Climate Change Adaptation in Human Settlements Using Integrated Water Resources Management (IWRM) Tools

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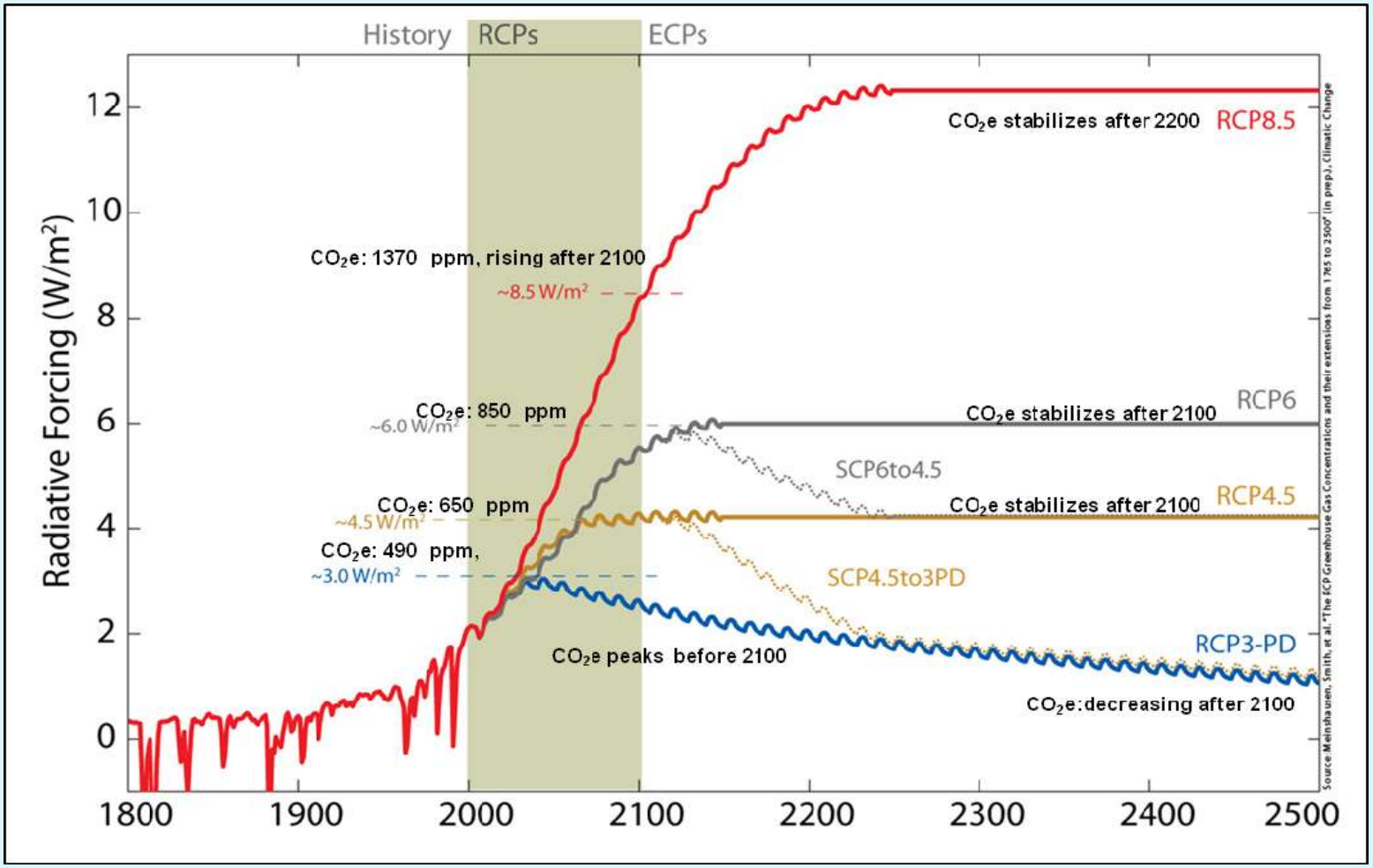


Figure 12: Modeled scenarios of radiative forcing including those for mitigation action/no action policy situations, RICCAR

RCP8.5 shows the constant increase of radiative forcing, rising to more than 8.5 W/m2 by 2100 and continuing to rise for some time thereafter. This concentration pathway represents the extreme case that applies in the case of little or no mitigation measures;

RCP4.5 shows a stabilization in radiative forcing after a peak of 4.5 W/m2 towards the middle and up to the end of twenty-first century. An alternative pathway for RCP4.5 peaks at 4.5 W/m2 before 2100 and then declines after 2100 to follow the path of RCP3-PD. This shows the possibility of a delayed climate response to mitigation measures, reflecting the effect of delayed policy action and climate momentum;

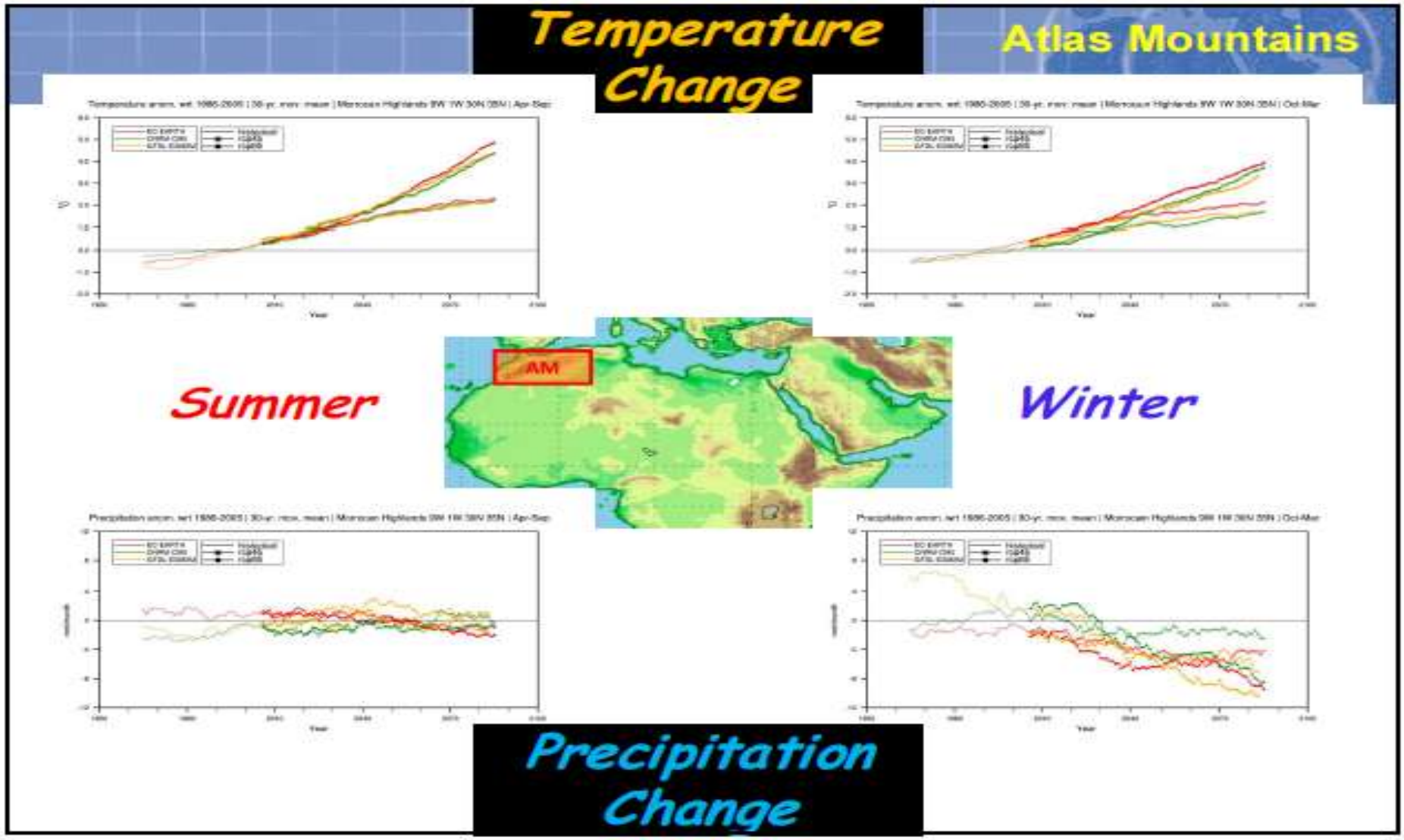


Figure 11: Expected temperature and precipitation change for Atlas mountains by RICCAR

With increasing urbanization, understanding the impacts of climate change on the urban environment will become even more important. Evidence is mounting that climate change presents unique challenges for urban areas and their growing populations. These impacts are a result of the following climatic changes:

- Warmer and more frequent hot days and nights over most land areas;
- Fewer cold days and nights in many parts of the world;
- Frequency increases in warm spells/heat waves over most land areas;
- Increased frequency of heavy precipitation events over most areas;
- Increase in areas affected by drought;
- Increases in intense tropical cyclone activity in some parts of the world; and
- Increased incidence of extreme high sea levels in some parts of the world.

Mediterranean and Middle East countries to predict the percent change in rainfall with respect to mean monthly values:

- The results show that in the dry season (April to September), by the year 2050, northern Africa and some parts of Egypt, Saudi Arabia, Iran, Syria, Jordan and Israel are expected to have reduced rainfall amounts of up to 20% to 25% less than the present mean values.12
- This decrease in rainfall is accompanied by temperature rises in those areas of between 2 °C and 2.75 °C.
- For the same period, the temperature in the coastal areas of the southern Mediterranean and Middle East countries will rise by about 1.5 °C. In winter, rainfall will decrease by about 10%–15%. Winter temperatures in the coastal areas will also increase, but by only 1.5 °C on average, while inside the region it will increase by 1.75 °C to 2.5 °C.

Ragab and Prudhomme (2000) claim that, given the above-mentioned predictions, in order to meet the water demands in the next century, more dams and water infrastructure will have to be built in southern Mediterranean and Middle East countries and, by rethinking water use with the aim of making it more productive, a new paradigm will have to be adopted. They argue that two approaches will be needed:

- Increasing the efficiency with which current needs are met and increasing the efficiency with which water is allocated among different uses.
- In addition, non-conventional sources of water supply, such as reclaimed or recycled water and desalinated brackish water or seawater, are expected to play an important role.

OBJECTIVES

- Present the draft module on Human Settlements and training materials with experts in the sector;

- Test the identified IWRM tools and adaptation measures and their possible incorporation in regional and national policies and plans;

- Exchange experiences and case studies from Arab States on climate change adaptation in human settlements and discuss their possible inclusion in the draft module; and

- Discuss the finalization of the module based on the input received from the workshop participants.

Training objectives and methodology

This Module aims to provide hands on training on how Arabian human settlements can adapt to future climate change impacts using identified tools of integrated water resources management (IWRM).

RICCAR outputs indicate that the Arab region will suffer serious impacts of climate change most notably lower rainfall and elevated temperatures. There are many tools within the domain of IWRM that local governments and various stakeholders including the general public can make use of within Arabian urban settlements that can help adapt human settlements of the Region to cope up with climate change induced impacts.

Training objectives and methodology

Secondary Objectives:

- The Module is one of a total of 5 module-training package that includes the sectors of agriculture, human health, economics and environment in addition to human settlements.
- It is hoped that by adopting a TOT (training of trainers) approach, the 5-module training manual will help stakeholders across the Arab countries respond to future challenges of CC impacts and the use of IWRM tools as means of adaptation and reducing vulnerability.

Training objectives and methodology

- Introductory PowerPoint presentation and question/answer session on basics of climate change science and expected trends using RICCAR outputs

Methodology, Cont'd

A total of 3 (three) Group Exercises using focus groups and reporting of group results on a flip chart

- GE # 1: **Factors for adaptive capacity in human settlements: Ranking exercise for the 4 (four) Arab sub regions**
- GE # 2: **Selection criteria for best IWRM tools → Screening/Ranking of best adaptation measures**
- GE # 3: **Water supply and Sanitation in Za'atari Refugee Camp in Jordan → Dealing with emergency situation!**

Methodology, Cont'd

Sector-based Impact assessment Case studies. A total of 6 (six) case studies will be considered whereby trainees read and then report in groups on each case and its contribution to adaptation. Details of the six case studies are outlined in the Appendix and the titles of these cases are noted below:

- CS #1: **Grey Water Reuse in Oman**
- CS #2: **Water Reuse in KSA**
- CS #3:**Using AutoCAD Civil-3D, SewerCAD and SSA Software to Adapt Storm and SewerNetwork Design for Climate Change Impacts**
- CS #4: **NRW reduction in Jordan>> Are we doing any better?**
-
- CS #5: **Managed aquifer recharge as an integrated water resource management approach for preventing seawater intrusion in Hazmieh, Beirut area, Lebanon (ACCWaM Pilot Project)**
-
- CS # 6:**Appropriate Water Abstraction through Bank Filtration to improve Drinking Water Supply in Upper Egypt**

Targeted stakeholders

- Water utilities' professionals and water planners in government
- Civil society and to a lesser extent local community representatives

RICCAR for HS Adaptation

- Climate change presents various challenges for human settlements and their growing populations. Level of urbanization has been high across all Arab countries due to the economic and social opportunity that urban centers provide compared with rural areas.

- The field of integrated water resources management (IWRM) provides a set of tools and measures that can help cities and urban centers adapt to impacts caused by climate change.

- RICCAR has resulted in a set of outputs that mainly imply lower precipitation rates, higher temperature degrees as well as more frequent and extended extreme events (sand storms, heat spills and flash rainfall storms) across the Arab region.

- Sea-level rise
- Heavy precipitation events and Flooding
- Landslides
- Tropical cyclones
- Extreme heat events
- Sand storms
- Drought

Physical Impacts

- Damage of residential and commercial buildings due to flooding, for example
- Disruption of transportation systems and damage of vehicles
- Energy systems: both energy demand and supply will be affected
- Damage and disruption of water supply and sanitation systems

Economic Impacts

- Industry and commerce
- Tourism and recreation
- Insurance: extreme climate events like storms and flooding could result in increasing demand for insurance while reducing insurability.
- Impacts on livelihood as well as ecosystem services

Impacts on Public Health

Climate change will increase the global and regional disease burden. At the city level, intense rainfall events and consequent flooding can include public health concerns associated with flooded sewage collection and treatment infrastructure. The higher temperature can result in accelerated occurrence of algal blooms in water reservoirs and re-growth of pathogens within potable water pipe networks.

Socio-economic Impacts

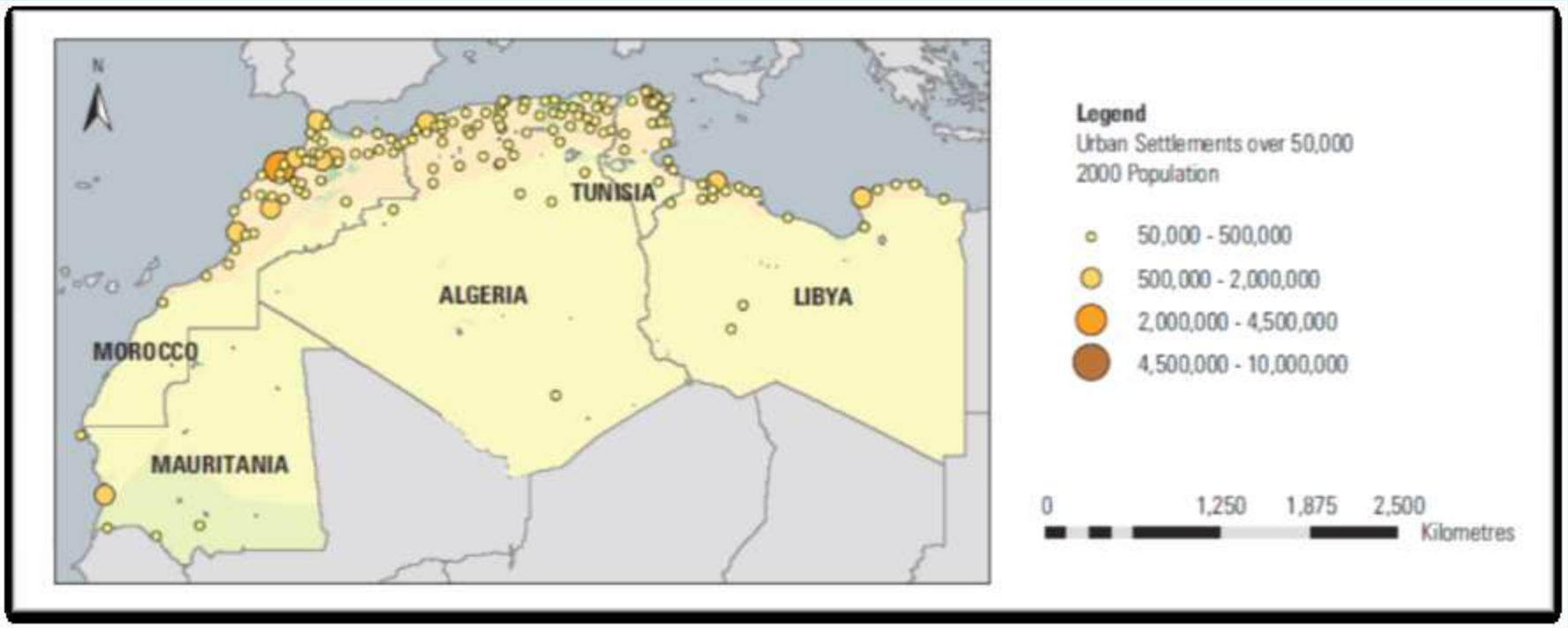
- Poverty and unemployment
- Gender issues
- Age groups like children and the elderly
- Ethnic and other minorities

TOOLS TO IDENTIFY/INDICATE CITIES VULNERABILITY

- Urbanization rate

  The Arab region is one of the highly urbanized regions of the World. Urbanization rate reaches as high as 90 percent in some Arab countries especially in the Gulf and in some North African countries
- Economic development
- Physical exposure: How much of a city population and economic assets are located in high-risk areas like flood plains
- Urban governance and planning
- Disaster preparedness
- Robustness of infrastructure systems
- Flexibility and responsiveness of urban management schemes

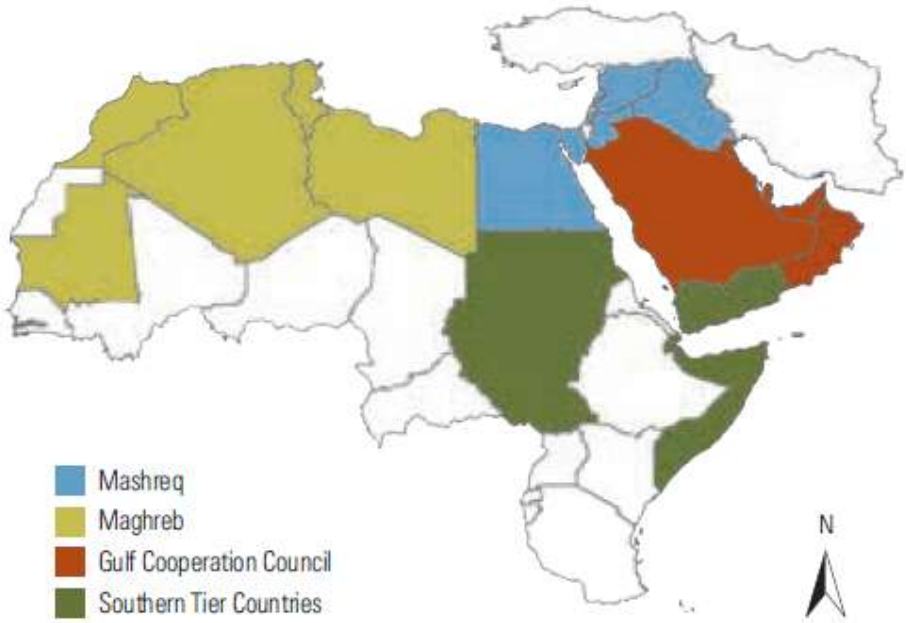
Sea Level Rise



Water supply in Arab human settlements continues to face economic and governance challenges in addition to the scarcity of the resource itself

Sub-Regions

- Mashreq: Egypt, Iraq, Jordan, Lebanon, Palestine, and Syria
- Maghreb: Algeria, Libya, Morocco, Tunisia, Mauritania
- GCC (Gulf Cooperation Council) countries: Bahrain, Kuwait, Oman, Qatar, KSA, UAE
- STC (Southern Tier Countries): The Comoros, Djibouti, Somalia, Sudan and Yemen

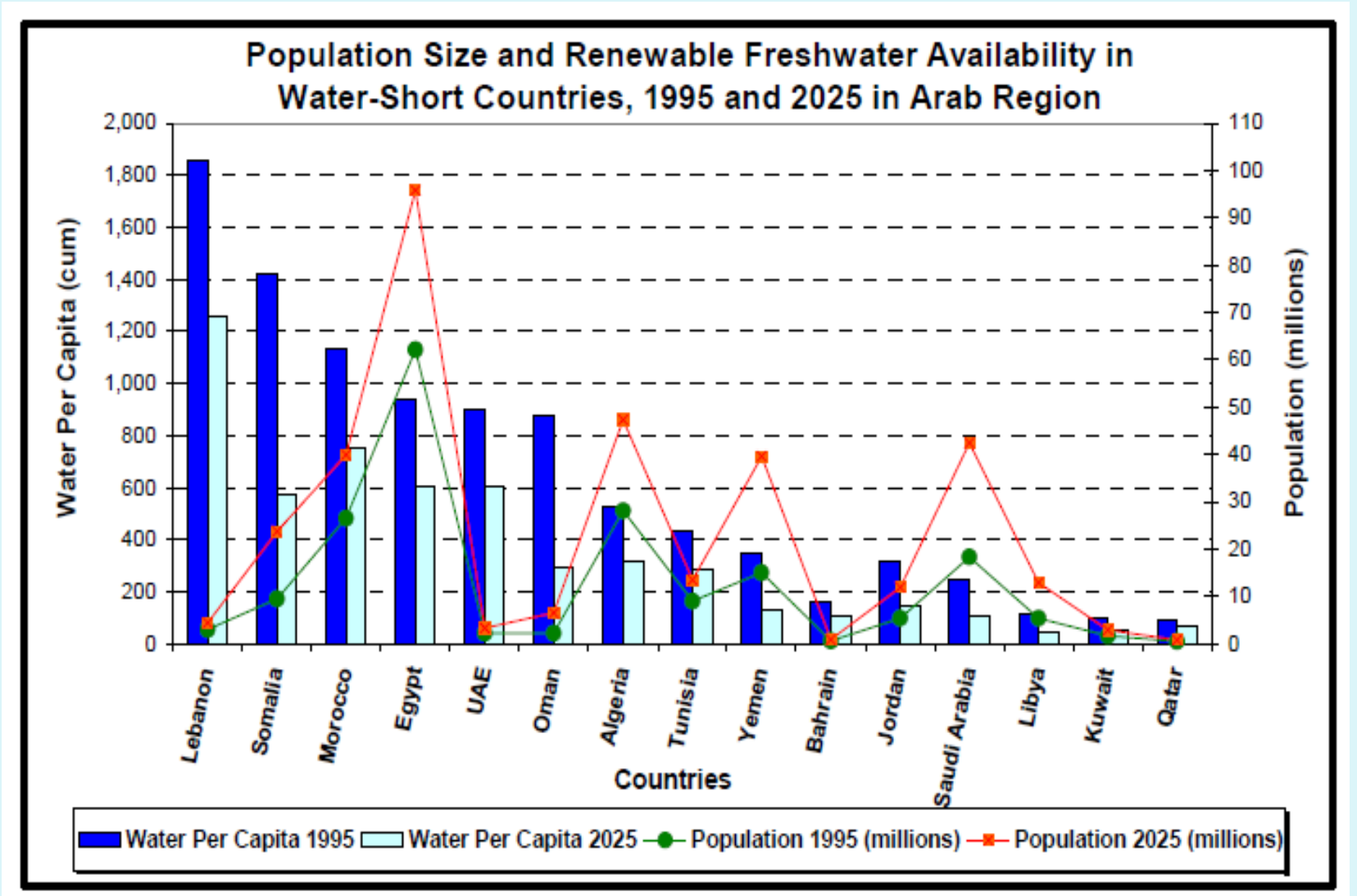


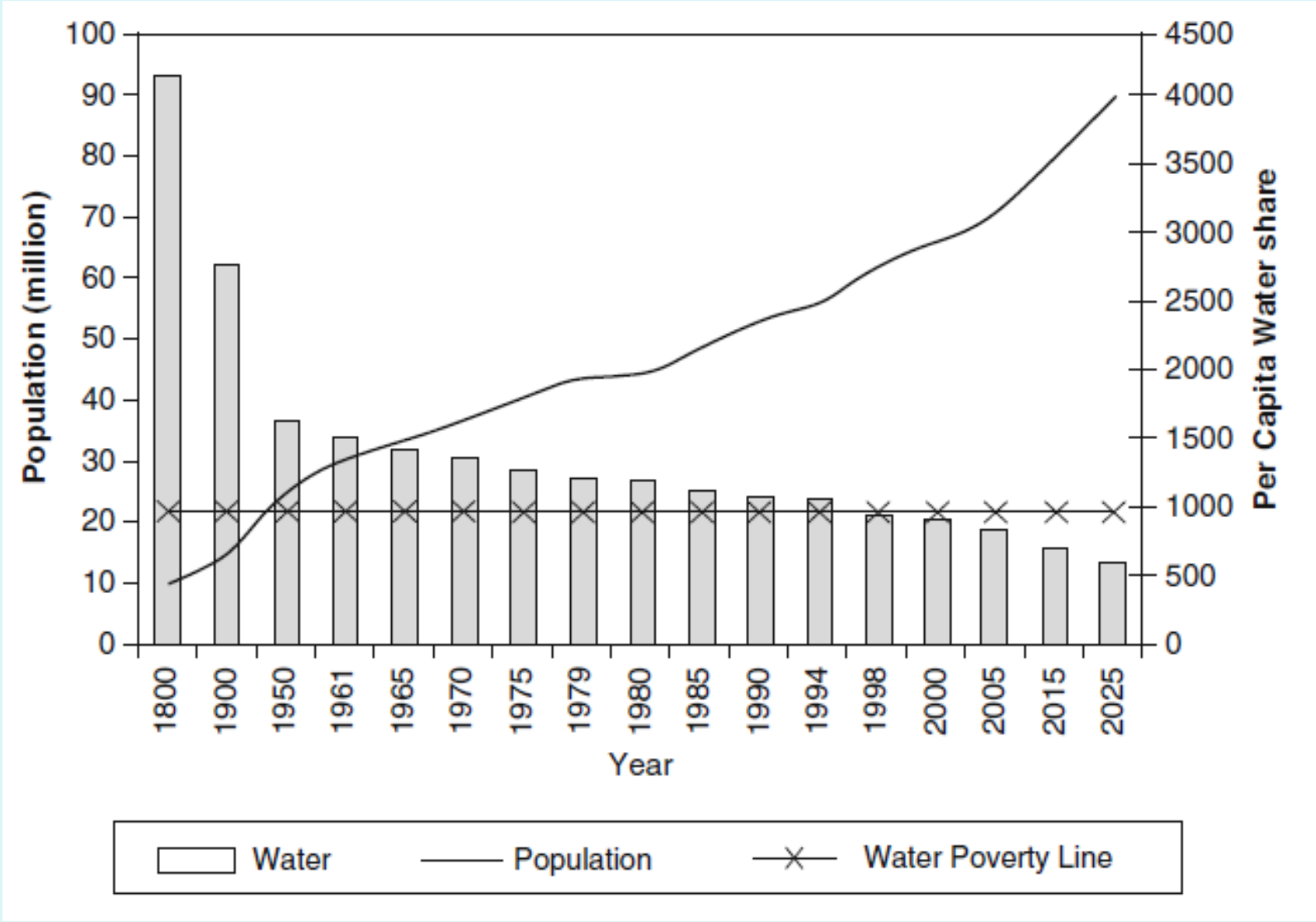
Mashreq	Maghreb	Gulf Cooperation Council	Southern Tier Countries
Egypt	Algeria	Bahrain	The Comoros
Iraq	Libya	Kuwait	Djibouti
Jordan	Morocco	Oman	Somalia
Lebanon	Tunisia	Qatar	Sudan[1]
Palestine	Mauritania	Saudi Arabia	Yemen
Syrian Arab Republic		United Arab Emirates	

Factors for Adaptive Capacity	Sub-regions of the Arab World			
	a	**b**	**c**	**d**
Strong institutions and good governance				
Quality of infrastructure				
Education and public awareness				
Socio-economic status				
IWRM programs in place				
Average WPC region-wide (projected at 2025)				

General features of IWRM and Its Tools in Arab Human Settlements

Resource challenge


Population Size and Renewable Freshwater Availability in Water-Short Countries, 1995 and 2025 in Arab Region
Water Per Capita (cum)
Population (millions)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
110
100
90
80
70
60
50
40
30
20
10
0
Lebanon
Somalia
Morocco
Egypt
UAE
Oman
Algeria
Tunisia
Yemen
Bahrain
Jordan
Saudi Arabia
Libya
Kuwait
Qatar
Countries
Water Per Capita 1995
Water Per Capita 2025
Population 1995 (millions)
Population 2025 (millions)


Population (million)
Per Capita Water share
100
90
80
70
60
50
40
30
20
10
0
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1800
1900
1950
1961
1965
1970
1975
1979
1980
1985
1990
1994
1998
2000
2005
2015
2025
Year
Water
Population
Water Poverty Line

- Limited water resources; which lead to a large gap between available resources and increasing demand for water due to the high rate of population growth, rapid urbanization and economic development.
-
- The impact of political instability in the Arab region (Arab Spring); which lead to internal and external migration in several Arab countries, has dramatically increased the demand for water in the host countries and damaged the infrastructure in the countries of the Arab Spring
-
- Most water utilities operate under centralized management; especially in the field of planning anddetermining tariffs, regulations and laws that regulates the work of water utilities (salary scales, andemployment regulations)
-
- Brain drain from the public sector to the private sector within the same country or from one country to another
-
- Limited financial allocations in many facilities in the area of training and capacity building, technology transfer and limited financial resources for the implementation of mega projects in water supply and sewage treatment plants
-
- Many Arab countries have reached lending ceiling, thus cannot take any more loans to implement water projects
-
- Very limited initiatives from the national private sector to finance strategic projects

Intermittent supply

- The need for water storage at the household level which incurs financial burden on the households due to:

-Cost of underground cisterns

-Cost of pumps

-Cost of roof water cisterns

- Extra cost for maintenance of the storage cisterns, pipes and pumps
- Reliance on water tankers
- Water quality problems associated with storage
- Water quality problems associated with unknown sources of tanker water (illegal GW wells, for example)

Enhancing water efficiency at the city level

- A. Improving infrastructure
- B. Better management

Status of storm and wastewater infrastructure in Arab cities:

Of particular significance is the urban planning policies that has to be reviewed and updated to enact measures such as:

- 1. Avoiding flood plains in locating institutional and economic enterprises such as emergency administration buildings and hospitals
- 2. Upgrading of existent storm water drainage and sewage collection networks to handle expected surges in flow
- 3. Capacity building and training technical staff to consider climate change scenarios in the design process in water and sanitation infrastructure
- 4. Building awareness especially among middle and high level decision makers on the seriousness of expected impacts by climate change on the city infrastructure

Figure 6 : flooded manhole in a sewage line in Irbid, Jordan, July 2015


وادي تالمعدرت

Impact and vulnerability assessment of the Sector based on RICCAR outputs

Human settlements and cities in the Arab countries should build adaptive capacity for extreme events of climate change

Adaptation measures implementation matrix

Tools of IWRM provide opportunity for human settlements in Arab countries to better adapt to climate change

Screening criteria

- Selection criteria for IWRM Tools of adaptation potential for Arab human settlements will be discussed, and input by trainees will be sought, organized and listed. This will be implemented through exercise # 1 mentioned above and in the Appendix. Based on sub-regions of the Arab World, selection of the most appropriate tools and the ranking therein might be a little different. For example; cities in the GCC sub-region consume much higher amounts of water per capita as compared to the other 2 sub-regions, yet high cost desalination is the main source of water supply within the GCC countries. Tools of water ration, public awareness as well as water tariffs might be more relevant/efficient to this sub-region than the others who suffer lower income as well as scarcity of water.

- In general, the following suggested criteria can be the basis of training dialogue on screening options and tools of IWRM at the human settlement level:
-
- 1.Technical feasibility of applying the tool within the urban context
- 2. Cost
- 3. Social acceptance
- 4. Addition to adaptive capacity of the human settlement
- 5. Indirect positive value
- 6. Previous experience and local capacity for implementation
- 7. Technology transfer of IWRM between Arab countries

	Technical feasibility	Cost	Social acceptance	Adaptive capacity	Indirect positive value
HH Harvesting					
Grey water reuse					
NRW Reduction					
WW Reuse/Recycle					
WDM					
Public Awareness					
Virtual water and WFP					
Sewage Networks					
WDS and storage facilities					
GW Recharge					

Category	Factor	Measure
Water resource planning and management	Application of IWRM	Level of application
	Efficiency of water demand management	Cost recovered from water fees (%)
	Water network losses	Water network losses (%)
	Water storage capacity	Water storage to total water resources (%)
	Status of strategic water reserves	Abstraction to total strategic water resources (%)
Economy	General state of the economy	Gross national income (GNI)
		Gross domestic product (GDP)
		Gross savings (% of GNI)
		Total reserves (% of total external debt)
		Total debt services (% of GNI)
		Lending interest rate (%)
	Population relative wealth	GNI per capita
		GDP per capita
		Unemployment (% of total workforce)
	Poverty	Population earning less than US$1.25 per day (%)
	Economic diversification	Value added – industry (% of GDP)
		Value added – services (% of GDP)
	Energy consumption	Electric power consumption (kWh per capita)
	Energy cost	Diesel fuel price
Demography and income	Population size	Total population
	Population growth	Population growth
	Population-female	Number of women to total population (%)
	Population density	Population per km^2
	High concentration of people in urban areas	Population in the largest city (% of total population)
		Population in urban agglomerations of more than 1 million (% of total population)
	Economically dependent population	Number of young and old to working-age population (%)
Agriculture	Dependency on agriculture	Agricultural land to total (%)
		Workforce in agriculture (%)
		Rural population (% of total population)
	Dependency on rain-fed agriculture	Rain-fed land (% of total)
	Level of land degradation	Degraded land (% of total)
Food security	Reliance on single or few crops	Top three strategic crops (% of total products)
	Reliance on locally produced food	Food produced locally (%)
	Food productivity	Cereal yield per hectare (kg)

Cost of one cubic meter of water saved/produced under shown adaptation measure, World Bank, 2012

Adaptation measure	Cost (US$/$m^3$ water)
Improve agriculture practice	0.02
Expand reservoir capacity (small scale)	0.03
Reuse domestic and industrial wastewater	0.03
Reuse irrigation water	0.04
Expand reservoir capacity (large scale)	0.05
Reduce irrigated areas	0.10
Desalination by renewable energy	1.30
Desalination by conventional energy	1.85
Reduce domestic and industrial demand	2.00

Stocktaking of available adaptation measures

- **1. Water Harvesting**

- The present water supply and stormwater problems in most cities of the Arab region will mount in future. The concept of 'Integrated Urban Water Management' (IUWM) seems to be most appropriate; it includes:
- (a) Water Supply Management: Rainwater harvesting on urban buildings or
- other sealed surfaces, offers new chances to cover the ever growing urban water demand.
- (b) Water Demand Management can be achieved through a combination of behavioural changes and technological fixes such as water saving devices (WSDs).
- (c) Excess Water Management deals with stormwater and floodplain management.
-

2. Water demand management and water ration

- Public awareness Campaigns
- Installing water saving devices (WSDs)
- Programs for water recycle/reuse for large water consumers like hotels

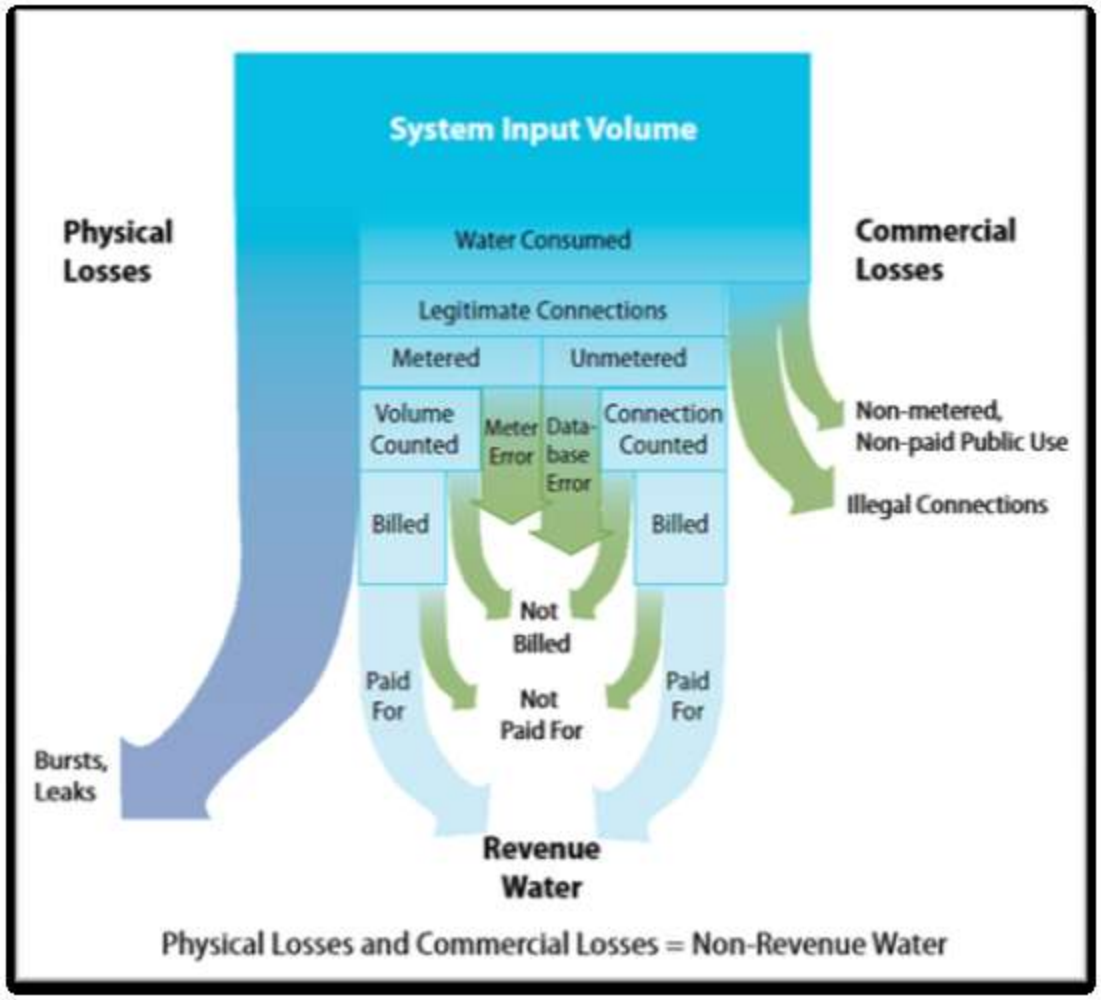
3. Reuse of Grey water

Toilet flushing	35%
Wash basin	8%
Shower	5%
Bath	15%
Laundry	12%
Dishwasher	4%
Outside use	6%
Kitchen sink	15%

4. Water Foot Prints tool

5. MDGs and SDGs after 2015

6. Cutting on the Non-revenue water (NRW)



Under climate change scenarios, water utilities should continue a good work of trying to reduce NRW which typically entails:

- Reducing physical losses
- Using advanced and innovative Sensors (acoustic and water borne) to detect leaks
- Investing in better governance with a goal of minimizing response time
- Administrative non-leak losses should also be investigated and resolved

Water losses in the water supply distribution system in selected Arab countries, 2005 (Source: FAO 2013)

Country	% of loss
Bahrain	15
Egypt	50
Iraq	50
Jordan	50
Kuwait	8-10
Lebanon	50
Oman	23
Palestine	40
Saudi Arabia	25-40
Syria	48
Yemen	30

7. Wastewater Reuse/Recycle

Obstacles to wastewater reuse implementation in Arab countries cab be summarized:

1. Technology and infrastructure availability
2. Water Resource Management frameworks
3. Regulations and Recycled Water Quality
4. Socio-Cultural Beliefs and Religious Practices
5. Public Perceptions and Terminology

Branding Recycled water! NEWater?

Social acceptance of reclaimed wastewater is still an issue in the Arab region that can be overcome via public awareness and carefully designed media messages and careful selection of vocabulary

Water Tariffs

Pricing policy is one of the main driving factors for water reuse or lack thereof. Water tariffs are set based on a number of formal criteria defined by law, as well as informal criteria.

Formal criteria typically include one or more of the following:

- Financial criteria (cost recovery)
- Economic criteria (efficiency pricing based on marginal cost)
- Environmental criteria (incentives for water conservation)

Social and political considerations often are also important in setting tariffs. Tariff structures and levels are influenced in some cases by the desire to avoid an overly harsh burden on poor users or by other political considerations. Water tariffs should be easy to understand for consumers. This is not always the case for the more complex types of tariffs, such as increasing-block tariffs and tariffs that differentiate between different categories of users.

9. Managed GW Recharge-Aquifer Recharge and Recovery

A variety of different types of water are stored or treated in managed aquifer systems, including:

- Reclaimed water
- Potable water (including desalinated water)
- Surface water (treated to varying degrees)
- Storm water
- Raw groundwater (inter-aquifer systems)

Managed aquifer recharge (MAR) was defined by Dillon (2005) as the *intentional banking and treatment of waters in aquifers*. The term *managed aquifer recharge* was introduced as an alternative to *artificial recharge*, which has the connotation that such use of the water was, in some way, unnatural (Dillon, 2005). MAR can be either a storage technology, treatment technology, or both. With respect to reclaimed water, MAR can be used to store seasonally available excess water (intra-annual supply management), to strategically store currently available excess water for future use, or to serve as a treatment (polishing) step in a multiple-barrier approach to reclaimed water reuse.