

# **GIS For Petroleum in the Curriculum of Geography: Case of UAE University**

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## **Abstract**

The objective of this paper is to address issues related to the introduction of GIS for Petroleum course in the Geography curriculum. Generally in the Gulf Cooperation Council (GCC) and the UAE the field of Petroleum industry is dominated by geology and engineering graduates. The Geography Program at the College of Humanities and Social Sciences, UAE University had renovated its curriculum in 2003 to meet the market demand. Among the vibrant and promising markets that had been identified is the field of Petroleum industry. Although the course opens new job opportunities for geography graduates there are some problems related to a suitable textbook that fits the course, heterogeneity of students register for the course, language constraint, difficulty in obtaining local petroleum data to train students on it, the need for specialized GIS and subsurface 3D software, and harshness of the petroleum environment.

**Key words:** GIS, Petroleum, UAE, Geography

## 1.0 Introduction

The United Arab Emirates (UAE) is founded in 1971 as a federation of seven emirates. Comprising an area of 83,600 square kilometers, the country lies between latitudes 22°-26.5° north and longitudes 51° -56.5° east. According to the 2005 census, the population of UAE is 4,104,695 with an increase of 74.8 per cent compared to the last census conducted in 1995 when the population was 2,411,041 (UAE YearBook, 2007).

The Geography Program was founded in **1977** and has produced more than 2000 graduates, with secondary school geography teaching their principal occupation. By the 1990s the market for teachers began to decline, and the program introduced a GIS track in **1999** to meet a growing demand in the GIS field. The Program's goals including adding more UAE nationals to the faculty, improving capabilities for research and publication, and placing more geography and GIS-trained graduates into the national workforce. In **2003**, the Geography Program began drafting a revised mission that reflects a growing university-wide commitment to intellectual development in a global context. Greater attention is given to interdisciplinary education, critical thinking, proficiency in English, and students' connections outside the University and the nation. The latest revision of the Program included developing three general tracks one covered world regional geography, the second concentrated on environmental issues, and the third focus on the technical side of geography that become known as Geographic Information Systems GIS or Geoinformatics. The Geography Program's curriculum indicates strong commitments both to the national priorities emphasized in its mission and to the education of well-rounded students of geography.

Within the 2003 revision, the program had started in 2005 a cross-disciplinary thematic application courses in response to the market demand. One of these courses is GIS for petroleum. The world will see more high demand for oil due to the increase in the number of population, industrial and commercial activities (Simmons, 2005). In 2008, the price for barrel hits U\$ 120 and it is predicted that by 2020 the price will hit U\$ 200. The Gulf Cooperation Council (GCC) have the lion share in this market (around 60%). Within

this, UAE produces 2.8 million barrels of oil per day (b/d) and plans to raise its production capacity to 3.5 million b/d in the next few years (UAE YearBook, 2007). Therefore, it is necessary to introduce courses that will qualify Geography graduates to compete in this vibrant market.

In 2007, Geography and Urban Planning Programs are merged to form Geography and Urban Planning Department. The continuous changes and restructuring of the courses in the Program and the merger indicate a dynamic nature and flexibility that the Program had and will follow to meet the market needs not only at the undergraduate level, but also at graduate level. In this context, the Program, in collaboration with other colleges within the University, had started in 2005 a Master program in Remote Sensing and GIS (Yagoub, 2005).

The number of students attending the department is increasing continually. The total number of students at the department in the second term of the academic years 2007/2008 reached 250 students (girls and boys). The number of faculty has reached 15, with various scientific ranks and specialties such as natural geography, human geography, and technical geography. Other educational facilities available at the Department include two GIS analysts, textbooks and references at the central library, fast speed connection to the internet (fiber optics), local UAE data, hardware (65 PCs + 8 GPS receivers, 5 printers) and software (58 ArcGIS 9.2 licenses and 33 ERDAS Imagine licenses).

The article starts with setting the objectives of the paper, highlights GIS application for petroleum, discusses GIS for petroleum course, identifies problems related to the introduction of GIS for Petroleum course, and proposes some recommendations.

## **2.0 Objectives of the paper**

1. Address issues related to the introduction of GIS for Petroleum course in the Geography curriculum.
2. Share experience with other Universities.
3. Explore suitable model for teaching GIS for Petroleum course.

## **3.0 GIS application for petroleum**

GIS provides a natural fit for the petroleum industry. Almost all petroleum operations can be geo-spatially defined then linked to tabular data sets, GPS, aerial photographs, remote sensing, and other real-time and historical information (ESRI, 2008). Beginning with the well prospect and ending at the gas pump, petroleum professionals involved in upstream, midstream, and downstream activities can use GIS for site selection, cross-functional and organizational communications, and economic and market analysis (Gaddy, 2003).

Virtually all petroleum business operations, from regional geologic exploration, through field appraisal and development, and from product distribution, facilities management and environmental modeling, to retailing or commercial and domestic supply, rely on fundamental spatial data components. GIS is not restricted to static maps, but it can be used to track movement of oil ships through GPS, generate electronic maps daily, and make these maps available wherever and whenever to petroleum staff through real time web-based GIS.

One specific exploration application involves the creation of reconnaissance maps. Such maps are usually performed across large geographic areas, where many data sets or map layers are used in the analysis of hydrocarbon potential. Raster data, such as aerial photos or satellite imagery, can be incorporated with vector data, such as elevation contours, and topographic landmarks or points of interest, can be presented. Where appropriate, coordinates from land surveys, such as section, township, and range, can be integrated with well data. Reconnaissance maps of mature exploration areas can present distinct trends, patterns, and anomalies. GIS is a particularly effective technology that enables

exploration team to share information, analyze data in new ways, and integrate the evaluation process.

#### **4.0 GIS for petroleum course**

The course provides a quick introduction to the fundamentals of GIS and Petroleum. It is presented in a lecture/laboratory format. The lecture portion deals with conceptual issues in GIS database design and development, analysis, and display (Table 1). The laboratory portion provides students with hands-on contact with GIS and remote sensing software products and their applications in the petroleum industry. The main objectives of the course can be summarized as follows:

- To develop an understanding of the applications of GIS in the petroleum industry.
- To expose the students to the applications of remote sensing and GPS in the petroleum operations.
- To review GIS models and spatial analysis related to the application of GIS in the petroleum field.

By the end of the course (course outcomes) a student will be able to:

- Integrate different GIS data to solve real petroleum problem (well site selection, pipe line siting, corridor selection, marketing, and environment).
- Evaluate and critically identify the strength, weakness, and constraints of applying remote sensing, GPS, and GIS in the petroleum industry.
- Demonstrate ability in using GIS software to build petroleum database, perform spatial analysis, prepare maps, reports, and charts for presentation of results.

The assessment of the course is based on quiz and report (15%), mid term exam(25%), course work (lab) (20%), and final exam(40%).

<b>Week</b>	<b>Topic</b>
1	Course outline and Introduction to GIS for Petroleum
2	Quick revision to GIS and Remote Sensing
3	Application of Remote Sensing for oil exploration and oil spill
4	Use of GIS Spatial Analysis for well Site selection
5	GIS Spatial Analysis for optimum pipeline network determination
6	Application of GPS in the petroleum industry
7	GIS for Petroleum marketing (supply-demand)-Network analysis
8	Visit to governmental/private departments implementing GIS for Petroleum
9	GIS as database management systems for the petroleum industry Integration of heterogeneous data and different software
10	Generation of 3D and sub-surface models to aid in petroleum exploration, management, and monitoring. Visualization, fly-over, animation
11	Global Mapping of oil
12	Web-based GIS and Mobile Mapping for the petroleum industry
13	Presentation of GIS For Petroleum projects

Table 1: Topics covered in the course

#### ***4.1 Visit to governmental/private departments implementing GIS for Petroleum***

The organization of a visit to governmental/private departments implementing GIS for Petroleum is considered an important element in the course. For instance on 18, March 2008 the students visited Abu Dhabi Company for Onshore oil operations (ADCO). The students and the faculty get to know about the daily operations of the company and how GIS, surveying engineering, GPS, and remote sensing are integrated for providing permissions for oil exploration companies, coordinating between various utilities departments, and managing the petroleum assets. GIS employers delivered talks on their experiences with GIS implementation in petroleum followed by live demonstration on GIS systems and open discussion with students.

#### ***4.2 The practical part of the course***

The practical part tries to provide students with hands/training on remote sensing and GIS software and at the same time satisfy the 3R (Researched, Relevant, Reactive) approach. Researched focus on setting the objective of the training, relevant means using data that is familiar to the trainees (UAE data), and Reactive ensures that expectations can be satisfied without isolating either fast or slow learners. The practical part of the course is formulated with the following objectives:

1. To develop an understanding of research methodology (problem identification, setting criteria, literature review, data collection, analysis, problems, recommendations, references).
2. To expose students to the applications of remote sensing and GIS in the petroleum industry and its link to various areas such as physical, environmental, and local planning.
3. To encourage students, from different fields “inter/multi -disciplinary”, to form some sort of communication and teaming (student-student interaction) to work towards common objectives and goals.

#### ***4.3 Example of students' projects***

Students were asked to carry out analysis using critical thinking to detect any clues for the relationship between the geological formation, land use type and areas of high oil reserved, generate 3-D model (contour-DEM) and overlay with the satellite image and check if there is any relationship between elevation/slope and oil availability, overlay the pipelines on the 3D model and satellite image and check whether the route through which the pipelines network passes is economically feasible (slope, cut, fill, soil stability) and environmentally sound (does it passes near or through population centers, agricultural land, valleys, habitat reserved, etc.), does pollution status near oil fields and refineries affect/endanger air, water, land, and human health.

Students gathered various data to solve the above problems. This include, UAE geological map, soil map, main roads, satellite image (land use), topographic maps (DEM, contour), location of oil fields, location of refineries, pollution status near oil fields and refineries, pipelines network for local distribution and ports.

Some of the students were able to generate oil world map with world satellite image as background and identify countries with high production, countries with high consumption, generate flow maps showing import and export of oil routes, factors affecting on marketing (distance, quality of oil), calculate the distance and find estimate for transportation (cost of \$/ton/per km) and the effect transportation means (trucks, rails, pipelines, ships, etc.), investigate the relationship between oil consumption and population density, industry, and economy.

Students had proved their capabilities to carry out a GIS project starting from field survey to presentation (*outcome*). Results of the projects are presented in a form of models, maps (Appendix B), reports, charts and a database with a custom interface that allows for an easy, step-by-step mapping process. Students who were feeling shy at the beginning of the course were able to talk at the end of the course and express their ideas and this is considered one of the educational outcomes (character and confidence building).

The lesson learned from these projects is that students are able to convince their families to participate in collecting of field data. This has a positive advantage that families (community) are becoming part of the educational process and they know what their daughters/sons are doing. After finalizing the projects, students' families have seen the products of their daughters and they are very pleased with the knowledge and the skills they have gained.

## **5.0 Problems related to the introduction of GIS for Petroleum course**

The problems related to the introduction of GIS for petroleum in the Geography curriculum include a suitable textbook that fits the course, heterogeneity of students register for the course, language constraint, difficulty in obtaining local petroleum data to train students on it, the need for specialized GIS and subsurface 3D software, and harshness of the petroleum environment.

### ***5.1 A suitable textbook***

While several GIS texts are in circulation, there are only few that truly stand out, balancing analytical techniques with a sufficient comprehensive treatment of the GIS for petroleum subject area. Efforts are being made to rationale a suitable textbook that can be used in the course, and finally the decision landed on:

Gaddy, Dean E., 2003. **Introduction to GIS for the Petroleum Industry**. Tulsa, Oklahoma: Pennwell Pub.

The text covers many topics such map projection, coordinate system, GIS, GPS, remote sensing and some real application examples of well site selection, corridor selection, and marketing. The problems with using the textbook for this course are:

- Some of the topics covered in the textbook such as map projection, coordinate system, GIS, GPS, and remote sensing are covered in separate courses within the Geography Department. Therefore, there is a repetition for Geography students while the topics are new for students from other departments.
- Some topics such as oil formation mapping, geophysical exploration mapping, pipeline route selection, oil Geo-Database Management System (GDBMS), applications of remote sensing and GIS in oil pollution, deserve their own chapters within the textbook.

The textbook is intended for both users and managers involve in all aspects of the business, ranging from geologic exploration to oil sales. It assumes that the reader has no previous background about GIS (Gaddy, 2003). Therefore, the textbook satisfies the

needs for some students outside Geography and as had been said "There is no shirt fits all sizes". Additional material had been prepared to complement the textbook. Other references that are recommended include Bonham-Carter (1994), Gary (2002), Hale (2000), Timothy and Jeffrey (2000), Geospatial Information and Technology Association (GITA) oil and Gas conference Proceedings (GITA, 2000) in addition to numerous web sites (Appendix A).

### ***5.2 Heterogeneity of students register for the course***

Students from other departments and other colleges, for instance, Urban Planning and Geology students, register for the course as elective. Some of these students have no background about GIS and remote sensing similar to Geography students. Such a situation compels the lecturer to keep *a balance* between those who know and those who do not know. This result in incompleteness of the topics set for the course. Short extra courses for those who have no background about GIS and remote sensing are introduced.

### ***5.3 Language constraint***

English is becoming a global language (Crystal, 1997) because of the extensive impact of the British Empire during the colonial period and the dominance of the 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 masters English. Within this move, the College of Humanities and Social Sciences started to use English as the medium of instruction in 2003. This has created new challenges for instructors who must teach their discipline in English to Arabic-speaking students who may not be fluent in the language.

The author uses some techniques to facilitate students' comprehension of the language, and thus the content-area of the GIS for Petroleum Course. Example of these techniques include: speak in short simple sentences, rephrase the concepts, content, and summarize the main ideas. The point is not to simplify the concept taught, but rather the way it is

conveyed. Visual aids such as notes written on the board or shown in multimedia format as well as photos, illustrations, charts, graphs, and maps provide context that helps students understand the linguistic/conceptual input (Nikki, 2004). Motivation of students to participate and express their ideas in English (through questions and answers), brainstorming (mind-mapping), presentations, group discussion, and quizzes are found to be useful in developing the students' speaking, listening, and writing skills.

#### ***5.4 Difficulty in obtaining local petroleum data***

Training students on local data has a great impact on understanding the course concepts and contents. Some relevant digital data (vector, raster, aerial photographs, satellite images, attribute) about UAE are compiled. Great efforts had been made to obtain local UAE petroleum data, but without success. The main reason is security issue. Although there is petroleum data available for sale from private organization such as Research and Markets-Energy Maps(<http://www.researchandmarkets.com/>), there is no budget allocated for such activities. Data collection (maps, tables) for a GIS project is time-consuming; therefore, students who register for this course are advised to identify their projects as earlier as possible, so they can work on it during summer or winter vacation. The available UAE petroleum data limits the range of research questions, problem-based, and applications to which students are exposed. Therefore, data from other parts of the world is utilized.

#### ***5.5 The need for specialized GIS and subsurface 3D software***

Following to the continuous negotiations with GISTEC Company (ESRI distributor in UAE), the company agreed to offer our students with one-year extendable free licenses of ArcView 9.2 software that includes 3D extension. Such offer helped us to go ahead with our plan of introducing laptops, so that our students can perform their geographical analysis wherever and whenever independent on the GIS Labs. The lesson learned from this exercise is that cooperation with the private organizations will lead to a win-win situation. That is to say, the students of today are the leaders of tomorrow and any

software they are familiar with it during their study is more likely to order it when they take positions in the industry. So, it is strategic investment for software vendors to provide free software for students. Another benefit is that in the past, GIS Labs close at 8:00 PM local UAE time and in many cases our students (majority females) would like to work after this time. This is only possible if some faculty/Lab assistant is present. Therefore, the use of laptops and free software had alleviated this problem. Almost 80% of the students have laptops either bought by their families or through loan from the University. Specialized software such as those dealing with environmental, geological, and sub-surface analysis (e.g. Environmental Visualization System from C Tech, Earth Science software from RockWare, 3D for earth from Golden software), and pipeline software are needed.

### ***5.6 Harshness of the petroleum environment***

Students have to attend internship/practicum as part of their degree and some need to be allocated with petroleum organizations. The petroleum operations in UAE are in many cases in harsh environments such as among sand dunes (200 m high) and offshore. Both situations represent a problem for our students putting into account around 70% of them are females. In addition to this, the high risk from the frequent spread of the Hydrogen Sulfide (H<sub>2</sub>S) gas in oil fields makes our students feel reluctant to do their internship or even join the oil field in the future. This gas is colorless, toxic, and flammable. Although of the safety precautions (sensors, training in dealing with the gas) and efforts to reduce fatalities from other petroleum hazards, still the petroleum field is considered among high risk fields in comparison to teaching and other office jobs. Discussion with Abu Dhabi Company for Onshore oil operations (ADCO) revealed that there are plans to prepare a suitable working environment for females.

## **6.0 Recommendations** (Explore suitable model for teaching GIS for Petroleum course)

From the visits to companies that work in the petroleum industry in UAE such as ADCO and Abu Dhabi Marine Operating Company (ADMA-OPCO), discussion with staff there (user needs/requirements), and the experience of the author, the following recommendations are made:

- The need for inclusion of a course dealing with surveying engineering and training students on determination of elevation, measurement of angles and distances using levels, theodolites, and total stations.
- Allocation of more slots within the course or in a separate course to GPS theories and applications in the oil industry.
- Market demands students with technical background (Bualhamam, 2007), therefore, mathematics and computer science should be integrated with university-based courses. Often, technical competence leads to creative spatial thinking which is essential to succeed at the graduate level and beyond.
- The current program's structure requires 132 credit hours for graduation with only 39 of them (30%) are allocated for geographic courses. Other 93 credit hours (70%) are for university, college and elective requirements. Although non-geography courses opened and widened students' understanding, it is recommended to allocate more credit hours to the specialty.
- The location of the Master Program of Remote Sensing and GIS is in Abu Dhabi, at 150 km from the undergraduate campus at Al Ain. It is necessary to provide some sort of monthly meetings that allow undergraduate and graduate students and faculty to mix and mingle to encourage pedagogy and research.
- Students are encouraged to collect their own data, search on the web for free available data, and explore geo-spatial innovation tools such as Google Earth, Microsoft Virtual Earth, and Geography Network, USGS, and Global Land Cover Facility at the University of Maryland.
- Include AutoCAD training as part of the GIS Lab for the students.
- Maximize the utilization of the available resources in the university, especially, during semester breaks for running "English plus content" courses and encourage more English-medium extra-curricular activities and societies.

## 7.0 Conclusion

The study provides a UAE perspective on teaching GIS for Petroleum course and may be useful and interesting to other departments around the globe. In general, the course provides students with a blend of theoretical and practical background about the use of geo-spatial analysis in the petroleum operations through integration of remote sensing, aerial photographs, Global Positioning System (GPS), and GIS in the frame of exploration, production, marketing, pipeline siting and monitoring, and environmental impact of oil. Key learning objectives such as critical thinking, self-learning, creativity, analysis, and developing IT skills are incorporated in the body of the course.

The majority of literature in GIS for petroleum field (references, journals, web sites) and software is in English and this represent a barrier to my students, I make the process more easier through extensive illustrations (maps, figures, satellite images, equations, numeric example, video clips) and provides real examples that are familiar to the students, keep in mine *"One image expresses thousands of words"*. Although there are divergence and convergence in opinions regarding teaching any GIS course or related one (Antonio, 2008), the general consensus is that adequate facilities should be available. This includes dedicated human resources, interactive students (brainware), hardware, software, textbook and reference material in the library, fast speed connection to the internet, and local data. It is difficult to estimate the success of the GIS for petroleum course against the main objective it is set for (job opportunities). This is because it had been recently introduced (2005) and by the end of this year the first batch will graduate. However, students who studied the course have great hopes that they will find opportunities that match their GIS skills not only in the petroleum field, but also in other areas such as municipalities, police, military, and environmental agencies.

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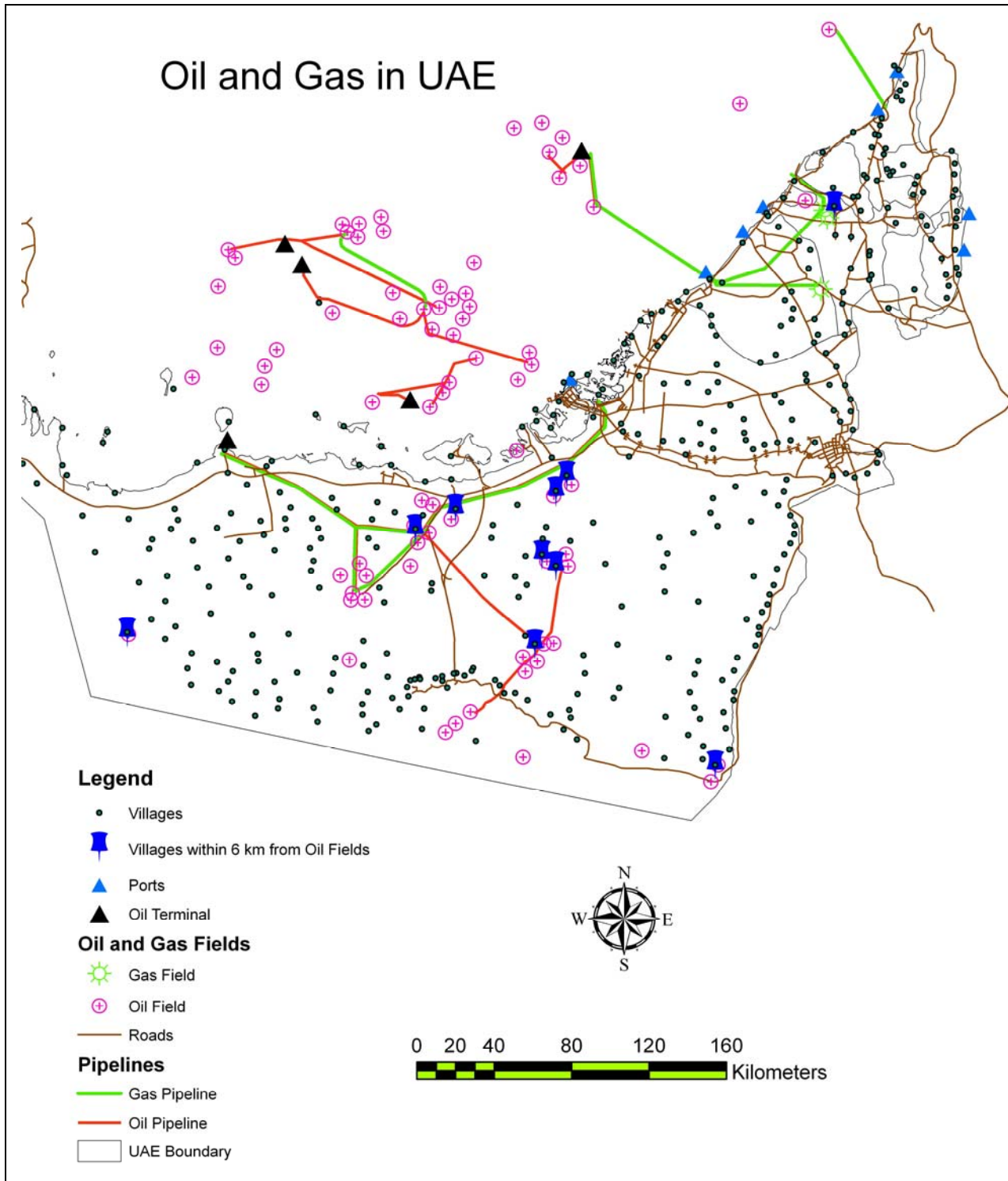
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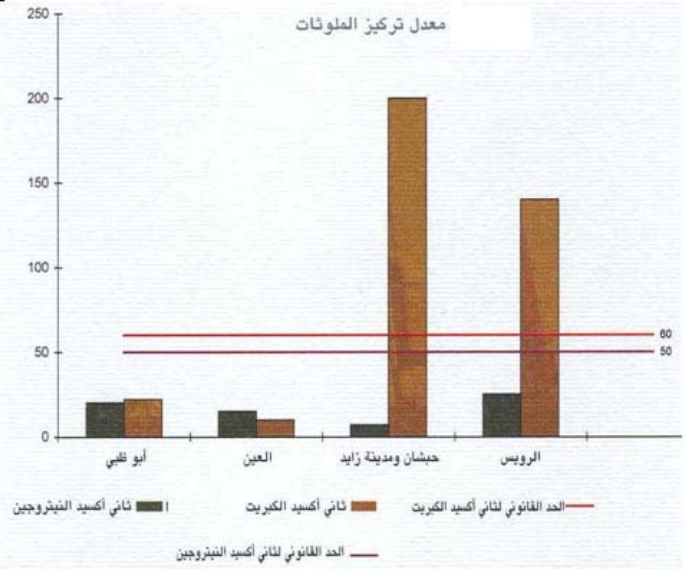
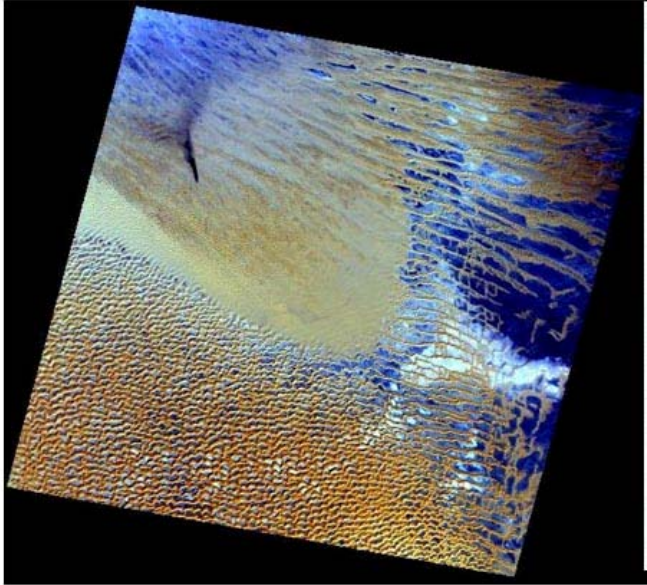
## **Appendix A: GIS for Petroleum Web Sites**

- American Geological Institute: <http://www.agiweb.org/pubs/globalgis>
- American Association of Petroleum Geologists :<http://www.aapg.org>
- Bio-Geo-Recon; Mineral Exploration with Remote Sensing:  
<http://www.biogeorecon.com/mineral.htm>
- ESRI Petroleum : <http://www.esri.com/petroleum>
- Federation of American Scientists: <http://www.earthsensing.com>
- Free GIS software: <http://www.freegis.org>
- GIS Café: <http://www.giscafe.com>
- GITA : <http://www.gita.org>
- Global Land Cover Facility at the University of Maryland for satellite data:  
<http://glcf.umiacs.umd.edu/index.shtml>
- Hyperspectral Image Analysis for Oil Spill Mitigation: <http://www.nus.edu.sg>
- More than 800 GIS sites: <http://www.gislinx.com>
- Oil and Gas Journal-Research Center: <http://www.ogj.com>
- Oil and gas maps: [www.earthscope.org](http://www.earthscope.org)
- Pennwell : [www.pennwell.com](http://www.pennwell.com) , [www.pennwellbooks.com](http://www.pennwellbooks.com)
- PenEnergy data: [www.pennenergydata.com](http://www.pennenergydata.com)
- Petroleum Exploration: <http://science.howstuffworks.com/>
- Remote sensing aid hyperspectral detection efforts; <http://www.pobonline.com>
- Research and Markets-Energy Maps: <http://www.researchandmarkets.com/>
- Satellite Mapping; Seeps and Oil Exploration;  
<http://www.npagroup.co.uk/oilandmineral/>
- Software: RockWare- Earth Science software: <http://www.rockware.com>
- Software : 3D for earth: [www.Goldensoftware.com](http://www.Goldensoftware.com)
- Software: Environmental Visualization System (EVS) from C Tech:  
<http://www.ctech.com>
- U.S. Geological Survey: <http://www.usgs.org>

## Appendix B: Example of students' projects



**Integration of remote sensing and statistical data to understand Air pollution in UAE**



**West Abu Dhabi- Liwa: Landsat Image showing smoke from oil well**

**West Abu Dhabi- Liwa: High Carbon Dioxide**