QUO VADIS AQUA MUNDI?

The future of water

IWRA
International Water Resources Association
XVIth World Water Congress
29 May - 2 June 2017, Cancun, Mexico
Worldwide, some 700 million people don’t have access to enough clean water. In 10 years the number is expected to explode to 1.8 billion. In many places, squeezing fresh water from the ocean might be the only viable way to increase the supply.

David Talbot, MIT Technology Review; *EmTechMIT2015*

About 783 million people, or 11% of the global population, remain without access to an improved source of drinking water.

UN Millennium Development Goals Report 2012
The current world population of 7.3 billion is expected to reach 8.5 billion by 2030, 9.7 billion in 2050 and 11.2 billion in 2100, according to the United Nations Department of Economic and Social Affairs report, “World Population Prospects: The 2015 Revision.”

About 44 percent of the world’s population lives within 150 kilometres of the sea (UN Atlas, January 31, 2010)
14 of the world's 17 largest cities are located along coasts. Eleven of these cities, including Bangkok, Jakarta, and Shanghai, are in Asia.

In addition, two-fifths of cities with populations of 1 million to 10 million people are located near coastlines.

The urbanization of coasts brings with it coastal development (including demands for fresh water and sewage treatment) and damage to coastal ecosystems.
With the coastal zone population growth and groundwater and aquifer systems in densely populated coastal areas are increasingly vulnerable to pollution and contamination.

Furthermore, projected sea level rises threaten the viability of many coastal zones and small islands.

The low-laying coastal areas are under autochton anthropogenic and allochton environmental stresses.

- **Diffuse-source (runoff) terrestrial stress**
- **Maritime surface and subsurface stress**
Sea water intrusion into phreatic aquifers along the coasts of Southern Florida
Miami Beach: castles built on sand and flooded beach at Coral Gables

Source: Encroaching Tides in Miami-Dade County, Florida; Facts Sheet, Union of Concerned Citizen

Maritime surface stress

Northern section of Bangkok on Oct. 30, 2011. (Kyodo News/AP)

Suburban Bangkok, on October 18, 2011. (Pornchai Kittiwongsakul/AFP/Getty Images)
Around 75% of California’s water supply comes from north of Sacramento, while 80% of the water demand occurs in the southern two-thirds of the state.

Waters of the Colorado River and Lake Mead were over-allocated to the seven riparian states on the basis of flow data of the early 1920’s assumed fairly constant. Unfortunately, the decades prior to 1922 were the wettest period in the last 500 years.

Farming in California uses 80% of the developed water supplies.

More than 40% of California farmland is still flood-irrigated.

Drought stress in California
Around 75% of California's water supply comes from north of Sacramento, while 80% of the water demand occurs in the southern two-thirds of the state.

There are six main systems of aqueducts and infrastructure that redistribute and transport water in California: the State Water Project, the Central Valley Project, several Colorado River delivery systems, the Los Angeles Aqueduct, the Tuolumne River/Hetch Hetchy system, and the Mokelumne Aqueduct.

In an average year, about 39% of California's water consumption, or over 42 km³, is used for agricultural purposes.

Alfalfa farmers pay about $0.05675/m³, in Los Angeles that same amount of water is worth $0.81 or over 14 times more.
Surface water delivery and groundwater storage during the last 50-years in the Central Valley, California

1 acre-foot = 1233.48 m³
Groundwater mining (withdrawals at the rates exceeding the rates of recharge)

Recent subsidence in the Central Valley, California due to groundwater withdrawals.

http://ca.water.usgs.gov/data/drought/drought-water-decisions.html
Water stress (local water withdrawals over renewable water resources) in the two most populous world democracies.

The current use of fresh water resources in the U.S.A. and India is unsustainable.

Water stress (local water withdrawals over renewable water resources) in the two most populous world democracies.
The current use of fresh water resources in many countries is unsustainable.
Internal fresh water resources and growth of population in selected Middle East and North African countries.

LEGEND
- Orange – population growth
- Blue – internal fresh water resources
- Green – 500 m$^3$/capita/year
- Red – 50 m$^3$/capita/year

Algeria

Israel

Tunisia

UAE

Jordan

Saudi Arabia
About 70% of the world’s freshwater (up to 95% in some countries) is used for irrigation.

In North America, of the estimated 85 km³ of wastewater generated each year, 61 km³ is treated. Annually, however, just only 2.3 km³ or 3.8% of that treated wastewater is used.

Many farmers in water scarce developing countries irrigate with wastewater because:

- It is the only water source available for irrigation year-round
- Wastewater irrigation reduces the need for purchasing fertilizer
- Wastewater irrigation involves less energy cost if the alternative clean water source is deep groundwater
- Wastewater enables farmers in peri-urban areas to produce high-value vegetables for sale in local markets.

Solutions

Reduce the use of freshwater in agriculture and replace it with recycled wastewater

Unfortunately, it seems that the more affluent society in developed countries (the U.S.A., Europe and Australia) are averse to the idea of wastewater reuse.
Israel produces 500 million cubic meters of wastewater every year, more than 90 percent of which reaches the various treatment plants. Israel utilizes 75% of the wastewater it processes (highest in the world, compared to 12% in Spain, 9% in Australia and 1% in Europe and the USA)

Highly efficient drip irrigation is used on 60% of Israel agricultural land

Israel’s desalination capacity has rapidly reached 560 million cubic metres/year with some of the world’s largest sea water reverse osmosis facilities, lowest costs (less than $0.40/m³) and numerous innovations.
CONCLUSIONS

- The current use of fresh water resources in many countries is unsustainable.
- Water stress can be eliminated even in the countries located in the most arid regions as demonstrated by the Israeli combination of:
  - reverse osmosis desalination of brackish and sea water a cost of less than $0.40/m³
  - high use of treated wastewater
  - use of recycled wastewater for crop irrigation
  - high use of cropland drip irrigation

<table>
<thead>
<tr>
<th></th>
<th>California</th>
<th>Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>38,802,500</td>
<td>8,270,000</td>
</tr>
<tr>
<td>Water districts</td>
<td>412</td>
<td>1</td>
</tr>
<tr>
<td>Per capita water use per day</td>
<td>371 L</td>
<td>231 L</td>
</tr>
<tr>
<td>Desalination plants</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>% waste water recycled</td>
<td>7%</td>
<td>86%</td>
</tr>
<tr>
<td>% cropland watered by drip irrigation</td>
<td>40%</td>
<td>70%</td>
</tr>
<tr>
<td>% drinking water produced by desalination</td>
<td>&lt;1%</td>
<td>60%</td>
</tr>
</tbody>
</table>