

# Climate Change and Lebanon's Water Resources

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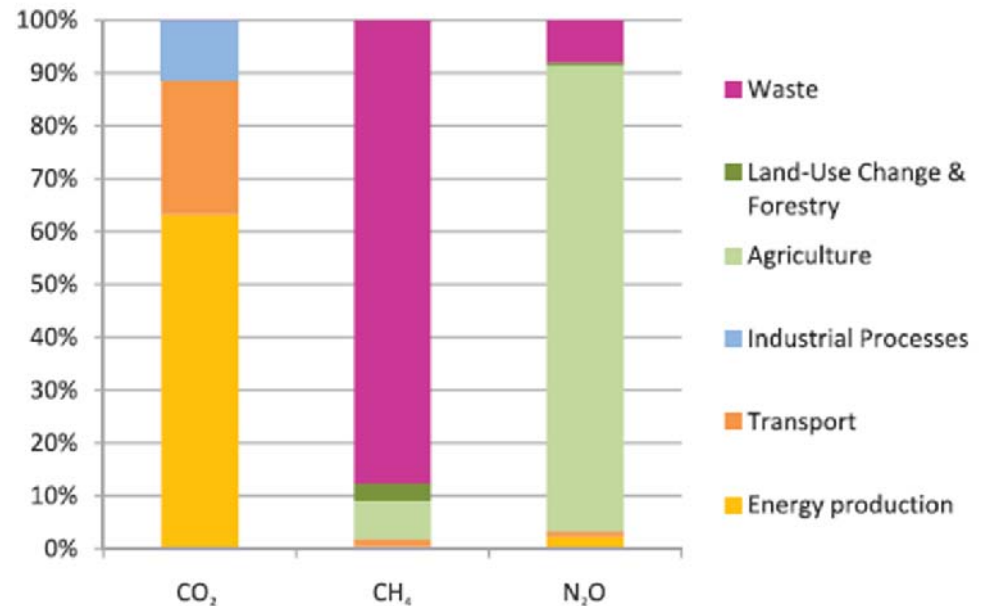
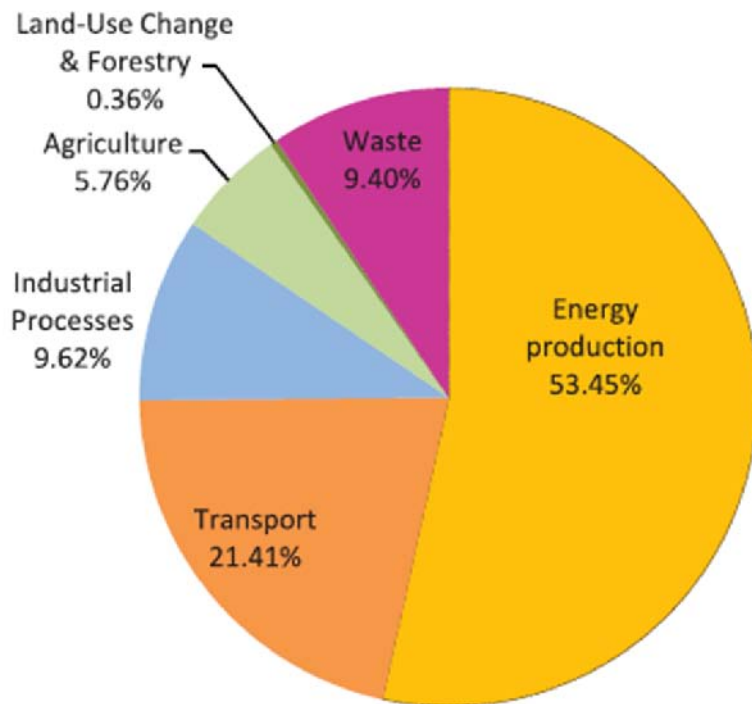
# Starting Point

## Climate versus Weather

- **Weather** is the day-to-day state of the atmosphere, and is a chaotic non-linear dynamic system.
- **Climate** — the average state of weather — is fairly stable and predictable. It includes
  - the average temperature,
  - amount of precipitation,
  - days of sunlight, and
  - other variables that might be measured at any given site.

# Some Current Numbers

## GHG Emissions in Lebanon – Year 2000



**Source: Lebanon's Second National Communication to the UNFCCC**

# Some Current Numbers GHG Emissions in Lebanon

	Total GHG emissions (Gg CO <sub>2</sub> eq.)	Energy (Gg CO <sub>2</sub> eq.)	Transport (Gg CO <sub>2</sub> eq.)	Industry (Gg CO <sub>2</sub> eq.)	Agriculture (Gg CO <sub>2</sub> eq.)	Land Use and Forestry (Gg CO <sub>2</sub> eq.)	Waste (Gg CO <sub>2</sub> eq.)
1994	15,901	7,743	3,991	1,924	1,130	210	902
2000	18,507	9,892	3,963	1,781	1,066	67	1,739
2004	20,299	10,979	3,976	2,178	925	12	2,227
% change 1994-2004	27.66%	41.79%	-0.39%	13.19%	-18.12%	-94.42%	146.99%
Average % change/yr	2.77%	4.18%	-0.04%	1.32%	-1.81%	-9.44%	14.70%

**Source: Lebanon's Second National Communication to the UNFCCC**

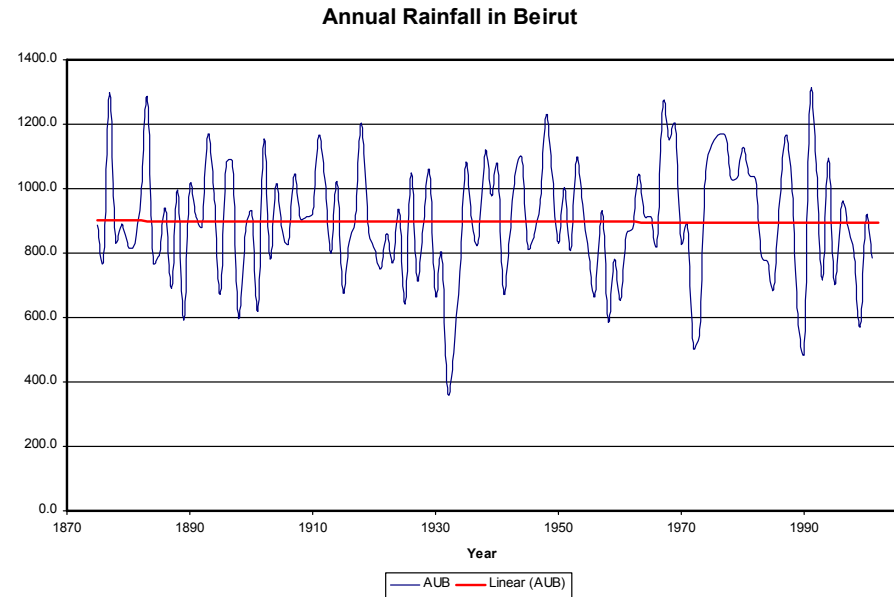
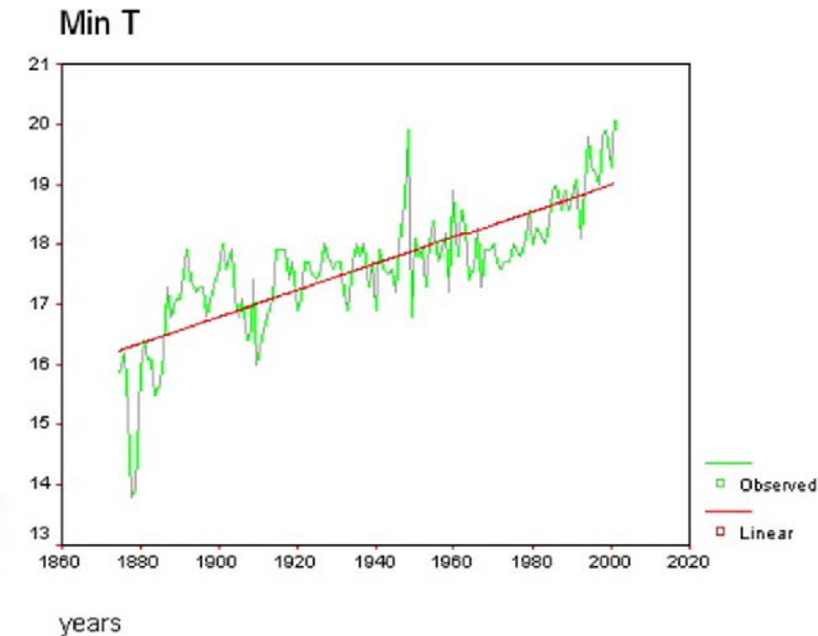
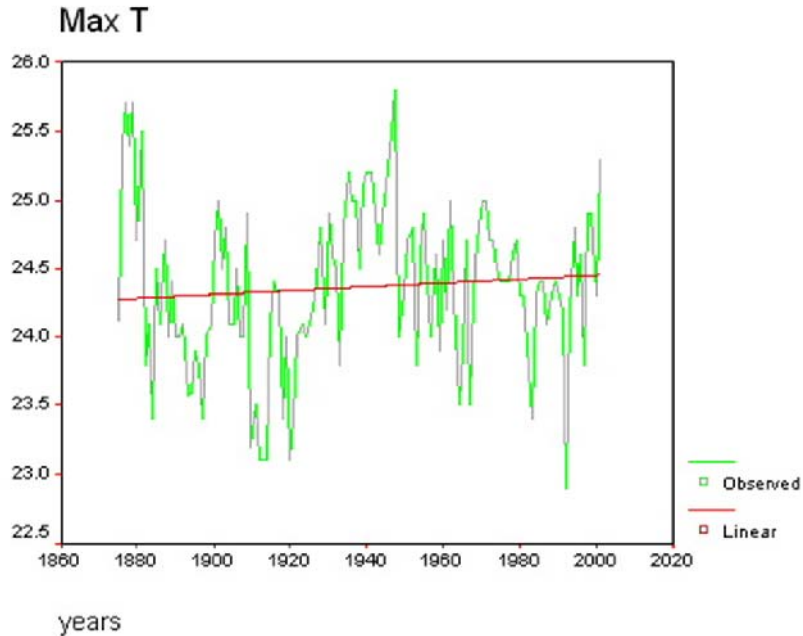
# Some Observed Effects - Region

- Increasing summer temperatures and decreasing winter temperatures.
- Increased dust storms affecting crops, human health, economic activity, and tourism
- Observed changes in the timing, form, and intensity of rainfall: decreased snowfall in Lebanon's mountains, and severe thunderstorms or unprecedented floods in Saudi Arabia, in Gaza, in Turkey, and along the Nile river
- A severe drought from 2006-2009 that spanned central Turkey and Syria
- Rising sea levels, observed throughout the eastern side of the Mediterranean basin, and the northern coastline of the Nile Delta (where land subsidence is a key factor)
- Low or empty dams and water storage facilities noted in Turkey, where half of the dams serving Ankara and Istanbul were empty, prompting the installation of a \$600 million emergency water diversion system
- Longer and more intense seasons for forest fires observed in Turkey and elsewhere.

# Some Current Numbers - Lebanon

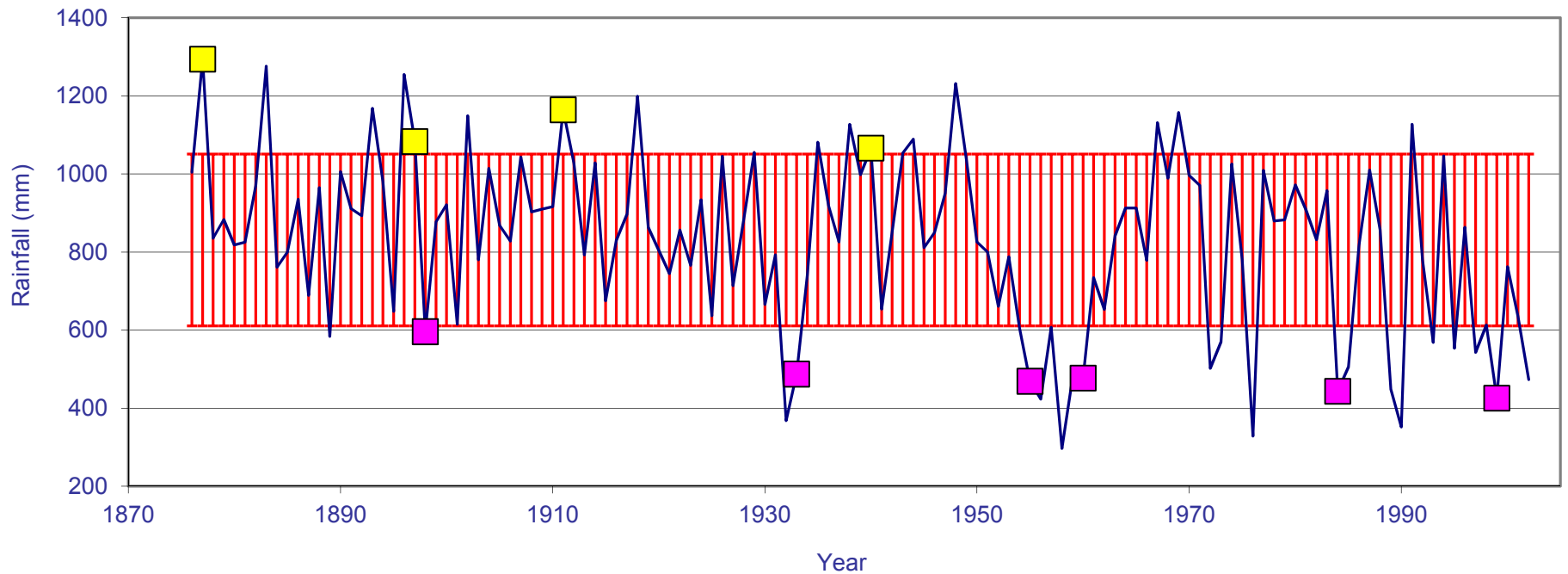
- Population in 2004 is estimated at 4.29 million
- Population growth rate ~ 1.0%
- Proportion of total population in urban areas ~ 83%.

# Some Current Numbers – Beirut, Lebanon



# Effects of ENSO on Precipitation

Year Total



El Niño  
La Niña



# Anticipated Impacts of Climate Change

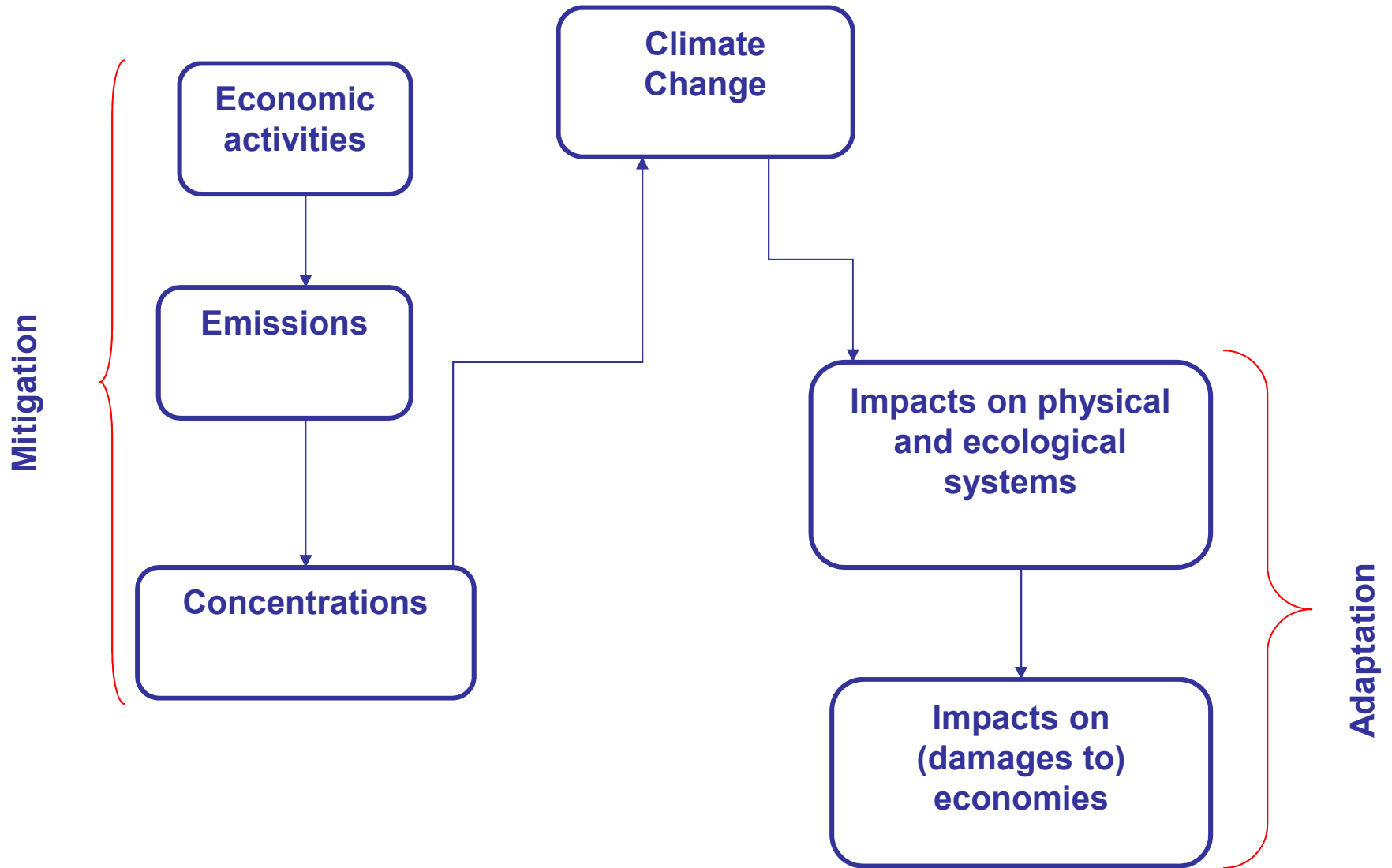
- reduction of about 20% in precipitation (rainfall and snowfall)
- reduction in snow cover
- increase in severe storms and their frequency
- increase in evapotranspiration
- increase in the occurrence and frequency of droughts

# Anticipated Impacts of Climate Change

- increase in forest fires leading to:
  - decrease in ground cover
  - increase in erosion
  - decrease in infiltration      decrease in groundwater recharge
- reduction in surface and ground water quality
  - higher temperatures reduce dissolved oxygen levels
  - reduced streamflow and lake levels ⇒ less dilution of pollutants;
  - increased frequency and intensity of rainfall ⇒ more pollution and sedimentation due to increased runoff
- sea level rise leading to
  - intrusion of seawater into coastal aquifers
  - Interference with sewage and stormwater sea outfalls/networks in coastal areas.

# Key Impacts of Climate Change on Urban Areas

- Disruption in supply of:
  - Water
  - Food
- Reduction in air quality
- Reduction in water quality
  - Groundwater: Sea water intrusion
  - Surface water: Reduced mixing
- Infrastructure failures:
  - Stormwater and sewage networks
  - Electricity networks
  - Transportation network
  - Increase in coastal erosion
- Stress on public health:
  - Increase in respiratory and vector borne diseases
- Stress on Social Services:
  - Increase in internal migrations
  - Associated unemployment
  - Disruption of school days



# Some Adaptation Measures

- Water Resources:
  - Improved urban demand management (new technologies, regulations on new construction and retrofitting, etc.)
  - [Demand management in agriculture](#)
  - Improved storage capacity
  - Alternate water sources
  - Virtual water
- Air quality:
  - Urban green spaces
  - Renewable energy sources
  - Public transport
- Water quality:
  - Wastewater treatment
  - Restriction on access to groundwater
- Food supply:
  - Roof top gardens, community gardens, etc
  - Vertical/structural agriculture
  - Agreements with foreign suppliers
- Infrastructure failures:
  - New technologies
  - Structural interventions (dikes, breakwaters, flap gates, etc.)
  - Zoning

# Consequences to No Action

- Reduction in national productivity due to illnesses, breakdowns of services, etc.
- Conflict over diminishing resources – internal and external
- Migration – from rural to urban areas with the associated pressures on infrastructure and social services
- Immigration – to better adapted countries, namely the West.

Thank you

# Water Demand Management

- Agriculture:
  - Irrigation:
    - conveyance efficiency from source to farm
    - application efficiency, e.g. sprinkler and drip methods
    - New management techniques, e.g. deficit irrigation
  - Crop production:
    - Stop growing crops that demand a lot of water
    - Select crops that are tolerant to drought or low precipitation
    - Shift crop growing areas to regions that have more rainfall or available water



# Water Storage Strategy

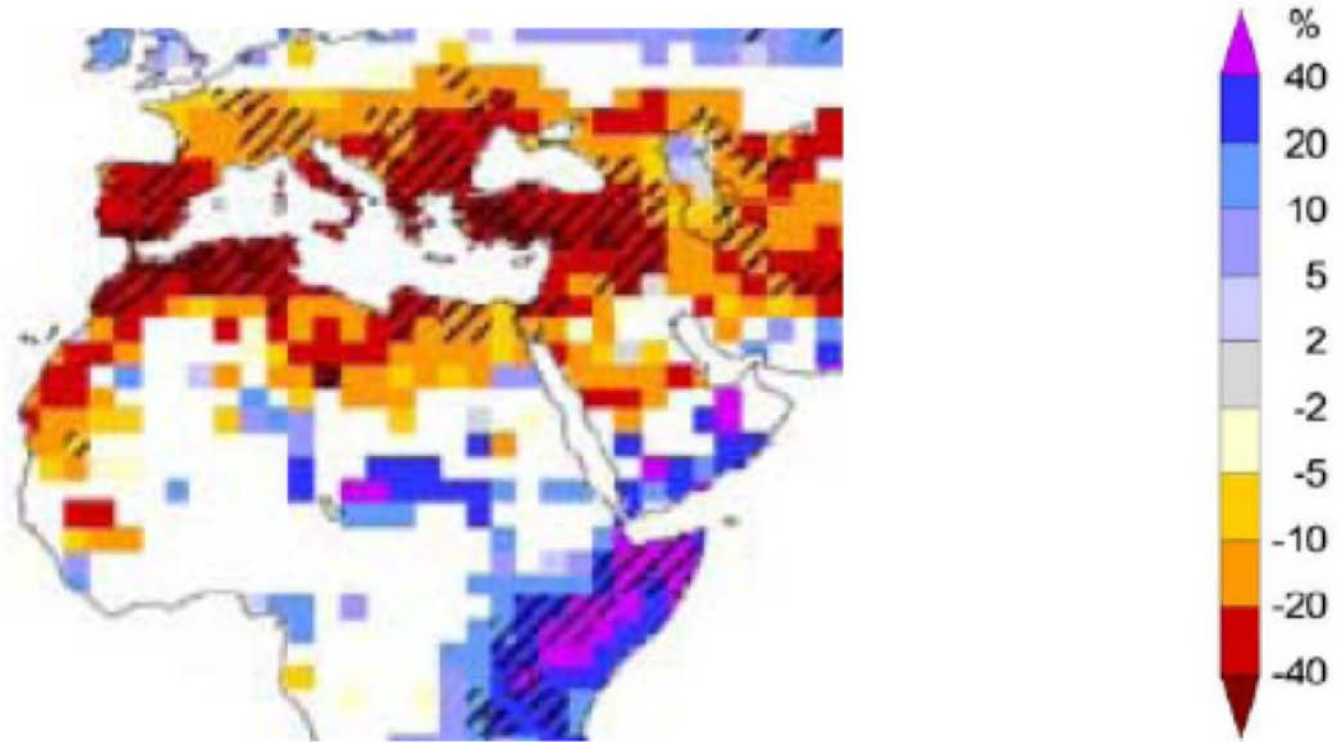
- Reservoirs (preferably closed)
- Hill lakes
- Groundwater recharge
- Dams

# Alternative Water Sources

- Use of treated sewage effluent
- Desalination
- Water harvesting



# Change in Precipitation



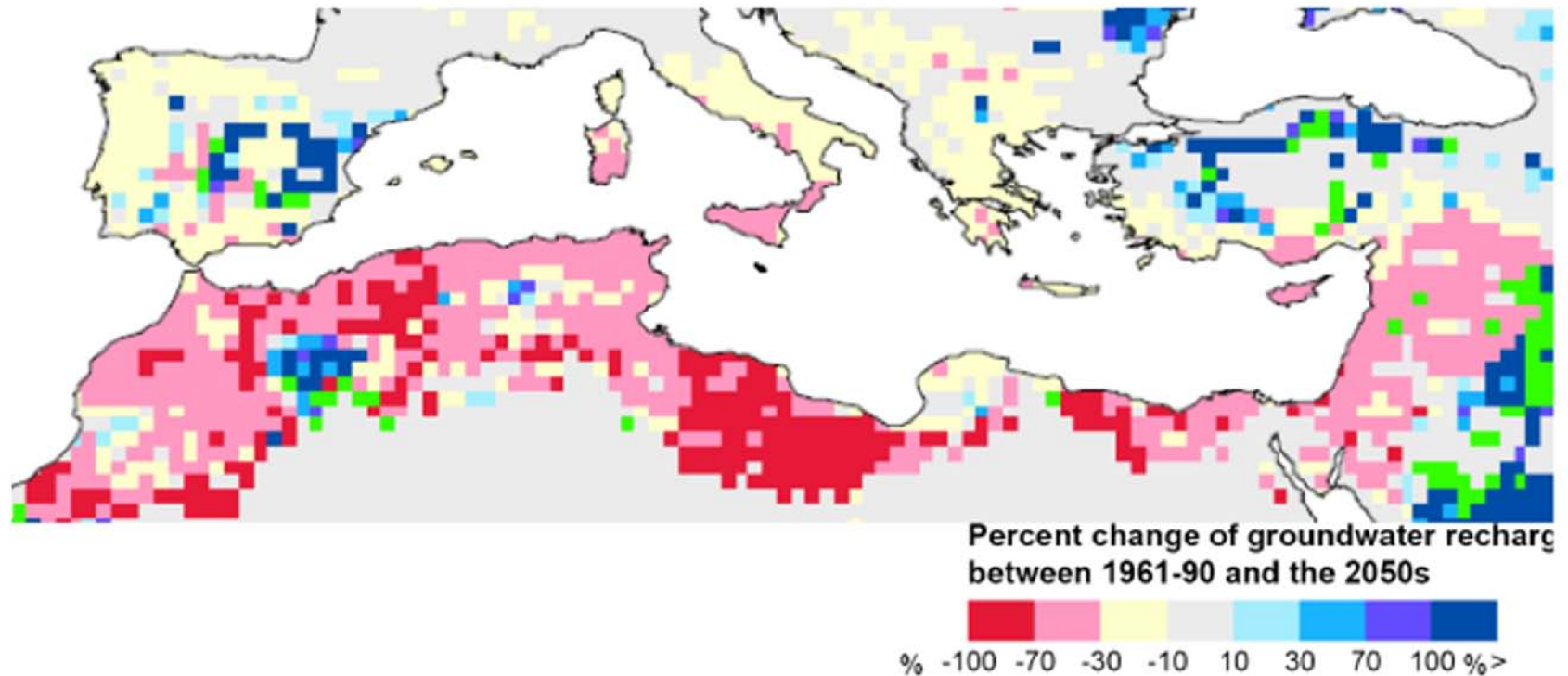
A1B scenario, mid 21st century relative to 1900-1970  
12 GCMs, hatched > 90% agreement

Milly et al 2005



# Change in groundwater recharge

B2 scenario, ECHAM4



Döll et al 2005





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SKILEB Sun Jan 12 15:00:00 2003



SKILEB Faraya Wed Jan 12 16:46:44 2005



SKILEB Faraya Fri Jan 12 16:26:27 2007



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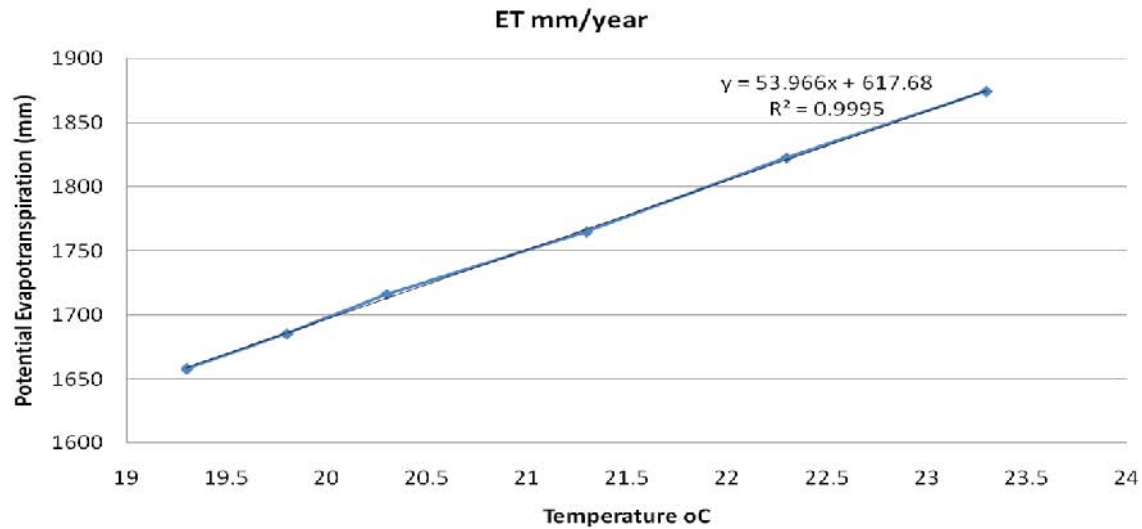


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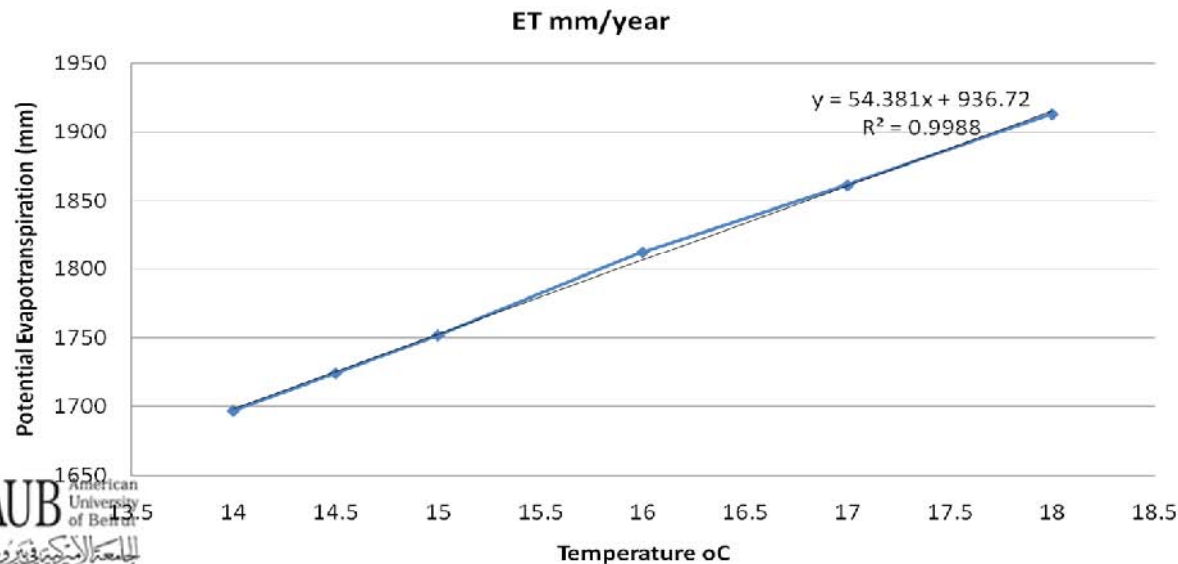


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# Increase in evapotranspiration



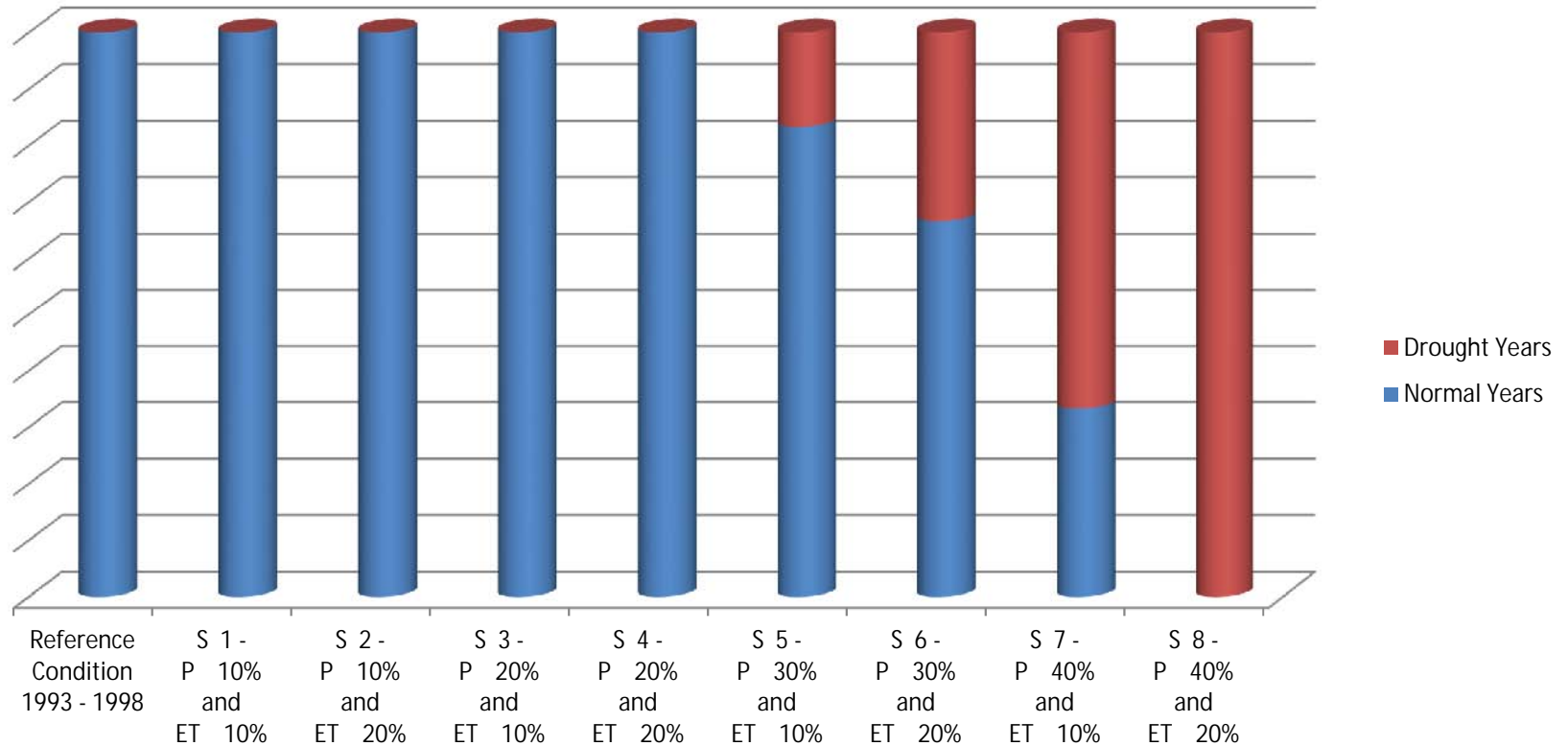
Coast



Inland



# Increase in the occurrence and frequency of droughts

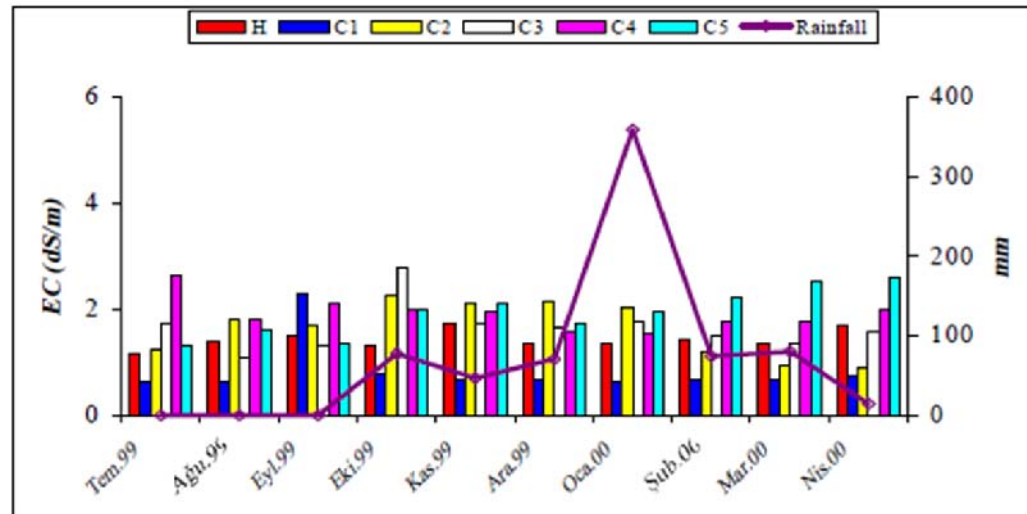




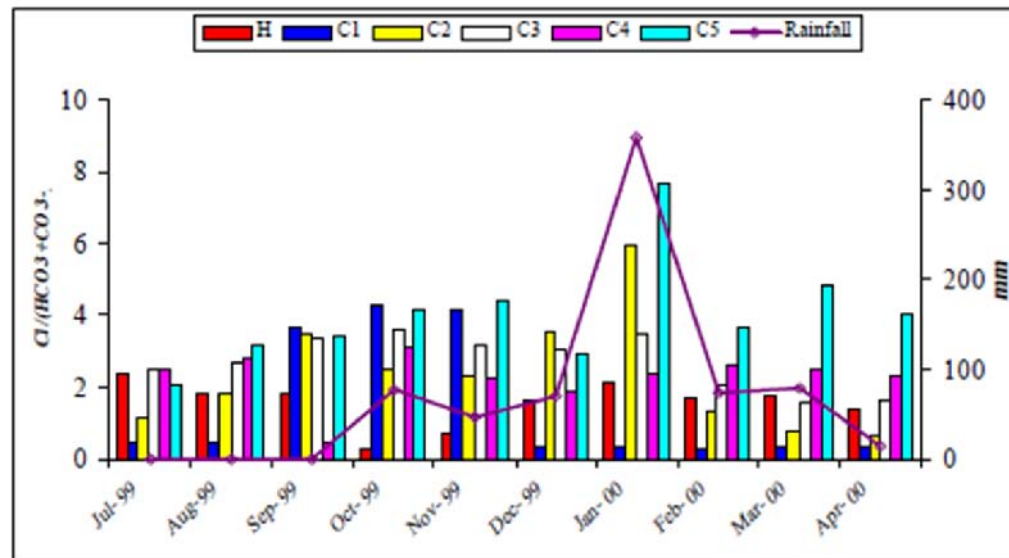








Choueifat - Hadath



Rmeyle

Source: Moujaber and Bou samra, 2002)

