

Satellites aid African aquifer management

As developing countries struggle to maximize use of water resources, Stefan Saradeth, Ruth Möller, Tobias Wever and Mohamed Safar-Zitoun of GAF AG in Germany, report on an ambitious Euro-African partnership project that uses Earth observation data from space to plan for groundwater sustainability in six North African countries.

AQUIFER is a project within European Space Agency's (ESA) Data User Element (DUE) which aims to manage internationally shared water resources better by establishing a long-term relationship between user communities and Earth observation (EO).

The Systeme Aquifère du Sahara Septentrional (SASS) and Lullemeden aquifers are two of the largest transboundary aquifers in northern Africa. The AQUIFER project focuses on the development and demonstration of EO-based products and services for supporting national authorities and international institutions in Niger, Nigeria, Mali, Tunisia, Libya and Algeria in managing the aquifers.

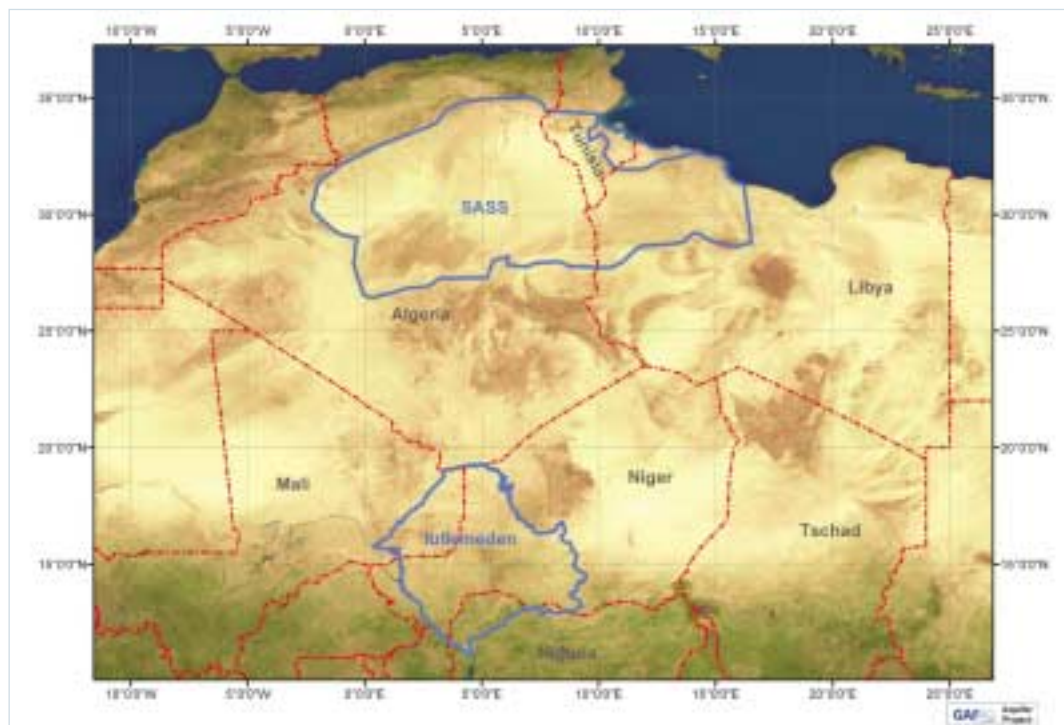
Threats to the aquifers and the related ecosystems are:

- Drastic land-use change in recharge areas and humid zones
- Climatic change
- Over-extraction in parts
- Human-induced water pollution and salinisation.

The SASS is a groundwater resource and freshwater reservoir lying under parts of Algeria, Libya and Tunisia. It occurs at varying depths (up to 1000m) and has negligible recharge.

Though the SASS resource is sufficient for many centuries to come (500-600 years at projected consumption rates), the intense development by the three countries in the past 30 years has exposed the aquifer to several serious risks:

- Groundwater drawdown;
- Loss of artesian pressure involving costs of excessive pumpings
- The salinisation of the aquifers by inversion of the flows between the aquifers and the chotts in Algeria and Tunisia
- The salinisation of the aquifers by inversion of the flows between the aquifers and the sea in Libya



Map showing the SASS and Lullemeden aquifers on a satellite backdrop

- The deterioration of water quality and land salinisation
- The drying-up of natural discharge systems.
- Support the relevant national authorities (six national ministries in charge of water resources) and international institutions with EO-based technology to enable better management of internationally shared water resources and aquifers
- Provide tailored and GIS-compatible products and services that facilitate daily operations
- Strengthen general and integrated water management practices
- Build up an independent service provision capacity that can ensure local service delivery after the project is completed, thus achieving the longer-term goal of service sustainability.

The Lullemeden multi-aquifer system is a sedimentary groundwater basin in Mali, Niger and Nigeria with minor, non-connected sections in Algeria and Benin. It represents one of the major freshwater reservoirs of West Africa and is linked to many humid areas and ecosystems, covering an area of 525,000 km².

In both aquifers, principal areas of interest, each of around 100,000 km², are defined by the users.

AQUIFER is at the same time one of the demonstration projects for the ESA's initiative Earth Observation for Integrated Water Resources Management in Africa (TIGER). The broad aim of TIGER is to put space technology to work supporting African countries in managing and conserving their precious water resources.

The main objectives of AQUIFER are to:

This complex undertaking will be implemented over 28 months with three phases each consisting of six core tasks. The flexible project approach allows for proceed/stop decisions at critical junctures during implementation, based on progress made and milestones achieved. Some of the key tasks will include requirement analysis, product/service design, prototyping and validation, production, operational use, training and overall management.

Responsibility for the development and delivery of this broad range of products and services will be sub-divided across the AQUIFER consortium that includes local service providers as well as the European partners.

Observation from space

It may seem contradictory that EO is confined to the surface of the Earth whilst groundwater, by definition, is usually hiding below the surface. In the optical domain, reflectance values of surface

features are measured because radar and thermal sensors are limited in their depth penetration to the cm/dm level. However, EO can provide important data and information on an indirect basis, for example:

- Mapping the drainage system and catchment areas
- Mapping land cover, water protection, irrigation management and water abstraction
- Generating maps for current land use, land cover and irrigated zones as a basis for water protection and abstraction/consumption data
- Locating water abstraction features such as wells, springs and waterholes
- Mapping water distribution infrastructure such as irrigation and water supply
- Estimating the potential maximum base flow in catchment areas
- Secondary effects such as subsidence due to groundwater abstraction

- Identifying fractured aquifer systems as potential drilling sites
- Identifying recharge areas

In addition, EO has proven to be cost-efficient in mapping and monitoring on an area-wide basis, and it can provide a uniform spatial data layer to complete sparse, isolated and discrete observations and to correlate and extrapolate isolated field data.

It must be noted that EO is not a stand-alone tool for groundwater monitoring, it relies essentially on ground truth for in-site calibration and on data integration and assimilation by GIS technology and modelling approaches.

Products and services

In the first phase of the project the user demands and requirements were consolidated and analysed. A set of specific products and services based on EO technology were defined and are now being considered for development in the next phases of the project.

Some products are based on

mature and proven technology and can be considered as operational, whereas others are more science-oriented and will demonstrate and explore the further capabilities of EO to support aquifer management.

Outlook

The project runs till the end of 2006 and in the next phase, prototype products will be generated and delivered for assessment by the users. Only after the verification of the specifications and validation of the overall utility and integrating the user comments will the products and services will be developed for the whole defined areas of interest.

An ancient Chinese proverb cautions that 'when you drink water, be careful not to neglect the spring', wise words that highlight the importance of water management and conservation initiatives worldwide.

AQUIFER sets out to the search for lasting solutions to a complex challenge where the stakes, social, economic and geopolitical, are unquestionably very high.

ESA awarded geo-information technology specialists GAF AG of Germany the contract to set up AQUIFER in October 2004. Their consortium of European partners and local service providers consists of:

- AGRHYMET - Niger;
- National Center for Remote Sensing (CNT) - Tunisia;
- National Center for Space Techniques (CNTS) - Algeria;
- Joanneum Research - Austria;
- Libyan Center for Remote Sensing and Space Science (LCRSSS);
- SCOT - France;
- Telespazio - Italy
- Jena and Vista universities - Germany

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