



The Arab Regional Center @ AGU

جامعة الخليج العربي  
Arabian Gulf University



# Urban Water Management in the GCC

## *Defining Sustainability*

---

Prof. Waleed K Al-Zubari  
Water Resources Management Program  
*waleed@agu.edu.bh*

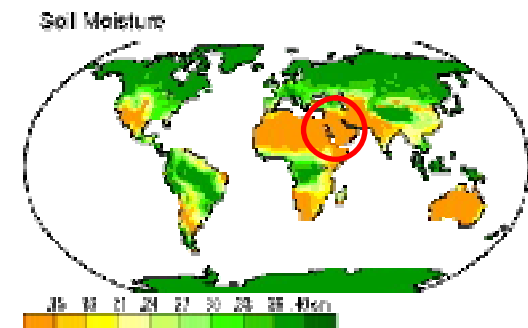
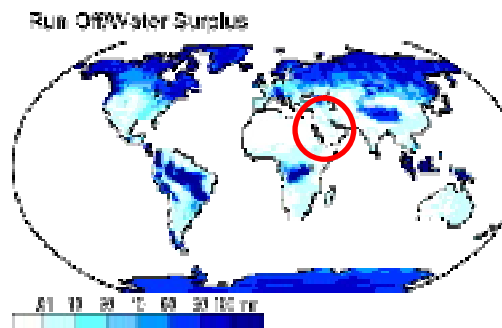
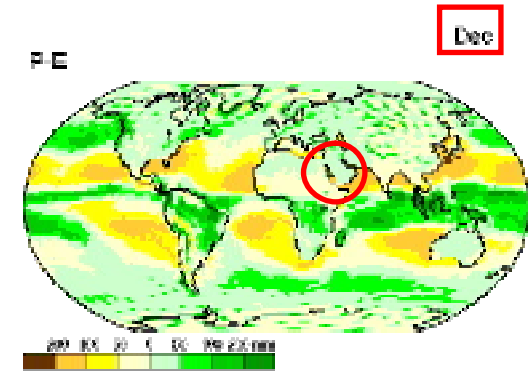
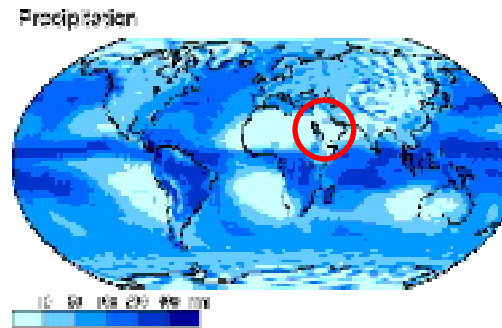
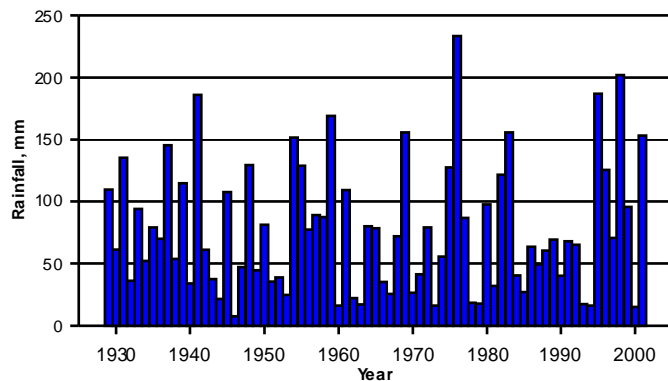
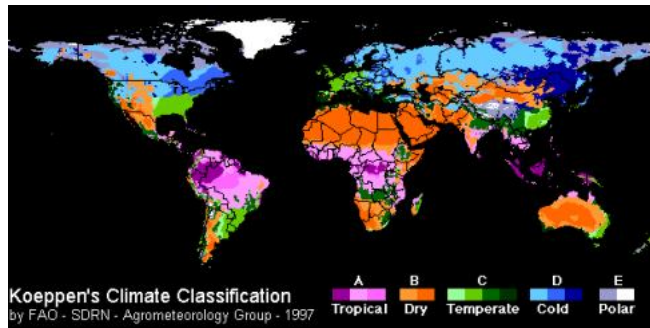
*Water Arabia 2011 Conference & Exhibition, 1-2 February, 2011, Bahrain*

# Overview

- Introduction
- GCC Water Resources & Use
- Municipal/Drinking Water Management
- Municipal Wastewater Management
- Urban Water Management in the GCC
- “Sustainable” Urban Water Management in the GCC
- Case Study: Urban Water Management in Kuwait City
- Conclusion & Recommendations

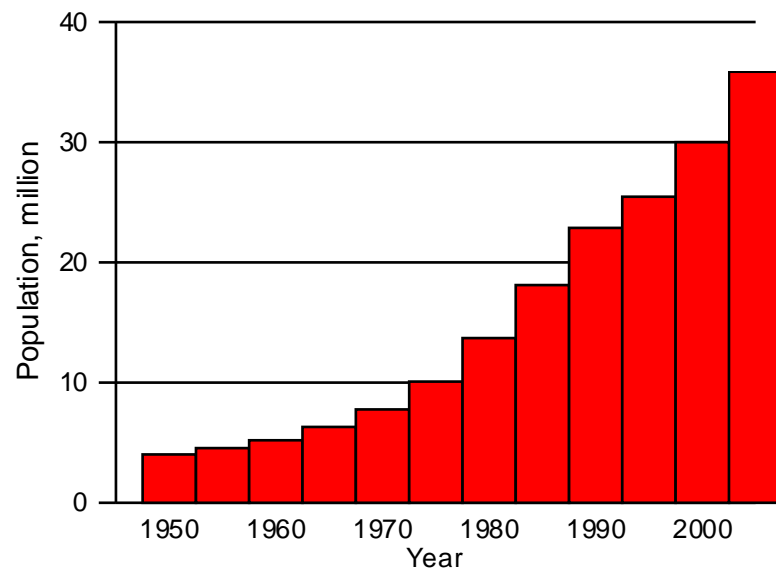
# Introduction

- Arid to extremely arid climatic conditions
  - Small and irregular rainfall in space & time (<100 mm/yr)
  - High evaporation rates (>3000 mm/yr)
- Generally devoid of surface water resources, depends mainly on groundwater, desalination, and reuse of TSE

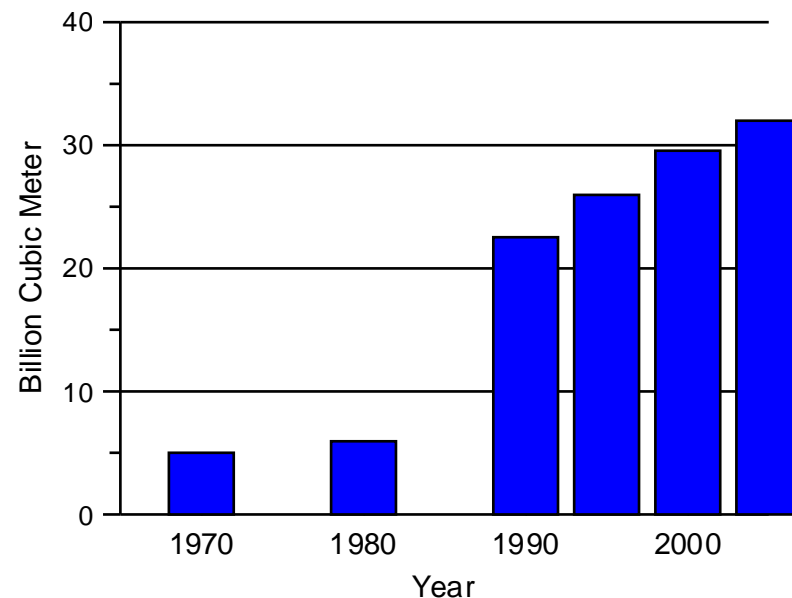


- Accelerated development growth since the mid 1970s
- Increase in the economic base, rapid improvement in the standard of living, and high rates of human development
- High population growth rates of national and expatriates (>3%) & intense urbanization
- Substantial and continuous increase in water demands

**GCC Population, Millions  
1950-2005**

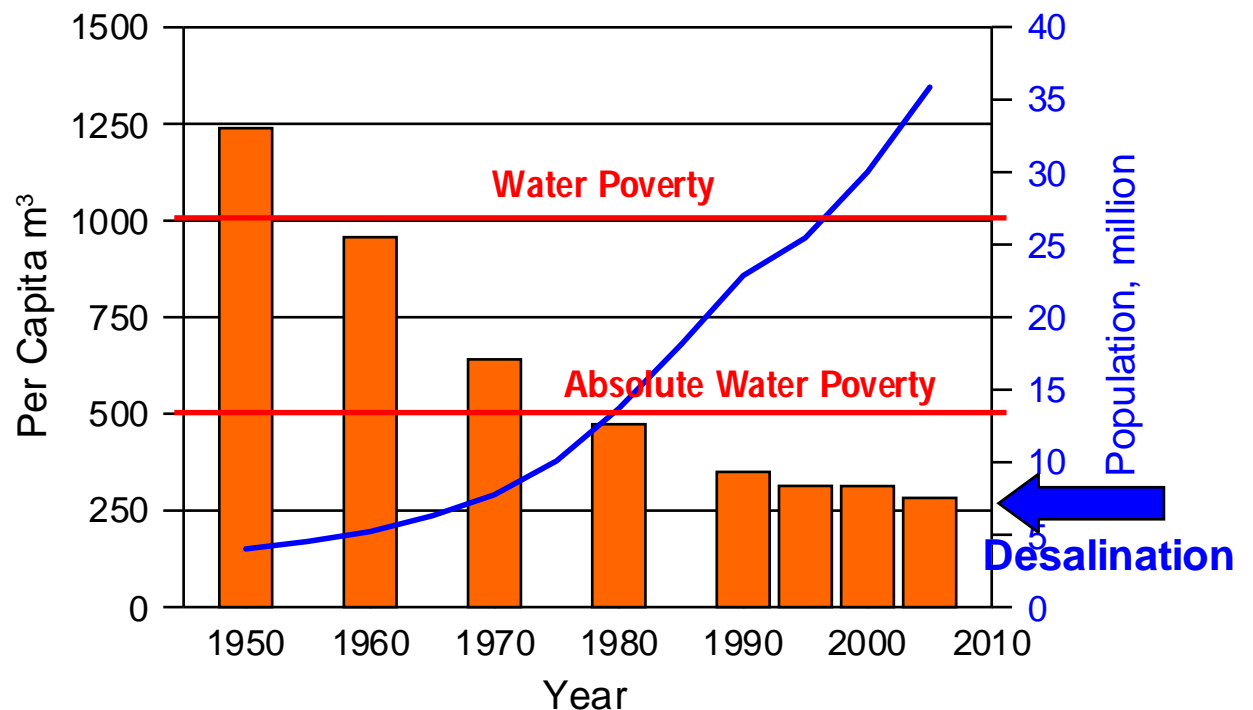


**GCC Water Demands, Bcm  
1970-2005**

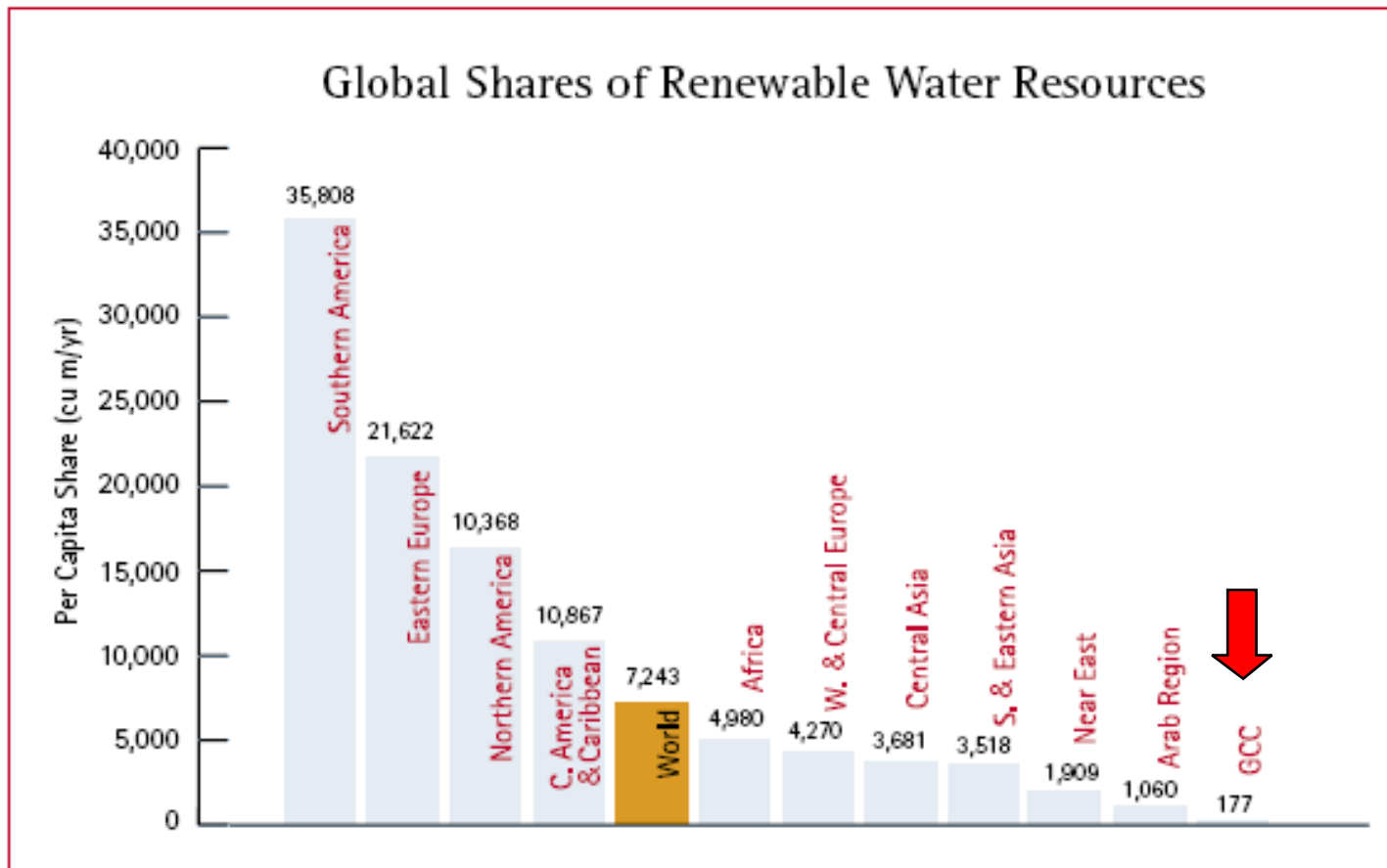


- Scarcity of natural water resources is aggravated by high population growth, expected to increase in the future
- Water is becoming an increasingly scarce commodity and its availability is decreasing with time

**Per Capita Available Water Share in GCC (traditional and non-traditional water resources) 1950-2005**

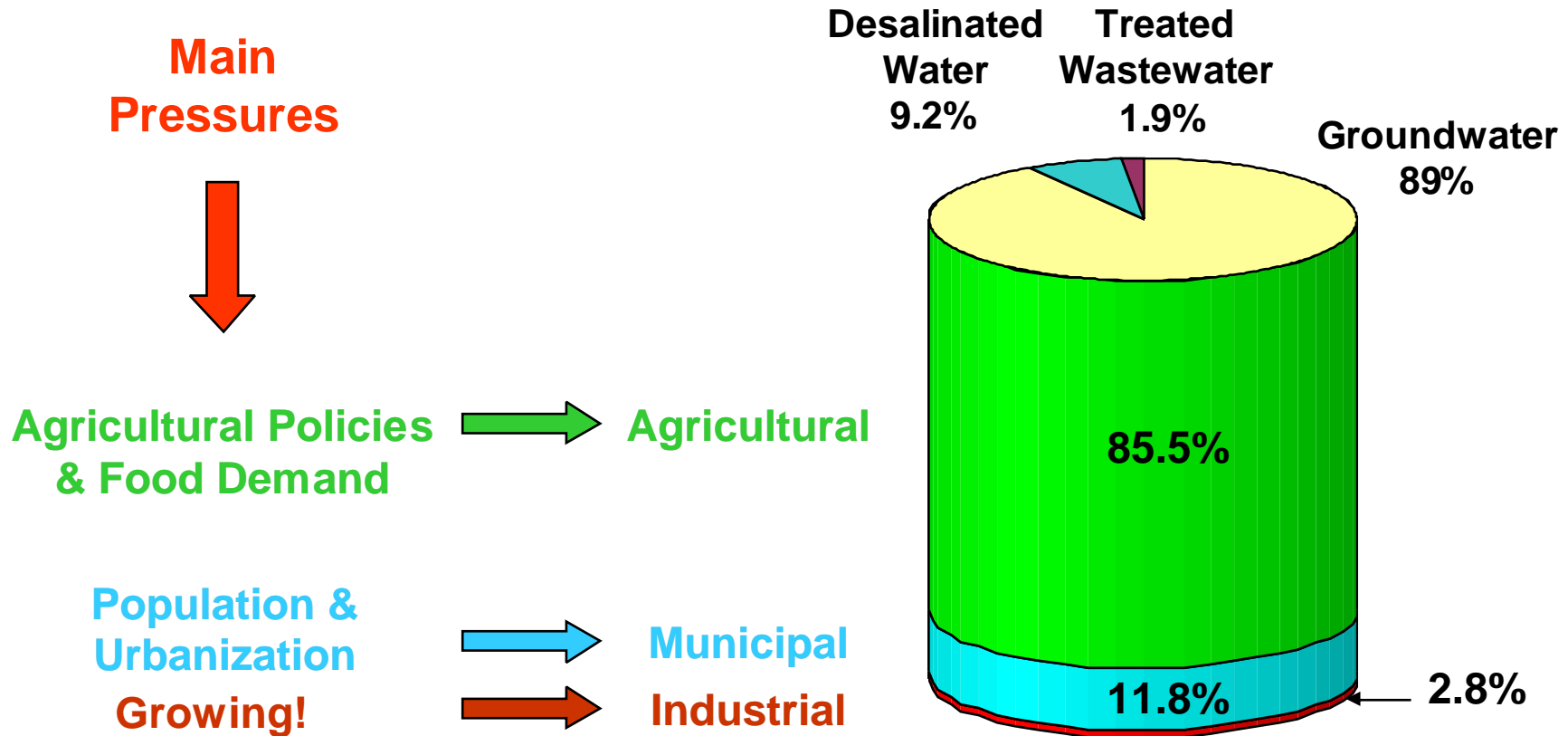


## Per Capita Freshwater Availability in the GCC Compared to the Global Level



(Arab Water Council, 2006)

## Water Resources & Uses in the GCC, 2005

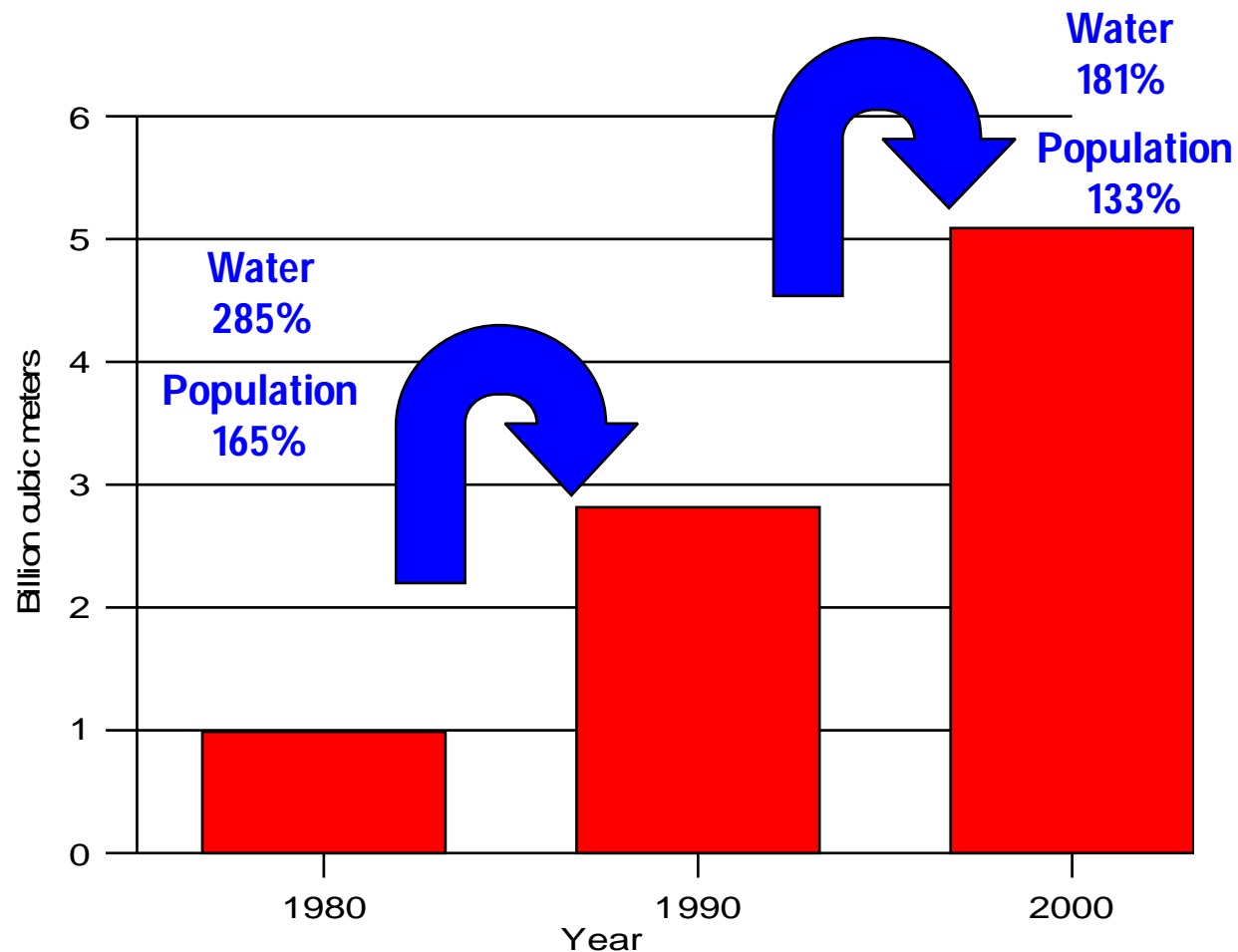


# Municipal/Drinking Water Supply

- Represents about 12% of total GCC water uses, escalating
- Source: Desalinated (56% of drinking water supply) and Groundwater
- Almost 100% water supply coverage
- However, an alarming increase in urban water demands, due to
  - Rapid population growth & urbanization
  - High level of unaccounted-for-water (UFW); >30%
  - Rise in per capita consumption



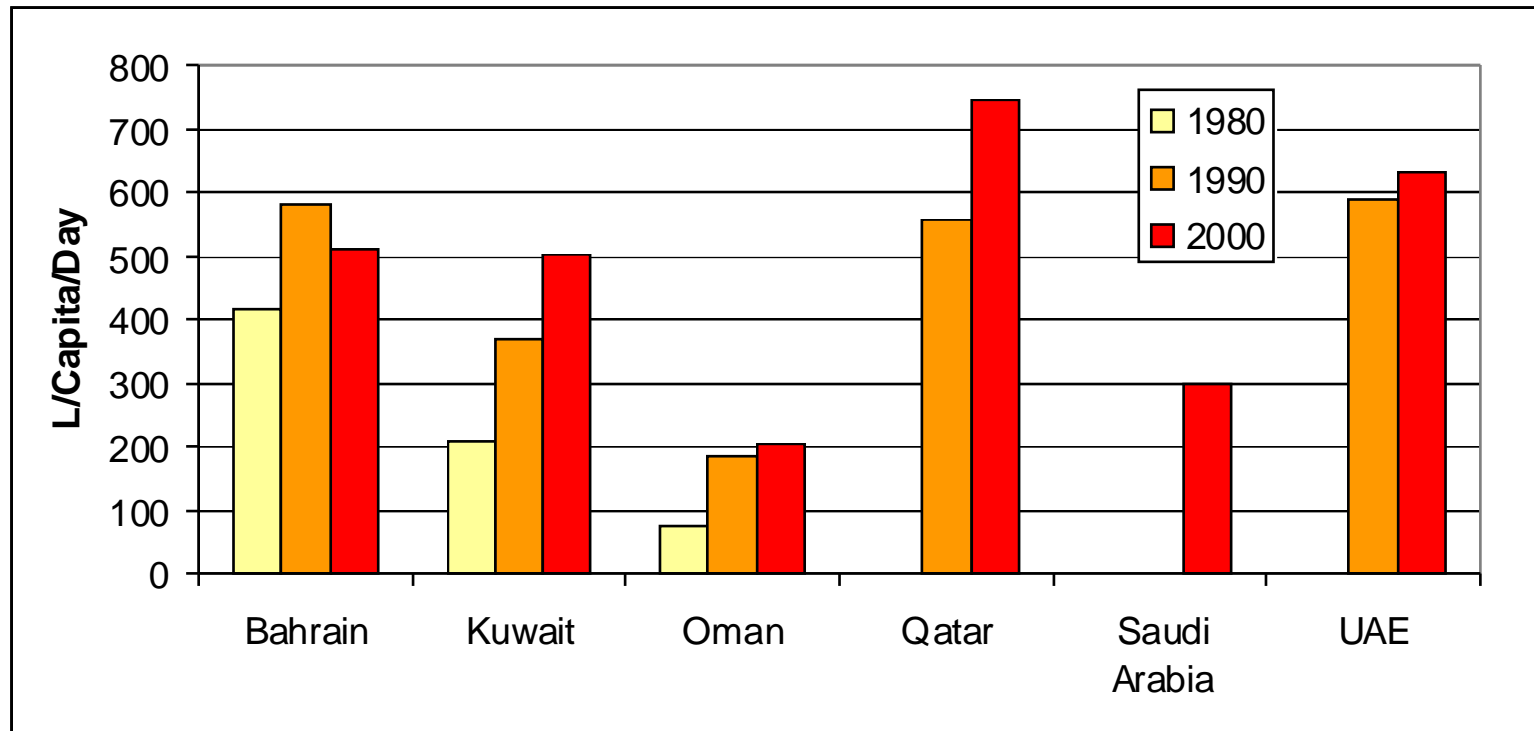
## Development of Domestic Water Demands in GCC 1980-2000



**consumption  
patterns in  
domestic  
sector are high  
and change  
with time**

**(reaches 750  
L/d/capita)**

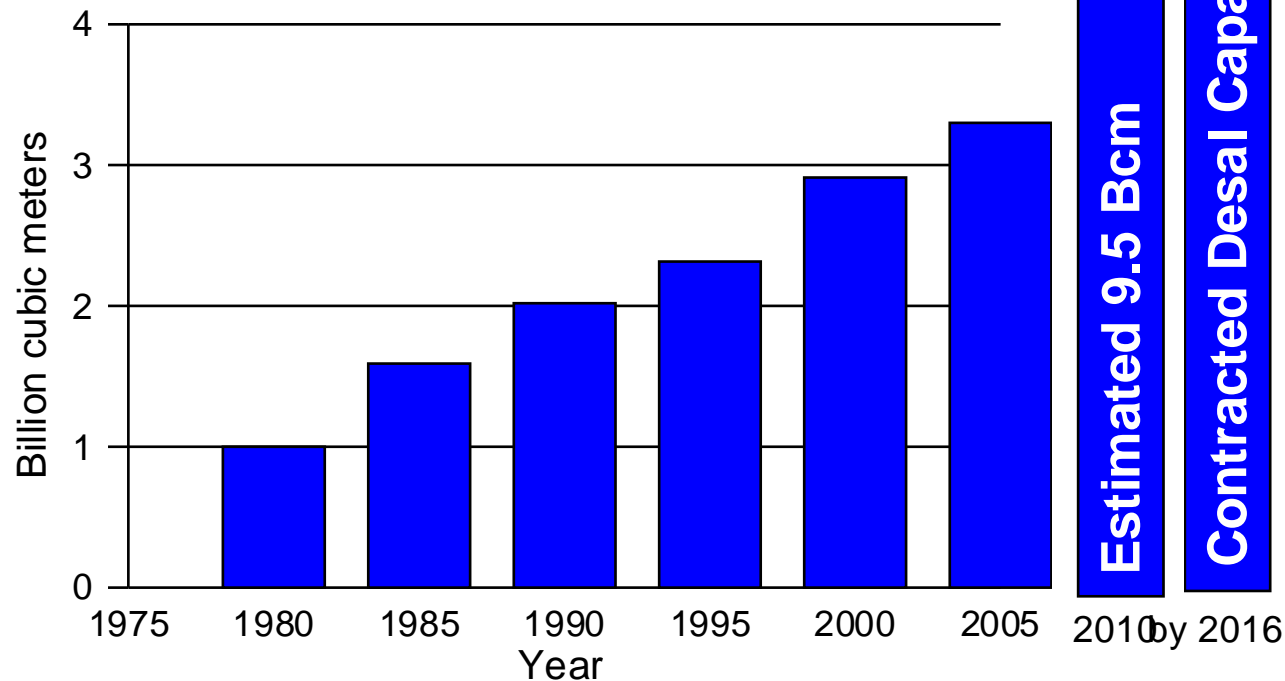
## Trends in Per Capita Municipal Water Consumption in GCC, 1980-2000



- Main reasons for the escalating and exaggeration of urban water demands
  - Focus on the “**Supply-Side**” of water management
  - Absence of proper “**Demand Management**”
    - *Economic tools*; non-existent of price-signaling 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

## Response: Supply Management & Augmentation

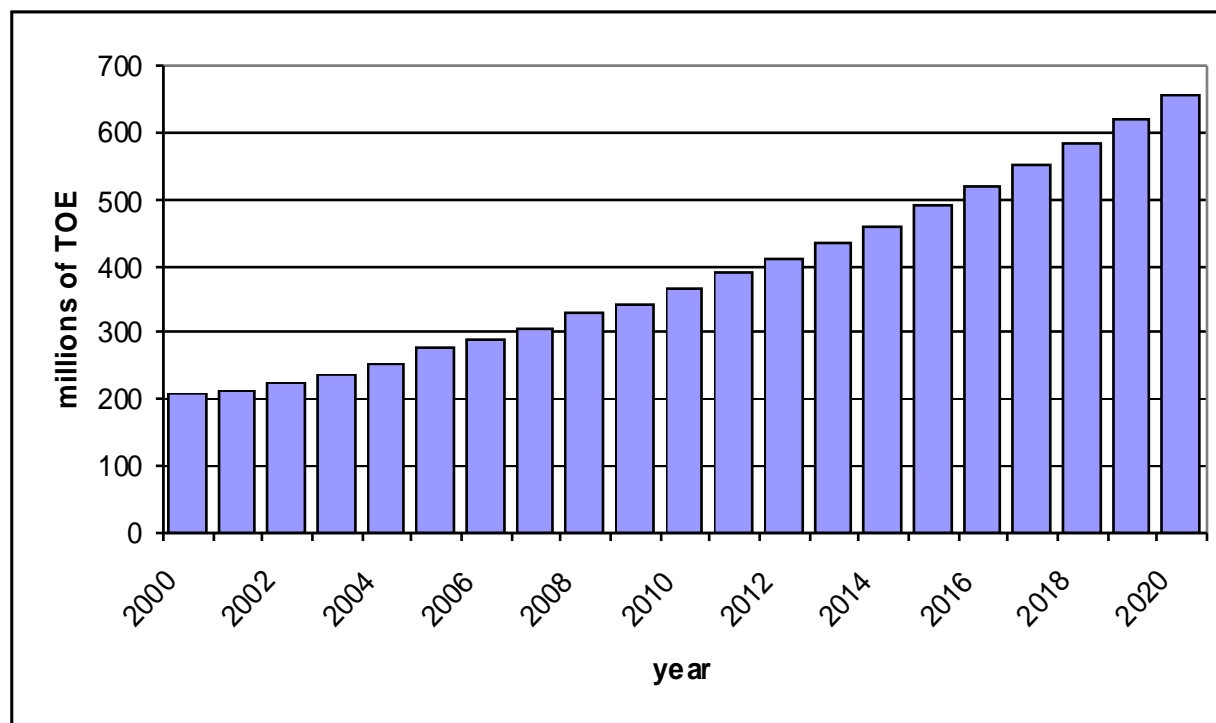
### Development of Desalination Capacity in the GCC Countries, 1980-2016 (and projected by 2016)





- Extensive installation of desalination plants, **BUT**
  - **Financial and economic impacts**
    - heavy burden on national budget, cost of desalination plants installed up to 2001 is US\$ 21 billion
    - Desalination cost, operating life, .....
  - **Environmental impacts**
    - Marine pollution (thermal, brine, residual treatment chemicals, ..), Air pollution by emitted oxides (mostly using oil)
  - **Imported Technology:** GCC still do not own the technology and limited added value to GCC economies
  - **Energy-intensive (fast depletion of oil reserves)**  
(Cogeneration Power Desalination Plants; MSF mainly)

## Energy consumption in the GCC in million TOE (2000-2009, and projected 2010-2020)

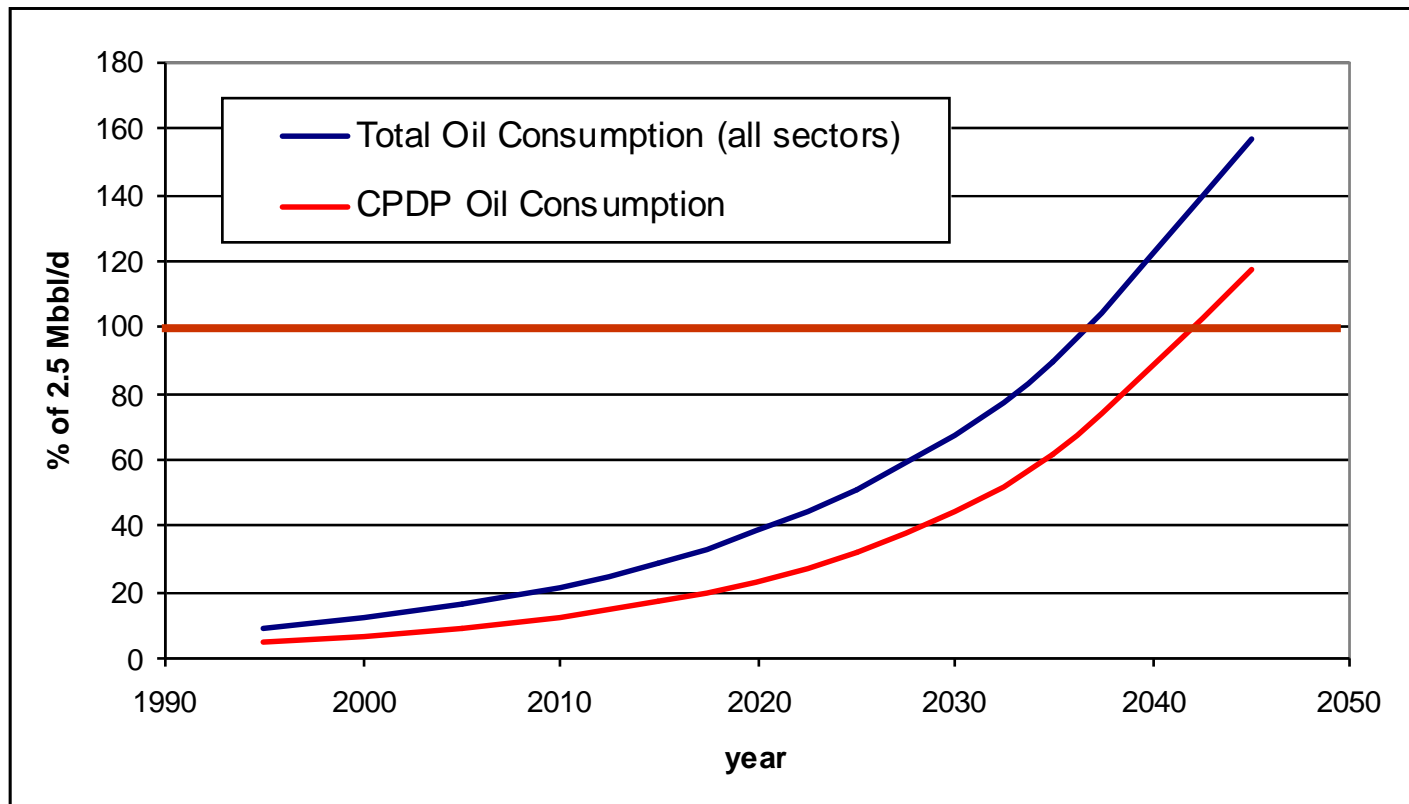


Source: Economist Intelligence unit, 2010

**>50% Cogeneration Power Desalination Plants (CDPD)**

## ■ Darwish, *et al.* (2010)

- In Kuwait, if the fuel oil production is kept at 2.5 Mbbbl/d (912.5 Mbbbl/y), all oil production (the country main income) will be consumed locally by the year 2035!





# Wastewater Management

- Increasingly significant water sources driven by escalating urban water consumption
- Became available in the early 1980s (wastewater treatment facilities and networks completion in large cities)
- Rate of wastewater collection is lagging far behind water supply service (20-40%), with relatively large areas covered by on-site sanitation facilities
- Designed treatment capacity is less than produced wastewaters:
  - Pollution of Shallow aquifers
  - Shallow water table rise in residential areas (e.g., Riyadh, Kuwait, Doha)
  - Pollution of coastal and marine environments (frequent fish kill)

## Fish Kill

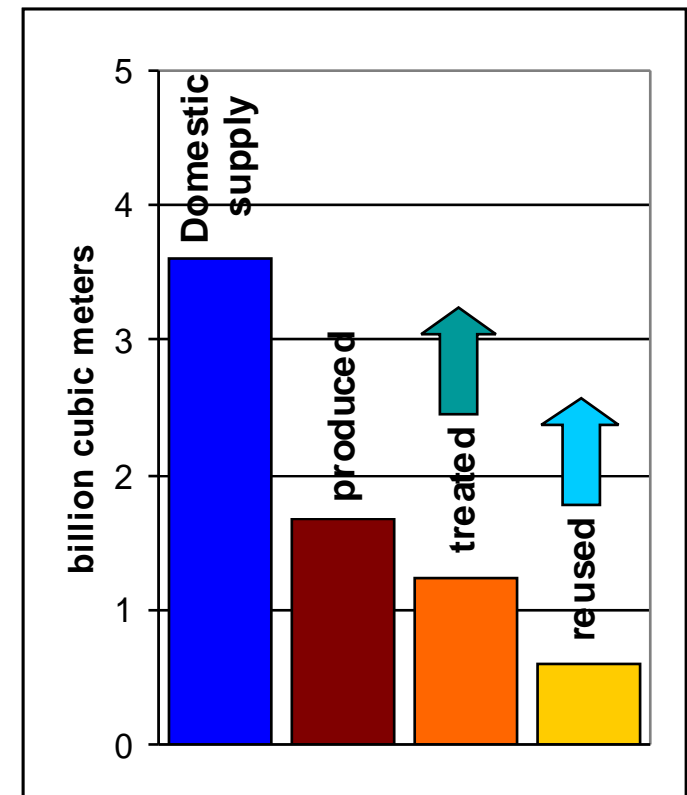


# e.g., Wastewater Problem in Bahrain (and many GCC)



- Almost all countries operating modern treatment facilities with tertiary and advanced treatment
- TSE represents about 46% of the total domestic water volumes
- Reused TSE <16.5% of available domestic water supply, about 47% of treated wastewater
- Reuse in irrigating urban gardens, parks, fodder crops, and highway landscaping

### Treatment and Reuse of wastewater in GCC (2005)



# Urban Water Management in GCC

- Addressing urban water problems from the **supply side**
- Very few efforts in demand management
- Fragmented, uncoordinated **sectoral** development and planning (i.e., between Water Supply, Sanitation, Reuse, ...)
- The current situation of water supply and sanitation is **unsustainable**, and requires strong management interventions and measures
- An **integrated approach** in the planning & management of urban water is urgently needed

# Urban Water Management System in GCC

## Downward Spiral Situation



**NO EXISTENCE  
OF MAJOR**

**COUNTER-FORCES!**

Supply a  
policies (

Increa:  
consumptio

Increasing costs  
(production & transmission)

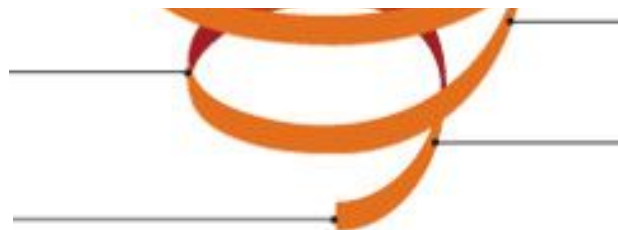
Increasing wastewater  
carryover volumes

ulation

dies, no  
mechanism

age  
rates (UfW)

Inadequate awareness  
(public assumption of  
plentiful of water)



# GCC Sustainable Urban Water Management

- **To supply water to users sectors in**

- Adequate Quantity
- Required Quality

- **With minimum cost**

- Financially and Economically
- Socially and Environmentally

- **With maximum societal benefits**

- Maximizing added value of use
- Contribute to overall national development (e.g., country Vision)

- **On long-term basis (future generations, not only for current!)**

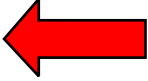
**WR Management  
Objective  
Function**



**Constraints  
and  
conditions**



**Dynamic,  
(things change  
over time and are  
non-linear!)**



---

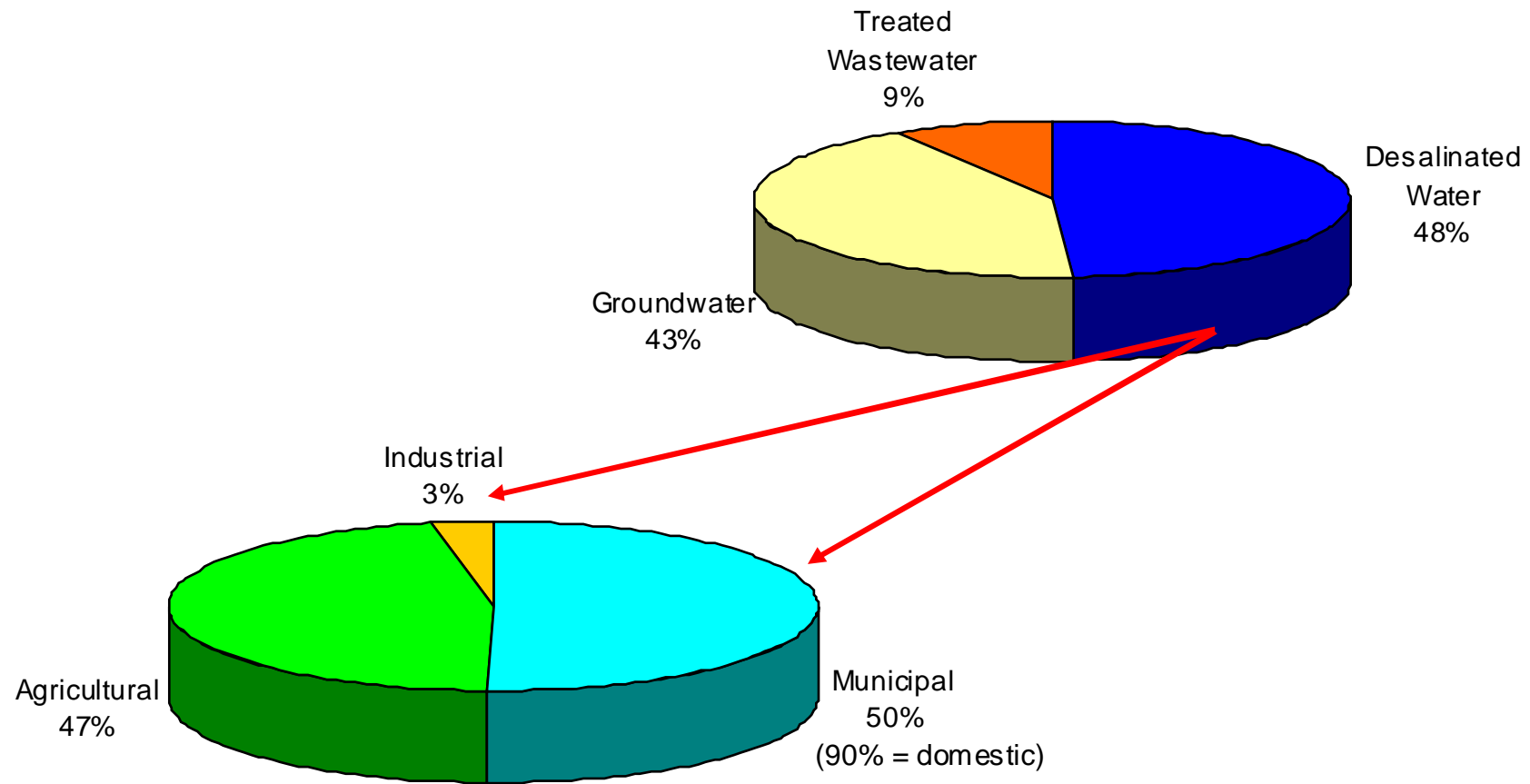
**Case Study**  
**Kuwait Municipal Sector**  
**Sustainable Management Model**  
**(Eidan and Zubari, 2010)**

# Kuwait Municipal Sector Management Model

- **Problem Statement:** dominance of sectoral urban water planning leading to inefficient management levels:
  - ❑ **Escalating water demands**, non-proportional to population growth
  - ❑ Increasing financial and economic **costs**
  - ❑ High frequency of water supply **shortages**
  - ❑ High negative **environmental impacts** (emissions, untreated/partially treated wastewater discharge into the coastal and marine environment, shallow water table rise, etc..)
- **Objective:** develop an **integrated planning and dynamic model** to assess the sustainability of urban water management and evaluate the effectiveness of a number of proposed management alternatives



## Water Resources and Use in Kuwait



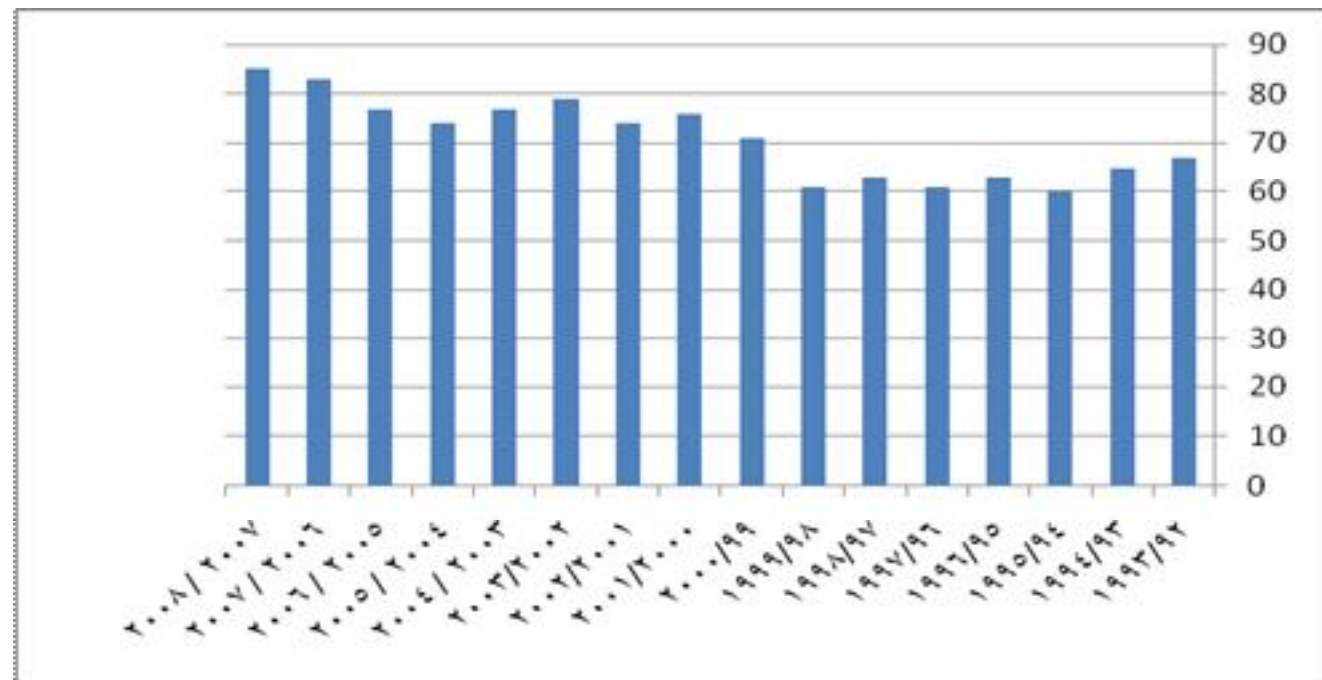
## Main Water Issues

- **Weak Institutional Framework:** absence of national water authority/Apex body to formulate comprehensive and integrated policies and coordinate between various water agencies
- **Escalating increase rates in municipal water demands exceeding state capabilities in matching the same rates:** demand increase from 226 Mm<sup>3</sup> in 1993 to 544 Mm<sup>3</sup> in 2006
- **Rapid population growth:** 5.5% (last 10 years)
- **High per capita water consumption:** >450 L/d
- **Low levels of treated wastewater reuse:** 20%

## Cont., Main Water Issues

- **High financial burden on national budget:**
  - Desalination plants construction and operation
  - Total water subsidies increased from 287 million to 1000 million US\$ in the period from 1992/93 to 2007/08
- **Low cost recovery: 8.4% in 2003, 6% in 2007**

% of  
subsidies for  
desalinated  
water (source:  
Kuwait Ministry  
of Planning)

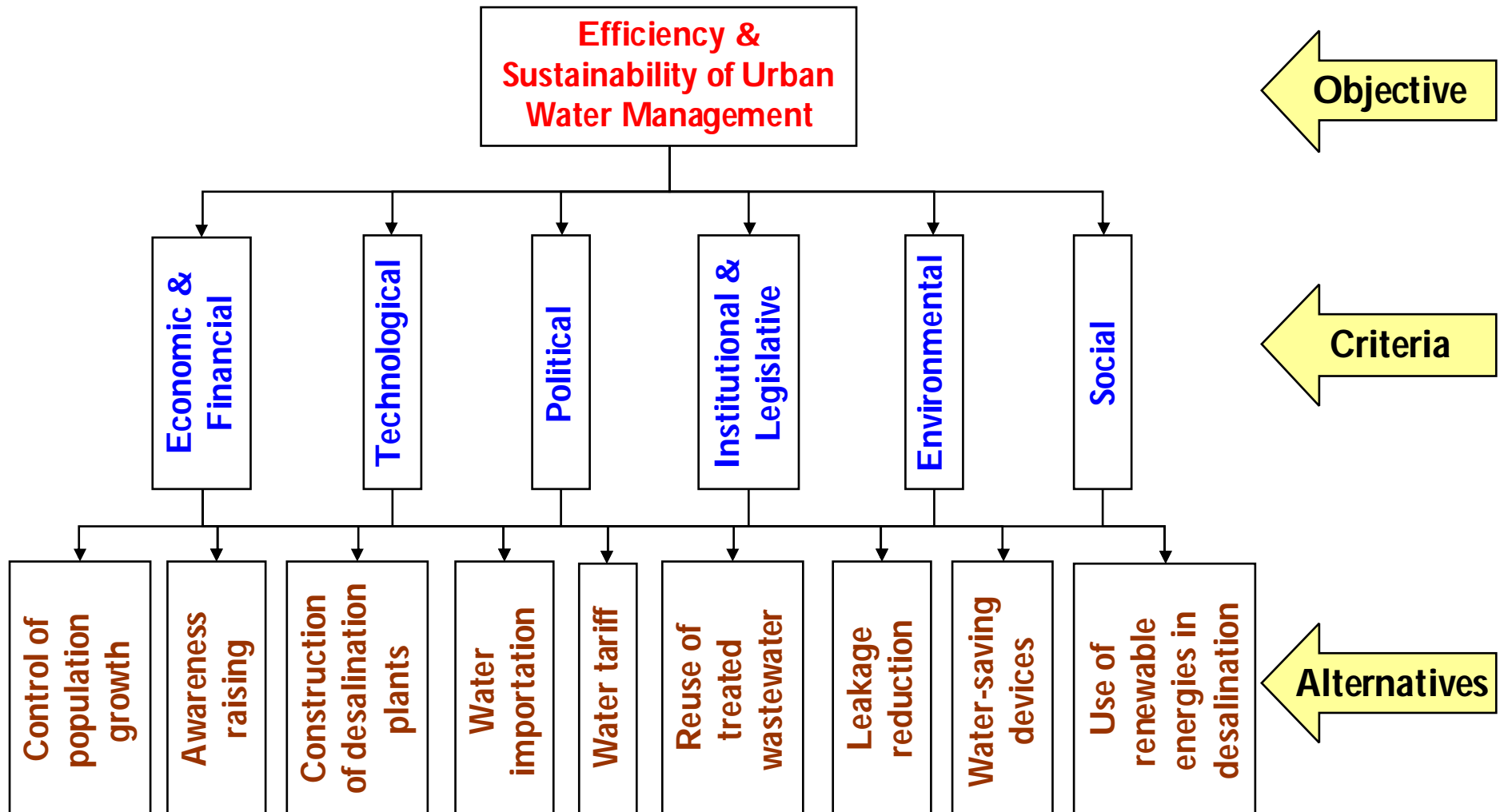


## ■ **Methodology**

- ❑ Evaluation of the current level of urban water management, indirect and direct driving forces, impacts, and response (IEA: **DPSIR**)
- ❑ Assessment and analyses of the “**sustainability**” of current water policies (IEA: **Policy Analysis**)
  - **Sustainability definition:** provision of water supply with minimum economic costs & environmental impacts
- ❑ Defining the most appropriate management interventions in urban water management
  - Multi-Criteria Decision Analysis (**AHP; Focus Group**)
- ❑ Development of **dynamic model** to evaluate the effectiveness of each proposed alternative
- ❑ Propose the most effective **management interventions** for the sustainability of urban water

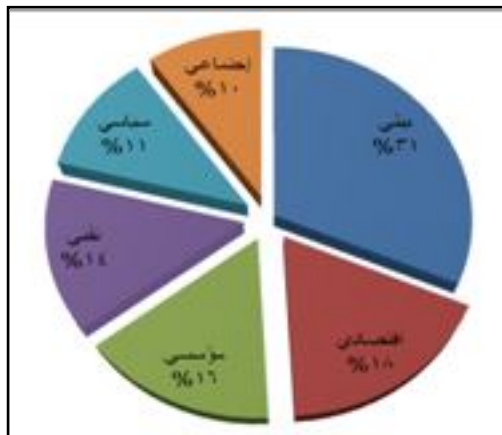
## ■ Results

- Analytical Hierarchy Process (AHP)



■ **Cont., Results (AHP)**

Criteria	Weight
Environmental	31%
Economical & Financial	18%
Institutional & Legislative	16%
Technological	14%
Political	11%
Social	10%

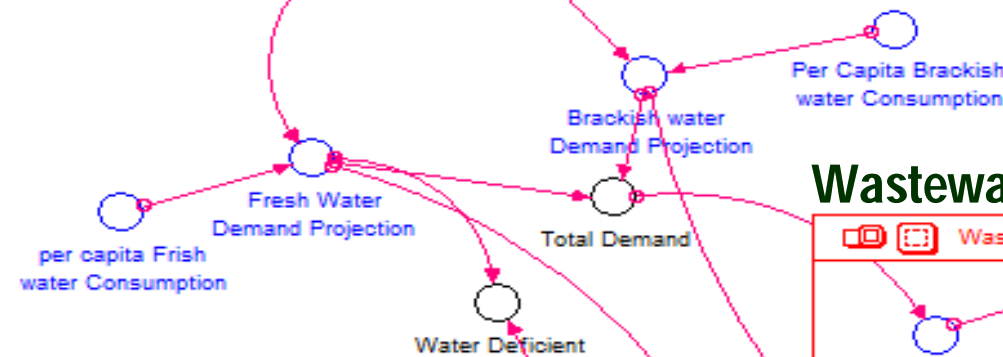
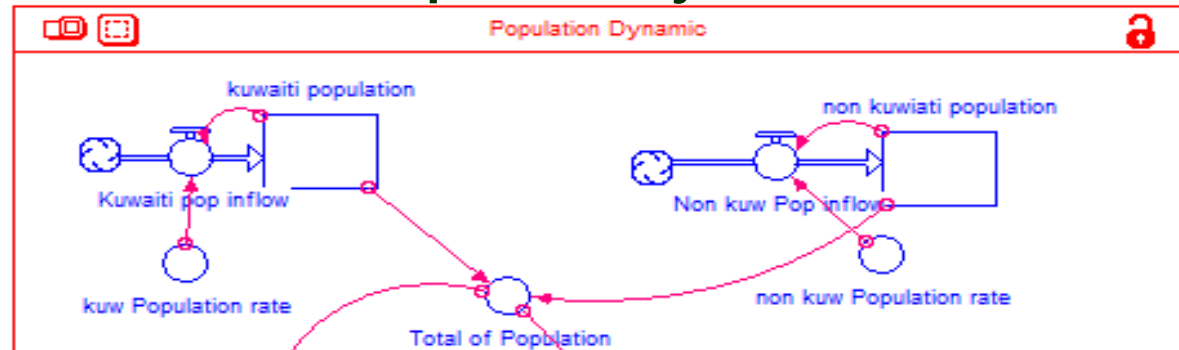


Rank	Alternative	Score
1	<b>Awareness raising</b>	444
2	Reuse of Treated wastewater	417
3	<b>Water-saving devices</b>	411
4	<b>Leakage reduction</b>	402
5	renewable energies in desal.	395
6	Water Tariff	380
7	Construction of desal. plants	373
8	Control of population growth	341
9	Water importation	340

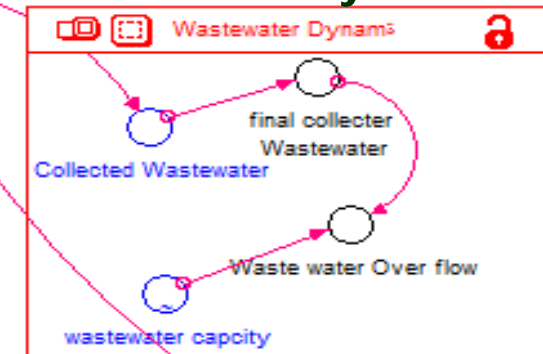
# Developed Urban Water Management Model

**Reference  
Management  
Model for  
Municipal  
Water Sector  
in Kuwait  
(current  
situation)**

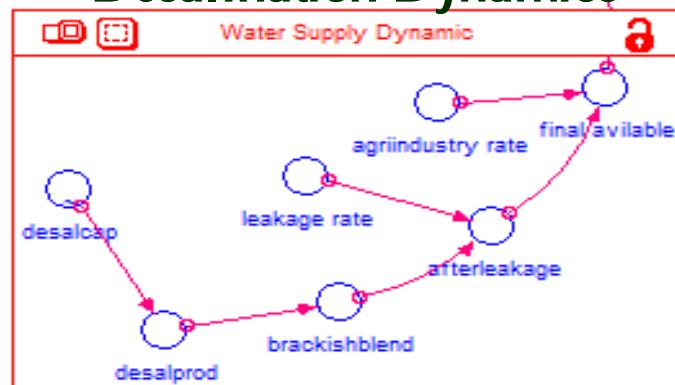
## Population Dynamics



## Wastewater Dynamics



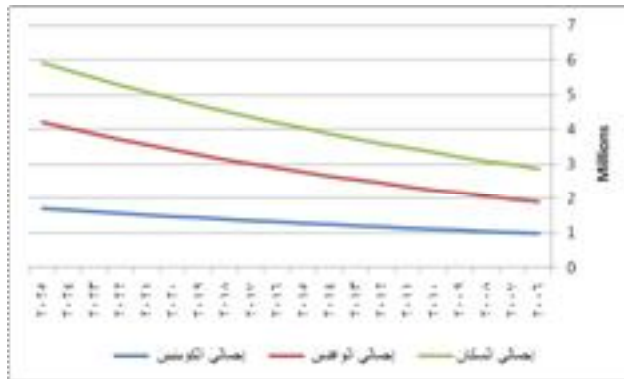
## Desalination Dynamics



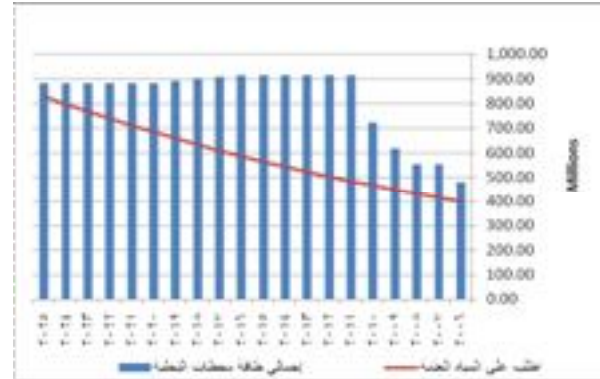
**Cost**

## Results of Reference Management Model (2025)

**Kuwaiti and non-Kuwaiti Population**



**Demands and planned Desalination Capacity**



**Max Monthly consumption & Desalination Capacity**



**Cumulative Cost of Water Production**



**CO<sub>2</sub> Emission from Desalination Plants**



**Collected wastewater & planned treatment capacity**





# Evaluation of Effectiveness of Management Alternatives

Population Dynamics

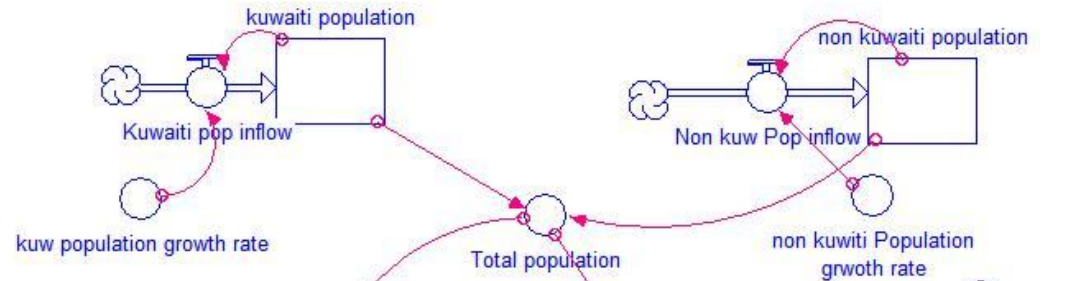
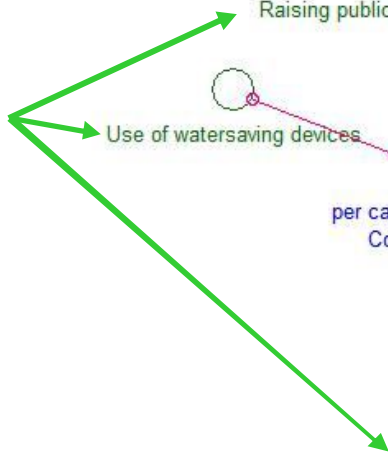


Table 1

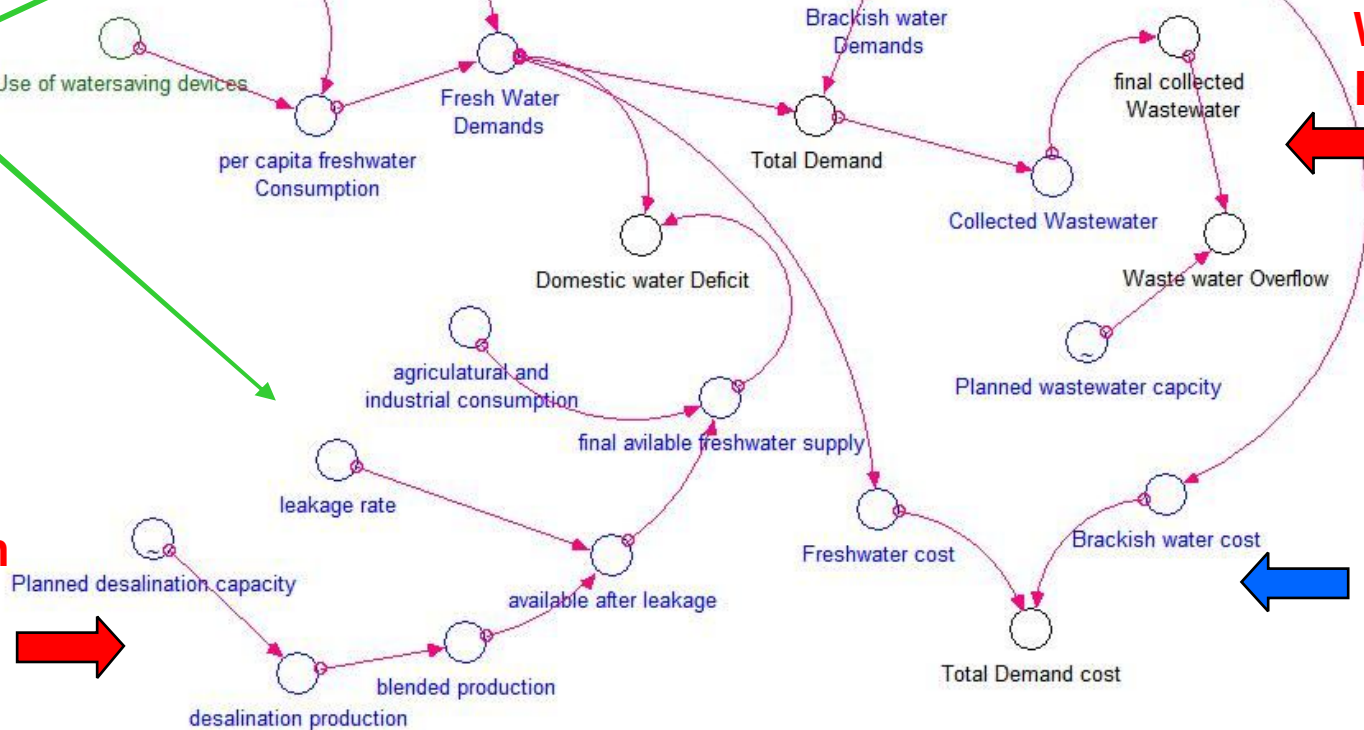


Table 2

Management Alternatives



Wastewater Dynamics



Cost

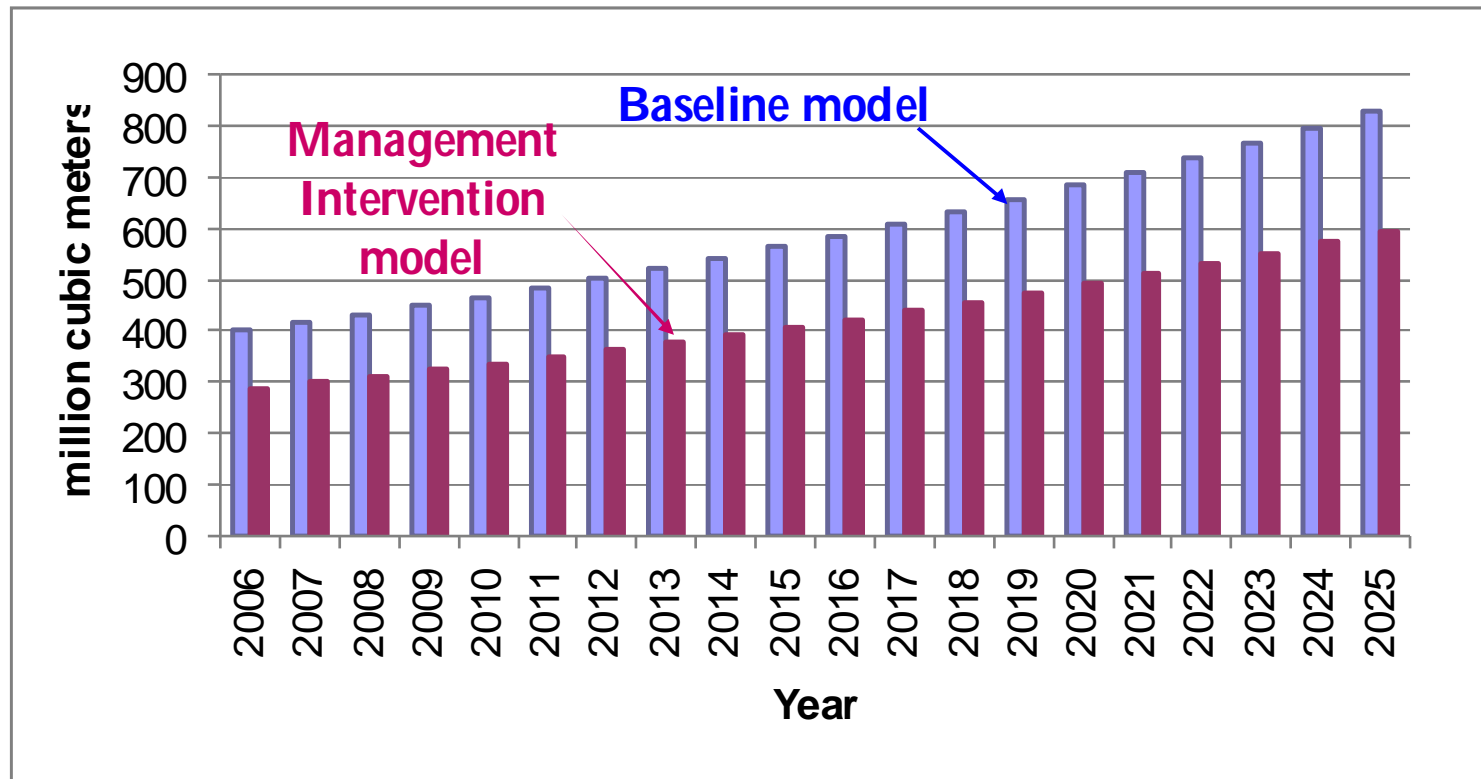


Desalination Production Dynamics



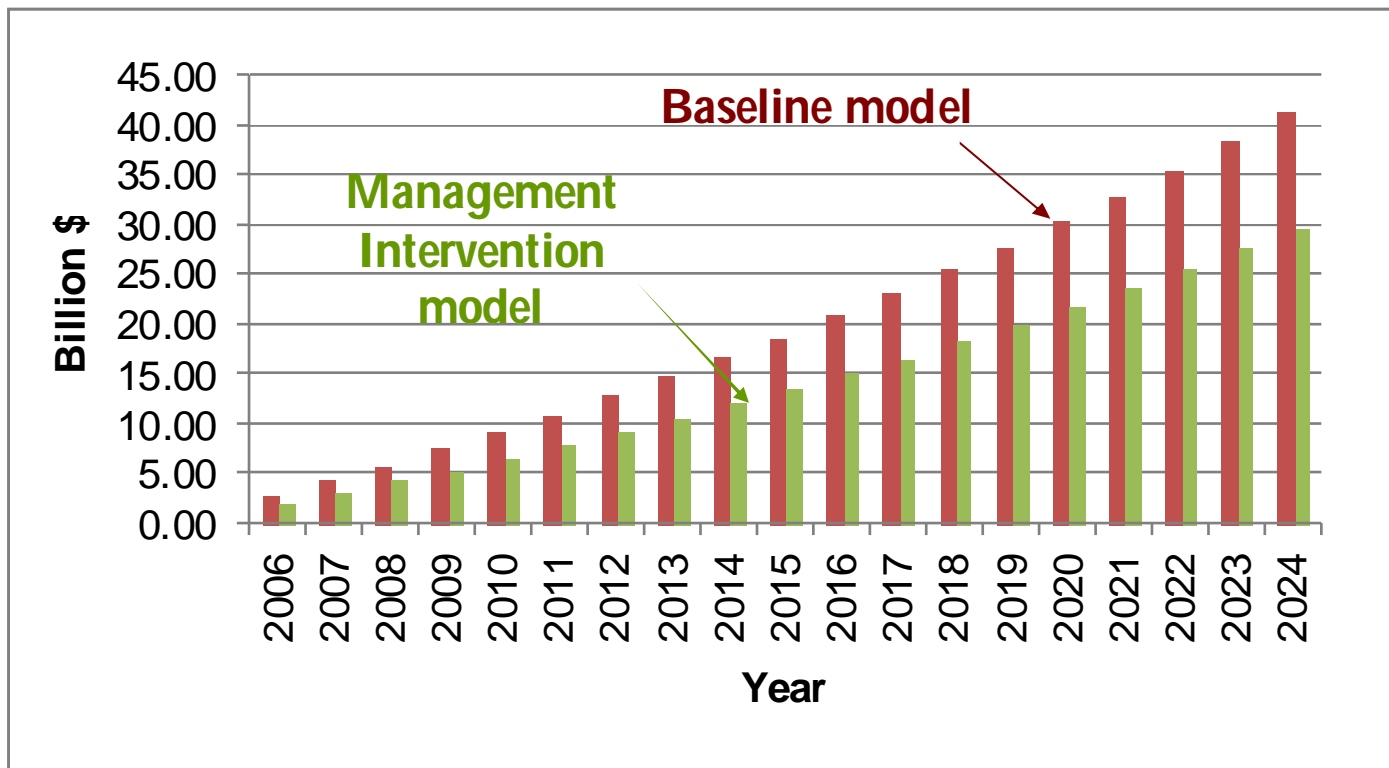
## ■ Modeling Results

- **Water Demands: reduction of demand by 28% by the year 2020 (from 683 Mm<sup>3</sup> to 490 Mm<sup>3</sup>)**



- **Cont., Modeling Results**

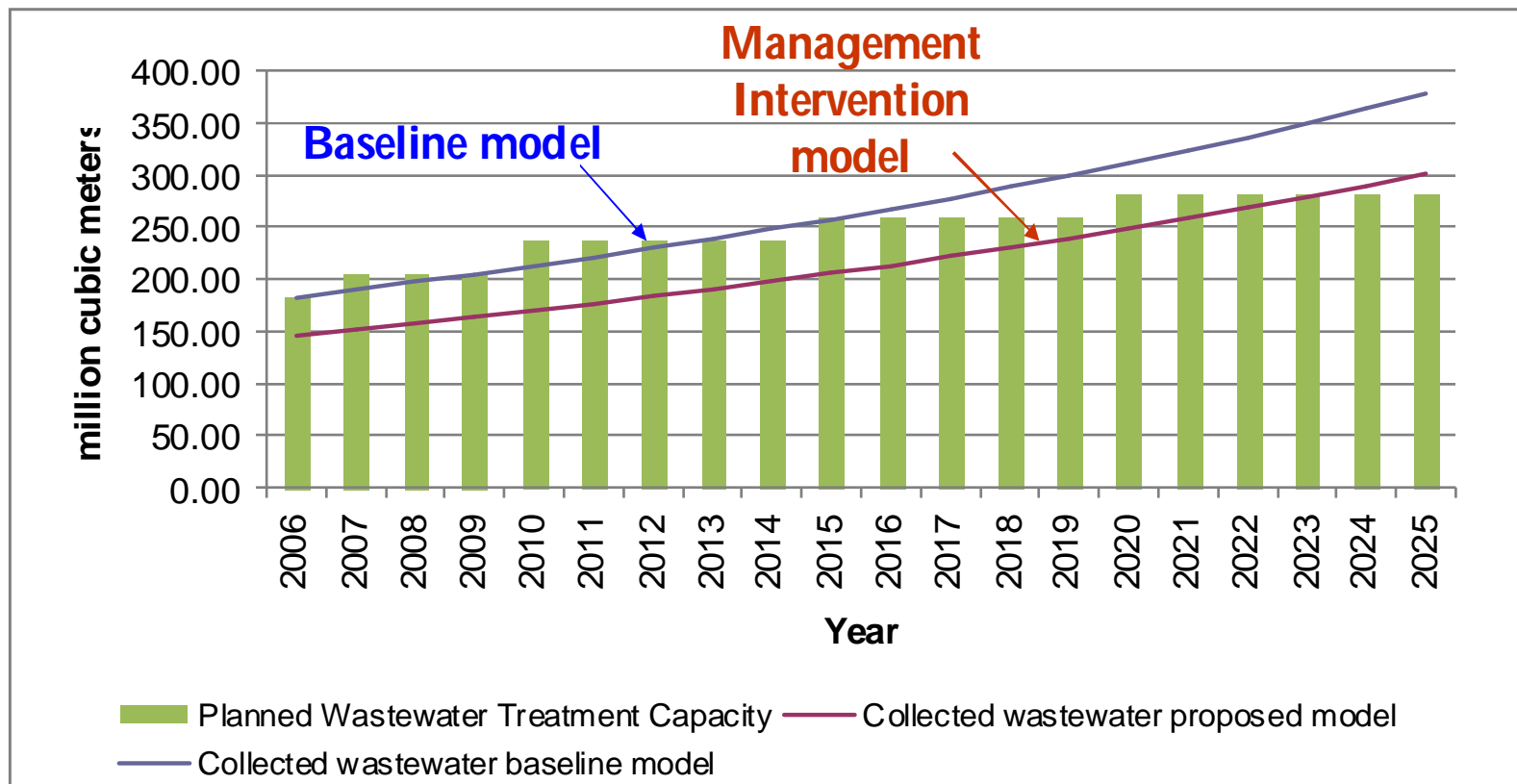
- **Water Cost: reduction of cumulative total cost by 8 billion US\$ by 2020**



- **Cont., Modeling Results**

- **Collected Wastewater**

- **Reduction in generated wastewater quantities by 20% by 2020**
- **Delay in current carryover by about 15 years**



# Conclusion & Recommendations

- GCC countries are experiencing an alarming increase in urban water demands (due to rapid population growth, high percentage of UFW, and unsustainable consumption patterns)
- The current situation of urban water supply and sanitation is “**unsustainable**” (over-stretched, high financial and environmental costs)
- The situation requires strong management interventions and measures, and need to be addressed from the demand side, coupled with water use efficiency and conservation
- An integrated approach in the planning & management of urban water is urgently needed
- Energy-Water Nexus and energy value-chain in urban water sector need to be addressed and researched

---

**Thank  
You!**