

# Applications of Space Techniques for Sustainable Development in West Asia

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## Abstract

*This paper presents the state of the art in terms of operational applications of space techniques in West Asia, particularly in the fields of Geographic Information Systems (GIS), Remote Sensing (RS), Global Navigation Satellite Systems (GNSS) and Communications. The developed methodology is composed of three phases: 1) Assessment of Spatial Data Infrastructure (SDI); 2) Evaluation of Space Technique Applications (STA); and 3) Education of Qualified Human Resources (QHR). The assessment of Spatial Data Infrastructure highlighted the necessity to create a West Asia Geodetic System (WAGES). It also showed the development of earth observation satellite systems by the Kingdom of Saudi Arabia (KSA) and recently by the United Arab Emirates (UAE). There are a great number of GIS and RS Symposia and Workshops held regularly. Many research institutions, centers for studies and universities have introduced geomatics sciences in every days life to support the decision making process. Space techniques were used to conduct development projects in collaboration with other organizations at both national and regional levels: AGEDI conducted by UAE in partnership with UNEP, REWARD by IUCN, and Arabian Peninsula Regional Programme by ICARDA, Coastal and Marine Action Plans by PERSGA and ROPME. GRID Database and Global Environmental Outlook (GEO) Reports were established by UNEP. World Bank & UNESCO have also supported some projects in the region. The review of space education showed that there is one United Nations Regional Center for Space Sciences and Technology Education in India for Asia and Pacific countries. The review also showed that only 4 West Asian countries out of 69 countries are member states of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). Geomatics education is provided mainly by the Arabian Gulf University, the UAE University and Al-Balqa Applied University in Jordan. Aerospace engineering is offered by the countries of KSA, UAE, Lebanon and Jordan. In conclusion, space techniques along with classical methods are being used in West Asia for sustainable development, depending on the needs at both national and regional levels to find out adequate solutions for natural resource management, environmental monitoring, meteorological forecasting, urban and regional planning, hazards and crisis management.*

## 1. Introduction

### 1.1 Definition

Space techniques include modern methods of measurements which make use of artificial satellites, particularly space imaging (RS), satellite positioning and navigation (GNSS), and satellite Communications.

### 1.2 History

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was established in 1959, to provide effective mechanism for keeping States informed of the activities of the international, governmental, and non-governmental organizations involved in this field. COPUOS has two subsidiaries: Legal Committee, Scientific and Technical Committee, and a Secretariat, the United Nations Office for Outer Space Affairs (UN-OOSA). The United Nations Program on Space

Applications (UN-PSA) was established in response to a recommendation of the UNISPACE Conference in 1986 (Lee, 2004).

### 1.3 Benefits

Forecast International is projecting deliveries of approximately 139 imaging satellites worth US\$ 16.3 billion over the next 10 years. The overwhelming majority will be Low Earth Orbiting (LEO) satellites, with 67 such systems planned for the forecast period. The production of 8 Geostationary Earth Orbiting (GEO) satellites planned for the forecast period is valued at US\$ 1.4 billion (Writers, 2006). According to BCC Research (2007), the global market for Remote Sensing products was more than US\$ 7 billion in 2006 and will reach US\$ 7.3 billion in 2007. At an annual growth rate of 6.3%, the market will grow to more

than US\$ 9.9 billion by 2012. The GIS market was estimated at US\$ 7 billion annually, including software and hardware and services. 47% of this industry is provided by USA, 33% by Canada, 17% by Europe and the remaining 3% by the developing countries (Daratech, 2002 and Geoworld, 2002). The confluence of three technologies, which are RS, GIS and GPS, lead many to predict that it would surpass US\$ 30 billion in sales by 2005 (BCC Research, 2007).

#### 1.4 Methodology

The methodology adopted (Figure 1) is composed of three phases: 1) Assessment of Spatial Data Infrastructure (SDI); 2) Evaluation of Space Technique Applications (STA); and 3) Education of Qualified Human Resources (QHR). These three components are supposed to be integrated and existing at local, national and regional levels.

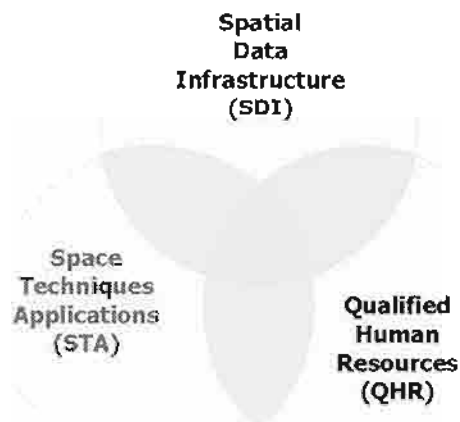


Figure 1: Methodological flowchart adopted

## 2. Spatial Data Infrastructure (SDI)

### 2.1 Concepts & Definitions

The resources for the collection, management, dissemination, and use of geo-spatial data and information are being treated as part of the substructure or foundation of a society, resulting in the concept of Spatial Data Infrastructure (SDI). The components of SDI are given as follow: Data, Database, Metadata, Data Network, Technology, Institutional Arrangements, Policies and Standards, and finally Users.

### 2.2 SDI in West Asia

SDI in Abu Dhabi, UAE, creates a seamless network of interoperable nodes- geospatial portals that will provide easy access to all geospatial information in the Emirate (more than 350 maps

services) (GSDI, 2009). The Survey and Land Registration Bureau has established a permanent network of 5 GPS stations to provide very strong foundation for all survey work in the country. A control centre receives and process data from individual sites and makes RTK connections available via both GSM and Internet communications (Hadi and Tuckerman, 2007). There are 5 organizations having Ground Receiving Stations, which are:

- The Institute of Space Research (ISR) in Saudi Arabia;
- The Dubai Space Imaging (DSI) in United Arab Emirates;
- The Global Scan Technologies (GST) in UAE; and finally;
- The Regional Organization for the Protection of Marine Environment (ROPME) in Kuwait;
- Space & Astronomy Research Center (SARC) in Iraq.

### 2.3 GIS & RS Forum

- GIS Conference & Exhibition in Bahrain (1998, 2002, 2004, 2007, and 2009)
- Map Middle East Conference (2005, 2006, 2007, 2009).
- ESRI Users Conference (2002, 2004, 2006, 2009)
- Kuwait International GIS Conference & exhibition (2005, 2006)
- Oil Spill Management Conference and Exhibition in Kuwait (2007).
- Conference on Land Degradation in Kuwait (2008)
- Use of Space Technology for Disaster Management for Western Asia in Saudi Arabia (2004) and Syria (2006)
- National GIS Symposium in Saudi Arabia (2006, 2007, 2009).
- GORS Conference, Syria, conducted every two years since 1992
- UN Workshop on the Use of Space Techniques for Monitoring and Control of Desert Environment for ESCWA region, Syria, 1995

### 2.4 West Asia Geodetic System (WAGES)

There is an immediate need to define, and realize an accurate 3-D Geocentric System. To achieve the best definition and accuracy, it is imperative that the recommendations of the International Association of Geodesy (IAG) and Conventions of the International Earth Rotation Service (IERS) on tidal and temporal effects modeling and latest estimates of the fundamentals constants are used. Kumar and Maul (2005) have proposed a new West Asia Geodetic

System (WAGES) 2005 as a replacement for the old datum's of the region.

### 2.5 National Space Programs

Developing small satellites with high capabilities but at a low cost would be accessible and affordable by universities, research organizations, and developing countries whose governments aspired to a space program (GISdevelopment, 2007). We can mention the existence of National Space Programs in the following countries:

- a- The Kingdom of Saudi Arabia is acting through the King Abdul-Aziz City for Science and Technology (KACST) Space Research Institute. Between 2000 and 2007 it launched 4 satellites for Education, 7 satellites for communications (SAUDI COMSAT) and one satellite for Earth Observation (SAUDI SAT). The latest one was launched in the year 2007 (COPUOS, 2009). They are part of a program of 24 mini-satellites manufactured and designed in the kingdom by a team of Saudi scientist and engineers as part of a program to harness space technology for commercial purposes.
- b- United Arab Emirates has successfully launched its first satellite in 2009, by the Emirates Institution for Advanced Science and Technology (EIAST). The satellite called DubaiSat-1 was stabilized from the earth observation station at the altitude of 680 km. UAE attempts to create a sound infrastructure to enable the collection of space and earth observation data to power the comprehensive development of the country (EIAST, 2009).
- c- Iraq Al-Anbar Space Research Center, 10<sup>th</sup> nation with a rocket powerful enough for space launches (This center with others were damaged in 1991 war).

### 2.6 Regional Space Programs

- a- Arab Satellite for Earth Observation (ASEO): will be managed by the League of Arab States, including Arab countries of North Africa and Middle East. The mission is the mapping, management and monitoring of natural disasters, and management and preservation of natural resources. The constellation will be composed with 3 high resolution satellites (2.5 m GSD). The Project cost 50 million dollars.
- b- SmartSat, a \$US 500 million joint venture, unveils the first private Arab Satellite, private company joint venture, based in UAE. It will offer services to the services providers in the MENA region, capitalizing on the increasing

number of media, telecom, and military users in the region.

- c- Communication satellites (e.g. ARABSAT) and Mobile satellites (e.g. THURYA).

### 2.7 National Centers for Remote Sensing

Many national centers or organizations of remote sensing exist at the national level. These centers differ from one country to another. Some of them are well equipped, others are not or slightly equipped:

- National Center for Remote Sensing (NCRS, Lebanon);
- Royal Jordanian Geographic Center (RJGC, Jordan);
- General Organization of Remote Sensing (GORS, Syria);
- United Arab Emirates University (UAEU, UAE);
- State Commission on Photogrammetry and Remote Sensing, Iraq
- Bahrain Center for Studies and Research (BCSR, Bahrain);
- National Survey Authority, Oman;
- General Authority of Lands, Surveying and Urban Planning, Yemen;
- Geographic Center and Technical Support, Palestine;
- Kuwait Institute for Scientific Research (KISR, Kuwait);
- King Abdul-Aziz City of Science and Technology (KACST, Saudi Arabia)
- Center for GIS (CGIS, Qatar).

### 2.8 Regional Centers & Organizations

We may mention the following regional organizations:

- The International Center for Agricultural Research in the Dry Areas, established in Syria, in 1977 (ICARDA, 2009).
- The Regional Organization for the Protection of the Marine Environment, established in 1982, to provide technical cooperation to the Kuwait Action Plan (ROPME, Kuwait).
- The Arab Center for Studies of Arid Zones and Drylands (ACSAD, Syria).
- The Center for Environment and Development for the Arab Region and Europe (CEDARE, Egypt).
- The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA),

### 2.9 International Organizations

Among United Nations bodies and Programmes, we may mention the following institutions:

- UNEP-ROWA: the United Nations Environment Programme Regional Office for West Asia, Bahrain.
- ESCWA: UN Economic and Social Commission for West Asia
- WHO's Regional Center for Environmental Health Activities.
- WMO Office for West Asia based in the Kingdom of Bahrain, inaugurated in 2007.
- UNDP: United Nations Development Programme, the World Bank, and UNESCO.

### 3. Space Techniques Applications (STA)

#### 3.1 International Development Projects

AGEDI: Abu Dhabi Global Environment Data Initiative (AGEDI) conducted by UAE Environment Agency – Abu Dhabi in partnership with UNEP (Kenya). The Seed money of \$US 5 million is provided by UAE plus other supplementary funds. AGEDI will improve the provision of high quality and comprehensive data for decision making at the local, regional and global levels. GRID: Global Resource Information Database is a joint project of UNEP, Global Resource Information Database (UNEP-GRID), and the Consultative Group for International Agriculture Research (CGIAR). GEO: Global Environment Outlook, initiative by UNEP. The UNEP meta-data Directory serves as a library/catalogue of environmental information. GEOCOVER Data: United Nations for Outer Space Affairs (UN-OOSA) provides Landsat satellite data sets for supporting sustainable development in West Asia. The OOSA, within the framework of United Nations Program on Space applications, has provided West Asia institutions free of charge with satellite data donated by the United States of America. UNEP/ROWA has been selected for the distribution of the data sets.

#### 3.2 Regional Development Projects (West Asia)

Regional Water Resources and Drylands programme (REWARD): five demonstration projects were identified in river basins and watershed of Jordan, Egypt, Palestine and Yemen starting in 2007. The Atlas of Environmental Changes for West Asia, aims to provide scientific evidence of rapid environmental changes around West Asia in preparation by UNEP/ROWA. Inventory study and Regional Database on Sustainable Water Management in West Asia,

by ICARDA. Management of Scarce Water Resources and Mitigation of Drought in Dry Areas (MegaProject 1). Arabian Peninsula Regional Program (APRP) of ICARDA is designed, in order to develop more productive and sustainable rangelands and irrigated production systems, including protected agriculture, through the more efficient use of natural resources of the Arabian peninsula, in particular water, energy, and indigenous plant species. Three major action plans aimed at preserving the coastal and marine environment and promoting the sustainable development of the coastal zones (GEO-4, 2007):

- The Mediterranean Action Plan;
- The Kuwait Action Plan;
- The Red Sea and Gulf of Aden Action Plan.

#### 3.3 National Development Projects

GIS and RS applications during the last 15 years (Figure 2):

- Urbanization encroachment on agricultural lands in Al-Ahsa Oasis; (Al-Rowali et al., 2004)
- Groundwater exploration and management in Saudi Arabia and Iraq; (Al-Aslami et al., 2004)
- Oil Spill on coastal zones of Saudi Arabia and Lebanon; (Al-Otaibi et al., 2006)
- Urban planning in the Isa City in Bahrain, and urbanization in Doha City; (Haider et al., 2008)
- Impact of sand movement on the Industrial City of Mussaid in Qatar;
- Fish kill investigation and beach management in Kuwait Bay.
- Environmental impact assessment of the Gulf War in Kuwait.
- Hydrological application in Al-Died, UAE.
- Topographic Map updating, in Jordan.
- Implementation of Urban GIS in major Municipalities in Saudi Arabia & UAE;
- Land-Based GIS Development and Marine Environmental GIS (MAREGIS), along with National Cartographic Database;
- GIS is been used by ARAMCO and Telecom for facilities management;
- Kuwait Environmental Information System (KEIS) by KISR;
- Petroleum Industry has Developed a GIS to support the decision making process in Oman;
- CGIS is leader in utilizing GIS technology on a country-wide: data integration of 16 government agencies.

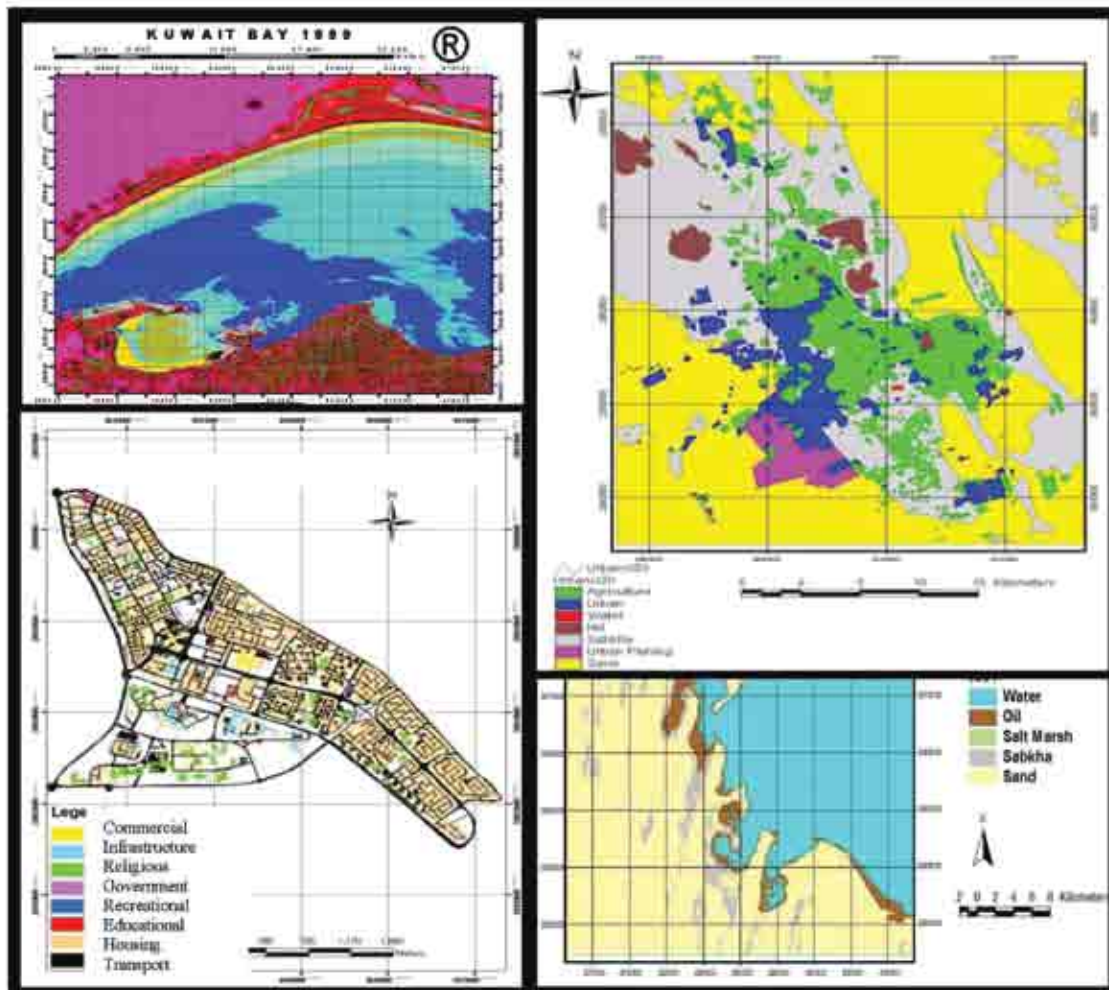


Figure 2: Selected national development projects using GIS and RS technique

#### 4. Qualified Human Resources (QHR)

##### 4.1 Education and Training

For education, we can mention the following Academic Programs:

- Arabian Gulf University, College of Graduate Studies, offers a post-graduate diploma and master degrees in GIS and RS.
- UAE University is also offering a Master of Science in RS and GIS.
- In Jordan, Al-Balqa Applied University, Department of Surveying and Geomatics is offering a degree.
- Dubai Aerospace enterprise (DAE) offers undergraduate and graduate level programs in the field of aerospace engineering, aviation management, and aviation maintenance management.
- In Saudi Arabia, the aerospace engineering university in Jeddah, and the King Abdulaziz University (KAU) in Riyadh, offering

Bachelor and Master in Aeronautical engineering.

- In Iraq, Space & Astronomy Research Center offers M.Sc. degree in the fields of basic science and remote sensing, and the universities of Al-Nahrain and Al-Mustansiria are offering M.Sc. and PhD in satellite technology & RS.

For continuing education, we can mention the following Training Courses and Workshops:

- Bahrain Center for Studies & Research (BCSR) is offering a professional course in RS.
- KISR is also providing a series of courses related to GIS and RS Applications.
- The Centre for GIS, in Qatar has implemented a training program with ESRI, USA.

- University of Qatar offers also a professional course focusing on the application of RS.
- KACST supports academic institutions.
- Dubai municipality has conducted some training on GIS applications.
- Royal Jordanian Center for GIS, in Jordan
- General Organization for Remote Sensing (GORS), in Syria
- KFUPM, in Saudi Arabia, training courses in GIS.
- Setting up a "Knowledge Village" in Dubai, UAE, to fulfill learning and training requirements.

#### 4.2 Regional Center for Space Sciences & Technology Education

Five United Nations Regional Center for Space Sciences and Technology Education were established in many parts of the world: in India for Asia and the Pacific, in Morocco for French speaking countries, in Nigeria for English speaking countries, in Brazil for Latin America and the Caribbean, and recently in Jordan for West Asia region for Arabic speaking countries. The mission of the regional centers is to build high quality capacity and critical mass of indigenous educator for application of space science and technology for sustainable development. The curriculum includes a post-graduate Diploma in the fields of 1) Remote Sensing and GIS, 2) Satellite Communications and GPS, 3) Satellite Meteorology & global climate, and 4) Space & Atmospheric Sciences (Jegede, 2005 and Harmsen, 2007).

#### 4.3 COPUOS Member States

The UN-COPUOS is composed currently of 69 member states, 4 of which are from the West Asia Region. The West Asian member states of COPUOS include: Iraq, Lebanon, Saudi Arabia and Syrian Arab Republic.

#### 5. Conclusions

Forecast International is projecting deliveries of approximately 139 imaging satellites worth US\$ 16.3 billion over the next 10 years. The GIS market was estimated at US\$ 7 billion annually, including software and hardware and services. The confluence of 3 technologies: GIS, RS and GPS led many to predict that a powerful new industry was born. Some predicted it would surpass US\$ 30 billion in sales by 2005. SDI is developing more and more in West Asia, especially in UAE, Bahrain and Qatar and at less extent in the other countries. Five Ground Receiving Stations for satellite data were build-up in the region by the following institutions:

KACST (KSA), DSI and GST (UAE), ROPME (Kuwait), SARC (Iraq). Conference and symposia are held more regularly in the regions (BSE, Map Middle East, ESRI, KU, GORS, and KACST). There is absence of unified geodetic reference system to support all the planned development in West Asia in terms of mapping, urbanization and GIS. Three countries have initiated their own national space programs, which are: KSA, UAE, and Iraq. There are also two regional space programs, which are: Arab satellite for Earth Observation (ASEO), and Disaster Monitoring Constellation (DMC). Many national centers or organizations of remote sensing exist at the national level. These centers differ from one country to another. Some of them are well equipped by human resources and equipments, others are not or slightly equipped. There is also a National Mapping Organization (NMO), or military survey in each country. At the regional level of West Asia, there are a number of regional organizations covering the whole region. We may mention the following organizations: ICARDA, ROPME, ACSAD, CEDARE, and PERSGA. Among United Nations bodies and Programmes in West Asia region, we may mention the following institutions: UNEP-ROWA, UN-ESCWA, WHO-RCEHA, WMO-OWA, UNDP, UNESCO, and WB. Development projects are conducted in collaboration with other organizations at international (AGEDI, GRID, GEO, GEOCOVER), Regional (REWARD, Environmental Atlas, expert System, APRP, Action Plans) and National (MAREGIS, KEIS, National GIS, Urban GIS, utilities, Telecom, oil spill, etc...) levels. Higher education programs in GIS/RS offered by the Arabian Gulf University (Diploma, Master), and the United Arab Emirates University (Master), Al-Balqa applied University, Dubai Aerospace enterprise, King Abdul-Aziz University (Bachelor, Master), Space and Astronomy Research Centre (Master), Universities of Al-Nahrain, and Al-Mustansiria (Master, Ph.D.). Training programs are also offered by the following institutions in the region: BCSR, KISR, CGIS, KACST, RJCGIS, GORS, and KFUPM. United Nations – affiliated regional Centers for Space Sciences and Technology Education have been established in India for Asia and the Pacific countries, in Morocco for French countries, in Nigeria for English countries, in Brazil for Latin America and the Caribbean, and recently in Jordan for West Asia region for Arabic speaking countries. Among 69 member states of COPUOS, 4 are from West Asia region: Iraq, Lebanon, Kingdom of Saudi Arabia, and Syrian Arab Republic.

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