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Remote Sensing and Geographic Information Systems in Developing Countries: Case of the United Arab Emirates (UAE)

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ABSTRACT

Remote Sensing (RS) and Geographic Information System (GIS) education and implementation is rapidly being adopted by universities in developing countries, such as the United Arab Emirates (UAE). Until recently, the use of GIS and RS in education in the UAE was hindered by the cost of hardware and the complexity of software. With the price/performance increase of desktop computer capabilities and new low cost and user-friendly software, more universities in the UAE have been able to acquire GIS/RS hardware and software. A survey investigating demand for scientists able to use these technologies in various organizations in the UAE showed that the demand for GIS/RS professionals is between one to fifteen persons per organization. This article focuses on GIS/RS education in the UAE, provides case studies of implementation of GIS/RS, highlights the global cooperation between UAE and international bodies, and identifies problems related to GIS/RS education as well as catalysts that may play an important role in its development. It is anticipated that other nations can make use of the UAE experience in GIS/RS education, implementation, identification of problems, and recommendations for possible solutions.

KEYWORDS

Remote Sensing, Geographic Information Systems, developing countries, UAE

1. INTRODUCTION

The main reasons for the rapid diffusion of Remote Sensing (RS) and Geographic Information Systems (GIS) throughout the world include the need for knowledge about spatial data to support decision making, use of English as a global language, and the expanding capabilities of the Internet. Knowledge of the use and impact of GIS is the key and the first step for proper understanding and application of GIS in traditional disciplines. Although there are differences in local needs of universities around the world, GIS courses are, to some extent, becoming global (Kemp and Frank, 1996). For example, over one hundred universities around the world use the GIS core curriculum developed by the University of California Santa Barbara in 1990 (Longley et al., 2001). Additionally, international universities specializing in GIS, such as UNIGIS, have succeeded in overcoming political, cultural, and linguistic boundaries. With the development of the Internet as a global access and communication tool, and its role in increasing distance learning, more and more institutions have started to offer courses and degrees in GIS, for example, the ESRI virtual campus, Pennsylvania State University, and City University. The Internet has also played a major role in the flow of up-to-date information; for example, in the past students in developing countries depended on out-dated sources to obtain information about GIS/RS. Nowadays, current information can be accessed from leading organizations within minutes.

2. PENETRATION OF RS AND GIS IN THE UAE MARKET

Established on 2 December 1971, the United Arab Emirates (UAE) is a federation of seven emirates comprising an area of 83,600 square kilometers; the country lies between latitudes 22-26.5 degrees North and longitude 51-56.5 degrees East (Figure 1). The population of the UAE is approximately three million with a growth rate of 6.5 percent per year (UAE, 2000). To meet the growth in population and to attain sustainable development, UAE is moving towards using RS and GIS for better management of its resources. Availability of data is the main and the first step in management of resources. Data in digital form has numerous advantages such as easy manipulation and efficient management which lead to reduction in time and hence minimization of cost for generating products (e.g., maps). In the UAE, there is a lack of land use data, and RS appears as a viable source of these data. Satellite images available from Landsat, SPOT, IRS-1C, ERS-1-2, RADARSAT, ENVISAT, as well as commercial imagery from satellites such as IKONOS and QuickBird, have already played an important role in data development (Baker et al., 2001; Loveland and Belward, 1997; Nemani and Running, 1995; Okamoto et al., 1997). Based on developing need and use, special RS and GIS labs have been created at various agencies throughout UAE to be used for land use mapping, oil exploration, water and electricity management, desertification monitoring, sand dunes delineation, and telecommunication management (additional details provided later).

An important factor affecting the penetration of RS and GIS in the UAE is the economy. UAE is an oil exporting country with revenues of US$ 73.35 billion in 2000. The revenue from oil places UAE in a better position than other developing nations for providing infrastructure for RS and GIS (hardware,

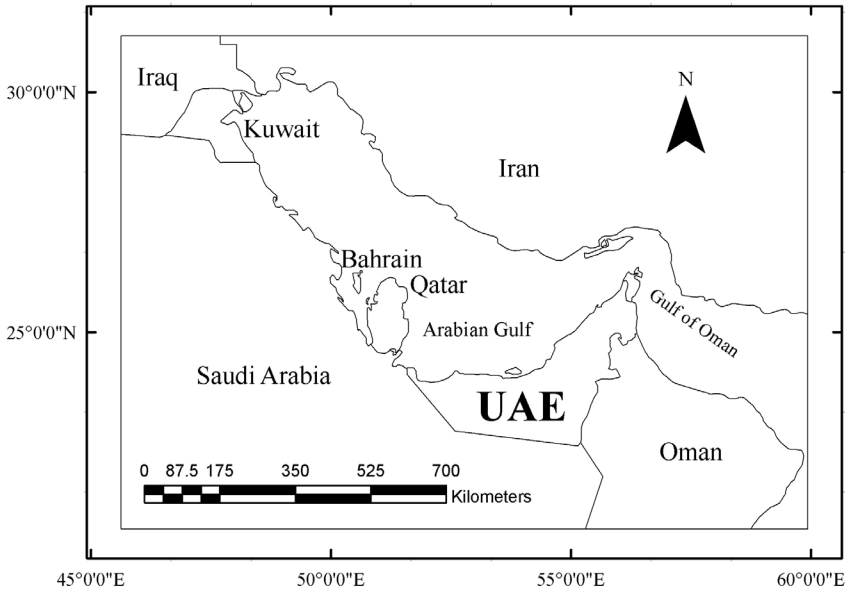

Figure 1. Location of the study area (UAE).

software, data, salaries, etc.). However, the diffusion of RS and GIS is not equal throughout the UAE.

Privatization of some governmental departments in the UAE has also affected the penetration of RS/GIS technologies. The objectives of privatization are performance, efficiency, and quick return. Management authorities in these departments recognized the potential for the use of GIS as a system that provides an integration framework, speeds customer services, makes the masses of information held in databases more accessible, and provides a strong foundation for executive decision support. Thus, it was recognized that GIS abilities help in achieving privatization objectives.

Openness of the government and private companies in the UAE to the *use of English* as a medium of instruction and communication in their transactions has also played a great role in the widespread use of RS and GIS. English is becoming a global language (Crystal, 1997; Perera and Tateishi, 1995) because of the extensive impact of the British Empire during the colonial period and the dominance of American economy, culture, science, technology, and politics in the contemporary world (Short et al., 2001). It is also true that being competitive in global markets requires that one master English. The biggest GIS user in the UAE (Etisalat) is using English as its first language. This is because of the wider market and the global services that Etisalat provides (e.g., the Thuraya telecommunication satellite owned by Etisalat covers more than one hundred countries).

Introduction of RS and GIS in the UAE is a part of a global GIS revolution (Achache and Aschbacher, 2003) as well as a result of a *regional impact* of actions of the Gulf Cooperation Council (GCC), for example, implementation of GIS in Qatar and Kingdom of Saudi Arabia. The revolution in GIS created a *demand for GIS professionals* worldwide (ESRI, 2000) as well as in

the UAE. A survey conducted by the authors to investigate the GIS setup in governmental departments in the UAE showed that the demand for GIS professionals is between one to fifteen persons per department. This demand has forced many universities in the UAE to restructure their programs and strategies to meet the demand.

3. RS AND GIS EDUCATION IN THE UAE

Each day, more universities and colleges are seeking information on how to begin RS and GIS programs. The reasons are many but four of the most important are (ESRI, 1998):

- The mandate for universities and colleges to upgrade technological education.

- The need for universities and colleges to find new sources of funding.

- Advances in hardware and software.

- The demand for more professionals trained in GIS by government and the private sector.

Currently, there are three public universities and ten private universities in the UAE. The public UAE University was the first university in the UAE to establish a GIS program, in its Department of Geography in 1999. The objective of the program is to produce skilled GIS graduates who can build, use, and maintain GIS databases. Courses and the curriculum are designed to meet this objective. The curriculum covers basic English courses, as English is used as a medium of instruction for six courses (Table 1), and geographical courses such as physical geography, human geography, geography of the UAE, and geography of Arid Zones. Courses related to RS and GIS are taught in English and this reflects the *globalization* of these courses; moreover, the textbooks assigned for these courses are also used in English-speaking universities in developed nations (Table 1). Upon completion of 132 credit hours (twenty-four credit hours in the field of GIS), a student will earns a Bachelor of Science degree in Geography with GIS. To make the courses more flexible and global, a special Web site has been designed to provide students with online material related to GIS. In addition, a comprehensive summary of a number of programs around the world that offer distance learning in the GIS discipline is provided at this site (Geocommunity, 2003).

Currently, the Department of Geography at UAE University has four faculty members who specialize in RS and GIS and another twelve faculty members teaching other geographical courses. The total number of students is three hundred, with seventy percent of them females. The Department's GIS labs (at the men's and women's campuses) have a wide range of computing facilities (seventy-seven personal computers). Input devices include ten digitizers, three handheld GPS receivers, and two scanners. Color graphics output is provided by two Hewlett-Packard color laser printers and an Hewlett-Packard plotter. The hardware is complemented by a comprehensive suite of software tools for geographical information processing. These include ESRI ArcView and ArcGIS, and the RS package ERDAS Imagine.

Table 1. Geo-science textbooks at the Department of Geography, UAE University.

Course	Textbook used by UAE University
Cartography	Robinson, A. H., J. L. Morrison, P.C. Muehrcke, A.J. Kimerling and S.C. Guptill 1995. *Elements of cartography*. New York: John Wiley & Sons, Inc.
Computer Cartography	Slocum, T. A. 1999. *Thematic Cartography and Visualization*. New Jersey: Prentice Hall.
Remote sensing I	Thomas Eugene Avery and Graydon Lennis Berlin, 1992. *Fundamentals of Remote Sensing and Airphoto Interpretation*, 5th ed. New York: Macmillan Publishing.
Remote sensing II	Jensen, J. R., 1996. *Introductory digital image processing: A remote sensing perspective*, 2nd ed. New Jersey: Prentice Hall.
GIS I	Longley, P. A., M. F. Goodchild, D. J. Maguire, and D. W. Rihnd, 2001. *Geographic Information Systems and Science*. New York: John Wiley and Sons, Inc.
GIS II	Fotheringham, A. S. and P. A. Rogerson, 1994. *Spatial analysis and GIS*. London: Taylor & Francis Ltd.

GIS and RS activities are not limited to only to the Department of Geography, but other departments in the UAE University offer courses related to RS and GIS, including the Departments of Civil Engineering and Environment, Architectural Engineering, and Geology. An important factor in the development of RS and GIS at the UAE University is that top decision makers (champions) are supporting Information Technology in general and RS and GIS in particular.

The UAE University approved a Master of Science degree program in RS and GIS. The program started in September 2004 and is the first educational track of its kind in the region. The Master of Science degree is designed to provide a unique educational opportunity for understanding of RS and GIS, together with their impact on society. This program has been developed as an interdisciplinary program to be offered jointly by the Geography, Geology, Civil Engineering, and Urban and Regional Planning departments, with support from the IT and Business departments. In this way, through GIS, isolated departments are starting to work together, and at the same time, each department feels a responsibility towards RS and GIS. Moreover, the lobby to convince the University of the value of such a program is becoming stronger. Therefore, universities in developing countries can use this model of creating an interdisciplinary program as one way to promote both GIS and RS programs and to strengthen interdisciplinary efforts. Core courses in the program include principles of RS and GIS, digital image processing, spatial analysis, database management system, and geo-statistics. Elective courses include project management, environmental planning and impact analysis, water resource management, and selected topics in RS and GIS. In addition to the core courses and elective courses, MS students have to develop a thesis. By the end

of the program, students have to complete thirty credit hours within two years for full-time students and within three to four years for part-time students.

A survey to assess the demand for students with this MS degree was distributed to agencies involved in the RS and GIS fields to estimate the market demand for graduates of the program. Nine governmental departments and three private companies participated in the survey. All of the respondents indicated the importance of the program, 42% indicated that there are very good opportunities for those with an MS degree, and 50% indicated that there are reasonable opportunities. The *majority* of the respondents (92%) are ready to send candidates to join the program, with an average of two candidates per department and a total of thirty-five. This number is considered more than enough to start the program, which is expected to have ten students per year. GIS experts (Professor Michael Batty, Professor Michael F. Goodchild, and Professor Nigel Waters) reviewed the program, and their comments and suggestions for improving the program were considered, and many were implemented. Introduction of such programs in developing countries means more opportunities for local communities, especially women and employees, to continue their education in the field of GIS. It also reflects the global need for GIS education to meet local market demand.

4. RS AND GIS IMPLEMENTATION IN THE UAE

Since RS and GIS are multidisciplinary fields, their application in the UAE is evident in various departments, including telecommunication, municipalities, health, water, electricity, oil, agriculture, and environment. Most of these departments are currently embarking on building GIS databases. A survey inventorying GIS in the UAE was distributed among thirty governmental departments and feedback was received from eleven of them (Table 2). Results of the survey showed that the budget allocated for GIS in UAE's departments during 2000, 2001, and 2002 varied between US$1,000 for small departments to US$14 million for large departments (e.g., Abu Dhabi Water and Electricity Authority). The majority of the departments were using ESRI products; 48% of all the GIS software used was ArcView, 39% ArcInfo, 4% Microstation, 4% AutoCad, 3% Geomedia, and 2% MapInfo. This result is not unexpected, because worldwide ESRI has two-thirds of the GIS market share. For RS and image processing, ERDAS is the dominant software, notably in the UAE University (Table 2). 75% of the departments participated in seminars and conferences related to GIS, especially ESRI user conferences. The majority of the departments were depending on digitization (70%) of existing maps as a methodology for spatial data input; this was followed by scanning (15%) of aerial photographs, digital total stations (10%), and GPS (5%) with a trend towards using satellite imagery.

All departments had input devices, such as scanners, and 82% had digitizers, and output devices (plotters, printers) supporting GIS activities were available in all departments (Table 2). Departments involved heavily in map production had more output devices, for example, the Al Ain Town Planning Department (Table 2). Although there is a rapid change in the number of hardware, software, and GIS professionals in UAE departments, the survey does provide a general overview of the status of GIS in the UAE. Understanding of GIS setups in governmental departments helped UAE University faculty

Table 2. GIS software and hardware at some governmental departments in the UAE (Numbers in () are the number of licences).

Department	Department	C	D	Pl	Pr	S
Abu Dhabi Town Planning Dept.	AutoCad (5) MapInfo (5)	45	5	4	10	2
ADNOC	Geomedia (1) Microstation (2)	3	0	2	1	1
Al Ain Town Planning Dept.	Geomedia (5) MGE/Microstation (6)	112	0	15	42	10
Diba Municipality	ArcView (1) AutoCad (1)	1	1	1	1	1
ERWDA	ArcInfo (2) ArcView (21) ERDAS (1)	25	1	1	3	1
Etisalat (Al Ain)	ArcInfo (7) ArcFM (7) GDS (30)	30	1	2	2	2
Fujairah Municipality	ArcInfo (3) ArcView (7) AutoCad (2)	9	2	2	3	1
Military Survey Department	ArcSDE (1) ArcInfo (20) ArcView (14) ArcIMS (1) ERDAS (4)	50	15	5	10	3
NDC*	ArcInfo (5) ArcView (3) ERDAS (1)	5	1	1	3	1
Sharjah Electricity and Water Authority	ArcInfo (8) ArcView (8)	20	1	1	3	1
UAE University	ArcInfo (32) ArcView (45) ArcGIS (40) ERDAS (33)	48	11	1	4	2

Number of C = Computers, D = Digitizers, Pl= Plotters, Pr = Printers, S = Scanners
* NDC: National Drilling Company (Ground Water Research Program)
Source: Field survey done by the author

formulate a strategy for introduction of different GIS software and pinpoint departments where students can have training or find jobs after graduation. In the following sections, GIS setups for some government departments are highlighted. The selected departments provide a sense of the use of GIS in telecommunications, water and electricity, and municipalities.

4.1. Emirates Telecommunication Corporation (Etisalat)

Since the establishment of the Emirates Telecommunications Corporation (Etisalat) in 1976, the Corporation has succeeded in transforming the UAE into one of the most advanced countries in the world in the field of telecommunications services. This includes launching of the Emirates Internet in Asynchronous Transfer Mode (ATM) in 1997. The majority of Etisalat work is of a geographic nature. For example, they need to know the locations of telephone lines, switches, fiber optics lines, cables, radio/TV stations, and mobile phone sub-stations. In addition to that, the spatial component is of great importance for coordination between the head office in Abu Dhabi and its six main branches in other emirates.

The history of GIS in Etisalat dates back to 1989 when Graphic Data System (GDS) was introduced. The system was adopted in all branches, and many engineers are familiar with it. The main function of the system is to display graphically the Etisalat network and telephone systems. However, in terms of a database management system, GDS is not user-friendly and has limited editing and storage capabilities. These limitations compelled Etisalat to shift to ArcInfo and ArcFM.

Supporting software for Etisalat operations includes Oracle database software (SQL), Network Engineer, ArcFM, and Rule Base Engineer-RBE. Shifting from one system to another (GDS to ARC/INFO) is sometimes a cumbersome and time-consuming process (conversion from GDS format *.fgb to ARC/INFO coverages). Etisalat followed a philosophy based on a modular approach and pilot study starting at small branches to address this issue. Problems and estimation of time, budget, and personnel were identified from the GIS database at the small branches and plans were prepared for conversion of GIS databases at larger branches.

Currently, Etisalat has introduced in its headquarters a combination of Microstation as a drafting system and a set of ESRI GIS products [ArcSDE (7), ArcInfo (400), ArcView (15)]. Based on the number of GIS licenses, Etisalat is the biggest GIS user in the UAE. Reasons for the large investment in GIS are: Etisalat has responsibility for IT in the UAE (Internet, mobile communication); therefore, by default it must have the lead in the GIS field. Secondly, Etisalat is the sole provider of telecommunications in the UAE; therefore, it has the highest profit among all other governmental departments. Since there is a good profit, Etisalat has invested *heavily* in GIS infrastructure. The investment in GIS infrastructure started in 1989, and every year there is a budget allocated for GIS data, hardware, software, and backup facilities.

There is a great potential for GIS graduates to find jobs in Etisalat. Etisalat managers were asked about potential *reservations* some departments might have about GIS graduates with a background in *geography.* They indicated that Etisalat provides a one-year training for any new employee. During this year, the new employee passes through all sections (planning, operation, accounting, etc.), and this period is enough for new employees to learn the principles of the working environment in Etisalat. This answer is very encouraging to our students in the Department of Geography at the UAE University. An initiative to sign a Memorandum of Understanding (MoU) between Etisalat and the UAE University is being pursued. The key role of the MoU is to establish a linkage for training of GIS students at Etisalt and training of the Etisalat employees at the University, so the benefits are bi-directional.

4.2. Abu Dhabi Water and Electricity Authority (ADWEA)

In 1966, the Government of Abu Dhabi established the Water and Electricity Department to provide safe and reliable supplies of water and electricity for consumers in order to promote the social and economic development of the Emirate of Abu Dhabi. By 1996, the Water and Electricity Department had grown to an installed capacity of nearly 3000MW and 200 million gallons of desalinated water per day.

In addition, the Water and Electricity Department carried a multinational compliment of technical and support staff of more than 15,000 employees. In 1998, the Abu Dhabi Water and Electricity Authority (ADWEA) was established. The principal goal and objective of ADWEA is the privatization of the water and electricity industry in Abu Dhabi (ADWEA, 2003). ADWEA recognized the benefits of GIS and this recognition was turned in 2002 into a real GIS project. The project addresses over 160 business processes in five companies and twenty-five regional offices covering the planning, design, operations, maintenance, and administration activities of water and electrical transmission and distribution for the entire Emirate. The Redlands Institute and GISTEC (local distributor of ESRI products) team were involved in this project. This US $14 million, 180 contractor staff, 240,000 person hour, fourteen month fast-track project is one of the most comprehensive and aggressive utility enterprise system implementation efforts ever undertaken anywhere in the world (Redlands Institute, 2002).

The software used included ArcSDE (1), ArcInfo (18), ArcEditor (60), ArcView (105), and ArcIMS (1). Currently, a spatial database for the electrical network and water system and GIS applications for the users are available at other water authorities, for example, Sharjah Electricity and Water Authority (Table 2). The main function of this application is to locate consumers by consumer number, plot number, and meter number. The application was developed based on MS-SQL Server 7.0, Visual Basic, and ArcInfo 7.2. Other power system studies and CAD works were also carried out. The office is connected to various distribution sections to exchange and share information. The Planning Office is equipped with a powerful dual Pentium server, Gigabit network connections, Pentium III Work stations, peripherals, and GIS software (Table 2). To detect a power cut or water leakage requires real time information. This data are captured using a series of flow meters installed along the cable or pipe. The meters are connected to a central database, either using a direct analogue cable link or via a remote link using transmitters in the flow meters, which then enables dynamic modeling of the network.

The lessons learned from implementation of GIS in water and electricity authorities are the importance of project management, GIS seminars for top managers and users, systems integration, decision support, and real applicability of enterprise GIS. Furthermore, GIS applications are becoming core systems and the main entry point for many end users, who just need to click on a map to access a host of data. These lessons increased awareness of GIS and convinced managers and decision makers about the viability of GIS, which has a diffusing awareness of GIS among other authorities working in water and electricity sectors in the UAE.

4.3. Dubai Municipality

All municipalities in the UAE are starting to implement GIS. The Dubai municipality was selected as an example, because of the number of GIS licenses and the noticeable GIS development. Currently, Dubai municipality has eighty personal computers running MicroStation, MGE, and Geomedia, in addition to that ESRI products (ArcSDE (1), ArcIMS (1), ArcInfo (2), ArcEditor (2), ArcView (8)). The main use of GIS in the municipality is in mapping and updating of master plans and utilities. The municipality uses the latest technology in mapping, the Continuously Operating Reference Stations (CORS) system that helps surveyors, GIS/LIS professionals, engineers, scientists, and others to position points for which GPS data have been collected. Governmental, academic, commercial, and private organizations benefit from this system. This modern technology helped the Dubai municipality eliminate the traditional way of keeping land records in paper files and it provides reliable updated data in digital formats.

GIS in the Dubai municipality is not limited to traditional hardcopy products, but has also moved to Web-based GIS. The GIS center in the Dubai municipality has developed an online GIS system for Dubai (http://www.exploredubai.ae) with the ability of zoom in and out, pan, info, and hotlinks. Added functions include the ability to search by community (district), street number, and building number. The search is classified by the type of services needed, for example, locate an address, find a facility (bank, hotel, schools, etc.), or locate a parcel. The system provides not only a map location of a facility, but also address, a photo of the facility, and what is nearby. The major advantages of the site are the ability to view X, Y coordinates of the searched facility, use of registered aerial photographs with the map, and support for Arabic language (Figure 2). With the use of handheld GPS receivers, the use of X, Y coordinates as a means of pinpointing a location is becoming commonplace. Therefore, if a user finds the coordinates of a facility, he or she can use a GPS receiver to identify its location easily. A line map is an abstraction of reality (incomplete); therefore, the use of aerial photographs with a map (photo-map) enhances visualization, because aerial photographs include more details (trees, water, real view of buildings and roads). The Dubai GIS site supports both English and Arabic. The English version serves the global community and the use of Arabic language (Figure 2) as a means of communicating maps and addresses attracts a large number of local and Middle Eastern users who are not familiar with English. This web site represents a very significant advance in the public use of GIS in the UAE. Through integration of GIS and the Internet, data about Dubai is becoming globally available to users anywhere and at any time.

5. GLOBAL COOPERATION BETWEEN UAE AND INTERNATIONAL BODIES

Transfer of RS and GIS technologies to developing countries can be achieved through cooperation between local institutions and foreign organizations. The link between UAE and foreign organizations dates back to the 1980s. Examples include the link with the United States Geological Survey (USGS), the

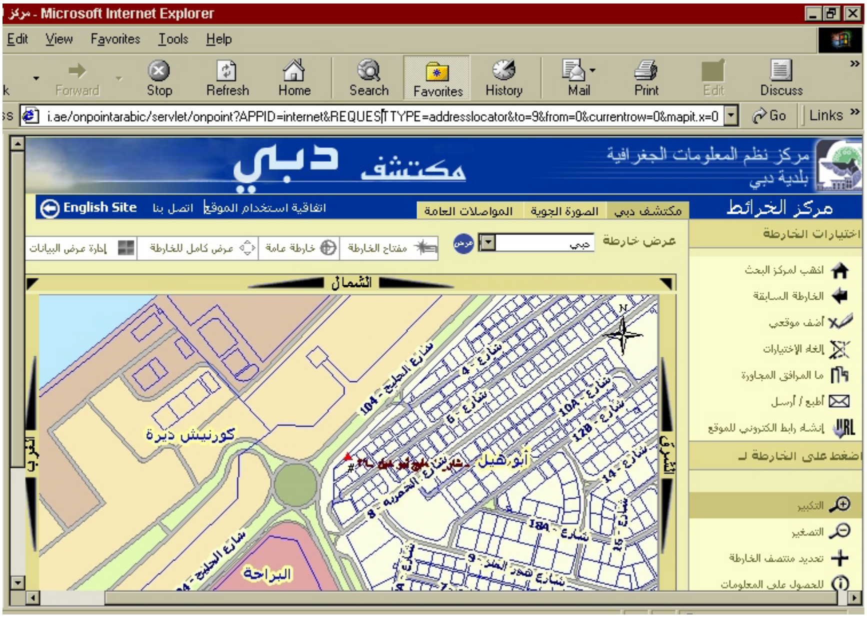

Figure 2. Example of UAE GIS-site using Arabic language. Source: http://www.exploredubai.ae

Center for Remote Sensing at Boston University, Groupement pour le développement de la télédétection aerospatiale, Japan Oil Development Company (JODCO), and Purdue University.

5.1. Cooperation between UAE and the United States Geological Survey (USGS)

Cooperation between UAE and the USGS is very strong in the field of oil exploration, however, need for water in the UAE has broadened the cooperation to include water studies. The National Drilling Company (NDC) of Abu Dhabi and the USGS worked together on a joint project investigating groundwater in the Abu Dhabi emirate. GIS was used for locating existing wells, selecting future drilling sites, and relating and displaying geographic, geologic, chemical, physical, and hydrologic data. Features such as agricultural areas, geological aquifers, roads, and coastlines were integrated with satellite images for analysis in a GIS environment. The GIS and RS software used included ArcView, ArcInfo, and ERDAS-Imagine (Table 2). Throughout the project, experts from the USGS played a significant role in transferring GIS and image processing skills to local staff. Results from this joint project include identification of areas where groundwater quality exceeds or is within the standards specified by the USGS and World Health Organization (WHO) for drinking, agriculture, and industry. Color-coded maps showing chemical parameters (e.g., pH, COD,

BOD) and physical parameters (e.g., temperature, turbidity, etc.) were generated together with their relationship to natural and artificial features on the surface of the earth (e.g., land use, roads). The main benefits of using GIS have been in database management, spatial analysis, and cartographic presentation.

5.2. Cooperation between UAE and the Center for Remote Sensing at Boston University

A joint research project on the use of space images for groundwater exploration in the Northern United Arab Emirates was performed in cooperation with the Center for Remote Sensing at Boston University. The project (June 2001-June 2004) was aimed at applying innovative approaches to identify the potential of groundwater resources in the Northern Emirates of the UAE. It started with the acquisition, enhancement and analysis of satellite images for the identification of potential sites for new groundwater resources. The analysis emphasized the potential of groundwater from two unconventional sources: (1) networks of fracture zones in the highlands based on the study of multispectral images; and (2) buried courses of former rivers and streams that were revealed by radar, which penetrate the sand cover in the desert plains of the Northern Emirates. A digital GIS database accompanied the Final Report on the research (El-Baz, 2003). The project included the training of two nationals from Sharjah including the granting of an M.S. degree from Boston University to applicants who satisfied the academic requirements. Other UAE nationals will also be trained on fieldwork and techniques. The project is a strong example of the application of RS and GIS in water exploration and management. Cooperation in such a project had public and political support, because of the direct impact of water on social, economic, and political life.

5.3. Cooperation between UAE and Groupement pour le développement de la télédétection aerospatiale

Another example of cooperation between a developed nation and the UAE is the joint research project between the Groupement pour le développement de la télédétection aerospatiale, Toulouse Centre in France, and the UAE Commission of Environmental Research. The focus of the project was to use RS (satellite imagery + aerial photos) and GIS to map coastal features such as mangroves, coral reef, sea grasses, biodiversity species, and minerals. The end product from this project was a coastal atlas for the UAE. The atlas was printed in 2002 at a scale between 1:50,000 and 1:100,000 (Blasco, 2001). Since 80% of the urban areas in the UAE fall along the coastal area, and the output product was in digital format, the project is considered of paramount importance to diverse disciplines and applications in the field of environment, planning, mapping, and GIS.

5.4. Cooperation between UAE and the Japan Oil Development Company (JODCO)

Upgrading of RS laboratories and training in space technology are two examples where developed nations can help developing countries. Japan through its Japan Oil Development Company (JODCO) has played a significant role in transferring space technology to the UAE. The cooperation between JODCO and the UAE University dates back to 1999 when JODCO helped upgrade the RS laboratory in the Department of Geology by providing both hardware and software. The hardware included six personal computers (Pentium III, 733 Mhz, 26 GB HD, 256 MB RAM), a flatbed A3 Epson GT scanner, HP LaserJet 500N and PICTOGRAPHY FUJI printers, HP DesignJet (A0) plotter, and Calcomp A0 Drawing Board III digitiser. The software includes six licenses of ER-Mapper 6.0 and ArcView 3.2.

JODCO also helped in joint research projects, presenting lectures, annual training to staff on the application of RS in geologic and environmental studies and hosting and training of students yearly in Japan. JODCO also contributed significantly to related conferences organized by the UAE University. One of the products from this cooperation was sea surface observations using satellite imagery for marine environmental protection offshore of UAE. Satellite imagery showing oil slicks (length, area, depth, direction of movement) and their impact on the marine environment along the UAE coast was generated and suitable recommendations for monitoring were made.

5.5. Cooperation between UAE University and Purdue University

The signing of the Memorandum of Understanding (MoU) between the UAE University and Purdue University in March 2004 demonstrates to local RS and GIS users and to the world that the UAE University is taking concrete steps towards international collaborative research and engagement programs in RS and GIS. The collaborative efforts are reflected in many benefits, such as:

1. Fostering interaction and exchange of ideas between local and international experts in the field of RS and GIS.

2. Involvement of Purdue University faculty members in teaching some courses and co-supervising M.S. students in RS and GIS programs at the UAE University.

3. Training of some faculty members and students from the UAE University for short periods at Purdue's Laboratory for Applications of Remote Sensing (LARS), Center for Advanced Applications in GIS (CAAGIS), and Purdue Terrestrial Observatory (PTO).

4. Carrying out joint research projects.

5. Planning for a joint M.S. Program in RS and GIS between the UAE

University and Purdue University. Such a joint program will be the first of its kind in the region and therefore it is expected to attract students from the other countries in the Middle East.

6. PROBLEMS RELATED TO RS AND GIS IN THE UAE

Problems with RS and GIS technology and data are common to all nations; however, within the UAE particular difficulties were encountered in the following areas:

6.1. Staff

Experienced personnel are an essential factor if RS/GIS technologies are to be applied successfully. A social factor that the GIS field faces in the UAE is that the majority of the material and software in these fields is in English, and English is not the native language for UAE nationals (Arabic is the native language). The proposal by the Department of Geography at the UAE University to introduce more courses in English will help in graduating GIS professionals with good backgrounds in GIS and English. In the UAE, many departments depend on consulting companies to establish their GIS database (outsourcing). Although there is in-house training for users, it is not enough to maintain a GIS projects. Non-availability of staff involved in the GIS project from the beginning is another factor that may result in failure of GIS projects. It was recommended that at least one or two very knowledgeable UAE people must be assigned to a project since such people can get help and advice from many sources, but must be able to use it. There is also migration among the trained staff to other branches of governmental departments and private sectors, for salary reasons. This problem can be resolved by providing incentives to GIS professionals to stay to the completion of key projects. Another problem related to staff in the UAE is that the majority of GIS professionals are expatriates, coming from the Middle East, Asia, and other countries. At the termination of expatriates' services, there may be not enough UAE nationals to take over. The Department of Geography at the UAE University will play a crucial role in solving this problem. It is anticipated that by late 2003, the first twenty-five GIS graduates of the UAE University will be released to the market and subsequent batches will follow. It is recommended that government and private departments offer adequate opportunities for domestic students, especially for females, because the majority of graduates are females (70%).

6.2. Data availability and sharing

Data availability in the UAE can be discussed from two viewpoints. First, existing information is often outdated or incomplete. For example, in some Emirates land use maps in rural areas have not been updated since the 1970s. Second, data are scattered among central, state, and regional departments. RS data can be used as a viable technology to update land cover and land use maps. Data sharing helps to reduce duplication of data and saves money, time, and manpower. A major problem with data in general and geographic data in

particular is the reluctance of the owners to share data (UN, 2000). If sharing data among organizations (at local, national, and global level) were easier, millions could be saved annually, and governments and businesses could become more efficient and effective. However, many departments in the UAE are reluctant to share their data because of security issues. In the UAE, there are two types of data: restricted and unrestricted. Restricted data mainly applies to large-scale topographic maps and aerial photographs, either in hardcopy or softcopy. With the new high-resolution satellites such as IKNOS and QuickBird, restrictions on large-scale data are by default eased. Formation of a central body that coordinates data acquisition and distribution among various emirates will be the key to an efficient exchange of data among the national agencies (Al Romaithi, 1995).

6.3. Budget constraints

GIS is considered as a technology; when this relatively high cost technology is going to be implemented or performed in developing countries, an array of problems can be expected (Hastings and Clark, 1991; Perera and Tateishi, 1995) relating to the cost of data, hardware, software development, trained manpower, leadership, organization, and funding (Saunders and Culter, 1994). The problems can be minimized with the maximum use of local resources, national and international cooperation, and with high creativity. Until recently GIS in the UAE has been implemented only in areas that have very large financial resources, for example, in Abu Dhabi and Dubai. This is because the Abu Dhabi emirate has high revenue from oil and the Dubai emirate has a good commercial profit. New versions of low-cost GIS packages, reductions in the cost of hardware, and the availability of low cost digital data may encourage other emirates and small-scale government departments to set up their own GIS. A key factor in funding a budget for GIS projects depends, to a large extent, on the champions who lead the drive to develop and use GIS. Therefore, GIS professionals in the UAE have to find leaders who support their initiatives based on clear understanding of the benefits of RS and GIS in many areas of economic development, infrastructure, services, planning, and management.

6.4. Coordinate system and map projection

Cadastral maps at the emirates level are based on the CLARK 1880 Zone 39 and 40 Universal Transverse Mercator (UTM) map projection. However, registration and transformation between neighbouring emirates is sometimes a problem. What is more, new topographic maps at the country level are in the World Geodetic System 1984 (WGS84) projection. Conversion from one system to another normally leads to some distortions (distance, angle, area) that make data incompatible even for the same emirate. Incompatibility between maps for the same area normally creates errors that are propagated with GIS spatial operations (Burrough and McDonnell, 1998). To minimize this problem, a common coordinate system such as WGS84 is recommended. The WGS84 is recommended because it depends on the center of the Earth (becoming a universal system) and it is compatible with GPS observations.

6.5. Software

Different departments in the UAE use different GIS packages such as Arc/Info, Geomedia, and MapInfo (Table 2). This has led to difficulty in exchanging data between these departments, thereby resulting in duplication of efforts (costing millions of dollars). Hopefully, this problem can be addressed by a national committee for standardization of GIS databases in the UAE. With ESRI products such as ArcView and ArcGIS gaining momentum in many departments (Table 2), it is recommended that DXF and shape file formats be used as a standard for exchange of spatial data and *dbase* format be used for exchange of attribute data. Another problem related to software is the poor relationship between the University and private organizations, mainly software vendors and data providers. In many developed countries, GIS software and data are provided to educational institutions at reduced prices, and vendors receive tax benefits for this. However, in the UAE the case is not the same. A possible solution to this problem can be through starting with low cost PC-based software such as ArcView and IDRISI, and low cost data such as Landsat MSS and TM. In addition, we recommend that the government consider providing incentives for vendors to provide software and data to educational institutions at reduced prices.

7. CATALYSTS FOR THE DEVELOPMENT OF RS AND GIS IN THE UAE

RS and GIS are not isolated islands but are affected by other activities such as computer literacy, development of the Internet, and awareness about technology. Schools in the UAE are starting to introduce computers in their classes, and this will have direct impact on RS and GIS. A survey carried out by Dubai IT Academy has shown that 60% of students in Dubai schools know how to operate MS Word, Excel, and PowerPoint (Al Aman, 2001). The same program (Computers in Schools) was started at Abu Dhabi during the academic year 2001-2002. The introduction of such programs in schools will increase computer literacy and lay a base for introducing subjects such as “Computers in Geography”. Schools can make use of the available free software on the Internet, such as ArcExplorer, Geographic Explorer, and GRASS.

The Internet is gaining a wider popular appeal among communities in the Middle East, and UAE is part of this trend, drawing more users from lower educational backgrounds and entering more homes and offices. The reduction in Internet rates and computer costs has encouraged many users in the UAE to join the revolution. This resulted in an increase of the ratio of Internet users to the total population from 0.1 percent in 1995 to 8.4 percent in 2000. The ratio is considered high if compared with the average ratio in the Arabic world (0.11 percent) and reasonable if compared with UK (12 percent), Germany (15 percent), and USA (27 percent). With the explosive growth of the Internet, its economy has reached the GIS market, and many GIS developers already have an Internet strategy to offer Web-enabled functionality in at least some of their products. For example, SDI launched the first GIS/e-commerce enabled ArcIMS site in the Middle East for the UAE and Dubai City (ESRI, 2001). Generally, in the UAE, there is an increase in the number of sites employing

online GIS approaches (Figure 2), for example, UAE interact, Dubai explorer, and Al Ain Town Planning Department (see for example, www.uaeinteract.com, www.uaelocator.com, www.exploredubai.ae, and www.spaceimagingME.com). The increase in the use of the Internet and in the number of GIS sites in the UAE means that more and more people will become enlightened about GIS advantages and also exert pressure on departments that have no GIS to start thinking about GIS.

Another catalyst that assists in penetration of RS and GIS to the UAE market is the increase in the number of conferences and seminars related to these fields. A series of conferences and seminars have been organized by UAE University and other government departments in cooperation with other agencies such as the Centre National d'Etudes Spatiales (France), ESRI Middle East, and Hewlett-Packard Middle East. The conferences and seminars provided a good opportunity for interaction and exchange of ideas that lead to the prosperity and development of the GIS field in the UAE.

The market for GIS in the UAE has increased in the last few years; this is evident from the increase in the number of small to large-scale GIS companies (a detailed list and addresses of these companies can be obtained from the authors). The companies perform activities such as surveying and mapping, photogrammetry and satellite imagery analysis, database design, hardware, software, training, and system integration. Most of these companies are based in Abu Dhabi and Dubai, which represents sometimes a logistical problem (additional cost) for GIS activities outside these cities. The reason behind this spatial concentration of GIS companies, especially in Dubai, is due to the flexibility of commercial laws and accessibility to local and regional GIS markets through sea, land, and air travel. The business of these companies depends completely on the economic situation in the region. Since the UAE has a good economy, more and more GIS projects are expected in the future. Examples of these companies include Hansa Luftbild, Hyder ACER, GISTEC (ESRI products), Global Technology, International Surveying and Mapping, Khatib and Alami, MAPS GeoSystems, NorPlan, Scott Wilson, Bentley Middle East, Intergraph Middle East, and Space Imaging Middle East. Availability of branches for global companies in the UAE gives an indication that there is a huge market in the field of GIS in the country. The GIS companies contribute significantly in convincing UAE departments to implement GIS projects. This is achieved through live demos and examples of real GIS projects. Moreover, the companies lobby via their owners to get GIS contracts, which results in more GIS projects and hence more awareness about GIS.

Ground receiving stations that are needed for monitoring, receiving, archiving, and exploiting the Earth observation satellites data can be a good start for developing countries. Hundreds of ground receiving stations are already spread around the globe (Bigot and Beruti, 2000). In the UAE, Space Imaging Middle East has established the first ground receiving station in Dubai in 1998. The station has contributed to international cooperation and also encouraged research, development, and applications in the field of earth-observation science and GIS.

8. IMPLICATIONS OF DIFFUSION OF RS AND GIS

With mutual understanding between developed and developing nations and common issues like global warming and sustainable development and with

the support of the UN Committee on Peaceful Uses of Outer Space, more developing nations can enhance their RS and GIS programs (Euroconsult, 1996). Sponsorship of education and research for transfer of these technologies to developing countries has already taken place by different agencies (Abiodun, 1993; Fea et al., 2002; UN, 1993; UN, 2000). The whole process of globalization of GIS is due to more open political and economical institutions, development of hardware, software, communication, reduction in cost of hardware and software, and above all the Internet. Therefore, adoption of the Internet in geography education in schools through universities has to be at the top of the agenda for academic institutes. Students who study GIS are by default assumed to have an understanding of global issues and approaches, and be proficient in English. This is because the majority of the literature in these fields (references, journals, Web sites) and software are in English, the "global language". Graduates who master GIS can compete in the global market of GIS jobs. Therefore, globalization of GIS will bring about a more general prosperity in the long run and in the shorter run it puts large numbers of people at risk.

Municipalities in the UAE control, directly or indirectly, around 80% of geographic data in the UAE. It is anticipated that any move for standardization led by them will find a positive response. Other governmental departments, private companies, and academic institutes that work or have interest can join the move. The move for standardization will allow easy data sharing, therefore, helping to reduce duplication of efforts, saving money, time, and manpower.

A key component in promoting GIS is the availability of documented examples, which readily display the benefits to be gained from exploiting geographic information and the associated technology, particularly in the area of policy formation and implementation. Celebrating GIS Day will raise awareness about RS and GIS among the public, governmental departments, private companies, and it helps in convincing decision makers about the benefits of RS and GIS.

9. CONCLUSION

The UAE is an example of a developing country where RS and GIS are diffusing at a fast pace. Some academic institutes in the UAE are now offering degrees in RS and GIS and more such degrees are in the pipeline. Implementation of RS and GIS in governmental departments has reached a solid foundation, and this has had an impact on the number of companies involved in RS and GIS activities, and the number of seminars and conferences related to these fields. Although RS and GIS are expanding rapidly in the UAE, there are many obstacles to their expansion. Among these obstacles are scarcity of specialists in these fields, data availability and sharing, budget constraints, incompatibility of coordinate systems and map projections between different emirates, and incompatibility of software. These obstacles can be overcome by utilization of local resources, sharing of resources, sponsorship by developed nations, and above all champions who can sell and convince the politicians about the significant contribution of RS and GIS in managing the environment and achieving the economic and social development goals of a nation.

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