http://www.scar.ac.cn
**Sciences in Cold and Arid Regions**
2013, 5(1): 0001–0005
DOI: 10.3724/SP.J.1226.2013.00001

# G-WADI—the first decade

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Received: October 30, 2012 Accepted: January 20, 2013

**ABSTRACT**

The G-WADI network by UNESCO promotes the global capacity for management of water resources in arid and semi-arid areas. The primary aim has been to build a comprehensive global network to promote regional and international cooperation so as to increase knowledge and improve management practices through the sharing of information. The G-WADI objectives and achievements of the past 10 years are reviewed. A number of key initiatives have been implemented—the formation of five regional networks, the creation of a central G-WADI web site, promotion of near-real-time rainfall distribution software enhanced by the inclusion of satellite based precipitation estimations, as well as workshop and web-based activities on chemical and isotopic tracers and on rain water harvesting. Two workshops on surface and on groundwater modeling, supported by publications have been held in India and China. The Asian G-WADI network remains very active, but activities in the other three regions are developing (Africa, Arab Region, Latin America and the Caribbean).

**Keywords:** UNESCO; semi-arid regions; water resources; groundwater modeling; global networks; water harvesting


## 1 Introduction

It has been ten years since UNESCO's Global Network on Water and Development Information for Arid Lands (G-WADI) was first proposed. Over this period of time, G-WADI has made valuable contributions to improving the global capacity for management of water resources in arid and semi-arid regions, and has since become a central activ-

ity of the UNESCO's International Hydrological Programme (IHP).

Across the world, arid and semi-arid areas are facing the greatest pressure to deliver and manage freshwater resources. At the time of G-WADI's inception, it was estimated that some 80 countries, constituting 40% of the world's population, were suffering from serious water shortages. These shortages have been exacerbated by population growth, expansion of agricultural activities, salinity increases and agricultural/urban pollution, and it is expected that these pressures will continue to increase in the future. By 2025, it has been estimated that two-thirds of the world's population will be living in water stressed countries.

Moreover, many arid regions are the focus of potential conflicts over scarce water resources. As such, there is a vital need to develop strategies to better manage these resources so as to support peace and regional stability. Improving scientific understanding, promoting regional and international co-operation, and facilitating the sharing of information are valuable ways of encouraging better management of water resources and supporting conflict resolution to avoid such crises.

Accurately assessing and managing available and renewable water resources of a region is significantly more challenging in arid and semi-arid areas compared to areas with abundant water resources. In arid and semi-arid areas, rainfall is less predictable and of a highly variable intensity and extent, flood events are difficult to quantify and estimations of aquifer recharge are particularly complex. Furthermore, in these areas few surface water diversions are accurately gauged, and many wells are not metered. Additionally, it is becoming clear that the amount of water being abstracted from deep aquifers is above the natural recharge rate, causing depletion of this valuable resource.

Acknowledging these challenges, it has become apparent that there is a serious need to improve the exchange of scientific knowledge of water resource management in arid and semi-arid areas. The creation of the G-WADI network by UNESCO was intended to address this need by strengthening the global capacity for management of water resources in these areas. The primary aim of this programme has been to build a comprehensive global network to promote regional and international cooperation so as to increase knowledge and improve management practices through the sharing of information.

## 2 Organization and objectives of G-WADI

To achieve the objectives of G-WADI, the network was established with an open membership, involving UNESCO related regional Centers and IHP National Committees and Programmes. Links were also made with other UN Organizations and recognized National, Regional and International Centers of Excellence, reputed Programmes and Associations as well as relevant NGOs.

The five main objectives of G-WADI have been:

### *Objective 1: Knowledge of hydrological systems*

As significant gaps exist in data and information on water management in arid and semi-arid areas, the G-WADI network will provide a means to share new and existing knowledge. This will include:

(1) Promoting a series of G-WADI basin studies to compare semi-arid zone hydrology and hydrogeology at different scales. These will be used as a basis for further integrated studies.

(2) Developing linkages with existing international water-related programmes.

(3) Supporting targeted studies related to spatial and temporal variability of rainfall, flash floods, drought, water harvesting, groundwater recharge, ecohydrology, salinization and geochemical processes and chemical and isotopic tracers.

(4) Facilitating the development and testing of new and existing models using common data sets.

### *Objective 2: Capacity building*

The G-WADI network will act as a focal point for information exchange and training initiatives in three specific areas:

(1) Exchanging information between UNESCO and other expert centres, including the sharing of teaching material, as well as translations to other languages.

(2) Integrating capacity building activities of individuals and institutions and supporting the creation of relevant partnerships.

(3) Organising G-WADI workshops in priority areas.

### *Objective 3: Dissemination to end-users*

G-WADI will act as a demand-driven filter of scientific and management information, aiming to improve the understanding of water resources in arid regions for non-specialists in four key areas:

(1) Providing a range of relevant web-based information, including CDs and newsletters.

(2) Creating linkages with existing centres such as SAHRA (University of Arizona), CHRS (University of California-Irvine), IHP National Committees, relevant UNESCO centres, the UNESCO Water Portal and other similar international initiatives.

(3) Preparing news items and public awareness campaigns on water issues, such as extreme or unusual hydrological events.

(4) Promoting popular publications linked to the activities of G-WADI and the website.

### *Objective 4: Exchange of experience*

In order to improve the management of water resources in arid and semi-arid areas, the network will provide a means

to share information and experience between regions by:

(1) Facilitating the exchange of information on both the application of advanced technologies and the adaptation of traditional knowledge for water management. This includes information on rain-water harvesting, groundwater management, coping with extreme events and water scarcity.

(2) Developing and exchanging case studies of successes and failures in arid zone water preservation.

(3) Identifying and analysing emerging global trends in water management issues, including issues of rapid, often unplanned, growth in urban areas, and associated questions of water demand management.

(4) Providing access to web-based near-real-time data and dataset projects (such as PERSIANN), with an emphasis on areas where gauges and other ground-based instruments are sparse.

(5) Promoting web-based discussions to identify the potential and limitations of modelling systems and advanced technologies such as remote sensing, GIS and isotope analysis.

***Objective 5: Integrated river basin management***

Based upon improved understanding of hydrological systems, G-WADI will promote initiatives for holistic water management—for human consumption, food production, socio-economic development, and ecosystem services through two specific activities:

(1) Supporting the development of IWRM and linkages with other international programmes and IHP projects (*e.g.*, FRIEND, GRAPHIC, HELP and ISARM) as well as promoting pilot projects for integrated studies (*e.g.*, G-WADI basins).

(2) Promoting dialogue between the scientific and user communities with policy makers in studies related to arid zones and the management of water resources.

## 3 The main output of G-WADI activities over the past decade

The activities and achievements made by G-WADI to date can be attributed to program support received from UNESCO and other agencies, as well as the energy, commitment and enthusiasm of individuals involved with the network. UNESCO provided seed money for the establishment of the programme and for the organization of meetings, particularly in the first five years of the programme. Additional funds were also provided by grants from DfID UK particularly during the initial years; the programme linkages were further developed with the Flanders Trust funded projects, while various activities have been supported by UNESCO Regional Centres.

However, one of the most important reasons for the success of G-WADI has been support provided by a number of universities which have acted as hosts for activities (*e.g.*, the website) or regional development activities. The main achievements made by G-WADI to date include:

### *3.1 G-WADI websites*

Three websites associated with the G-WADI network have been developed. These are:

(1) **http://www.gwadi.org/**: The G-WADI website was initially developed by SAHRA at the University of Arizona, and is now co-sponsored by ICIWaRM and the G-WADI Technical Secretariat. The primary purpose of this website is to serve as the main conduit of information for all G-WADI regional centres, activities and information.

(2) **http://hydris.eng.uci.edu/gwadi/**: Developed by CHRS at the University of California-Irvine. This website was developed to provide real-time high resolution satellite precipitation data for the G-WADI user community.

(3) **http://asian-gwadi.westgis.ac.cn/**: This web site is devoted to the very active Asian G-WADI network.

### *3.2 G-WADI GeoServer: Real-time rainfall distribution and analysis*

Limitations of available and reliable data sources are a serious constraint for the development of effective science-based management strategies for water resources in arid and semi-arid areas. To address this issue, G-WADI has been able to promote access to web-based remotely sensed global data products and datasets. This has included near-real-time rainfall distribution software from the UCI GeoServer, which has been enhanced by the inclusion of satellite based precipitation estimations from cloud classifications allowing a near-real-time (+/− 1 hour) imaging at a 4 $km^2$ resolution. This was made possible by value adding on relevant NASA funded research initiatives.

Over the past decade, the G-WADI GeoServer has gone through several key upgrades. These upgrades have resulted in the launching of two operational GoogleEarth based applications for high resolution (4 $km^2$) real-time global precipitation mapping and for severe precipitation mapping at multiple time intervals, ranging from 3 to 72 hours. Previous upgrades have also included providing an enhanced user interface, as well as a server optimization to increase the server speed, particularly for low band-width connections.

The G-WADI GeoServer has been used to analyze severe precipitation events during the recent catastrophic floods in Pakistan (http://chrs.web.uci.edu/PakFlooding.html), as well as recent flood events in Namibia. To facilitate the use of the GeoServer by users, two instructional training videos were developed and made available on YouTube (http://www.youtube.com/user/hydrometeorology1).

### *3.3 Chemical and isotopic tracers*

Chemical and isotopic tracers can be used as "fingerprints" to better understand the origins of water and its movement, including groundwater residence times, groundwater

recharge, as well as the interaction of salinity and pollution. Promoting the use of chemical and isotopic tracers for this purpose is considered to be central to G-WADI activities in semi-arid regions. Primarily, this technology is being used to assess the renewal rate of water resources in these areas, as well as identifying where unsustainable and irreversible groundwater mining is occurring.

The G-WADI network is facilitating the use of both conventional chemical tools and state-of-the-art isotopic tracers in arid and semi-arid regions to further promote their application in water management. G-WADI seeks to define the tracers and isotope material needed by a wide range of users and is working to make isotopic tests understandable and available to users.

Case studies and further information has been made available to users on the G-WADI website. The website also includes information on the use of various isotopes and tracers as well as explanations on analytical methodologies for their application. A major feature of the website has been the inclusion of an interactive periodic table of the elements and their isotopes of principle use as tracers. This feature has proved to be a valuable reference material for users.

### *3.4 Workshops*

G-WADI has brought together international experts, scientists, policymakers, researchers and stakeholders through a series of workshops to discuss key research topics related to climate change impacts, risk assessment and management of water resources of arid and semi-arid regions. Through these workshops, detailed on the web site, leading experts have provided water harvesting and modelling training to professionals from arid regions in China, India, Iran and Syria. A further book on water harvesting was published as part of the Water for Life International Decade for Action 2005–2015 (Singh, 2008).

As a result of a workshop organized by G-WADI in 2005 on hydrological modelling, training materials were developed and disseminated to users via the G-WADI website, relevant software was made available, software tutorials were established and a book on hydrological modelling in arid and semi-arid areas was published (Wheater *et al.*, 2008). A subsequent workshop was also organized in Lanzhou, China in June 2007 to review state-of-the-art techniques for modelling groundwater, which is often the dominant water resource in arid areas. The management of salinity, coastal saline intrusion, and tools to support recharge estimation were also addressed at this workshop. These training materials were subsequently published in Wheater *et al.* (2010).

### *3.5 Regional networks*

After 10 years since the inception of G-WADI, there are now four G-WADI regional networks. These regional networks are the:

(1) Asian G-WADI: secretariat hosted by the Cold and Arid Regions Environmental and Engineering Research Institute of the Chinese Academy of Sciences in Lanzhou, China.

(2) Latin American and Caribbean G-WADI: secretariat hosted by the Water Centre for Arid and Semi-Arid Zones in Latin American and the Caribbean (CAZALAC) in La Serena, Chile.

(3) African G-WADI: secretariat hosted by the Regional Centre for Training and Application in Agrometeorology and Operational Hydrology (AGRHYMET) in Niamey, Niger.

(4) Arab G-WADI: secretariat proposed to be established in Muscat, Oman.

#### *3.5.1 Asian G-WADI Network*

The Asian G-WADI Network was established in March 2005 by representatives from Afghanistan, China, India, Iran, Kyrgyzstan, Mongolia, Pakistan, Tajikistan and Uzbekistan to confront the urgent need for increased regional cooperation for sustainable development of arid and semi-arid zones. The Asian G-WADI has developed an active website which provides an introduction to the network, access to training materials and other relevant publications, including on aquifer recharge and water harvesting in the Asian region (Neupane *et al*., 2006) and on regional water resources (Salih *et al*., 2007) (also see http://asian-gwadi.westgis.ac.cn).

The network has organized training workshops in which global experts provide training to participants on climate change, the application of new models and techniques in groundwater management, the management of artificial recharge and rainwater harvesting. Regional network meetings have been held in Tehran, Iran (2010) Beijing, China (2010), Lanzhou, China (2007), and Roorkee, India (2005).

#### *3.5.2 Latin American and Caribbean G-WADI*

CAZALAC in La Serena, Chile, has served as the secretariat for the network since December 2010. Most recently, the network has been focusing on developing activities, creating a Latin American and Caribbean G-WADI website and expanding the membership of the network. CAZALAC and ICIWaRM are collaborating on regional frequency analysis software and applications to assist water managers during periods of droughts. A project on "Managing Water Resources in Arid and Semi-arid Regions of Latin America and the Caribbean (MWAR-LAC)", within the framework of G-WADI, is being implemented with funding support from the Flanders Trust Fund. An Atlas has been published on the semi-arid regions of the Latin American countries and the Caribbean (UNESCO, 2010)

#### *3.5.3 Sub-Saharan African G-WADI*

The G-WADI Network for Sub-Saharan Africa was

formally established in December 2010 in Paris, France, following the recommendation of the participants of an April workshop held in Dakar, Senegal on issues related to arid and semi-arid areas in the region. The Sub-Saharan African G-WADI network secretariat is now based in AGRHYMET, Niamey, Niger and will facilitate knowledge exchange and best practices among the different sub regions, which will, in turn, contribute to the capacity building of institutions and individuals for better management of arid and semi-arid regions in Sub-Saharan Africa. A follow-up capacity building workshop on drought monitoring was held in January 2012 in Niamey. This meeting was organized by AGRHYMET in collaboration with UNESCO (IHP), Princeton University (United States), ICPAC (Kenya), numerous basin organizations (NBA, OMVG, OMVS, LCBC), hydrologists in some countries of the CILSS (Senegal, Niger, Burkina Faso and Mali), and the International Center for Integrated Water Resources Management (ICIWaRM; USA). The workshop objectives were to transfer the tool, developed by Princeton University, to AGRHYMET, to strengthen the capacities of participants in the use of the tool while examining ways and means of validation at the regional level, and to organize a meeting to launch the activities of the G-WADI network in sub-Saharan Africa.

#### *3.5.4 Arab G-WADI*

Better management of scarce water resources of the Arab region is a key element in attaining sustainable development in the region. Capacity building and networking are two important vehicles for sharing information and building an effective scientific and technical water management community in the Arab region. The Arab G-WADI network was officially established in Muscat, Oman in June 2011 at a meeting of representatives from Arab countries. The participants identified a series of priority areas with a focus on the theme of coping with water scarcity. The Arab League Educational, Cultural and Scientific Organization (ALECSO) and the Islamic Educational, Scientific and Cultural Organization (ISESCO) are supporting further developments of the network.

### *3.6 Representative basins*

At the onset of the G-WADI programme, a series of pilot basins were envisaged that would be used to improve the understanding of the special characteristics of hydrological systems in arid and semi-arid regions, allowing best practice management strategies to be shared internationally. Activities within each basin would relate to the overall G-WADI objectives. In addition, user participation (*e.g.*, by local NGOs) would be encouraged and ideally the end-user communities would become involved in the activities and provide feedback on application of the science. It was intended that these pilot basins would be widely publicised and used to attract and become a focus for future research.

The Asian G-WADI network has been particularly active in this space, and has established a series of representative basins from both hot and cold regions of Asia. In selecting these pilot basins, a standard, peer-reviewed process agreed by the Asian G-WADI Steering Committee was adopted. These pilot basins have provided a mechanism for the sharing of information, knowledge and experience internationally. The pilot basins that have been established so far include the:

(1) Heihe River Basin (China);

(2) Jaisamand Lake Catchment in the Gomti River Basin (India);

(3) Krishna-Godavair River Basin (India);

(4) Kashafrud River Basin (Iran);

(5) Taleghan-Hashtgerd River Basin (Iran);

(6) Chu River Basin (Kyrgyzstan);

(7) Vakash River Basin (Tajikistan).

### *3.7 Future strategy*

In the first ten years of its operation, the G-WADI programme has played a vital role in improving the global capacity to manage scarce water resources in arid and semi-arid regions around the world. G-WADI has been able to effectively draw together relevant stakeholders in this field to share knowledge, expertise and experience to more sustainably manage the water resources of these vulnerable regions. The G-WADI website and GeoServer now represent an invaluable reference resource of data and information on water management in arid and semi-arid areas, and the G-WADI network has firmly established itself at the forefront of global efforts to better manage our precious water resources.

Looking into the future, G-WADI will continue to grow as each of the regional G-WADI networks becomes better established in their respective regions. G-WADI will continue to develop the website and improve access to global data products, specifically tailoring these to the needs of arid and semi-arid areas. As new G-WADI pilot basins are established, these will be used to stimulate and integrate regional activities, attract new scientific research studies and integrate science outcomes with the needs of society.

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