Sustainable Management of Surface and Groundwater in the Arab Region

By

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Eleventh Gulf Water Conference
“Water in the GCC Countries Towards Efficient Management”
20-22 October 2014, Muscat, Oman
Global Water Resources
Global distribution of fresh water

Total Volume: 35.2 million km\(^3\)

- Oceans 97.50%
- Ground Water
  - Freshwater 2.50%
  - Lakes 67.40%
- Surface & Atmos. 0.40%
- Permafrost 0.80%
- Soil Moisture 12.20%
- Atmosphere 9.50%
- Wetlands 8.50%
- Biosphere 1%
- Rivers 1.60%

Water and Population

Water is not everywhere

Approximate percentage of global water supply:
- 8% 13%
- 26% 6%
- 15% 8%
- 36% 60%
- 11% 13%
- 5% 1%

Approximate percentage of global population:
- 8%
- 13%
- 11% 13%
- 5% 1%
The Deepening Water Crisis in the Arab Region

A baseline of water scarcity
Precipitation

Mean Annual Precipitation (1961 - 1990)

Scale 1:120,000,000

Precipitation in mm/a

Source: Gridded Precipitation Normals Data Set, Global Precipitation Climatology Centre (GPCC), Offenbach 2007
State of Water in the Arab Region

Freshwater availability is falling to crisis levels:

- 1960: 3500 cubic meters per capita per year
- 1999: 2000 cubic meters per capita per year
- 2025: 500 cubic meters per capita per year

Graph showing the decrease in freshwater availability from 1960 to 2025.
Rainfall Distribution in the Arab Region

Legend

<table>
<thead>
<tr>
<th>Category</th>
<th>Area (%)</th>
<th>Qty (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 100</td>
<td>52.0</td>
<td>14.1</td>
</tr>
<tr>
<td>100 - 200</td>
<td>22.0</td>
<td>17.8</td>
</tr>
<tr>
<td>200 - 300</td>
<td>8.0</td>
<td>10.8</td>
</tr>
<tr>
<td>300 - 500</td>
<td>7.0</td>
<td>15.0</td>
</tr>
<tr>
<td>500 - 800</td>
<td>5.5</td>
<td>15.3</td>
</tr>
<tr>
<td>More than 800</td>
<td>5.5</td>
<td>27.0</td>
</tr>
</tbody>
</table>

Transverse Mercator Projection
Longitude 15° 00'

For areas and quantities calculation, Albers equal area Projection was used
Standard Parallels 7° 40' N and 38° 20' N
Aridity

- Hyper-Arid
- Arid
- Semi-Arid
- Dry-Sub humid
- Moist-Sub humid
- Humid
Most of the Arab countries suffer water scarcity.

Freshwater availability, cubic metres per person and per year, 2007.

Source: FAO, Nations unies, World Resources Institute (WRI).

Data non available
Fresh Water Withdrawal In the Arab Region

Water Withdrawal $10^9$ m$^3$

- **Agricultural**
- **Industrial**
- **Municipal**

Countries: Algeria, Bahrain, Comoros, Djibouti, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Gaza & West Bank, Oman, Qatar, Saudi Arabia, Somalia, Sudan and South Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates, Yemen.
Water Withdrawals in the MENA Region by Source

Source: Siddiqi and Anadon, 2011
Excessive withdrawal of renewable water in the Arab region

The percentage of the total renewable water stock at the beginning of the year 2000

Excessive use of water

No data

The Arab region faces the highest pressure on its limited water resources.

Water withdrawal as a percentage of total available water:
- More than 40%: Orange
- From 20% to 10%: Light blue
- From 40% to 20%: Yellow
- Less than 10%: Dark blue

1995

2025
Water Demand: Consumption in the Arab region
WATER CONSUMPTION (%) BY SECTOR IN ARAB COUNTRIES, 1999-2006*

- Agricultural water withdrawal (% of total freshwater withdrawal)
- Domestic water withdrawal (% of total freshwater withdrawal)
- Industrial water withdrawal (% of total freshwater withdrawal)

*Latest values for all 22 Arab countries

Source: UNDP, 2009
Conservation is a necessity & a core sustainability principle
Elements of Conservation

Water Loss Reduction (WLR)
- Distribution LR
- Usage LR
- Value of Water

Unconventional Resources
- New Supplies
- Reuse-recycle
Arab Agriculture
Conservation is a Must
The water-food nexus
Relatively High Agricultural Water Withdrawal in The Arab Region
Inefficient use of water resource in the agricultural sector

Such a wasteful use of scarce water resources should not continue

More efforts should be directed towards water conservation practices.
Improve irrigation methods

To
Conservation in Municipal Water Use
Cities will grow fast in the MENA Region

FIGURE 3
MORE PEOPLE WILL LIVE IN URBAN AREAS

<table>
<thead>
<tr>
<th>System input Volume</th>
<th>Authorized Consumption</th>
<th>Billed Authorized Consumption</th>
<th>Billed metered consumption</th>
<th>Revenue water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water losses</td>
<td></td>
<td>Un-billed Authorized Consumption</td>
<td>Un-billed Metered Consumption</td>
<td>Non-Revenue Water</td>
</tr>
<tr>
<td>Apparent losses</td>
<td></td>
<td></td>
<td>Unauthorized Consumption</td>
<td></td>
</tr>
<tr>
<td>Real losses (Physical Losses)</td>
<td></td>
<td></td>
<td>Leakage in Transmission &amp; Distribution Mains</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Storage Leaks and Overflow from storage Tanks, Service ConnectionLeaks Up to meter</td>
<td></td>
</tr>
</tbody>
</table>
Water Challenges in the Arab Region
Challenges in the Arab Region

- Water Scarcity and High Stress.
- Growing Population and Accelerated Demand.
- Inefficiencies in Water allocation.
- Spatial and Temporal Variability.
- Pollution.
- Climate Change.
- Problems of Governance and Institutional Arrangement.
- Inadequate Capacity Development.
- Poor finance to Research on science, Technology and Innovation
- Transboundary Constraints
Consensus and recognition of key challenges

Arab Ministerial Water Council approved Arab Water Security Strategy
Arab IHP Nat Com: Regional Meeting and consultations
Arab Water Council: Arab Water Forums

Recommendations

Past Investments?

Lack of safe sanitation & reliable water supplies
Risk of contamination
Aquifer depletion
Over extraction
Urban/Irrigation water infrastructure deficiencies
Inefficient poor performance lack of maintenance

State of water sector

Severe water shortages projected

Reduced agricultural productivity
Increased Poverty
Public health issues
Environmental degradation
Undermined human development

Declining availability of water
Climate change/variability
Population growth

State of Water is Critical & Demanding immediate attentions

URGENTLY NEEDED

Changes in

Policies
Sustainable use
Sharing of water resources
Climate Change
An Added Pressure
Global average temperature 1850-2010
Based on Brohan et al. 2006

Anomaly (°C) wrt 1961-90

Annual average and 95% confidence range
Smoothed annual average and 95% confidence range

Met Office Hadley Centre
Source: www.metoffice.gov.uk/hadobs
Crown Copyright 2011
Climate Change and Drought

1. Increased GHG Concentration leads to heating of the atmosphere.

2. Higher temperature leads to higher rates of evaporation from and evapotranspiration, leading to faster depletion of soil moisture (Drought conditions).

3. Hotter atmosphere has a higher water holding capacity. More moisture remains in the atmosphere and the rate recycling through precipitation slows down. Increased evaporation rate leads to even higher amounts of atmospheric moisture, and water vapor, being a GHG can contribute to further heating.

4. More vapor is available for precipitation, but at lesser frequency of events. Rainfall variability increases and the probability of extreme events may increase despite of little or no change in total annual precipitation. Water vapor is a GHG and its increase may exasperate the problem.

On the earth's surface, more extreme events are likely. Snow seasons shorten and the intense precipitation causes flood. The lower frequency of rain days and increased evapotranspiration contribute to drought conditions.
Lack of Information and Data: Real Constraint
Lack of information and data at a time when we need it more than ever to deal with increasing complexity
Transboundary Challenges.....
Will Scarcity lead to Conflicts
The Transboundary issues

The Nile River basin

The Jordan River basin

The Tigris Euphrates basin
According to IGRAC, the identified number of Transboundary aquifers increased as follows:

- Year 2007: 273 TA
- Year 2009: 380 TA
- Year 2012: 455 TA
- Year 2014: 608 TA
The reality

One war over water: Umma/Lagash in Somer 4500 yrs ago

Bar (Water Event Intensity) Scale

-7 Formal war (0)
-6 Extensive military act (21)
-5 Small scale military act (17)
-4 Political/Military hostile acts (6)
-3 Diplomatic/economic hostile acts (68)
-2 Strong/official verbal hostility (227)
-1 Mild/unofficial verbal hostility (420)
0 Neutral, non-significant act (122)
1 Mild verbal support (682)
2 Official verbal support (276)
3 Cultural scientific agreement (246)
4 Non-military econ, techno, agreement (334)
5 Military, econ, techno agreement (7)
6 International water treaty (164)
7 Unification into one nation (0)

Number of Events (1948-2008)

Data: Oregon State University
“But the water problems of our world need not be only a cause of tension; they can also be a catalyst for cooperation.

....If we work together, a secure and sustainable water future can be ours.”

*Kofi Annan, February 2002*

There is an increase in the percentage of cooperative events in 4 basins:
    Jordan,
    Tigris-Euphrates/Shatt al Arab,
    Ganges-Brahmaputra-Meghna,
    Danube
BAR-scale for MENA Region switches mode from negative to positive
Globally
65.9% of the water-related events were cooperative
29.4% were conflictive events.
Inadequacy in Capacity Building
Remains low compared to developing countries
Scientific publications/Million of population (2002/2008)

- **Egypt**: 2,304 / 3,963
- **Tunisia**: 540 / 2,026
- **Saudi Arabia**: 1,321 / 1,745
- **Morocco**: 1,041 / 1,167
- **Algeria**: 410 / 1,289
- **Jordan**: 459 / 928
- **United Arab Emirates**: 270 / 660
- **Kuwait**: 469 / 607
- **Lebanon**: 256 / 591
- **Oman**: 185 / 315
- **Syria**: 106 / 198
- **Qatar**: 38 / 195
- **Iraq**: 55 / 184
- **Sudan**: 76 / 146
- **Libya**: 41 / 100
- **Bahrain**: 49 / 98
- **Yemen**: 35 / 56
- **Mauritania**: 16 / 13
- **Djibouti**: 0 / 2

Opportunities
Non-Conventional Source: Water Harvesting
## Potential for Water Harvesting in Arab Countries

(AOAD, 2002)

<table>
<thead>
<tr>
<th>Country</th>
<th>Volume in BCM</th>
<th>Utilization as % of rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rainfall</td>
<td>Utilization</td>
</tr>
<tr>
<td>Jordan</td>
<td>8.5</td>
<td>0.425</td>
</tr>
<tr>
<td>Tunisia</td>
<td>36</td>
<td>0.936</td>
</tr>
<tr>
<td>Sudan</td>
<td>400</td>
<td>4</td>
</tr>
<tr>
<td>Syria</td>
<td>85</td>
<td>2</td>
</tr>
<tr>
<td>Morocco</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>Yemen</td>
<td>68</td>
<td>6.12</td>
</tr>
<tr>
<td>N. Libya</td>
<td>30</td>
<td>0.9</td>
</tr>
<tr>
<td>Algeria</td>
<td>192</td>
<td>5.76</td>
</tr>
<tr>
<td>Mauritania</td>
<td>175</td>
<td>4.37</td>
</tr>
<tr>
<td>Egypt</td>
<td>15</td>
<td>0.225</td>
</tr>
</tbody>
</table>
Water Harvesting Tradition in the Arab Region

Earth dam

Rooftop

Hafir

Cistern

Flooding

Staircase

Yard Collector
Rainwater harvesting techniques and management practices used in Yemen
ICQHS
International Centre for qanats and historic structures

Restoration of Qanat and introduction of new technology
NonConventional Source: Desalinization
NonConventional Source: Virtual Water and the water-food nexus
Role of Virtual Water (% of total water use)

Regional virtual water balances and net interregional virtual water flows related to trade in agricultural products, 1997-2001

Net virtual water imports (billions of cubic metres per year)

-108 North America
-107 South America
-70 Oceania
-45 North Africa
-30 South-East Asia
-16 Central Africa
-5 Southern Africa
2 Central America
13 Former Soviet Union
18 Eastern Europe
47 Middle East
150 Central and Southern Asia
152 Western Europe

Regional virtual water balance (billions of cubic metres per year)

Source: Based on Hoekstra and Chapagain 2008.
Global Average Embedded Water Litres/Calorie for different food products

Data from Chapagain and Hoekstra 2004 and the author’s own calorie estimates
Water Intensity in Comparison to Various Diets

WATER SCARCITY and REGIONAL CONSTRAINTS

New Paradigm: Water Scarcity as an opportunity for sustainable development

Strict but rational management of water demand (Conservation)

Combine Approaches

Seek ways and means to preserve and augment the supply

Potential for utilizing

- Water Harvesting
- Desalination
- Swamps and wetlands
- Water Reuse

There remain deficiencies of managerial capabilities and high level of technology in order to successfully achieve the above approaches.
Meeting the demand
Without managing the supply
مياه جوفية طافحة على سطح الأرض
Sustainability means providing an adequate and reliable water supply of desired quality – now and for future generations – in a manner that integrates economic growth, environmental protection and social development.

*American Water Works Association*
Sustainability Challenge: Increasing Population

GCC Countries Population and Water Use 1950-2025

Source: Dawoud and Abderrahman, 2006
Per Capita energy consumption in the GCC countries is rising significantly.

**Source:** Economist Intelligence Unit, 2010
Sustainability Challenge: Increasing Water Demand

Projected water demand in selected GCC countries, millions of imperial gallons, 2000-20

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>170,476</td>
<td>188,604</td>
<td>216,205</td>
<td>225,479</td>
<td>240,206</td>
<td>246,065</td>
<td>266,656</td>
<td>290,081</td>
<td>315,564</td>
<td>343,286</td>
<td>373,444</td>
</tr>
<tr>
<td>Qatar</td>
<td>32,303</td>
<td>34,843</td>
<td>34,918</td>
<td>36,116</td>
<td>48,643</td>
<td>56,222</td>
<td>65,111</td>
<td>75,406</td>
<td>84,206</td>
<td>94,116</td>
<td>104,780</td>
</tr>
<tr>
<td>Dubai</td>
<td>41,354</td>
<td>49,081</td>
<td>58,357</td>
<td>72,588</td>
<td>91,653</td>
<td>98,178</td>
<td>108,964</td>
<td>123,355</td>
<td>133,361</td>
<td>143,970</td>
<td>155,109</td>
</tr>
</tbody>
</table>

Sources: Saline Water Conversion Corp (Saudi Arabia); Electricity and Water Authority (Bahrain); Qatar Statistics Authority; Dubai Water and Electricity Authority, EIU estimates and forecasts

**Source:** Economist Intelligence Unit, 2010
Main reasons for the escalating and exaggeration of urban water demands in GCC

Focus on the “Supply-Side” of water management

Absence of proper “Demand Management”

- Economic tools; non-existent of pricesignaling mechanism: metering & pricing, subsidies

- Technological tools: water-saving devices

- Legislative tools: building codes and bylaws

Inadequate public awareness of the Water scarcity and situation in the region

Source: Al-Zubari, 2011
Water at UNESCO
Evolution of IHP: From Hydrological Science to Integrated Science, Policy, and Society
IHP-VIII 2014-2021

- Water Related Disasters and Hydrological Changes
- Groundwater in a Changing Environment
- Addressing Water Scarcity and Quality
- Water and Human Settlements of the Future
- Ecohydrology Engineering Harmony for a Sustainable World
- Education, Key to Water Security

Water Security, Addressing Local, Regional and Global Challenges

- Integrated Water Ressource Management
- Transboundary or Shared Waters
- Human Dimension
- Governance
- Global Change
UNESCO Water Family

27 Approved centers, 22 signed agreements (Established)
5 New Centres in process
30 Water related UNESCO Chairs

After Bisher Imam:
Water Cooperation in the Nile Basin: From Concepts to Action
3 – 6 Dec. 2013, Dar es Salaam, Tanzania
UNESCO Water Family Meeting

Category-2 Centers in the Arab Region

- Regional Centre for Training and Water Studies of Arid and Semi-arid Zones, Egypt
- Regional Center on Capacity Development and Research in Water Harvesting, Sudan
- Regional Centre for Shared Aquifer Resources Management, Libya
- Water Research Centre, Kuwait Institute for Scientific Research, Kuwait
- Central Laboratory for Environmental Monitoring, Egypt
Regional Networking

Arab G-WADI

Arab Network on Wadi Hydrology
Arab Network on Groundwater Protection

Water Science for Peace and Sustainable Development in the Eastern Nile

Network of Universities
G-WADI GeoServer

Applications

Drought Management  Flood Forecasting  Water Resources

Algorithm

GOES

Web Services

Center for Hydrometeorology & Remote Sensing, University of California, Irvine
### Ongoing IHP Projects in the Arab Region

- An Expert Group Meeting was successfully organized in Sharm El Sheikh, Egypt during 17-18 September 2014.
- A proposed initial title of the initiative is "Sustainable Water Resources Management under Scarcity Conditions in the Arab Region".
- Fourteen regional water experts attended the meeting representing 8 Arab countries, namely: Egypt, Sudan, Oman, Bahrain, Tunisia, Morocco, Kuwait and Jordan in addition to representatives of regional organizations and institutions such as League of Arab States (LAS), Arab Water Council (AWC) and UNESCO Cairo Office (UCO).

#### Capacity Building for Water Strategies and Action Plans formulations
- Joint collaboration with Arab G-Wadi Secretariat-Oman, LAS, ISESCO, AWC, GIZ, ALECSO.
- A regional workshop is planned during 16-18 Nov. 2014

#### Gender Mainstreaming in IWRM at Rural Areas
- Preparation of a comprehensive technical study in Morocco in joint collaboration with UNESCO Chair on Water, Women and Decision Power of Morocco
- Support the organization of a special session within the 3rd Arab Water Forum in joint collaboration with the Arab Water Council

#### Groundwater Governance in the Arab Region
- Organization of a regional Workshop on Effective Groundwater Governance in the Arab Region, Sharm El Shiekh, Egypt; 19-21 September 2014
- Thirteen regional water experts attended the workshop representing 11 Arab countries, namely: Egypt, Sudan, Oman, Bahrain, Tunisia, Morocco, Kuwait, KSA, Yemen, Algeria and Jordan in addition to representatives of UNESCO Cairo Office (UCO)

### Preparation of Water and Education General Guide for Teachers of the Arab Countries
The challenge we all have

How to put water in the minds of people?