Towards Making A Road Map for Using GIS in Oman

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***Abstract*—A geographic information system (GIS) is viewed as the science of geographical or spatial information which possesses its own set of research questions. In the other hand, GIS is viewed very much as a technological tool which helps the analyst to use his/her knowledge and insight to study substantive issues. GIS is particularly important for Oman because of its convergence towards knowledge economy, smart location, harsh geographical nature, and scarcity of population. This paper will discuss opportunities of GIS in Oman. More specifically, we will discuss key application domains such oil resources, water resources, community development, car and urban planning. This research seeks to create a road map for using GIS in Oman. This map will help both government and private sector to achieve their existing and future goals and strategies in an effective way.**

***Index Terms*—GIS, GIS in Oman, GIS software applications, GIS domains**

I. Introduction

Oman is the oldest independent state in the Gulf founded in 1950. Sultan Qaboos came into power in 1970's. The country is blessed with mineral resources like petroleum, copper, marble, natural gas etc. However the government heavily relies on oil revenues while taking the country to new heights of economic developments with special attention on industrial, educational and health sectors. The Sultan has introduced measures to broaden popular participation in government.

Oman is situated in the southeastern part of the Arabian Peninsula with the land area of about 309,500 sq km. It is surrounded by the sea on two sides, the sea of Oman to the northeast and the Indian Ocean to the southeast; it has joint land borders with Saudi Arabia to the west, Yemen to the south, and the United Arab Emirates to the north.

Oman has a bi cameral system of government. His majesty Sultan Qaboos is the head of the State. The Basic Statute of the State was promulgated by His Majesty Sultan Qaboos bin Said al Said in 1996 which provides the legal framework for the development and implementation of all legislation and government policy. It comprises the Consultative Council whose member are elected by Omani citizens and the State Council whose members are appointed by the Sultan.

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According to 2010 census the population is 2,773,479 out of which 1,957,336 are Omani citizens and 816,143 are expatriate residents. The population consists of the Arab, Asians, Africans and Baluchi. Among Asians are Indian, Pakistani, Bangladesh, Sri Lanka. [1]. Therefore, developing maps and database of these water resources would assist in regulating and managing these resources efficiently.

In his introduction to GIS Delphine Jasmin-Bédisle, young archaeologist currently intern at Spatial Consultants to learn the usefulness of GIS for Archaeological, he summarized some of the key aspects of using the GIS in daily live as it used in a variety of fields, from national government to local environmental project, passing by commercial retailers used to solve a wide range of problems, from simple mapping to complex analysis of geographic and none-geographic (e.g. lifestyle information) data used every day by the majority of the population, consciously or not [2]. This paper presented the GIS in developing countries for better decision and policy making and analyses. Both the private sector and government can play an integral role to collaborate in using GIS in all sectors. In particular, the environment is the subject to many variables and conditions. These conditions and variables need electronic systems to be analyzed. In addition, a robust management of water resources would significantly benefit from such context relevant electronic systems. For example, by GIS it will faster for the government to detect subsurface groundwater accumulation and land.

II. The GIS Software Applications and Domains

Geographical Information System (GIS) is a term describing any information system that collects, stores, integrates, edits, analyzes, disseminates, and displays geographic information for the purpose of decision making and problem solving [3]. In other words, the GIS term describes any information system that collects, stores, integrates, edits, analyzes, disseminates, and displays geographic information for the purpose of decision making and problem solving. Its data represents real objects such as roads, population distribution, land usage, elevation, water and natural resources, etc. The geographic approach helps researchers to better understand our planet and employ geographic knowledge to organize data, analyze activities and processes, and model relationships. It helps managers and decision

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makers to investigate, design, plan and change geographically related phenomenon. The power of GIS stems from its a multidisciplinary nature as it is a field that integrates geography, astronomy, information Technology. Gold discusses the essence of GIS, its boundaries, dimensions, cross disciplines, and capabilities. For instance, GIS can describe and classifies terrain surface, manage changes, update maps, manipulate log files, and visualize topological connectedness, maintaining dynamic topologies, according to Gold [4].

From the presentation of these definitions we can summarize the following:

- GIS is set of integrated tools for spatial analysis
- GIS encompasses end-to-end processing of data:capture, storage, retrieval, analysis /modification, display
- GIS uses explicit location on earth's surface to relate data
- GIS aimed at decision support, as well as on-going operations and scientific inquiry

From one aspect, GIS can be viewed as the science of geographical or spatial information which possesses its own set of research questions. In the other hand, GIS is viewed very much as a technological tool which helps the analyst to use his/her knowledge and insight to study substantive issues.

The science and modern technology used in GIS focused by many researchers, governments, and many institutions. In other words, GIS used in collecting and organizing special information in order to empower the decision-making positions.

There is no specific area to use this information in. GIS can be used in different fields classified by Briggs in his presentation "GIS fundamentals" as shown in Appendix A [5].

Globally there is still in need for producing new software applications and new companies need to enter to the market of the technology of the GIS. In Appendix B are some of these software applications, companies, their market shares, and their specifications.

III. Applications of GIS in Oman

Oman attempts to use GIS are simple and unorganized. For example: NORPLAN has been awarded a contract to develop a new addressing system for Muscat Governorate in the Sultanate of Oman. People prefer giving directions by providing references to landmarks, establishments and locally known reference points rather than providing their street address [6].

The numbering principles applied in the existing system (Addressing system) are also not able to absorb the urban growth of cities and the need for a solution to this problem is pressing.

Another try for identifying the important of using GIS in health sector in Oman was addressed by Dr. Said Al Lamki in his presentation "PHC in Oman & Wilayat (District) Health care System", organized by the Director of PHC Department in Ministry of Health, Sultanate of Oman. He Focused on identifying the needs of specific target groups and develop specific health strategies e.g for adolescents and old ages. Therefore necessity for GIS is came. He suggested that the Ministry of Health needs to know the geographical areas location for those people and how far they are far from HC Catchment Area in all Wilaya. [7]

GIS used to support the renewable energy in Oman. Charabi and Gastli used ArcGIS to present a map of the potential solar power prospects in Duqum province in Oman. The results obtained show very high potential of solar power in this area. Researchers found that using a 2.4 km 2 area to produce 100 MW. [8]

In his paper "Using remote sensing and GIS for damage assessment after flooding, the case of Muscat, Oman after Gonu tropical cyclone 2007: Urban planning perspective", Lotfy Kamal Azaz suggested to emphasize the importance of using remote sensing and GIS in damage assessment phase as part of effective Disaster Management Plan. He mentioned that GIS used to organize the damage information and the post-disaster census information, and in the evaluation of sites for reconstruction. In this study, two IKONOS satellite images of Muscat, Oman have been utilized; one image before the cyclone and one after. [9]

In his study The Potential of Solar and Wind Energies in Oman" Prof. Adel Gastli, and Dr. Yassine Charabi, are proceeding with a research project on the assessment of the potential of solar and wind energies in the Sultanate of Oman, which is funded by the Research Council (TRC). As part of the project, case studies were conducted to raise the awareness and to enhance the skills among the key actors in the building architecture, energy sector and urban planning with regard to the small scale renewable energies applications. Studies were conducted to assess the capacity of the roof-PV in energy production through the GIS based model and the economic value of domestic Solar Water Heater (SWH) systems, residing mainly in the amount of electrical energy they save in addition to the degree of independence from conventional and polluting energy supplies they create.[10]

In Oman and GCC, there is a need to address new domains for the application of GIS. For instance: there is a need for GIS to minimize the traffic and the accidents, the matter of concern to both the public and the government. Also, in Oman there is a demand for using GIS to organize and manage the private small business in active and influential way to improve the quantity and the quality of many projects run by young Omanies. In addition, GIS is needed to manage the renewable energy resources. The government is looking to enhance better utilization of water resource by using GIS.

Oman needs to prepare a comprehensive strategic plan for encouraging using GIS in both private and government sectors. Therefore, this will help the government to achieve the existing and future goals of the development plans and strategies in effective way.

Creating a road map for using GIS in Oman, requires a team of researchers and technicians with competence and experience in GIS and databases, technology and infrastructure, web services and some other specialists as needed. Also, it needs a financial support and logistical support from both government and the private sector.

IV. Private Sector Involvement

The main reason that may prevent the contribution of the private sector in the preparation of a comprehensive plan for geographic information systems in some countries is cost-related concern arises when government GIS information is distributed by private companies as mentioned by Tom Wright. He suggested that any private sector involvement in government GIS applications should be accompanied by an assurance that the public's access rights are not reduced. [11].

V. Future Applications of the GIS for Oman

GIS is used also to empower women participation in local initiatives. Fig. 1 shows community services and historical imagery related to the development in York Region. Community service is defined as a service or activity that is performed by an individual or a group of people for the benefit of the local community or the public at large. Such maps could be useful for women organizations in Oman. For instance Omani women's associations and sport clubs can use such maps to better achieve their programs and goals of community services and women empowerment in the society. Moreover, Ministry of National Heritage and Culture and Ministry of Tourism both could collaborate and develop a national historical Atlas that represents the most important historical places, attractions, hotels, etc. in Oman. In general, this would increase the tourist in Oman.

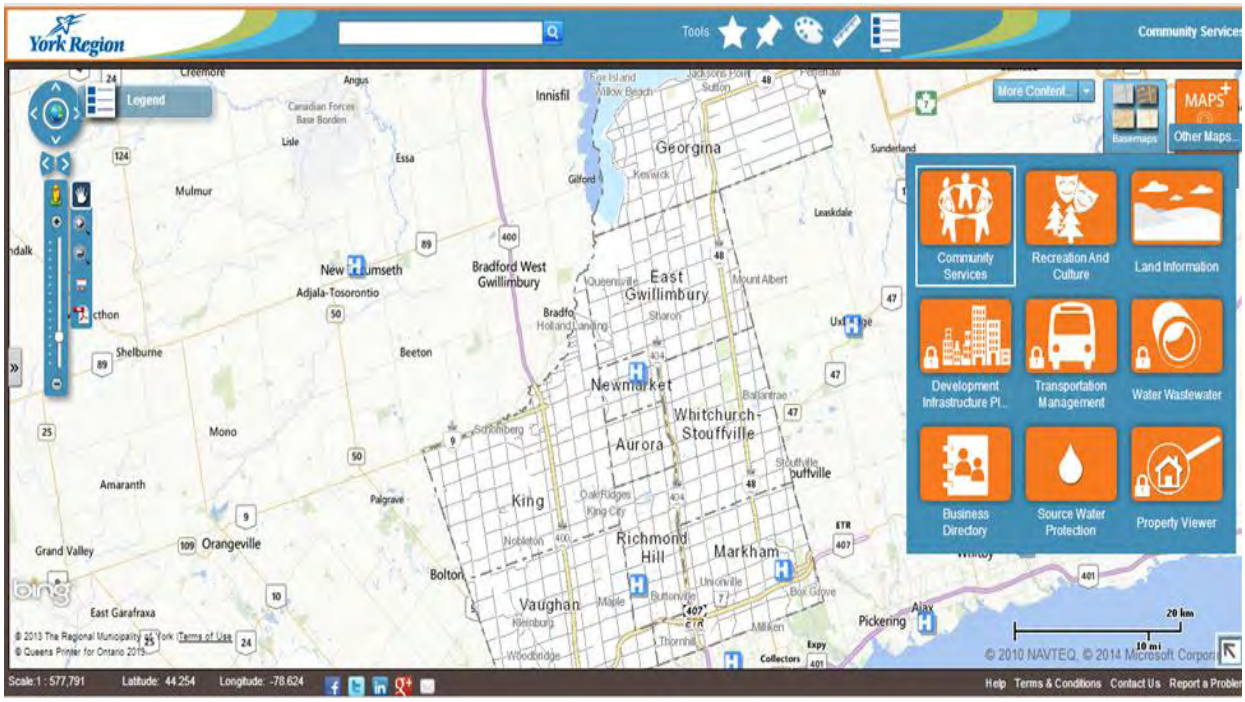

Figure 1. Community services and historical imagery map in York region

Controlling road accidents in Oman has grown to be on the priority list of the government. GIS will decrease cars accidents in Oman. Fig. 2 shows how the application of GIS for tracking vehicles crashes in Virginia. The system creates maps that provide detailed information about crashed cars, degree of accidents and their location.

The system is used also to provide driving direction to car drivers. Moreover, this map gives some extra services such as:

- Identifying locations with high accident rates
- Accessing crash locations to see the crash summary
- Accessing information related to injuries, poverty damages, and their party loses

To summarize, the advantages of using the GIS for traffic are as following:

- Reduce traffic congestion;
- Decrease traffic accidents;
- Provide accurate online information about the accidents and their places;
- Facilitate the work of police department;
- Increase the awareness among drivers; and
- Provide abundant information for insurance companies to assess and regulate road accidents.

McLeod defines community map as a tool that facilitate communications between local communities and organizations. Fig. 3 shows a simple map for community information. In particular, it shows places of interest, property boundaries, main roads, district boundaries, single family residential, medium / high residential etc. Such maps promote location-based services. Due to the geographical difficulties in Oman, described above, Oman can use electronic maps to provide citizens, businesses, and government entities special information related to social, economic, and public activities. Such information can also help local governors and policymakers to plan, implement, and manage community-focused projects and initiatives. The biggest potential beneficiaries of these maps may include municipalities, the Ministry of Urban Planning, the Ministry of Social Development, etc. [12]

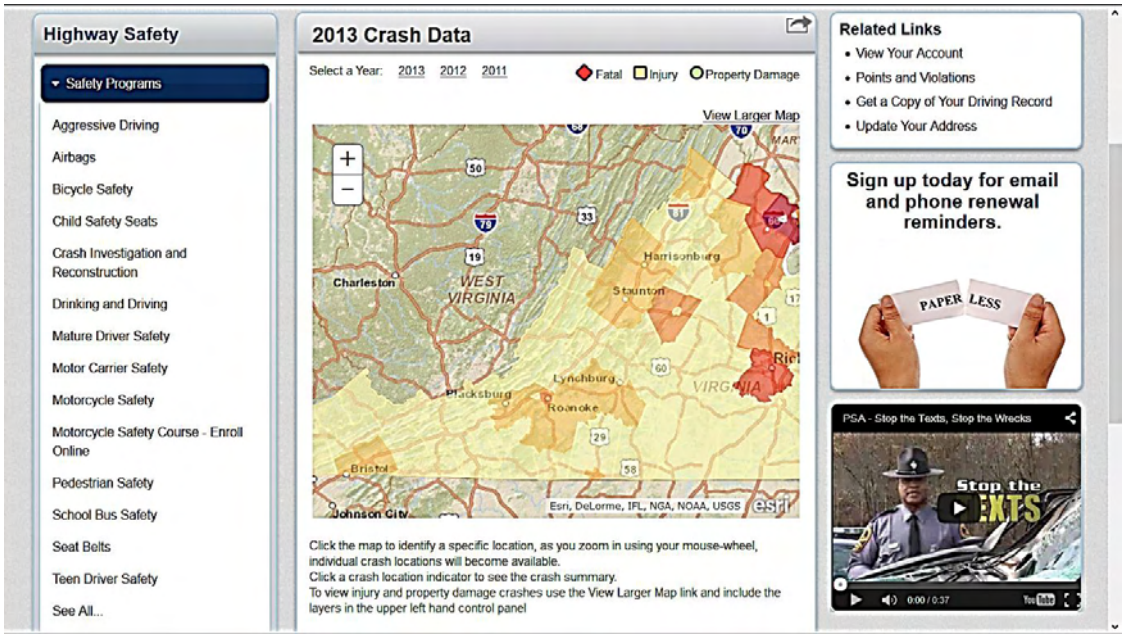

Figure 2. Using GIS for tracking car accidents in Virginia, USA.

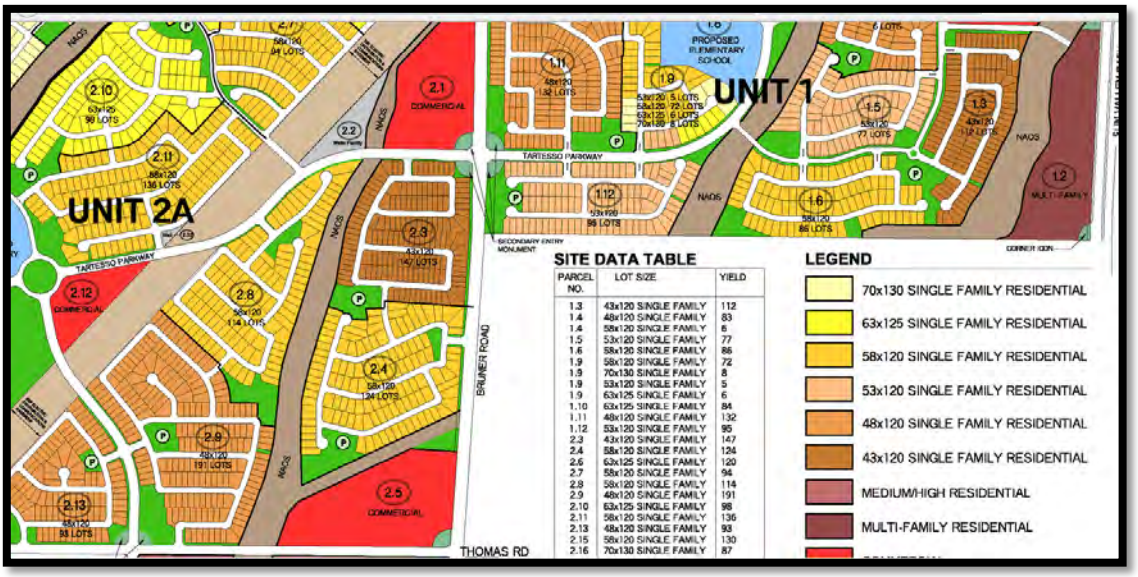

Figure 3. Mapping information of local community

VI. The Future and the GIS in Oman

Creating any comprehensive or special central GIS for a country, requires a team of researchers and technicians with competence and experience in the field of GIS and databases, technology and infrastructure, web services and some other specialists as needed. Also, it needs a financial support and logistical support from both government institutions and the private sector.

There are three steps for building any GIS database and using the GIS to analyze the data for source waters as mentioned by Bice and others:

- Determining data needs
- Inventorying data sources
- Determining coordinate system and data to characterize the study area and inventorying sources of contamination.

VII. Conclusions

On the one hand, an extremely wide awareness exists of the need GIS in many sectors in many countries, and the numbers of range of adopters are rapidly growing. On the other hand, many governments seem intended to fuel this growth far into the future.

A belief exists that the typical use of GIS in Oman introduced by some companies has not progressed far beyond the use of mapping, query, and spatial data inventory management, and that the potential analytic power of the technology to help solve complex societal and environmental problems has yet to be realized yet.

For this happen, there is a need for fundamental research into the science of geographic information, a need for more widespread and enhanced higher education in this science, and a willingness on the part of the GIS

industry to nurture this science and be ready to adopt and promote the analytical techniques it produces.

APPENDIX A GIS FIELDS AND PURPOSES

The Field	Purpose
Urban Planning, Management & Policy	Zoning, subdivision planning Land acquisition Economic development Code enforcement Housing renovation programs Emergency response Crime analysis Tax assessment
Environmental Sciences	Monitoring environmental risk Modeling storm water runoff Management of watersheds, floodplains, wetlands, forests, aquifers Environmental Impact Analysis Hazardous or toxic facility siting Groundwater modeling and contamination tracking
Political Science	Redistricting Analysis of election results Predictive modeling
Civil Engineering/Utility	Locating underground facilities Designing alignment for freeways, transit Coordination of infrastructure maintenance
Business	Demographic Analysis Market Penetration/ Share Analysis Site Selection
Education Administration	Attendance Area Maintenance Enrollment Projections School Bus Routing
Real Estate	Neighborhood land prices Traffic Impact Analysis Determination of Highest and Best Use
Health Care	Epidemiology Needs Analysis Service Inventory

APPENDIX B GIS SOFWARE AND THEIR SPECIFICATIONS

Software Name	Company	Description & Specifications
ESRI, Inc.	Redlands, CA	Clear market leader with about a third of the market originated commercial GIS with their ArcInfo product in 1981 privately owned by Jack Dangermond, a legend in the field Strong in gov., education, utilities and business logistics
MapInfo	Troy N.Y.	Aggressive newcomer in early 1990s, but now well-established. Strong presence in business, especially site selection & marketing, and telecom
Intergraph	(Huntsville, AL)	Origins in proprietary CAD hardware/software Older UNIX-based MGE (Modular GIS Environment) evolved from CAD Current GeoMedia was the first true MS Windows-based GIS Strong in design, public works, and FM (facilities management), but weakening
Bentley Systems	(Exton, PA)	MicroStation GeoGraphics, originally developed with Intergraph, is now their exclusive and main product.. Strong in engineering; advertises itself as "geoengineering"
Autodesk	(San Rafael, CA)	Began as PC-based CAD, but now the dominant CAD supplier First GIS product AutoCAD Map introduced in 1996 Primarily small business/small city customer base
Vector GIS		**Smallworld Systems** (Englewood, CO) First to use OO (early '90s), but failed to compete as established vendors did same Purchased by GE in 2000 Emphasis on FM & utilities **Manifold** (CDA International Corp): o low cost, but low market share o another low cost one
Raster GIS		**ERDAS/Imagine** o long established leader o acquired by Leica Geosystems in 2001 **ER MAPPER** o aggressive newcomer originating in Australia **Envi,** o relative newcomer, radar specialization o acquired by Kodak in 2000 **PCI**--Geomatica o long-term Canadian player **CARIS** o newer Canadian entry **GRASS** (Rutgers Univ.) o Classic old-timer originally developed by US Army Construction Engineering Research Lab(CERL) in Champaign, IL; o army ended dev. & support in 1996 but assumed by Baylor University o **IDRSI** (Clark Univ) ▪ pioneering, university-developed package

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