enhancement of the quality of decision making, expediting data sharing between the municipality and the public, providing Internet-based transactions and information, and contributing to the overall municipal performance (Kunka *et al.* 2005).

The literature encompasses various approaches to investigating the requirements for GIS development and IT in general (Coad and Yourdon 1991; Norman 1996). Most enterprise GIS approaches are business oriented and focus on processes in the institution covering analysis of all GIS components, i.e. hardware, software, staffing, data and applications (Maguire *et al.* 1991; Zlatanova 2001). However, this study is concerned with data and applications that specifically include needs assessment, application requirements and data needs (Geoplan 2001; Bails 2002; Hall 2004).

2.1 *Assessment of needs*

This is a primary stage in GIS development which employs different approaches that can be grouped into two categories. The first is goal-oriented, centering on the

production process; in contrast the second is object-oriented, analyzing the items involved and their relationships (Zlatanova 2001). This article concentrates on the municipal functions, services and activities as they influence and manage urban development, because the city is usually the centre of the various urban activities run by the different departments. However, the municipal departments responsible for managing and controlling city development adhere to organizational structures that govern their relationships, duties and procedures. Therefore, the approach suitable for the scope of this study focuses on the goals and objects, i.e. functions and relationships.

2.2 *Application requirements*

Applications manifest a translation of user needs; accordingly they form an important part of enterprise GIS. Municipalities usually face financial constraints as well as other challenges and therefore, have to spend, act and progress wisely. Although municipal staff understand the benefits of GIS, they need to be helped to produce a framework for their needs. Given the wide similarities between the municipal functions, GIS applications are found to grow more prudently and efficiently through partnership (Wastell 2006). Benefits from GIS applications can be realized by (1) developing work-centred applications that use spatial data technology to produce a natural, easy to use interface for well-defined functions and (2) considering the organizational factors that affect enterprise applications by relating institutional, organizational and technological factors when defining application requirements (Wellar 1993). GIS applications will support the re-engineering of business processes, therefore municipalities have to be aware of the need to change their procedures to fit with the proposed enterprise applications. Such changes will eventually lead to a social change within the municipality that will affect human behavior as well as the decision-making process (Sussman 1996). In general, corporate GIS applications can be grouped into three categories based on their support characteristics (Geoplan 2001; Kunka *et al.* 2005): (1) corporate applications to deal with multiple municipal departments; (2) workgroup applications that support operational needs within a specific municipal department and (3) external applications that relate the municipal functions to other local agencies. It is also important to realize that the automation of some municipal functions requires other associated technologies such as global positioning systems (Vanier 2004). Therefore, it is wise to explore the suitability of available technologies for supporting function automation and application development. This can be facilitated by designating tasks to each business function in order to clarify the best technology for it.

2.3 *Data requirements*

Municipal staff are required to reword and document data more than any other local agency; therefore municipal data, whether it is spatial or attributable data, form a major component of enterprise municipal GIS. Results from the preceding two steps, i.e. assessment of needs and application requirements, will definitely pave the way for the building of a comprehensive data model that deals with the city as a system of integrated parts. Nevertheless, there are certain issues that have to be considered in creating a municipal data infrastructure. In this regard, it is worth recognizing the following strategies (Municipality of Anchorage 2004): (1) formation of a centralized geographic and relational database valid for collective municipal departments; (2)

setting up data standards and maintenance procedures to be followed by all municipal departments; (3) collaborative work to develop relational databases (spatial and non-spatial) that accord with and are functional with available municipal databases and (4) the establishment of a cadastral foundation. These strategies provide sensible guidelines that address practical issues in approaching municipal databases for both spatial and non-spatial components by focusing on the establishment of a centralized municipal database, which can be used as a data model that collapses all data barriers to the data sharing required to run inter-linked municipal applications. In addition, municipal databases need to recognize the breaking down of data into areas by availability, maintenance and responsibility (Geoplan 2001). However, the hierarchy within the municipal data structure would have to be consistent with the dominant administrative structure and organizational relationships among the municipal departments and their relationships with other public bodies within their jurisdiction.

3. Framework for corporate municipal GIS

The foregoing sections discussed the major issues involved in building an enterprise municipal GIS that include business functions, GIS application requirements and data need. This section aims to articulate these issues in order to establish a framework for the development of enterprise municipal GIS. As mentioned above, the framework deals with the production of services and the relationships associated with the carrying out of municipal services. The framework starts by assessing the municipal needs based on municipal business functions and their relationships as affected by the organizational structure and procedures applied to carry out these functions (Figure 1). Defining existing municipal business functions lends itself to spelling out the IT application requirements. In fact, within the context of an enterprise solution, each municipal function needs to have an IT solution that may incorporate different technologies that includes, among others, GIS.

Professionally speaking, all municipal business functions are associated with various municipal tasks that spell out the detailed work needed to accomplish each
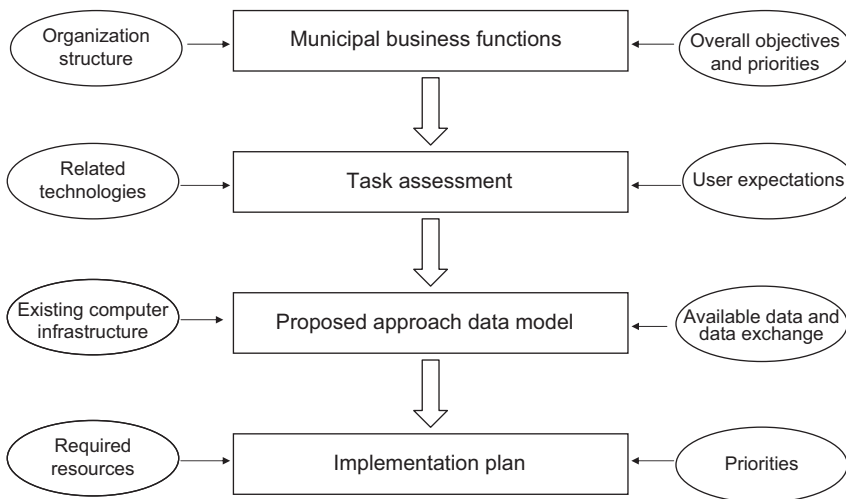

Figure 1. Framework for municipal enterprise GIS.

function. Automation of the municipal tasks requires certain technologies that are central to application development. Further, exposition of the municipal tasks allows the application development to follow a modular approach by using core IT applications suitable for automating those municipal functions that employ common tasks.

Furthermore, existing municipal business functions and tasks are associated with typical data sources that include both spatial and tabular data that need to be defined in order to understand the inter-departmental data circulation. Developments of the GIS applications cannot proceed without defining their data requirement, which will eventually lead to the creation of a municipal data model. It should be noted that the data model aims to provide a road map to help the Saudi municipalities to develop their GIS applications with a vision that leads to an enterprise municipal GIS. However, municipalities must be aware that this framework provides basis for putting a detailed GIS implementation plan that must attempt to consider success factors related to GIS projects, clear steps for accomplishment and the awareness of issues associated with the implementation of IT and budgetary requirements. Although these issues are beyond the scope of this study, the proposed framework will definitely be helpful in providing insights that help to develop any municipal GIS project. The next sections adapt this framework to the Saudi municipalities. For this purpose, Municipality of Jeddah (MOJ) is selected as a reference because of the author's knowledge about MOJ as he was a Deputy Mayor between 2002 and 2005. In addition, MOJ is a major municipality that shares other Saudi municipalities, on the same rank, similar structure and functions. Data required for the application of the proposed framework was collected by a series of interviews with heads and key officials of major departments of MOJ in 2004. Interviews were structured for a thorough review of each department's work processes and functions to get precise primary information on department's functions, tasks existing mapping and spatial data processes, available databases, maps produced and used, expectations from enterprise GIS and required data. Interviews were supported by survey forms to record data on a coherent method.

4.   Municipal business functions

Municipal administration in Saudi Arabia runs a two-tier system: MOMRA at the national level and the municipalities at the local level. The former sets rules and regulations while the latter are empowered to implement them with varying mandates. Municipalities are divided into four categories depending on their function and population size. Amana is the top category and usually includes the regional capitals. Amana (municipality of a regional capital or major city) is answerable to the minister in charge of MOMRA and enjoys a relatively wider mandate than other types of municipalities that are categorized into A, B and C grades with decreasing powers and mandates. All major Saudi municipalities follow a comparable administrative structure as shown in Figure 2. In the main, each municipality is chaired by a mayor who is responsible for its management, conduct and achievements through the organization of his institution. In general, municipalities have two deputies: one for services and the other for construction and projects. In addition, the municipal structure includes two specialized directorates, i.e. Land and Properties, and Administration and Finance together with other subordinate supporting units. Each of the major bodies is sub-divided into various departments that carry out specialized functions. Geographically, each municipal jurisdiction is divided into a number of districts where each district is served by a sub-municipality responsible for the provision of municipal services and
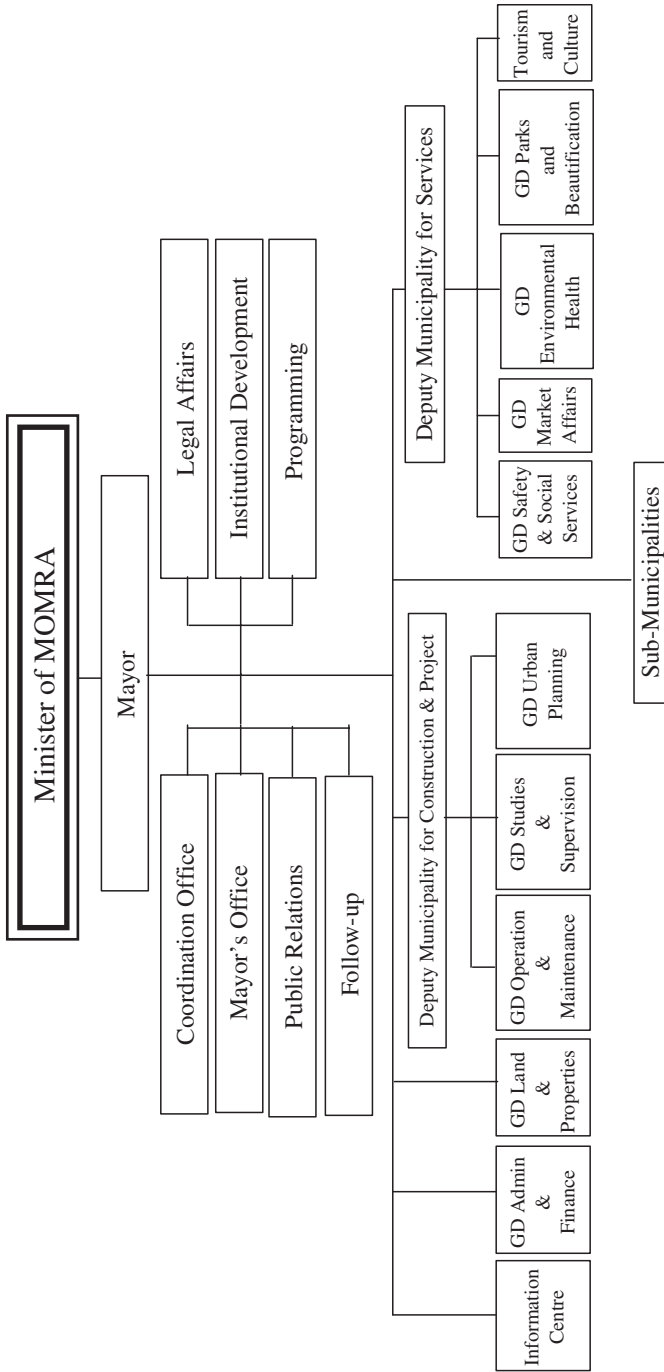
Figure 2.   A typical municipal structure.
Source: Municipality of Jeddah. 2005.
Note: MOMRA refers to ministry of municipal and rural affairs and GD refers to general directorate.

management of urban and environmental issues. Sub-municipalities are answerable to the mayor and the two deputies in accordance with their specialty. Although vertical communication dominates the municipal administration, some municipalities allow their departments to have some horizontal links to ease the inter-departmental transactions. Above all, this municipal set up is empowered to perform a diversity of duties and functions that employ various procedures. The municipal structure presented in Figure 2 was enforced at the beginning of the 1980s with few changes confined to the addition of Municipal Investment Department and a few subordinate units. It has long been criticized of being rigid rather than becoming adaptive and responsive to changes in surrounding circumstances, especially in coping with developments in e-government, public private partnership and in dealing with pressures to become more responsive to the public. In 2005, MOJ started introducing several changes to its setting, but it is too early to judge their feasibility.

Municipalities undertake a wide range of functions that cover planning, controlling, designing, building, operating and maintaining municipal resources and city interests. It is rare to find a comprehensive reference to all the municipal business functions that can be used for the purpose of this study; however, there have been a few attempts to define the applications carried out by various municipal departments (Municipality of Madina 1993). These ventures produced a long list of applications with a narrow grouping that does not resemble a practical guide to municipal functions. More recently, the MOJ conducted a Quality Assurance Study that defined elaborate business functions for the two major deputies and a typical sub-municipality (Municipality of Jeddah 2006). This study showed an uneven distribution of functions among the municipal departments accompanied by varying lengths of procedures and actions (Table 1). The total number of processes or functions was

Table 1. Business processes for municipal deputies and a typical sub-municipality.

Directorate	Number of processes	Total actions	Average actions per process
Deputy for services			
Environmental health	15	88	6
Markets and premises	20	181	9
Parks and beautification	15	145	10
Comfort and social services	11	88	8
Tourism and culture	6	87	14
Sub-total	67	589	9
Deputy for construction and projects			
Urban planning	34	529	16
Studies and supervision	24	270	11
Operations and maintenance	51	476	9
Spontaneous development	5	87	17
Information and development	2	24	12
Sub-total	116	1386	12
Sub-municipality			
Services	13	159	12
Inspection	25	242	9
Administration	14	98	7
Sub-total	52	499	10
Total	235	2474	11

Source: Gathered from Municipality of Jeddah (2006), quality assurance study.

235 with nearly half of them being carried out by the Deputy for Construction and Projects. By contrast, the Deputy for Services performs about one-third of the tasks while the remaining lower portion is accomplished by the sub-municipalities. The high number of municipal functions presented in Table 1 refers to the fact that most functions are performed by more than one department, which makes for duple (or more) counting of one function in two or more departments. Given the scope of this study, it is difficult to deal directly with the high number of detailed, and probably duplicated, functions as presented in Table 1, not to mention the very limited grouping associated by departments' names, which may be acceptable for the purpose for which it was done but which is certainly not adequate for the present purpose. Alternatively, this study provides a useful schema that reflects the main nature of the municipal functions while eliminating most duplication and overlapping, as shown in Table 2. Broadly speaking, the mainstream municipal functions cover the following: planning and development control, public works, land and property, environmental health and premises, city aesthetics, calls and operations, specific social and cultural services together with municipal investments. Additional support activities are also performed by a few municipal departments, these include finance and administration, legal and IT. This schema provided a clear-cut typology that takes into account 67 municipal functions employed by the various departments with inconsistent frequencies as shown in Table 2. In particular, definition of municipal functions presented in Table 2 goes online with functions prescribed in the Law of Municipalities and Villages that governs municipal affairs. Further the schema used in Table 2 is principally based on results from interviews conducted with key officials in the MOJ and on the author's practical experience in municipal administration.

Obviously, all municipal functions are dominated by multi-department performance; each function simultaneously becomes a main operation, amongst others, to one department. The inter-related municipal functions show the high degree of inter-departmental linkages and dependency in conducting municipal tasks that support the need for an enterprise solution. However, it is important to know that, while Table 2 attempted to provide a thorough range of municipal business functions, individual municipalities may find that some specific functions are not included. For example, the municipalities of Makkah and Madina (Holy cities) need to recognize specific activities related to pilgrimage performed by millions of Muslims in each year. Table 2 provides a comprehensive outline of the activities included within the departmental functional area which require IT. GIS applications are useful for functions that incorporate a spatial dimension as will be shown below. In addition, frequencies in undertaking municipal functions vary; while some functions are continually performed by certain departments they are carried out weekly, monthly or even yearly by other departments (Table 2). In general, frequencies of performance of municipal functions will facilitate the understanding of the inter-relationships among municipal departments and functions and can certainly help in setting priorities for application development.

5. Municipal tasks

Typically, municipal functions are realized by undertaking certain pieces of work or tasks as illustrated in Table 3. Obviously, municipal tasks include different groups distinguished by the character and nature of the work contained in each task group as concluded from results of the interviews with MOJ officials as noted in Section 3.

Table 2. Municipal functions and departments.

Source: Author, based on Interviews with Key Officials at the Municipality of Jeddah on 2004.

O = occasional;
P = planned;
M = monthly;
A = annually;
▓ main function of department;
C = continuous;

Table 3. Municipal functions and tasks.

P, primary; S, secondary; R, routine.

Source: Author, based on interviews with key officials at the Municipality of Jeddah in 2004.

Accordingly, municipal tasks can be recognized as general, field work, controls, procurement, project management, studies and queries and information. To a large extent, each category includes inter-related pieces of work or duties; for example, general tasks are necessary for almost every municipal function and cover common tasks such as the preparation of a work plan, filing, assigning duties and generating periodic reports. Practically speaking, accomplishing each municipal function requires many tasks that make up the business process of that function. Thus, building an IT application for any business function must consider the automation of the required tasks. Tasks can therefore form modules or units that can be used to build the various municipal applications. Further, it is important to realize that municipal tasks are carried out at different levels: primary, secondary or routine according to the functional activity associated with the task. Therefore, it is not surprising to find that all the general tasks are routine jobs for the business functions, while most of the remaining tasks become primary or secondary tasks for different functions according to the specialty of each function that calls for certain tasks be it primary or secondary. For example, planning and development control functions are overwhelmingly dominated by various planning and control tasks. In contrast, functions of public works involve a varying range of tasks that include enormous field work operations, adherence to various controls, compliance to town planning proposals and maps, dependence on procurement procedures because of involvement of contractors, application of project management to meet contractual obligations and manage city wide operations, and to be able to answer increasing queries and pass on information about public works projects. Obviously, the remaining municipal functions involve various tasks and task groups that fit with the nature of the function performed.

In general, municipal tasks present an inventory of application units required to support a municipal enterprise solution that can be sustained by related technologies as shown in Table 4. Hence, most municipal activities and functions are location-related; therefore it is undeniable that most municipal tasks can incorporate GIS applications that range from map production to spatial analysis. The GIS applications referred to in Table 4 are the most common functions employed for spatial queries and map production; more advanced applications can be built to meet certain municipal requirements or specific user expectations. In addition, some other related geospatial technologies can be helpful for specific tasks. For example, automated vehicle location can be used with GIS to support municipal tasks that require route planning, vehicle dispatching and fleet management. Similarly, global positioning system is significant for field works and surveying. Centrally, work flow and document management can provide the backbone for enterprise applications as they support data flow, storage and archiving. However, it should be noted that while Table 4 attempts to include fundamental technologies that support municipal tasks, other technologies not listed in Table 4 may deserve to be included, if they are found to be helpful in accomplishing municipal tasks.

6. Data requirements

The last two sections defined municipal functions, applications and the associated tasks required for an enterprise municipal solution. This section attempts to re-create the data needs for municipal applications. It begins by shedding some light on the existing common municipal data issue in Saudi Arabia in order to move towards a

Table 4. Municipal tasks and related technologies.

Municipal tasks		Base map production	Parcel maps	Map production and maintenance	Utility map production and maintenance	Incident mapping	Thematic map production and maintenance	Custom mapping	Query/update facilities and thematic data	Custom report generation	Preliminary engineering planning and design	Support plan review	Link GID and CAD	Link to existing databases	Tracking	Network analysis	Demographic analysis	Spatial aggregation and analysis	Site analysis	Global positioning system (GPS)	Personal digital assistant (PDA)	Mobile computing	Automated vehicle location (AVL)	Road weather information systems (RWIS)	Remote sensing	Document management	Work flow
		GIS applications																		**Geo-spatial**						**Other**	
General	Work plan							●																		●	●
	Filing							●																		●	●
	Assign duties							●																		●	●
	Periodical report					●	●	●	●	●																●	●
Field work	Delineate (service) area					●		●	●	●				●				●							●	●	●
	Fix problems/complaints							●	●	●				●	●					●	●	●				●	●
	Remove violations							●	●	●				●	●					●	●	●				●	●
	Inspection		●		●			●	●	●				●	●			●	●	●	●	●	●	●		●	●
	Site surveying		●					●	●	●				●						●	●	●			●	●	●
	Rout planning					●	●	●	●	●				●		●				●	●	●	●	●	●	●	●
	Crew dispatch					●	●	●	●	●				●						●	●	●	●			●	●
	Issue penalties							●	●	●				●						●	●					●	●
Controls	Permitting		●					●	●	●	●	●	●	●	●			●	●							●	●
	Licensing		●					●	●	●			●	●	●											●	●
	Charges/fines							●	●	●				●						●	●	●				●	●
	Bylaws							●	●	●				●												●	●
Planning	Studies							●	●	●				●			●	●								●	●
	Development		●					●	●	●	●	●	●	●			●	●								●	●
	Future plans							●	●	●				●			●	●								●	●
	Plan/design review							●	●	●				●												●	●
	Mapping	●	●	●	●	●	●	●	●	●				●						●	●	●			●	●	●
Procurement	Specification/estimates							●	●	●	●		●	●				●	●	●						●	●
	Analyze facility data			●				●	●	●	●		●	●				●	●							●	●
	Need assessment							●	●	●				●			●	●								●	●
	Bid documents							●	●	●				●												●	●
	Proposal evaluation							●	●	●				●												●	●
Project management	Supervise contracts							●	●	●			●	●						●	●	●				●	●
	Planning (short/ long)							●	●	●			●	●												●	●
	Facility inventory							●	●	●			●	●						●						●	●
	Performance assessment							●	●	●			●	●												●	●
	Issue payments							●	●	●				●												●	●
	Project review							●	●	●	●	●														●	●
	Routine maintenance							●	●	●				●	●							●	●		●	●	●
	Preventive maintenance							●	●	●				●	●							●	●			●	●
Queries & information	Answer queries							●	●	●				●												●	●
	Incident reporting							●	●	●				●											●	●	●
	Provide information							●	●	●				●						●						●	●
	Public awareness							●	●	●				●											●	●	●

Source: mainly author, some GIS applications were defined by Municipality of Madina (1993).

reasonable approach for tracking municipal data. Discussion here is based upon findings from the interviews conducted with the heads of principal municipal departments at MOJ as referred to at the end of Section 3. In fact, municipal functions require more rewording and more documentation than any other local agency;

developments in IT facilitate this. Municipal data are composed of maps and non-spatial data. Base maps are usually generated from aerial photography and produced at various dates. For example, the maps of Jeddah date back to 1983 and are now being updated. Base maps are mainly available in paper format, while recently generated or updated maps are produced in both digital and paper formats. However, most municipal departments, especially those with no IT applications, depend upon paper maps. As far as non-spatial data are concerned, municipalities retain paper files for functions carried out by them. Paper-based data are difficult to retrieve, update and share. The development of some database applications led to the conversion of some data into digital format, but they generally maintain limited access due to the individual nature of most applications. Progress in the conversion process among Saudi municipalities varies according to city size, resources and support.

The vast amount of data available for various municipal departments comes from different sources. Data maintained by any department are a result of inputs from one or more departments. In fact, there is a complex network of exchanging data that makes data management a major concern for municipalities. Most municipalities responded by creating information centres to cope with their increasing need to deal with all the information. However, the absence of reliable geographic referencing to available data limits their use and the extent of sharing. So far municipalities depend on plot numbering and sub-division referencing to identify locations for zoning and building permits. This method is not practical for other applications such as land acquisition, land registry, infrastructure, shop licensing, etc., which rely on site description rather than proper addressing due to the absence of a comprehensive street naming and a property numbering system. Therefore, addressing becomes a major issue.

Data sharing is further complicated by the fact that municipal departments require external data maintained by other agencies such as the service and utility authorities who are facing the same dilemmas about data storage, sharing and management.

In summary, the municipalities face three data issues: initial data collection, data updating and data management. As far as initial data collection is concerned, there are instances where some city areas have no maps or aerial photographs because those areas were developed after the last aerial photographs were taken. In addition, there is a deficiency associated with the condition of the existing data. In reference to data updating, most municipalities rely on aerial photography, which is costly and time consuming, to amend and renew their base maps. Incremental updating carried out by the various municipal departments remains isolated and causes confusion. There is also concern about the poor quality of the paper maps, the awkward administrative process in requesting maps among departments, and the lack of geo-referencing of the collected data. This particular issue complicates linking spatial data with tabular data. Accordingly, there is an urgent need to manage and organize the data so that the decision makers, at the various levels, can obtain the data needed to support their decision making.

In view of the above data issues, applications and tasks defined in the preceding sections, the municipalities need to develop a system that is able to eliminate the existing data problems and support the required applications. Because all the local municipalities have similar functions, MOMRA can play an important role in data building by suggesting a comprehensive urban data model that can be adapted by the local municipalities in accordance with the state of their GIS. This will pave the way for data standardization and reduce the failures and risks in GIS diffusion among the Saudi municipalities.

7. Conclusions

Saudi municipalities face increasing pressures to deal with rising urban problems that call for quick decisions based on valid, reliable and available data. Though the municipalities own most of the city data, they lack applications. Data need to produce information to support the municipal functions and duties. GIS facilitates the management of data especially if supported by suitable applications. It is found that municipal data are complex and disorganized because of the widespread distribution of municipal functions among the various departments and sections. Rapid development in IT, especially GIS, encouraged the municipalities to buy technology and develop applications. However, acquiring GIS does not mean good utilization because most municipalities seem to be stuck in limited departmental applications that hinder the use of IT to cope with the diverse municipal functions. Although the municipal staff may show a reasonable understanding of GIS and IT, they need to be helped to formulate a framework for their needs so that they can obtain practical solutions that provide them with significant savings in time and money. Accordingly, this article proposed a framework for an enterprise GIS solution for the Saudi municipalities. This article started by reviewing the major issues that affect the building of a framework for an enterprise municipal GIS. These factors include the assessment of needs, application requirements and data needs. Revision of these factors provides the basis for an understanding that paves the way to building the intended framework to guide the Saudi municipalities in applying GIS at a corporate level. The proposed framework centres on municipal business functions that are influenced by the common setting and objectives. The definition of these functions leads to the identification of the associated municipal tasks that form units or modules to develop the varied municipal applications. However, the framework calls for establishing an urban data model that deals with major data issues that include data, sources, sharing and management. Integration of these components of the proposed framework provides the basis for the municipalities to automate their functions and overcome the obstacles that prevent them from doing so. Finally, the commonalities shared by the Saudi municipalities suggest that GIS applications can grow more effectively and reasonably well through partnership.

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