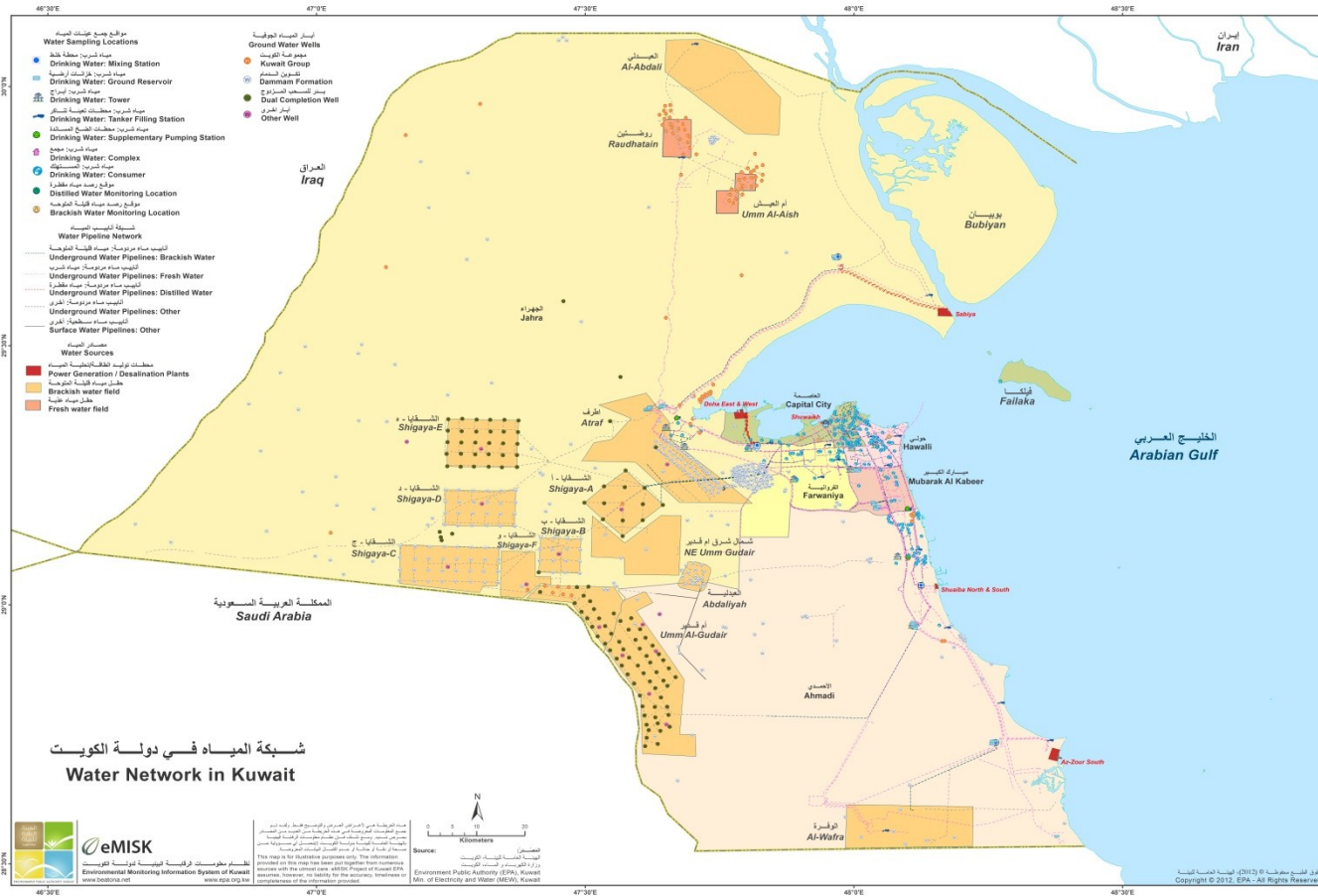


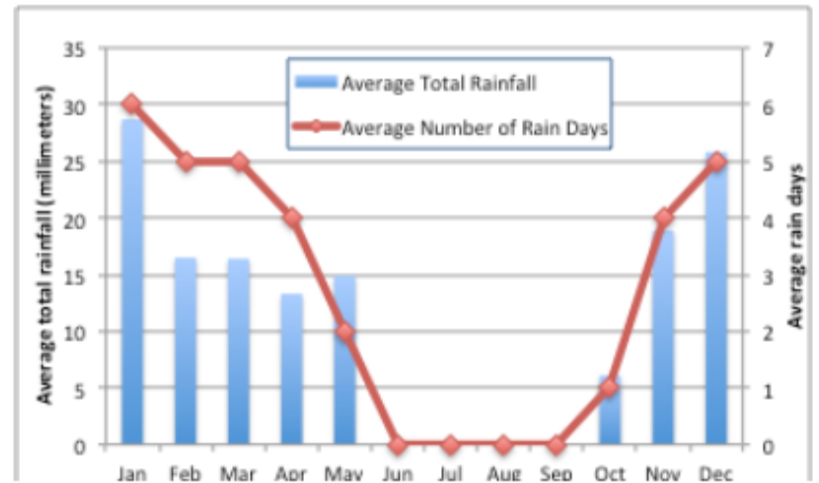
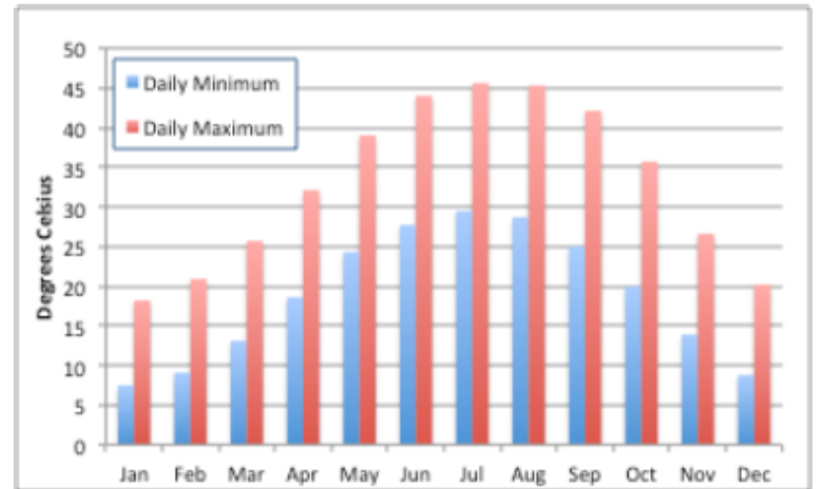
## Impacts of Climate Change on Sea Level Rise and Water Resources Management in Kuwait



# Climate

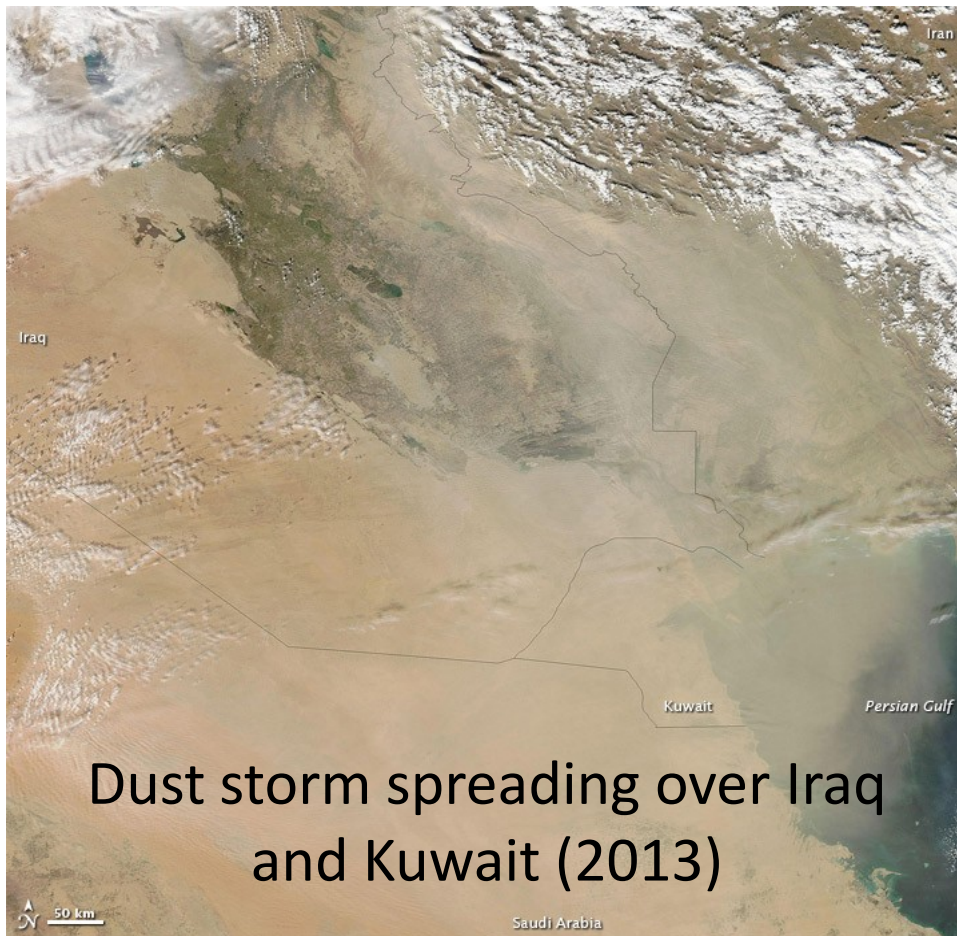
- Kuwait has a hyper-arid desert climate, very hot and dry.
- Average rainfall typically varies from 75 to 150 mm/y.
- Average daily high temperatures range from 42°C to 46°C.
- Maximum daily temperature may reach above 50 °C in July and August.

Figure 1-5: Kuwait average monthly temperature and rainfall, 1962-2008 (source: Kuwait Meteorology Department)



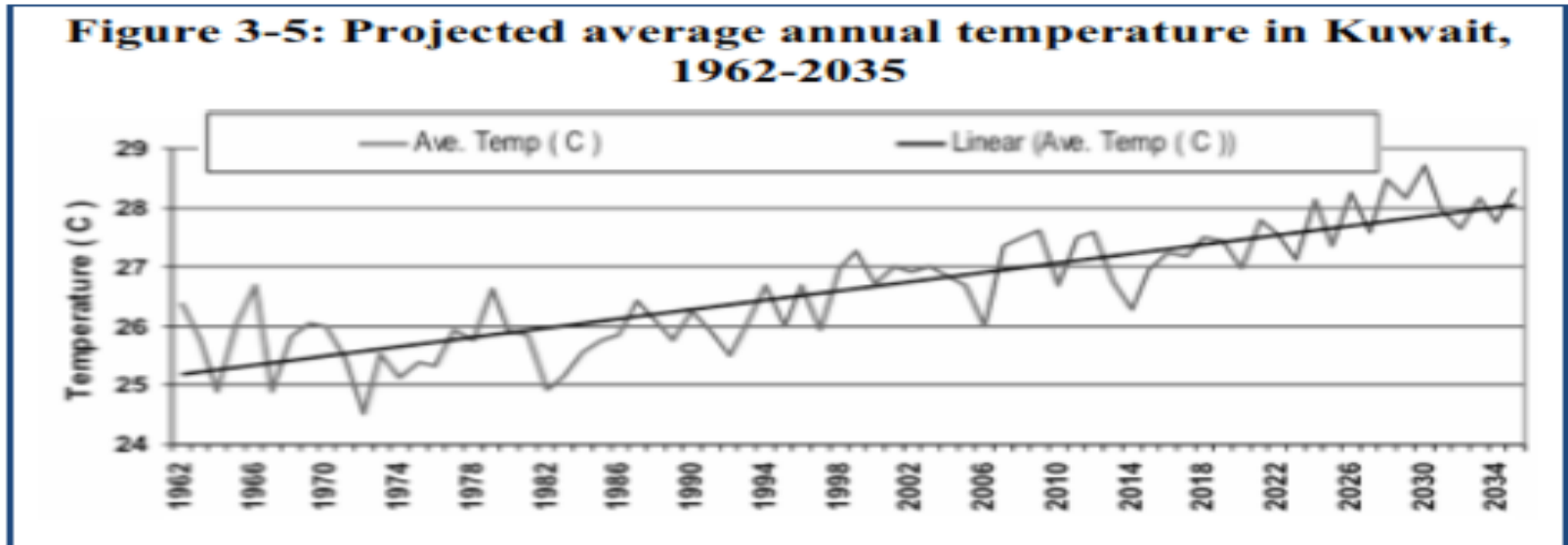
# Climate

- Dust storms are particularly frequent during spring and summer
- More than 100 days/year are dusty days
- PM10 concentration can reach above 6000  $\mu\text{g}/\text{m}^3$ )



Dust storm approaching Kuwait City on 25<sup>th</sup> March 2011

# Projected Increase in Temperature

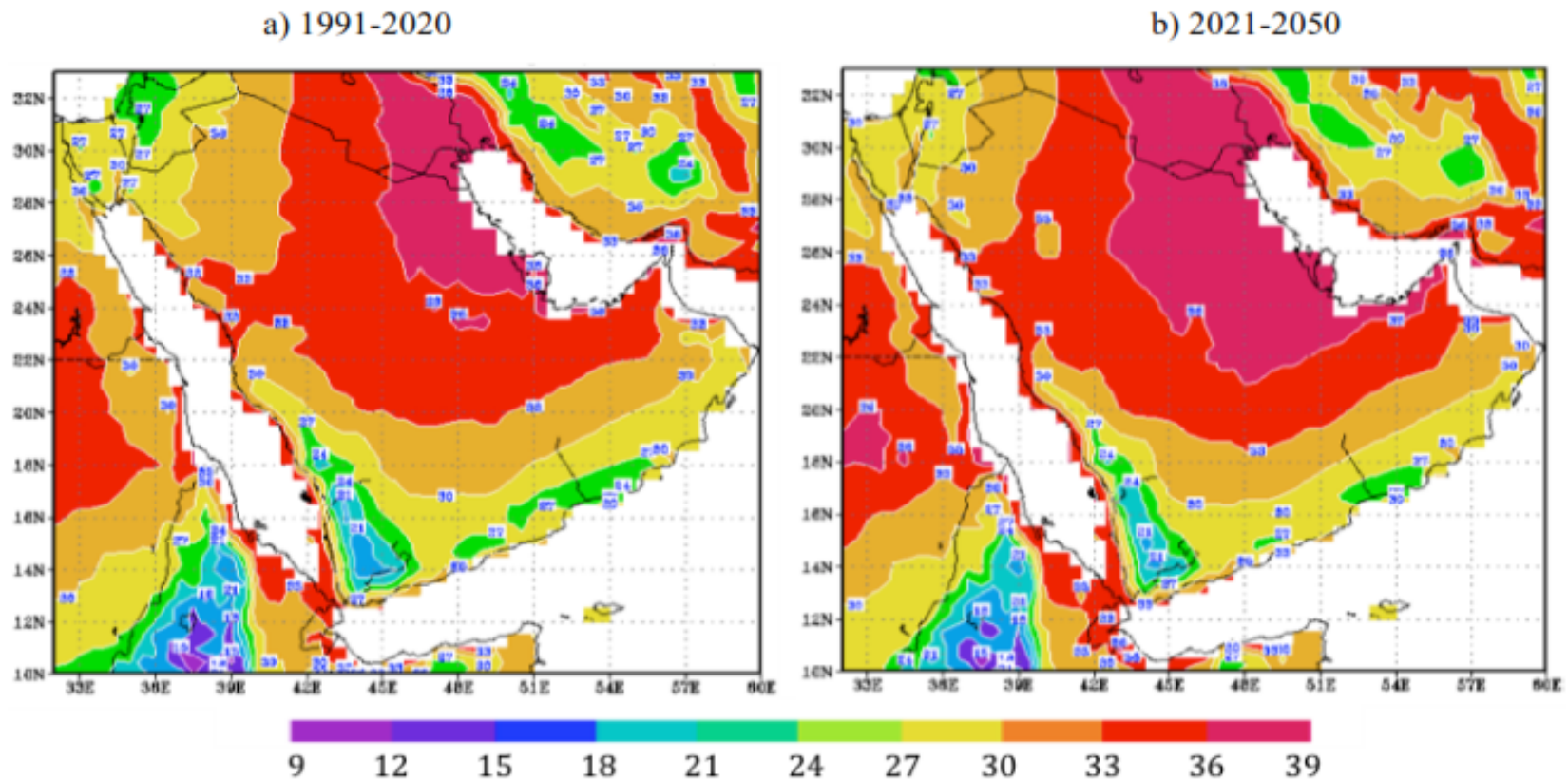


1. average annual temperatures will increase in the future with average annual temperatures projected to reach a high of about 28.7°C in Kuwait during the 2010-2035 period.
2. This represents about a 1.6°C increase over the average annual temperature of the past decades.
3. Temperatures in Kuwait are expected to rise about 0.4°C per decade over the coming years.

# Projected Increase in Temperature

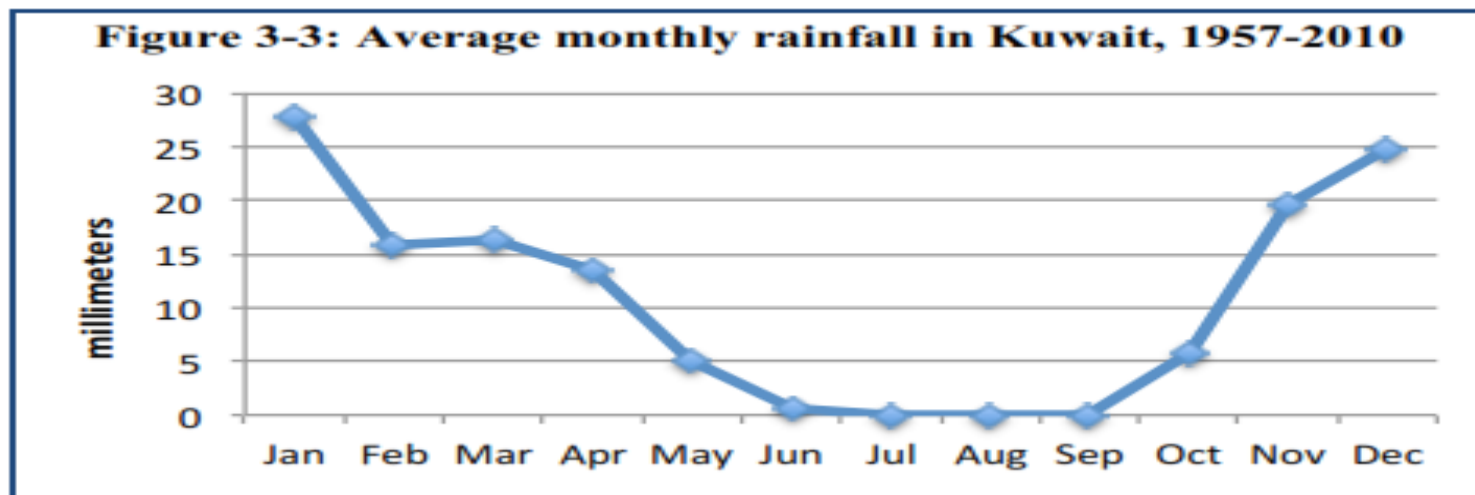
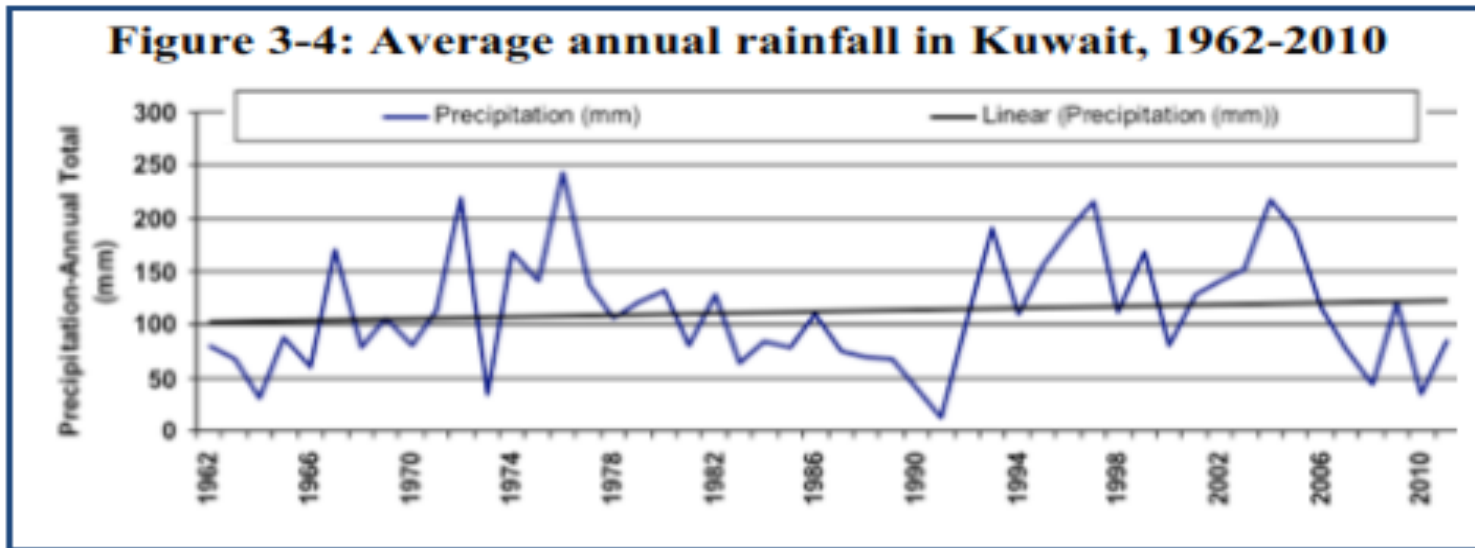
- Modeling results show that the Arabian Peninsula is projected to experience a gradual enlargement of the land area where Kuwait's July-like temperatures (i.e., greater than  $36^{\circ}\text{C}$ ) can be found.

Figure 3-6: HadCM3 projected mean temperature in July at 2 meters above ground level



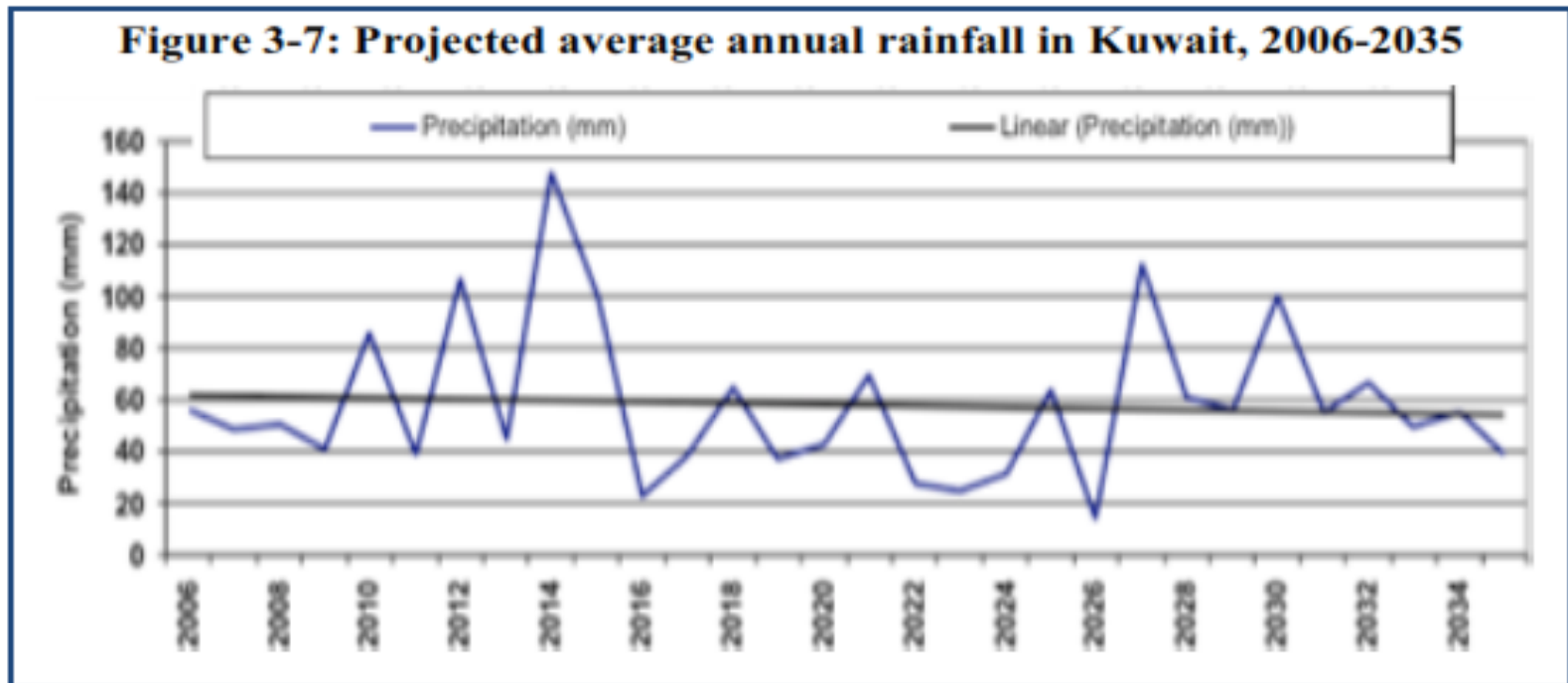
# Rainfall

- The average annual rainfall in Kuwait is about 116 mm per year.
- On a monthly basis, rainfall is concentrated in the winter and spring months



# Projected Decrease in Rainfall

1. Average annual rainfall levels are projected to be consistently below 70 mm per year over the 2016-2026 period,
2. Over 60 mm per year lower than the historical average.
3. A potentially serious adverse impact to grazing areas.
4. Possibility for increased dust storms



# Coastal Zones in Kuwait

## Physical Features :

Table 3-1: Key features of Kuwait's shoreline

Sediment type	Coastline share	Key features
Soft mud tidal flats	57%	Found on Kuwait Bay, the Khiran area, Al-Subiya tidal channel and around Bubiyan Island
Sandy beaches underlain by rock	17%	Found south of Kuwait Bay from Ras Al Ardh to Ras Az-Zor; high wave energy; currents flow from south to north
sandy-rocky tidal flat	9%	Found in western part of southern coast of Kuwait Bay, along the southern coast of Bubiyan Island and in Ras Al-Subiya; nursing area for shrimp and fish
Coral reefs	9%	Found off the southern islands
Artificial sandy beaches	5%	Reclaimed tidal flat land around Kuwait City for recreational purposes
Oolitic limestone beaches/cliffs	3%	Found along southern coast; cliffs are 2-8 meters in height and separated from the sea by narrow beaches bound seaward by 700 m of wide rock tidal flats, partly covered with coarse sand





# Coastal Zones in Kuwait

- 350 km of coastline.
- Most of Kuwait's urban areas lie within 20 km of the coast.
- is the region where most of the critical infrastructure is located (commercial buildings, port facilities, oil industries, road networks, and recreational facilities).



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المصدر: مركبة من صور القمر الصناعي الفرنسي سبوت فيو أرتشيو (2010)، في حين أن الخلفيات شائعة  
من صور القمر الصناعي الأمريكي لاندسات (2006)، حيث تم تصحيح الصور عن الأخطاء بتدرجات من اللون  
الأخضر، وهي تقيس العمق من اللون الأزرق، شدة الانعكاسية المرئية من اللون الأصفر إلى البرتقالي، وتمثل  
من خطوط طول وخطوط العرض، النظام الجغرافي العالمي (WGS84 Datum).  
المصدر: نظام معلومات لولاية الكويت - هيئة العامة للبيئة - دولة الكويت (2010)  
Mosaic of Satellite Images from SPOTView Ortho (2010) and LANDSAT (2006) Color Composite,  
where significant vegetation is represented in shades of green color and depth of water is shown  
in shades of blue. Ticks in Black represent Geographic Coordinates System (WGS84 Datum).  
Source : eMISK, EPA - 2010



# Impacts on Coastal Zones

- Climate change-induced sea level rise could lead to serious adverse impacts on future socioeconomic development.
- Rising sea level is projected to flood low-lying urban infrastructure,
- Threaten coastal lagoons and salt marshes,
- Contribute to the deterioration of groundwater quality.

صور القمر الصناعي لدولة الكويت  
Satellite Image of The State of Kuwait

المصدر: مركبة من صور القمر الصناعي الفرنسي سبيوت فيو أرتزو (2010)، في حين أن الخلفيات الملوحة من صور القمر الصناعي الأمريكي لاندسات (2006) حيث تم تصحيح الصور عن الأخطاء بتواريخ من اللون الأحمر، وهي على العمق من ارتفاع من اللون الأزرق، شبكة الإحداثيات الجغرافية العالمية (WGS84 Datum) من خطوط الطول وخطوط العرض، الإسناد الإقليمي، نظام الإحداثيات الجغرافية (WGS84 Datum).

المصدر: نظام معلومات الرقعة الجغرافية لدولة الكويت - هيئة المساحة لليبنة - دولة الكويت (2010)  
Mosaic of Satellite Images from SPOTView Ortho (2010) and LANDSAT (2006) Color Composite, where significant vegetation is represented in shades of green color and depth of water is shown in shades of blue.\_ticks in Black represent Geographic Coordinates System (WGS84 Datum).  
Source: eMISK, EPA - 2010



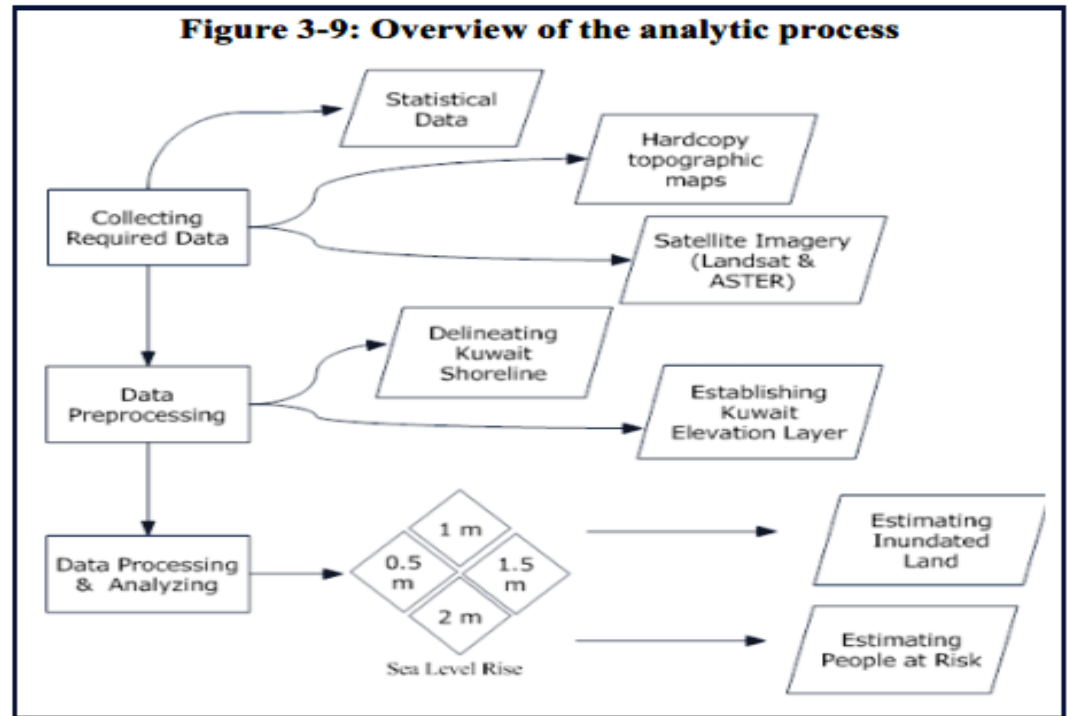
eMISK

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# Assessing Affected Coastal Zones from Sea Level Rise

- Statistical data of MHTL (baseline sea level)
- Topographic maps & Satellite images for shoreline delineating
- DEM
- 4 Scenarios of SLR (0.5, 1.0, 1.5 and 2 m).
- Population data



**Table 3-2: Scenarios evaluated in the coastal zone assessment**

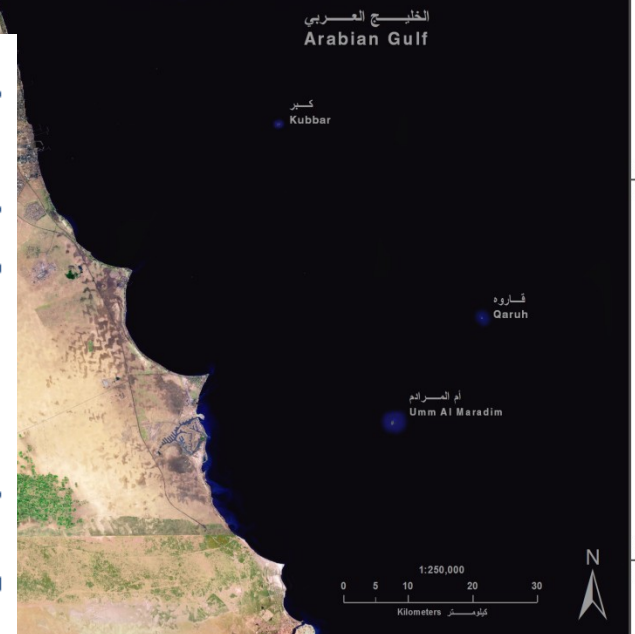
Scenario name	Baseline sea level	Assumed change in sea level due to climate change (meters)	Assumed future sea level (meters)
Low SLR	Mean High Tide Line (MHTL), based on historical average along Kuwaiti coastline	0.5	High tide + 0.5
Central-Low		1.0	High tide + 1.0
Central-High		1.5	High tide + 1.5
High SLR		2.0	High tide + 2.0

# Extent of inundated area and population at risk under the SLR scenarios



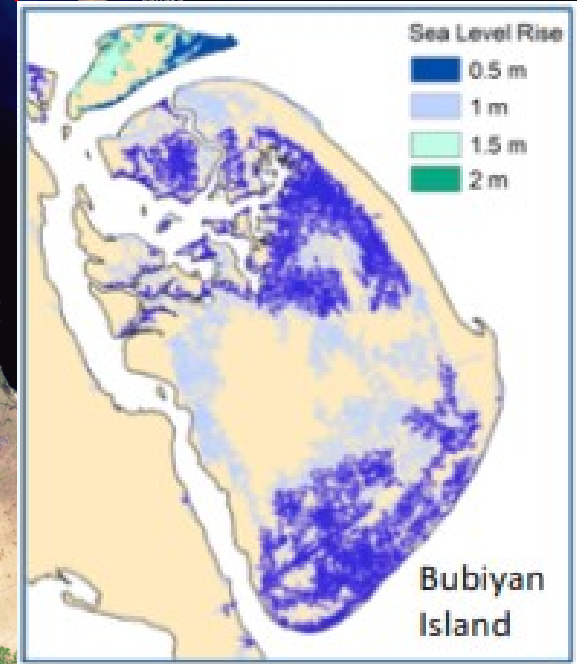
Sea level rise scenario

	Low (MHTL + 0.5 m)		Central-Low (MHTL + 1.0 m)		Central-high (MHTL + 1.5 m)		High (MHTL + 2.0 m)	
	Km <sup>2</sup>	% of total	Km <sup>2</sup>	% of total	Km <sup>2</sup>	% of total	Km <sup>2</sup>	% of total
<b>Coastal zone</b>								
Northern	199	1.1	408	2.3	416	2.3	419	2.4
Central	34	0.2	34	0.2	34	0.2	76	0.4
Southern	7	<0.1	7	<0.1	46	0.3	46	0.3
<b>Total inundation</b>	<b>241</b>	<b>1.4</b>	<b>450</b>	<b>2.5</b>	<b>496</b>	<b>2.8</b>	<b>542</b>	<b>3.0</b>
<b>People at risk (thousand)</b>	<b>65.1</b>	<b>1.8</b>	<b>65.1</b>	<b>1.8</b>	<b>125.8</b>	<b>3.5</b>	<b>173.7</b>	<b>4.8</b>



# Northern Zone

- Up to 419 km<sup>2</sup> of current land area would be inundated in the Northern zone.
- This corresponds to over 2.4 % of the total land area of Kuwait and nearly 80% of the inundated area in the highest SLR scenario.
- Nearly all of the inundation, about 97%, would take place from sea level rise of up to 1 meter.



Satellite Image of The State of Kuwait

المصدر: خريطة من صور القمر الصناعي الفرنسي سبيوت فيو أرتزو (2010)، في حين أن الخلفيات استمدت من صور القمر الصناعي الأمريكي لاندسات (2006) حيث تم تصحيح الصور عن الأخطاء بتدرجات من اللون الأحمر، وبنسبة على العمق من المياه من اللون الأزرق، شبكة الإحداثيات الجغرافية من نظام الإحداثيات الجغرافية (WGS84 Datum). من خطوط الطول وخطوط العرض، الإحداثيات الجغرافية من نظام الإحداثيات الجغرافية (WGS84 Datum). المصدر: نظام معلومات الرقابة البيئية لولاية الكويت - هيئة العامة للبيئة - دولة الكويت (2010)

Mosaic of Satellite Images from SPOTView Ortho (2010) and LANDSAT (2006) Color Composite, where significant vegetation is represented in shades of green color and depth of water is shown in shades of blue. Ticks in Black represent Geographic Coordinates System (WGS84 Datum). Source : eMISK, EPA - 2010

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# Central Zone

- up to 76 km<sup>2</sup> of current land area would be inundated in the Central zone. This
- corresponds to just under 0.5% of the total land area of Kuwait and just over 14% of the inundated area in the highest SLR scenario.
- almost all of this land is heavily populated and filled with commercial activities that contribute greatly to the Kuwaiti economy.



# Southern Zone

- Up to 46 km<sup>2</sup> of current land area would be inundated in the Southern zone.
- This corresponds to about 0.3% of the total land area of Kuwait and just below 9% of the inundated area in the highest SLR scenario



صور القمر الصناعي لدولة الكويت  
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الصور المركبة من صور القمر الصناعي الفرنسي سبوت فيو ايرث (2010) في حين ان الخلفيات مستقاة من صور القمر الصناعي الإسرائيلي لاندسات (2006) حيث تم تصحيح الصور عن التغيرات من اللون الأخضر، وعن عمق المياه بتدرجات من اللون الأزرق. شمسية الاحداثيات المبرءة تشمل جميع الاحداثيات الجغرافية من خطوط العرض و خطوط الممران، انشأتان بالقياس الى نظام الإحداثيات الجغرافية العالمي (WGS84 Datum). المصدر: نظام معلومات لرقابة البيئة لدولة الكويت - هيئة لمتابعة البيئة - دولة الكويت (2010)

Mosaic of Satellite Images from SPOTView Ortho (2010) and LANDSAT (2006) Color Composite, where significant vegetation is represented in shades of green color, and depth of water is shown in shades of blue. Ticks in Black represent Geographic Coordinates System (WGS84 Datum).

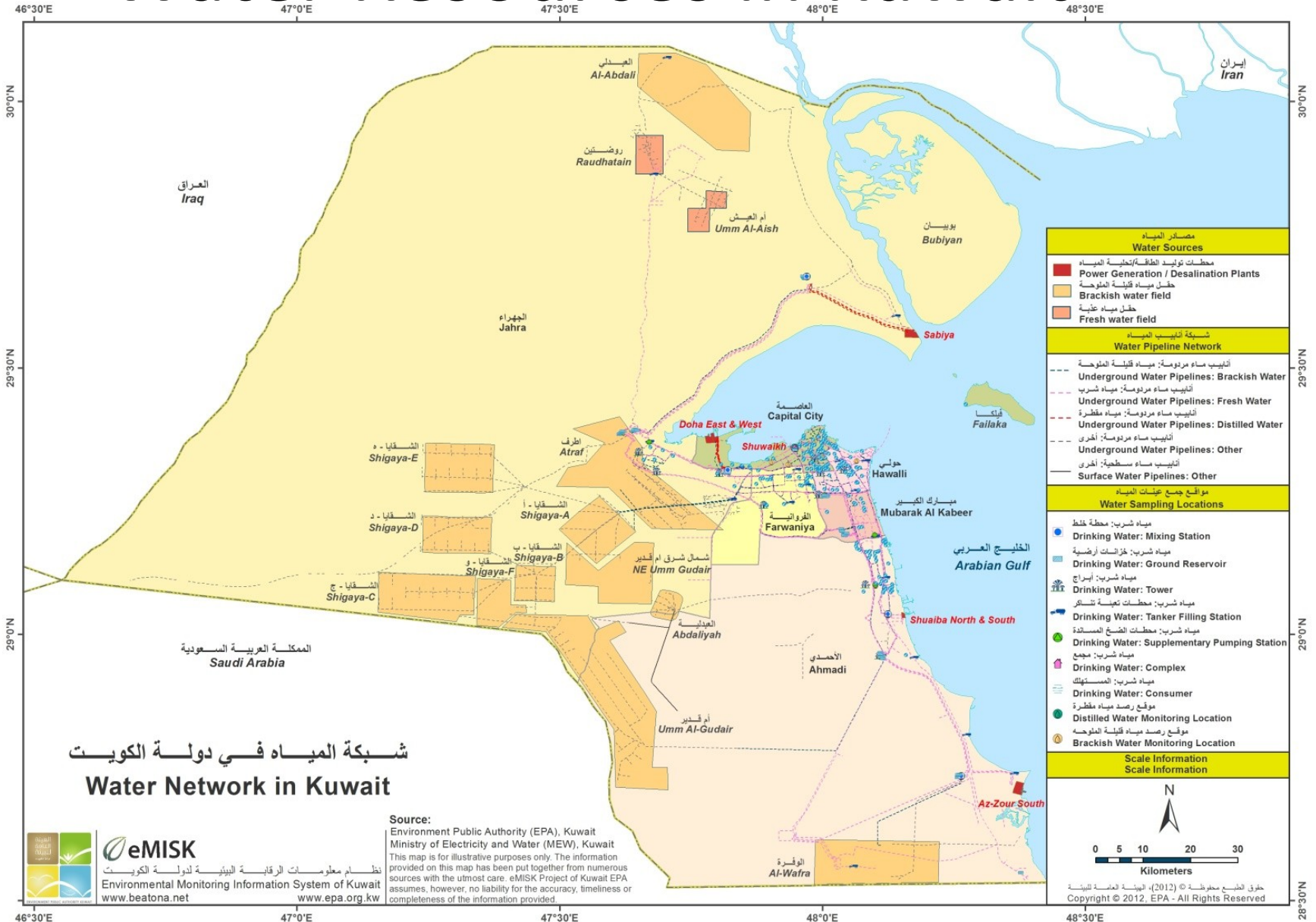
Source : eMISK, EPA - 2010

# Conclusions and Recommendations

- *Enhancing coastal information systems:*
  1. *Data collection and information development a prerequisites for coastal adaptation.*
  2. Enhanced information systems should include data and information on coastal characteristics and dynamics and patterns of human behavior,
  3. It is also essential that there be a general awareness among the public, coastal managers and decision makers.



# Water Resources in Kuwait



## شبكة المياه في دولة الكويت Water Network in Kuwait

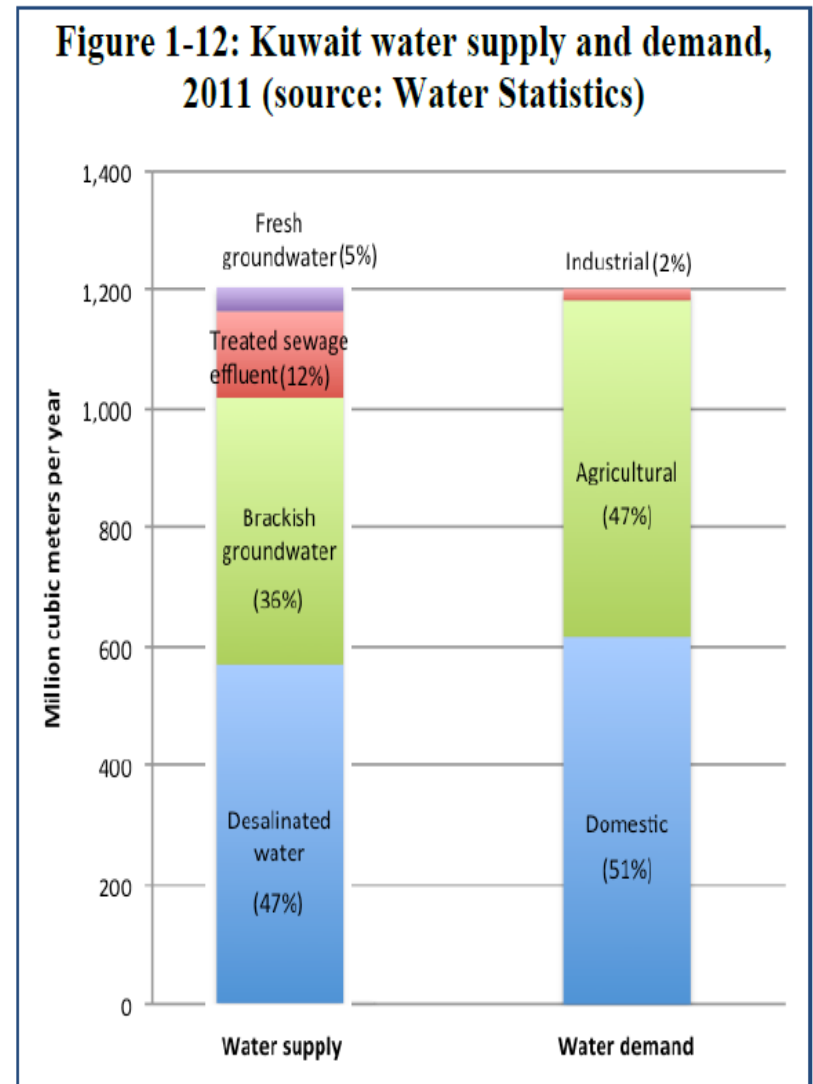
Source:  
Environment Public Authority (EPA), Kuwait  
Ministry of Electricity and Water (MEW), Kuwait  
This map is for illustrative purposes only. The information provided on this map has been put together from numerous sources with the utmost care. eMISK Project of Kuwait EPA assumes, however, no liability for the accuracy, timeliness or completeness of the information provided.



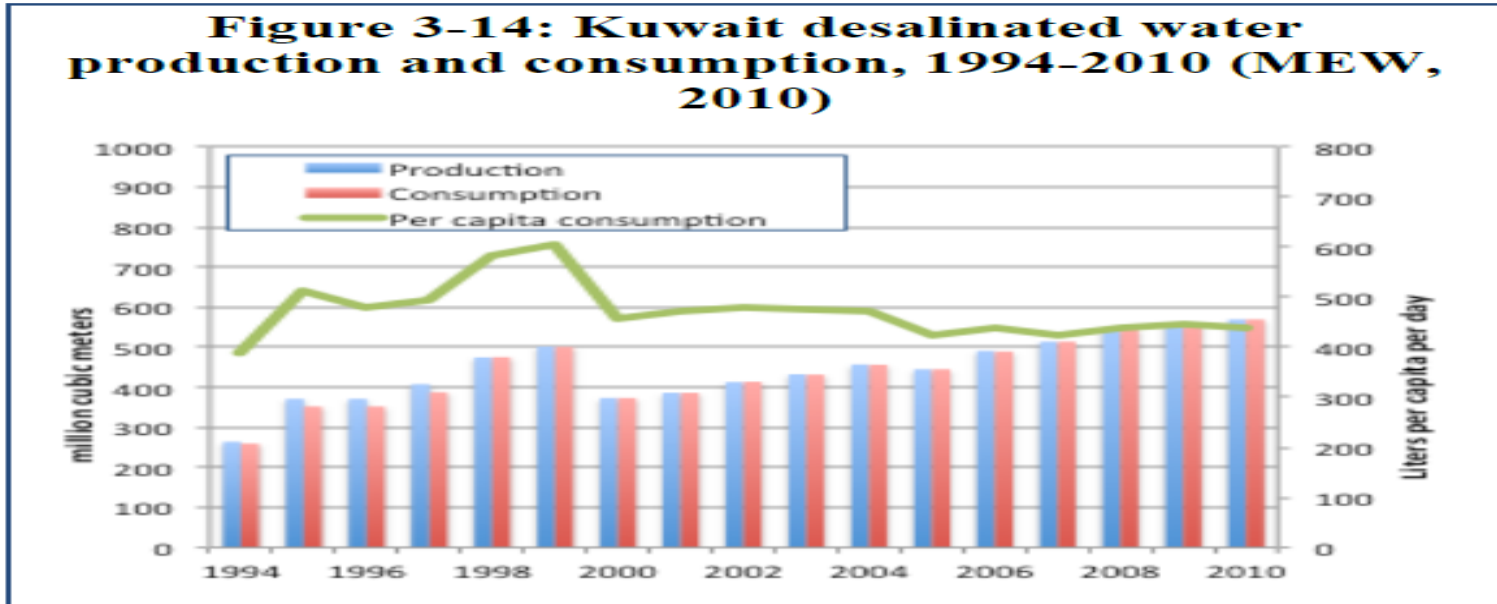
**eMISK**  
نظام معلومات الرقابة البيئية لدولة الكويت  
Environmental Monitoring Information System of Kuwait  
www.beatona.net  
www.epa.org.kw

# Water Resources in Kuwait

- Kuwait relies on desalinated water and fresh groundwater to meet drinking water needs.
- Brackish groundwater and treated wastewater are used in agriculture and industrial applications.
- Households and agriculture sectors dominate Kuwait's total water demand, with only a small share devoted to industrial applications.



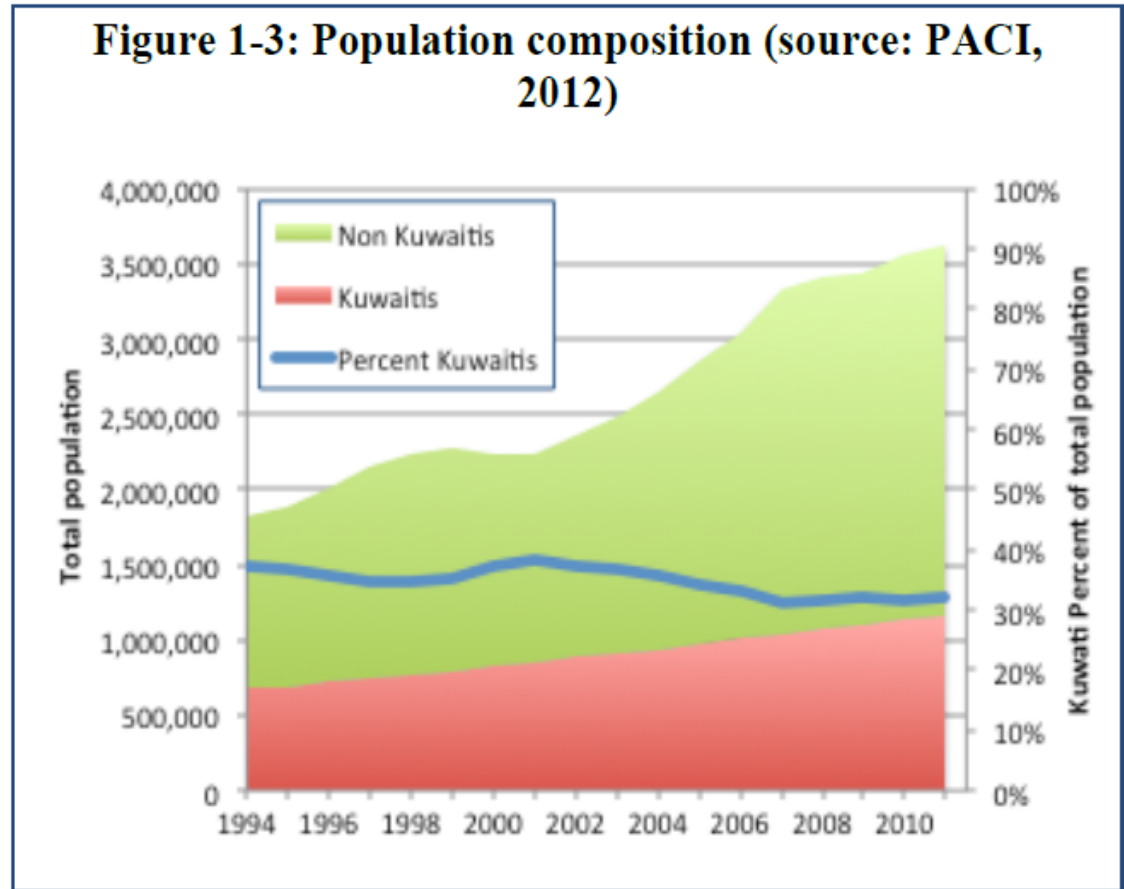
# Water Production & Consumption



- Total installed capacity for desalinated water supply is about 2.1 million cubic meters per day .
- Water consumption has been growing at an average annual rate of about 5.0% per year,
- On a per capita basis, there has been significant improvement in water use since 1999. In 2011, desalinated water use was about 429 liters per person per day, or nearly a 30% decrease from 1999 per capita consumption levels

# Impacts on Water Resources

In Kuwait, water is considered to be a precious resource that will become even more valuable as the population continues to grow and the climate becomes hotter and potentially drier.



# Impacts on Water Resources

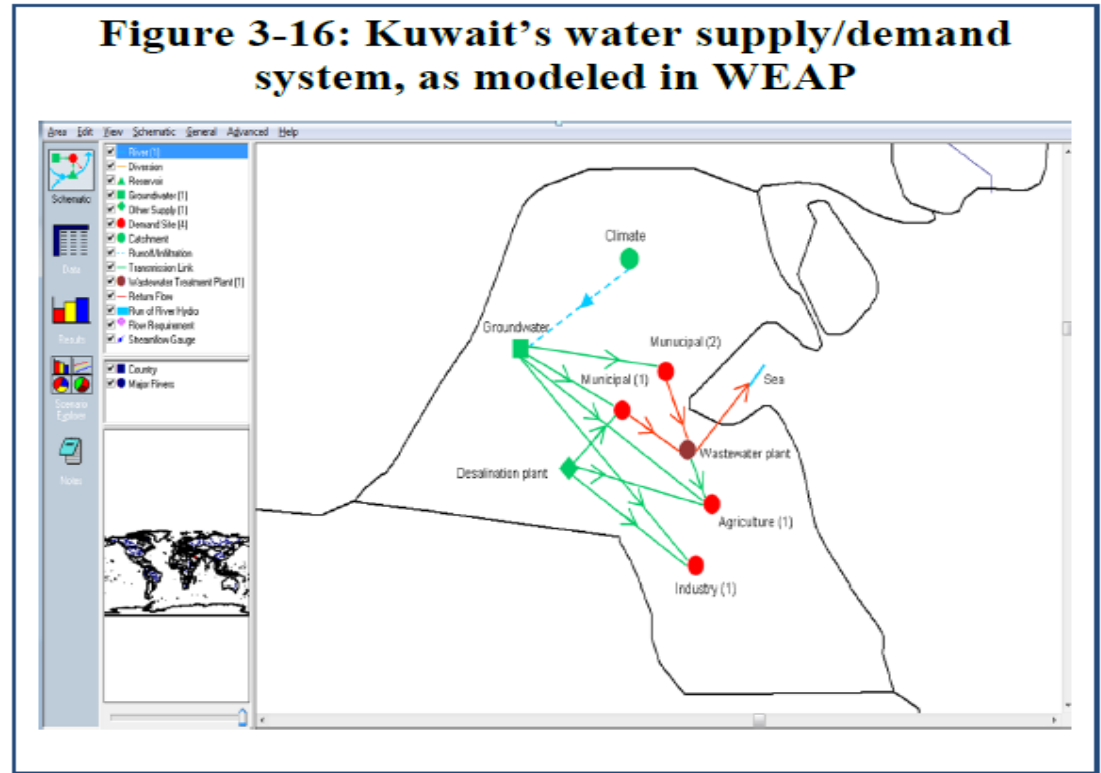
## *Assumptions*

- The focus was on domestic water demand, and is expected to grow rapidly .
- The domestic water sector relies on desalinated water and fresh groundwater supplies.
- The vulnerability of Kuwait's domestic water demand and supply system was defined as the additional future amount for urban water supply that would be needed due to climate change.
- Higher temperatures are a key driver for changes in future water consumption patterns in the domestic sector.
- As temperature increases in the future due to climate change, water production will also increase due to greater need of water for a variety of domestic activities and industrial activities, especially in the hot summer months.

# Impacts on Water Resources

## *Methodology*

- **Water supply:** *rainfall, groundwater aquifers, desalination plants and wastewater plants.*
- **Water demand:** *water demand sectors (domestic, agricultural and industrial sectors).*
- **Water transmission:** *links between supply sources and water demand sectors, between rainfall and groundwater, and between demand sectors and either treatment or the sea*



The Water Evaluation And Planning (WEAP) model, was used to evaluate water supply and demand balances under climate change, with and without adaptation strategies

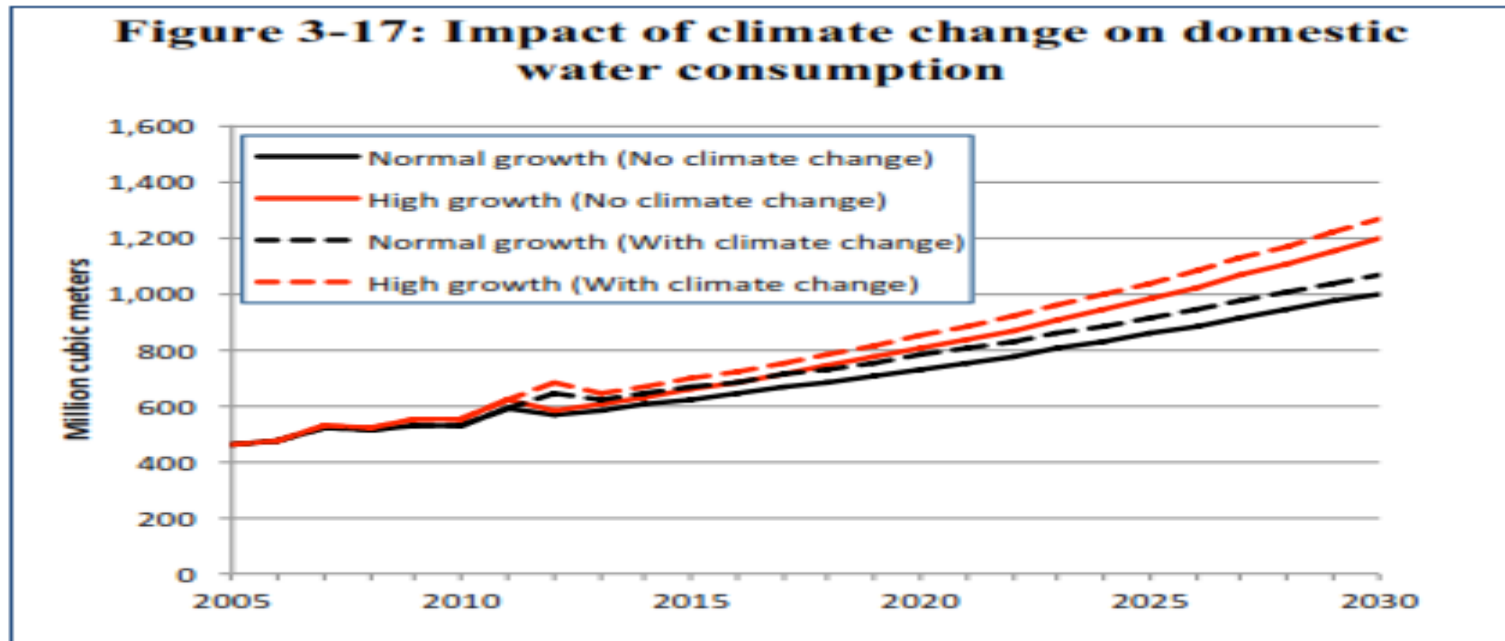
# Impacts on Water Resources

## *Scenario framework*

1. **Normal Growth, no climate change:** *annual population* growth rate of 3.2% per year.
2. **High Growth, no climate change:** *annual population* growth rate of 4.7% per year.
3. **Normal Growth, with climate change:** 3.2% per year and per capita water consumption rates increase from 440 to 443 l/cap/day .
4. **High Growth, with climate change:** 4.7% per year and an increase in per capita water consumption rates from 440 to 551 l/cap/day.

# Water Consumption Implications

## Business as usual

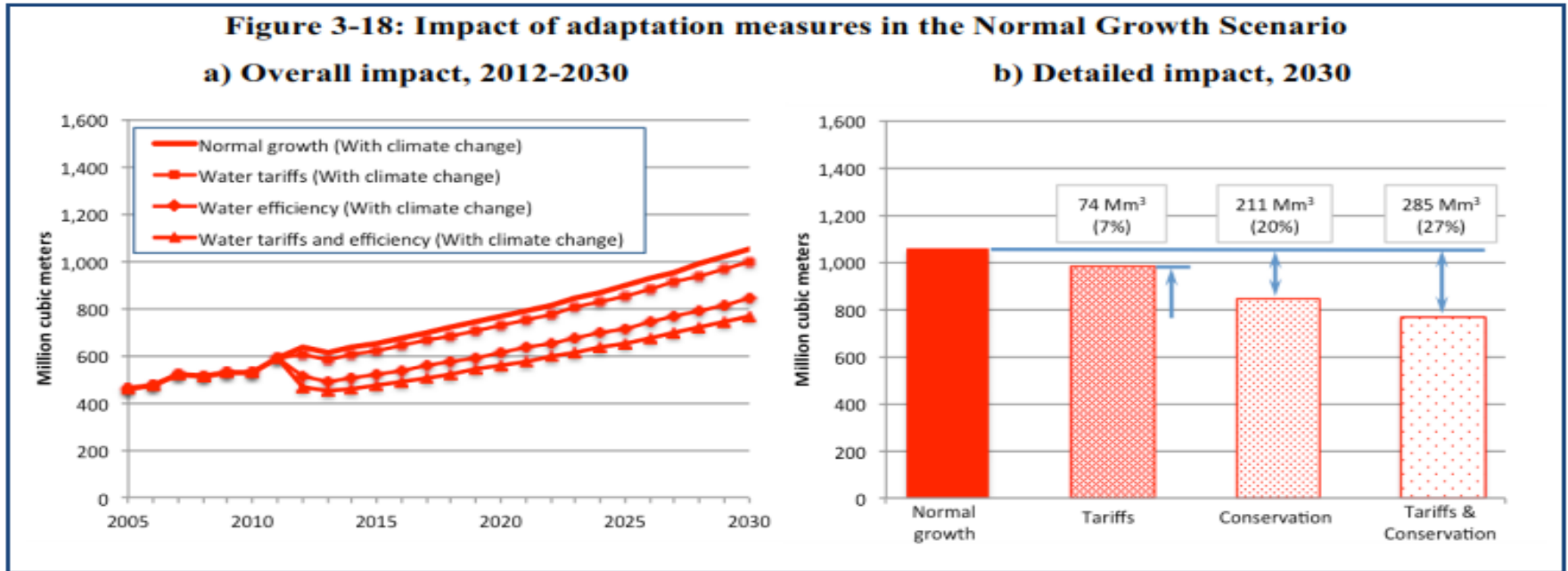


- **Baseline scenarios without climate change:** *Total domestic water consumption in 2030 reaches 1,000 Mm<sup>3</sup> and 1,200 Mm<sup>3</sup> in the Normal and High Growth, respectively.*
- **Climate Change scenarios:** *Total domestic sector water consumption in 2030 reaches 1,050 Mm<sup>3</sup> and 1,260 Mm<sup>3</sup> in the Normal and High Growth climate change scenarios, respectively.*



# Water Consumption Implications

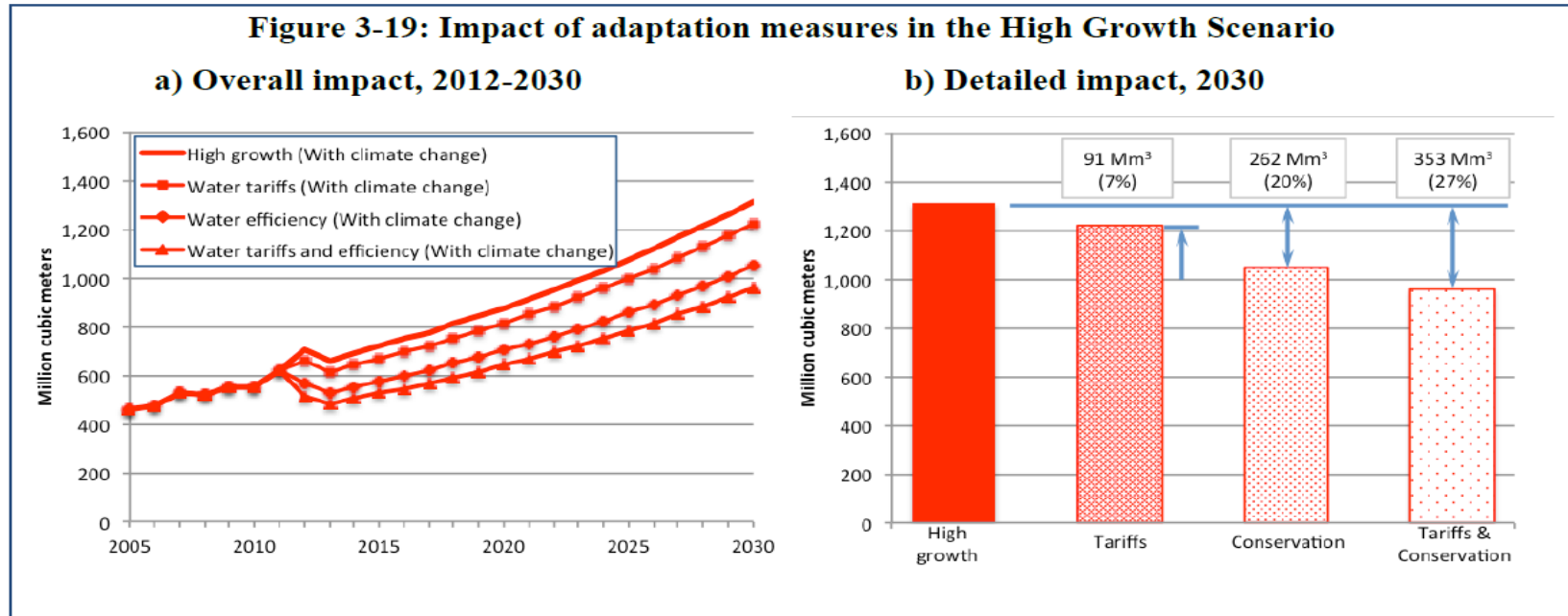
## Normal Growth



- **Water Tariffs:** lowering domestic water consumption by about 74 Mm<sup>3</sup>. The reduction is about 7%. Per capita consumption would decline from about 438 to about 412 l/cap/day.
- **Water Conservation:** lowering domestic water consumption by about 211 Mm<sup>3</sup>. The reduction is about 20%. Per capita consumption would decline from about 438 to about 355 l/cap/day.
- **Water tariffs and conservation:** lowering domestic water consumption by about 285 Mm<sup>3</sup>. The reduction is about 27%. Per capita consumption would decline from about 438 to about 324 l/cap/day.

# Water Consumption Implications

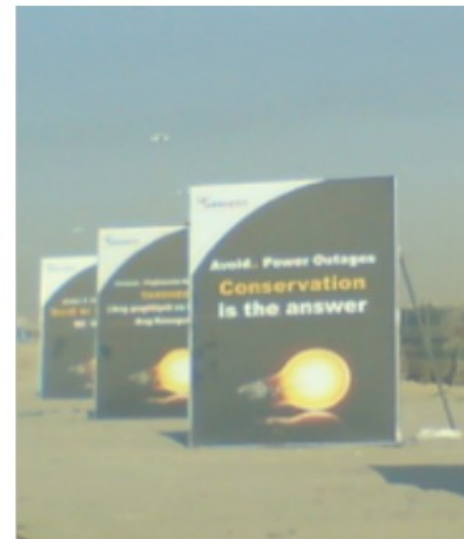
## High Growth



- **Water tariffs:** lowering domestic water consumption by about 91 Mm<sup>3</sup>. The reduction is about 7%. Per capita consumption would decline from about 551 to about 512 l/cap/day.
- **Water Conservation:** lowering domestic water consumption by about 262 Mm<sup>3</sup>. The reduction is about 20%. Per capita consumption would decline from about 551 to about 441 l/cap/day.
- **Water tariffs and conservation:** lowering domestic water consumption by about 353 Mm<sup>3</sup>. The reduction is about 27%. Per capita consumption would decline from about 551 to about 402 l/cap/day.

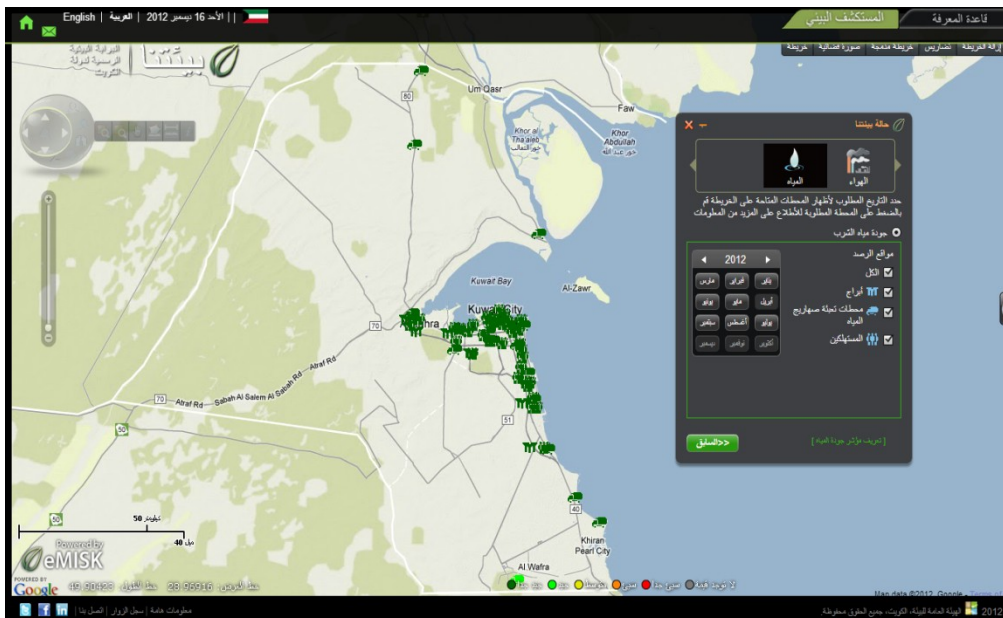
# Public Awareness Campaigns

- The ministry of electricity and water initiated a national multi-million environmental conservation campaigns called “Tarsheed”.
- The main goal of the campaign was to reduce the per-capita consumption of electricity and water.



# Data Dissemination

- The Environment Public Authority in Kuwait (KEPA) established in 2011 the Kuwait Official Environmental Portal ([www.beatona.net](http://www.beatona.net)) which is intended to provide environmental awareness to the public through sharing authentic scientific information and real-time environmental data and news.
- Data on air quality and drinking water quality are presented to the public in a nice and friendly GIS applications and maps.



the public through “Beatona and eMisk” project



# Higher Education

- Designated undergraduate programmes at Kuwait University and the Public Authority for Applied Education and Training.
- Post-graduate courses and research at Kuwait University

## **Box 1-1: Higher learning programmes and courses in environmental education in Kuwait**

### **Faculty of Science programs:**

- Existing programs in Marine Biology and Desert Studies
- Forthcoming programs in Marine Science and Environmental Sciences
- Environmental courses for students majoring in Biology, Chemistry and Geology

### **Faculty of Science departmental courses:**

- *Department of Biological Sciences:* Marine Sciences, General Ecology, Marine Biology, Marine Ecology, Desert Ecology and Environmental Biology
- *Department of Earth & Environmental Sciences (DEES):* Geological Oceanography, Marine Geology, and Environmental Science
- *Department of Chemistry:* Marine chemistry and environmental pollution

### **College of Women courses:**

- Courses in Environmental Education aimed mostly towards enhancing the role of women in environmental protection.

### **College of Social Sciences courses:**

- Department of Geography course called "Man and the Environment" for non-science majors.

### **Kuwait University program**

- Joint Master's Program in Environmental Sciences across Faculties of Science, Engineering and Law in College of Graduate Studies

# Education

- Climate change concepts and sub-concepts in the Ministry of Education curriculum- Grades 1 - 12

**Table 6-1: Climate change principal concepts and sub-concepts in the Ministry of Education curriculum (grades 1-12)**

Level	Topic	Principal Concept	Sub-concept 1	Sub-concept 2
Grade 2	Nature around us	Get to know the components of the environment	Desert environment	Marine environment
Grade 3	Climate elements	The difference between climate and weather	Climate	Weather
Grade 3	My country's climate	Students should know the climate of Kuwait	The four seasons	
Grade 3	The beauty of Kuwait's nature	How to protect the environment		
Grade 3	Environmental protection is the duty of everyone	Instill environmental protection concept	Environmental reserve	
Grade 4	Jaber Al-Ahmad Marine Reserve	The role of reserves in protecting the environment	Marine reserve	
Grade 4	Environmental problems	How can students protect the environment	Recycling	
Grade 5	Natural plants in my country	Get to know the names of the plants of Kuwait		
Grade 5	Factors affecting the climate of Kuwait	Get to know the Climatic factors	Geo-location	Land and water distribution
Grade 6	Environment Science	Environment Science	Ecosystem's components	
Grade 7	The Arabian peninsula	The geography of the Arabian peninsula	The climate of the Arabian peninsula	
Grade 8	Environment	Develop an awareness of environmental issues		
Grade 9	Human and the environment	The elements of the environment	The elements of the environment	The relationship between human and environment
Grade 9	Environmental solutions	Environmental solutions	How to reduce the human-activity impact on the environment	Protection concept
Grade 9	Human-activity impact on the environment	Examples of plants chemical reactions	How humans impact nature cycles	Importance of biodiversity
Grade 11	Natural geography and its fields of study	Lithosphere, hydrosphere, atmosphere and biosphere	Pollution levels	Pollution types
Grade 12	Planet earth in danger	Raise the awareness of the importance of plants to the ecosystem	Ecosystems	

# Alternative energies and water reuse

- Water desalination and electric power generation using solar energy (Al-Sheqaya Project).
- Reuse of treated wastewater in irrigation (Al-Wafraa, Al-Abdalay and Al-Sulaibieh Farms)

Thank you