SESSION 1: IDENTIFYING CLIMATE CHANGE IMPACTS ON WATER RESOURCES IN THE SWIM COUNTRIES

Training workshop on the identification and development of climate change no-regret actions in the water sector, 3-5 October 2012, Amman

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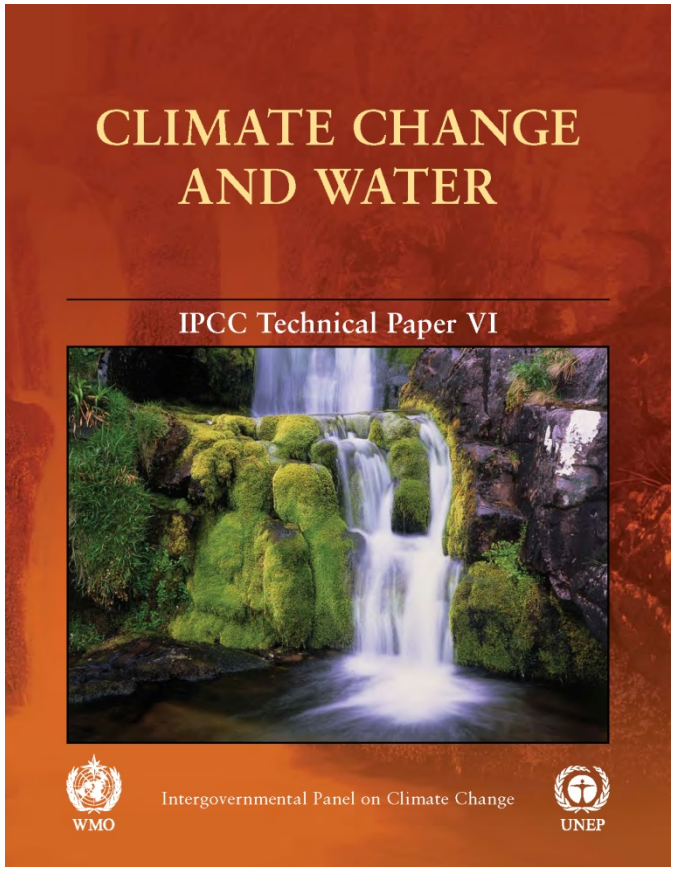
Objectives of Session 1

- **Goal:** Providing an overview of the regional climate change context and raising the awareness on the potential impacts of climate change on water resources and management

- **Learning Objectives:**
  - Get an understanding of the actual and future climate change trends and dynamics in the SWIM region
  - Identify the nature and magnitude of impacts on water resources
  - Understand the main drivers of vulnerability in the PCs

Climate Change is unequivocal



IPCC concluded that:

‘’Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.”

“Globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits”

"Water and its availability and quality will be the main pressures on, and issues for, societies and the environment under climate change"

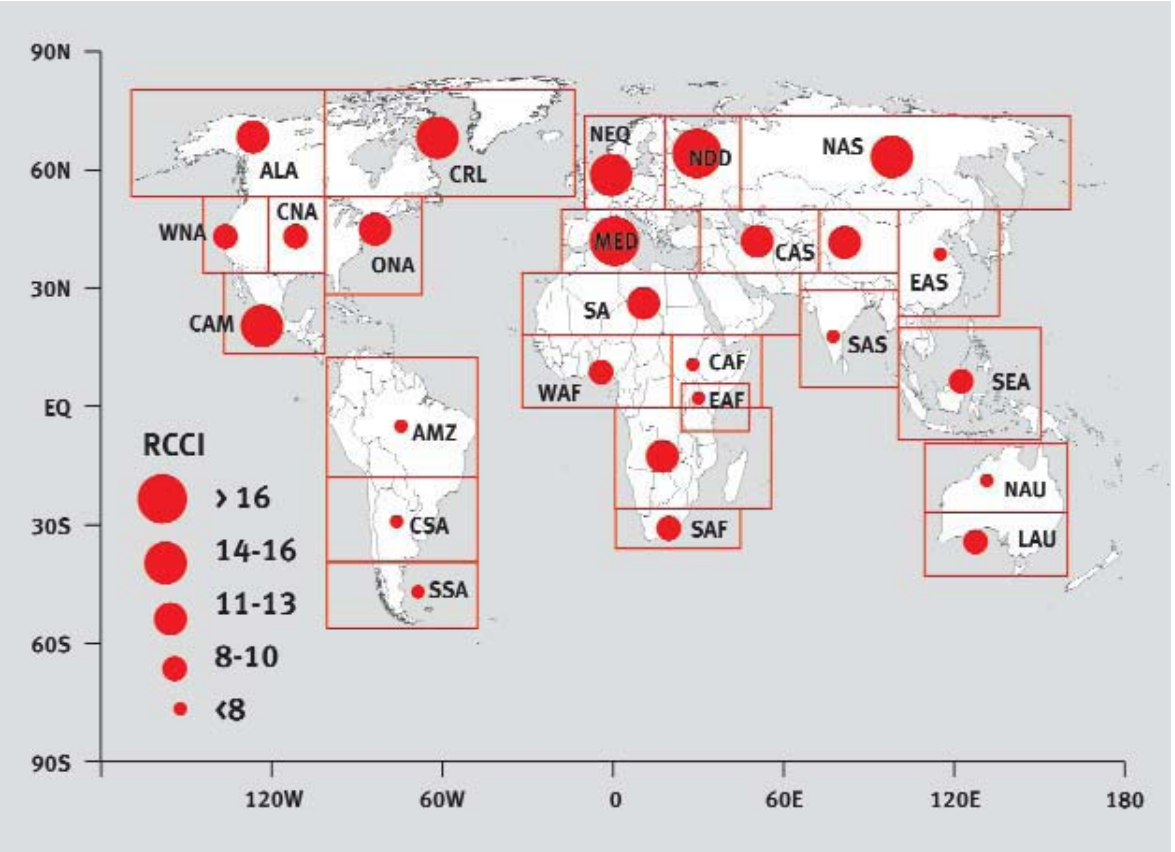
The climate of the region is already changing

- Getting hotter, drier and more variable

- In recent decades in the Arab region (WB, 2011):
  - Temperature increased by 0.2-0.3°C per decade
    - More frequent and intense heat waves
  - Less, but more intense rainfall, leading to increased occurrence of drought and flood events
    - Occurrence of drought events increased by 3 in Morocco
  - Reduction of winter precipitation and storage in snow mass (e.g. Morocco, Algeria, Lebanon)

The Mediterranean region is a hotspot of climate change (1)

Regional Climate Change Index, looking ahead to 2080–2099 (Giorgi, 2006)



RCCI is estimated from the mean trend in rainfall and temperature, inter-annual temperature variability, and the relation between regional and global temperature trends, for the dry and wet seasons. The Mediterranean region and north-eastern Europe are the areas of the globe with the highest RCCI (greater than 16)

The Mediterranean region is a hotspot of climate change (2)

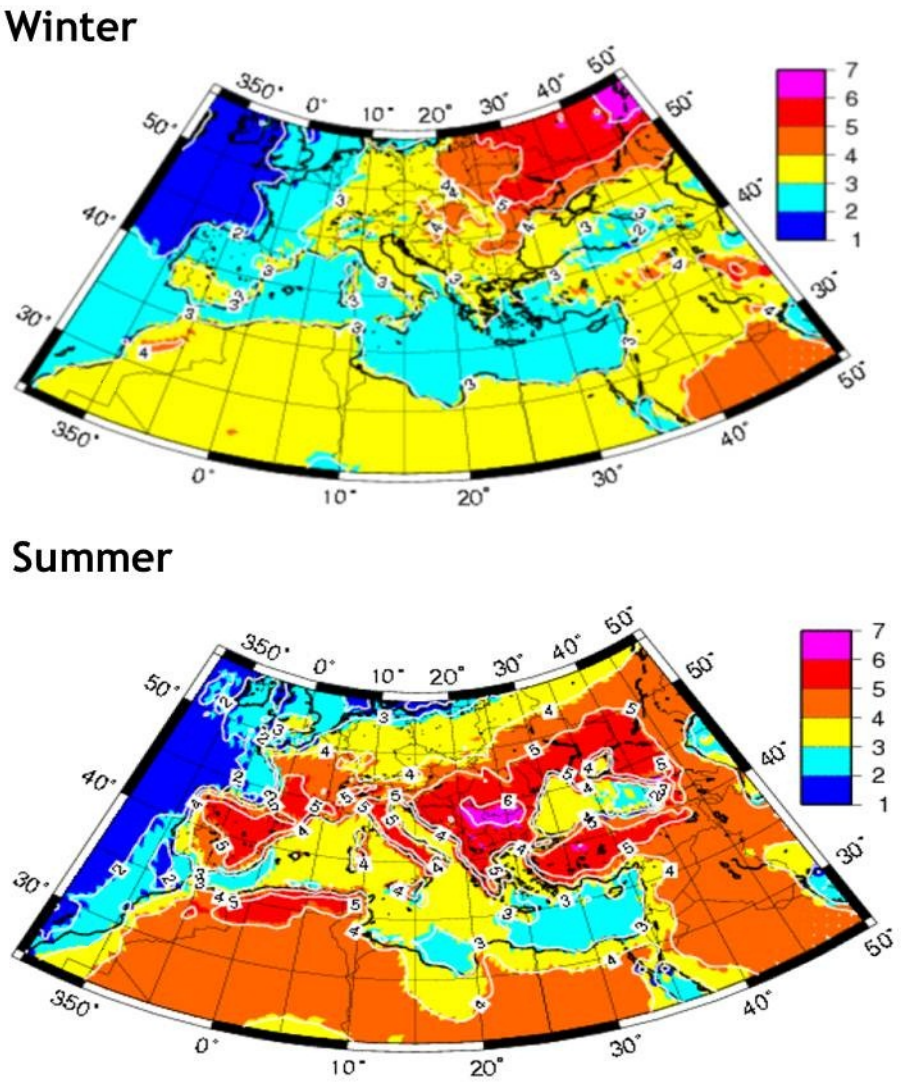
Projected changes in temperatures

- All projections indicate that temperatures increase are likely to happen in proportion greater than the global average (1,5 times faster than the global average)
- Increase by 2°C as early as 2040 (IPCC 2007a: 874), and potentially by 5°C during summer at the end of the century
- Increase in frequency, length and intensity of heat waves

→ **Increase in evapotranspiration**

→ **Reduction in soil moisture**

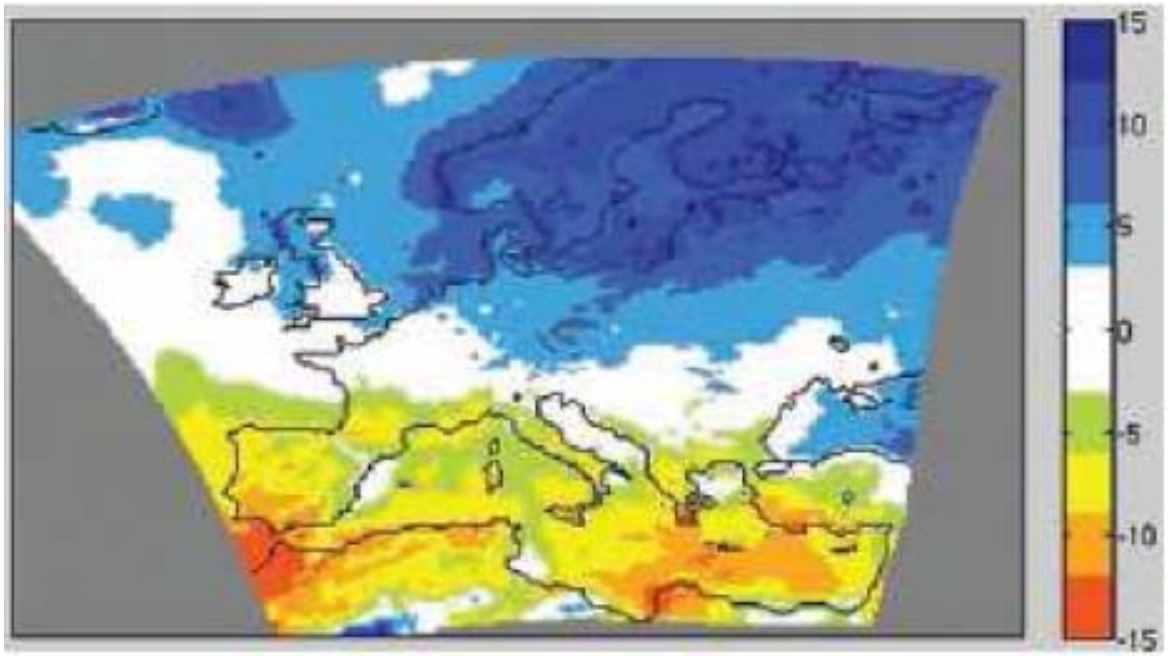
→ **Reduction in snow pack**



Température 2070-2099 vs. 1961-1990
Using AORCM, scenario
(Somot et al., Plan Bleu, 2007)

The Mediterranean region is a hotspot of climate change (3)

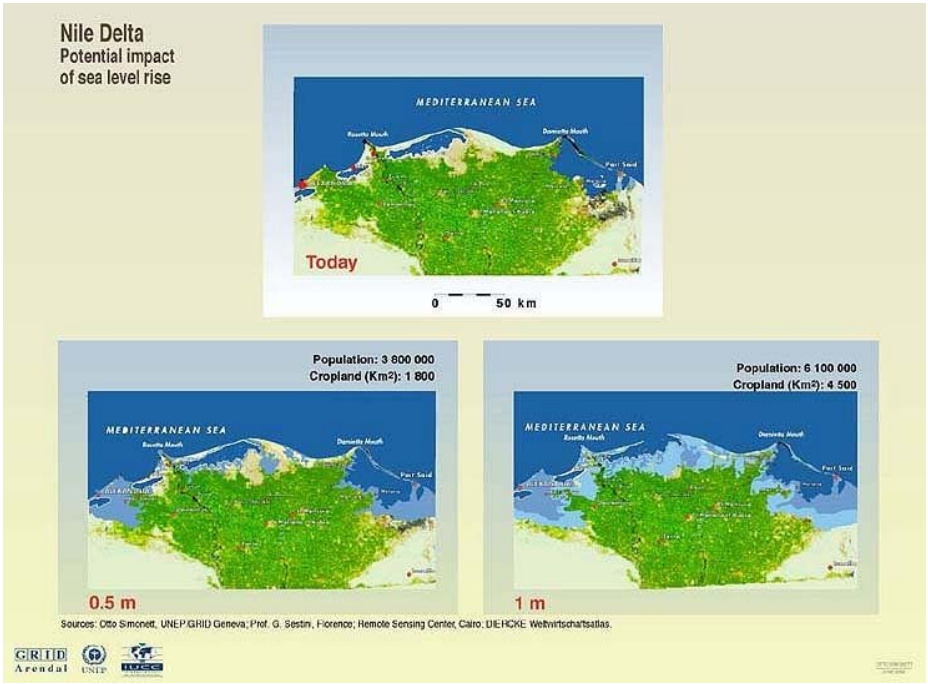
Projected changes in precipitation



Annual precipitations, 2021-2050 vs. 1961-1990, ENSEMBLE, multi-models mean (RCM) (Goodess et al., 2009).

- Good agreement across most RCMs on a regional decrease in average rainfall by 10-20% in 2050 and 20-30% in 2100 (in some areas > 20% and up to 40% resp. in 2050 and 2100)
- Greater seasonal and inter-annual variability (greater concentration during winter)
- Less frequent but more intense (greater precipitation extremes)

The Mediterranean region is a hotspot of climate change (4)



Projected changes in Sea-Level Rise

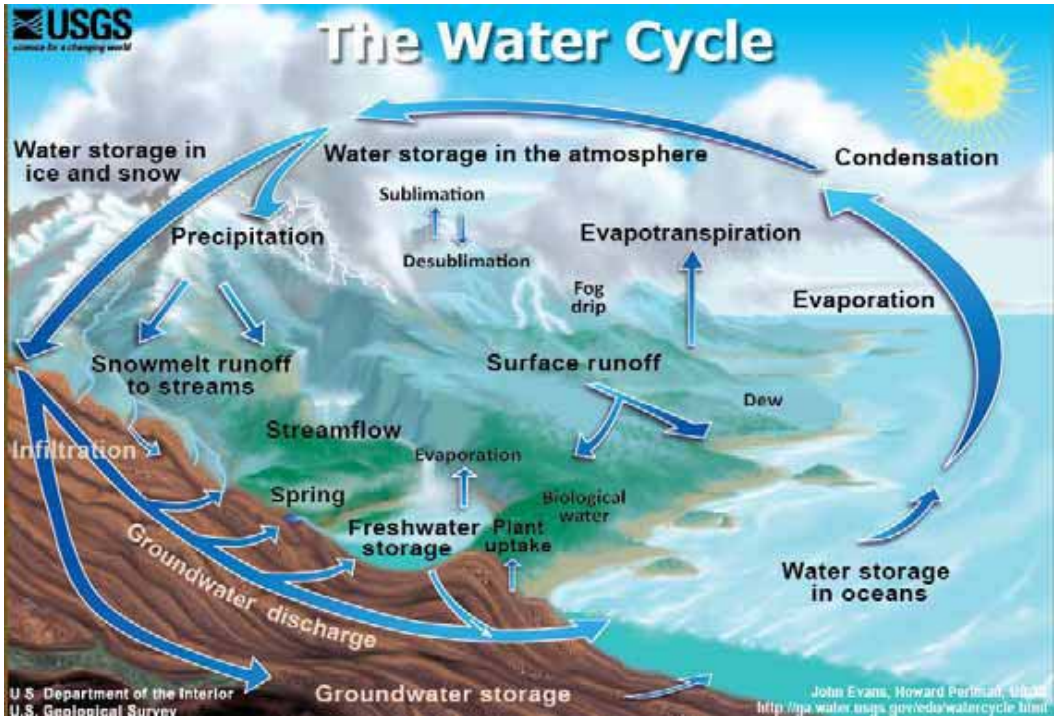
- SLR comprised between 20 and 60 cm by 2100
- Certain GHG scenarios project a 1 m SLR, which would affects 3% of the population of the MENA region; 3 times more than global average

→ Exacerbated effect on submersion and flooding from storm surges in low-elevation coastal zones

→ Salt water intrusion in estuaries and coastal aquifers

→ Reduction in the availability of coastal fresh groundwater resources

Climate change will profoundly affect the hydrological cycle



Drivers of change

- ↘ *in annual average precipitation*
- ↗ *atmospheric vapor*
- ↗ *frequency and intensity of precipitation extremes*
- ↘ in *snow cover*
- ↗ *in melting of ice*
- ↗ *Sea level rise*
- ↗ *Evapotranspiration*
- ↘ *Soil moisture*

- **It is projected that many of the currently observed changes in the water cycle will become more pronounced with continuing climate change.**

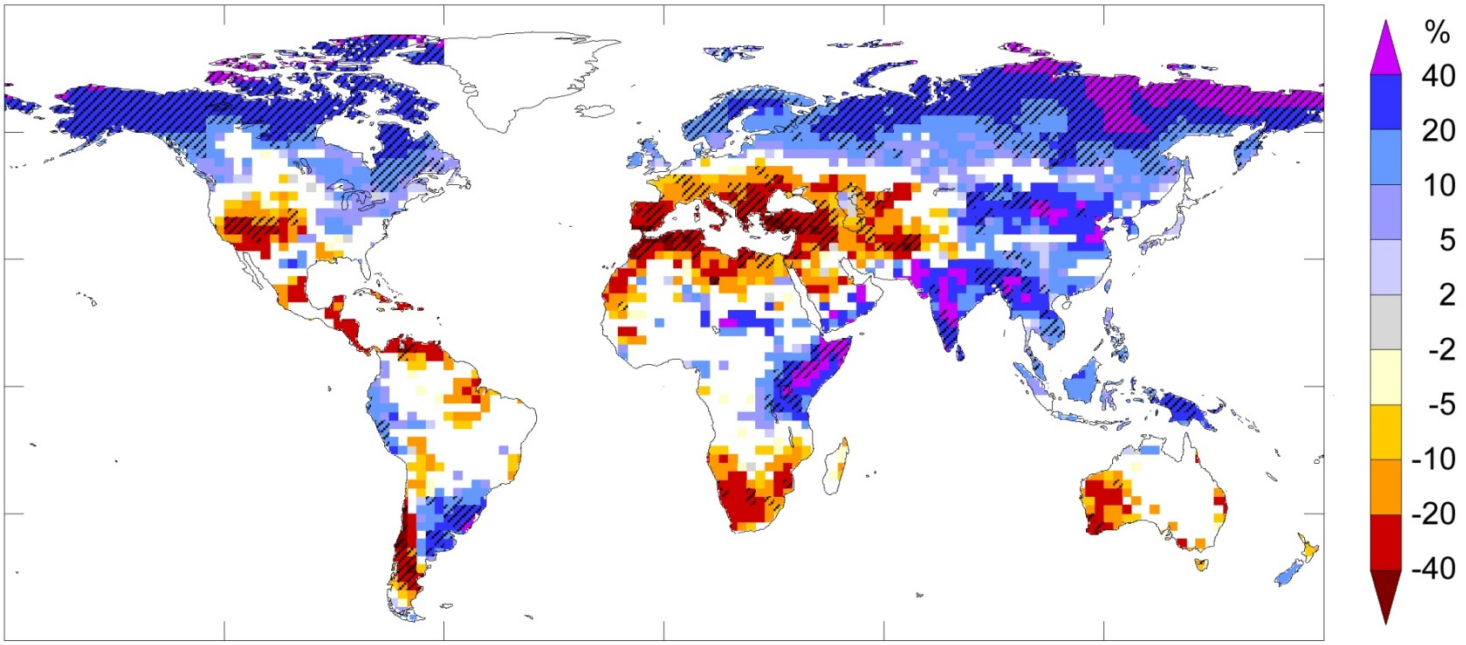
- **Future changes in climate are expected to lead to a further <u>acceleration</u> and <u>intensification</u> of the hydrologic cycle**

Shifts in hydrological conditions and growing variability will lead to significant changes in resources

- **Increased temperature** and **potential evaporation** combined with **decreasing and more erratic precipitation** will have both **direct and indirect effects** on water **supply** and **demand**
- **Supply side**
  - water quantity
    - Changes in volume of run-off
    - Changes in steam and river flows (both annual and summer flows)
    - Changes in groundwater level and recharge rates
  - water timing
    - Change in seasonnal and inter-annual distribution of precipitation and run-offs
    - Change in period of return of extreme events (drought and floods)
  - water quality
    - Salinization of coastal groundwater due to sea level rise
    - Changes in bio-physico-chemical characteristics of water bodies
  - supporting ecosystems and functions:
    - impacts on ecosystems integrity
    - Impacts on ecosystem services
- **Demand side**
  - Change in water needs and uses of most sectors, particularly agriculture

Impact on water quantity (1)

- **Severe decrease in average runoff (>20-40% by 2100)**

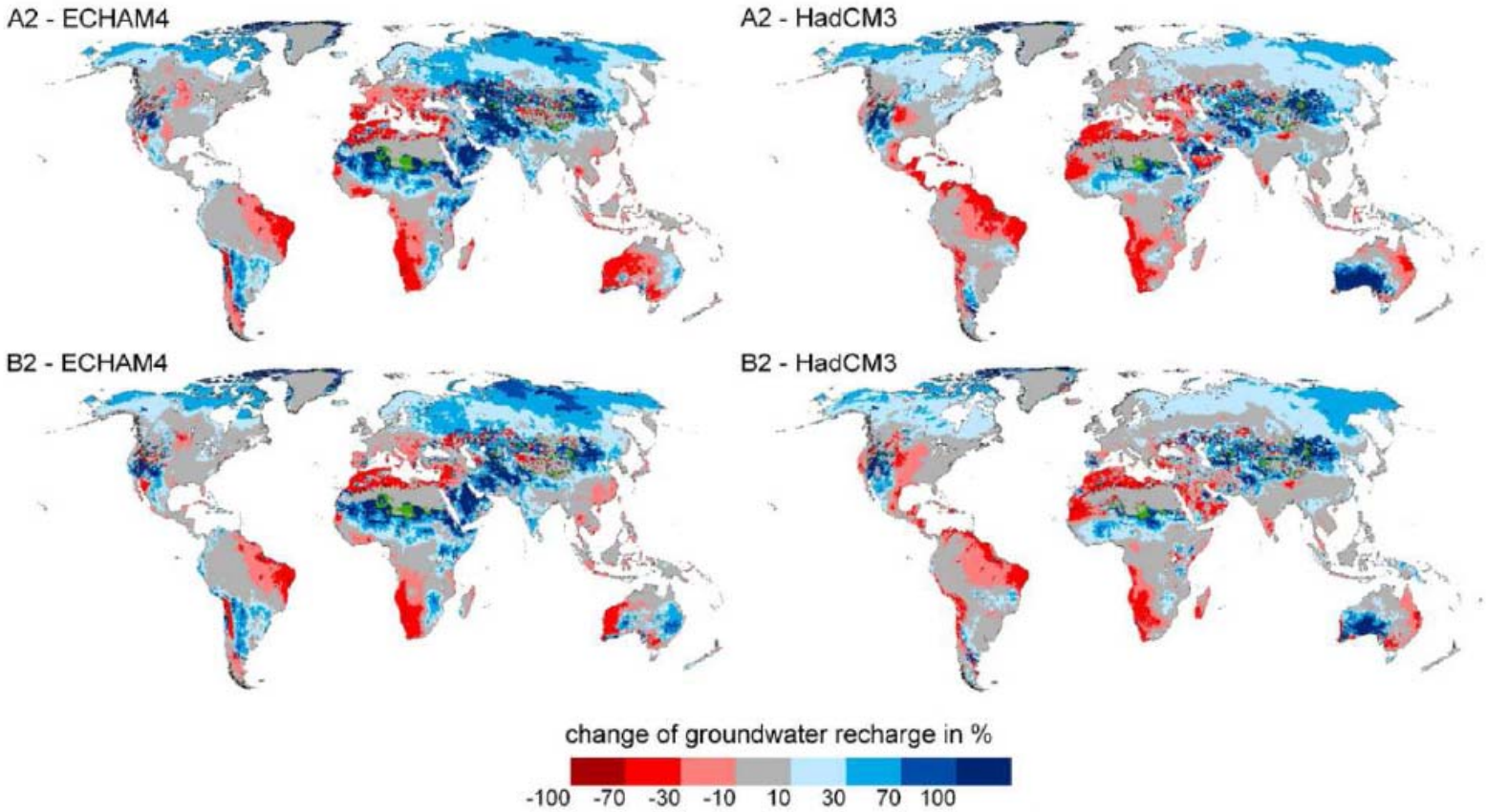


A1b emissions scenario, multi-model ensemble mean, change by 2090-2099 relative to 1980-1999. White areas denote regions with little agreement (IPCC, 2007)

Results from local hydrological modelling show that decreasing run-off will translate in significant reduction of flows of river upon which a number of SWIM countries depend for their development (e.g. -23% in Upper Jourdan)

Impact on water quantity (2)

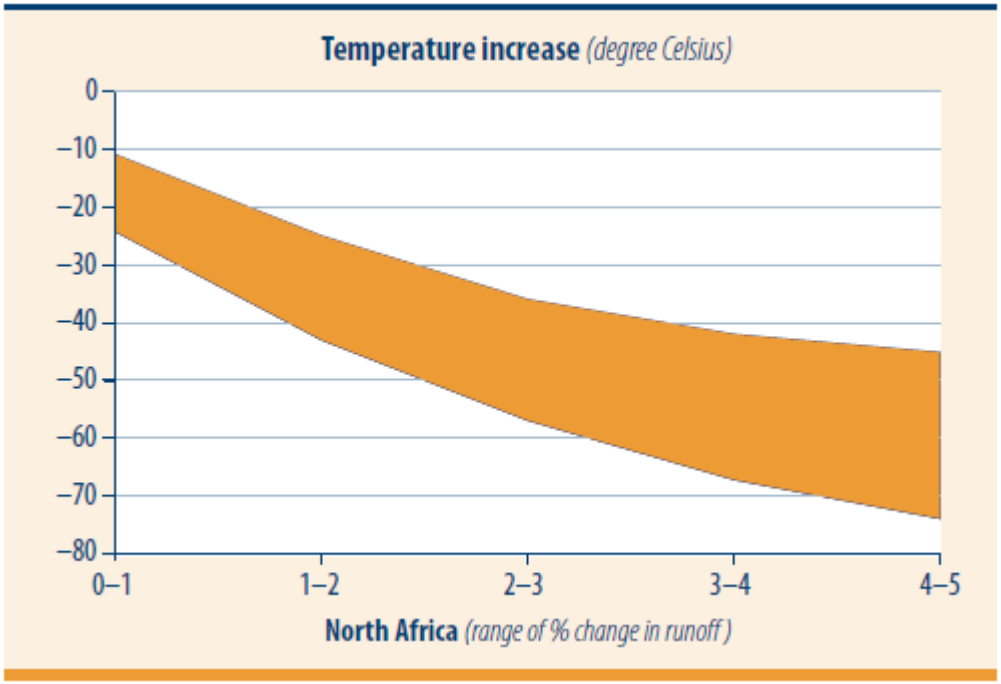
- **Decrease in groundwater recharge**



Average groundwater recharge simulated for the year 2050 by Watergap (Döll, 2009)

Impact on water quantity (3)

- In North Africa even modest temperature increases could dramatically change water availability. For example, a 1° Celsius increase could reduce water runoff in Morocco's Ouergha watershed by 10 percent by 2020. If the same results hold for other watersheds, the result would be equivalent to losing the water contained by one large dam each year.



Impact on water quantity (4)

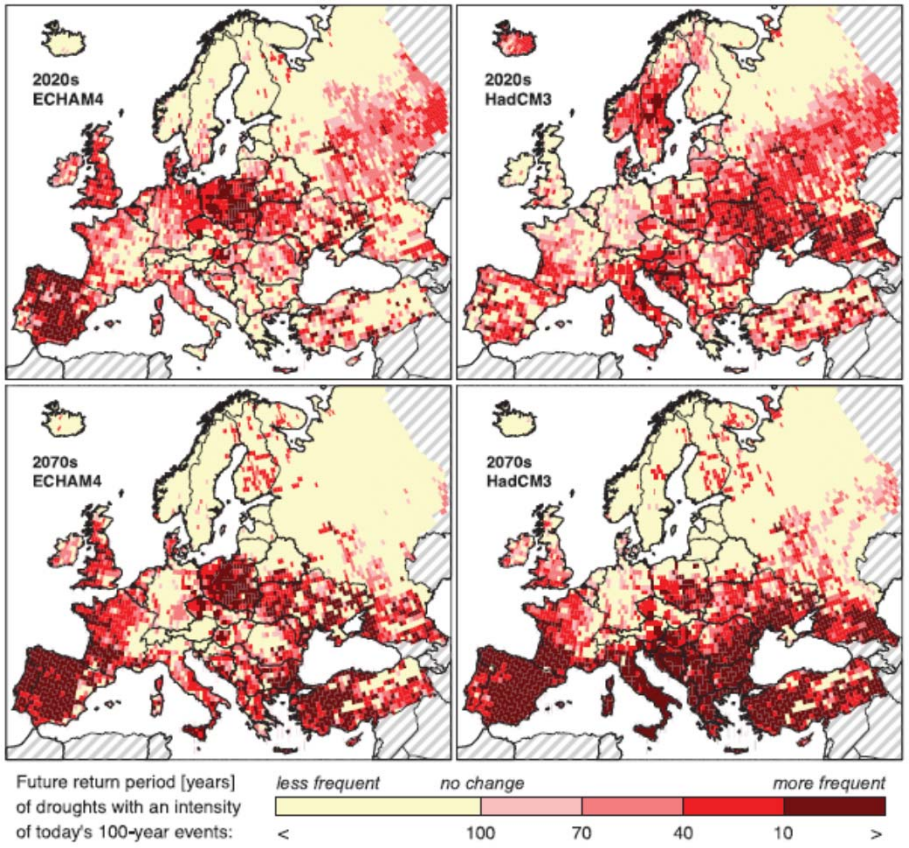
- In Lebanon, a 1.2° Celsius increase in temperature is projected to decrease water availability by 15 percent because of changed runoff patterns and evapotranspiration.

- In Syria, renewable water availability could decline by 50 percent by 2025 as compared to 1997 levels.

- Regionally, reduced river flow and groundwater recharge might lead to a reduction in water supply of 10% or greater by 2050.

Impacts on water timing - extremes events

- Changes in precipitation variability and intensity is projected to increase the risks of droughts and flooding across the region



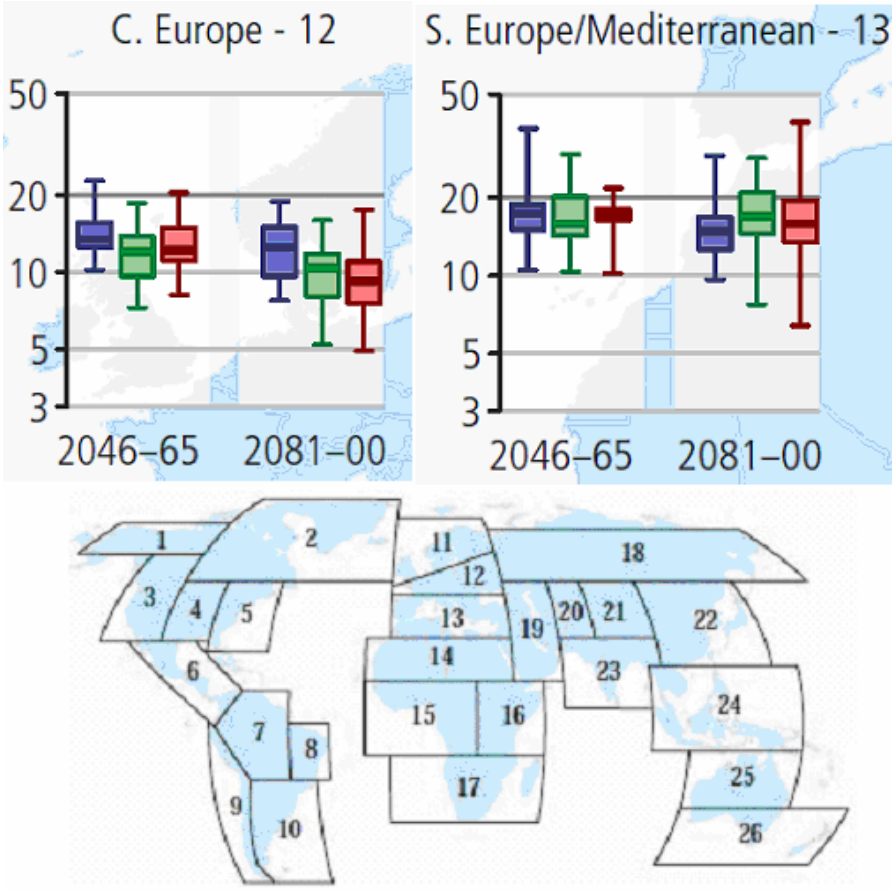
2020

Increase in return period of the current 100-year drought

2070

(IPCC, 2008)

Increased flood hazards



Future return period of current 20-year precipitation event (A1, B1, A2) (IPCC, 2012)

Potential trend towards increase in frequency of high-probability-high impact flood hazards

Higher water temperatures and changes in extremes are projected to affect water quality and exacerbate many forms of water pollution

More specifically, the following potential effects are projected (IPCC, 2008):

More intense rainfall:

- Increase in suspended solids/turbidity
- Pollutants (fertilizers, pesticides, municipal wastewater)
- Increase in waterborne diseases

Reduced/increased water flow in rivers:

- Less/more dilution of pollution
- Fluctuations in salinity estuaries

Lowering water levels in lakes:

- Re-suspension of bottom sediments
  - increased turbidity
  - liberating compounds with negative impacts

Higher surface water temperatures:

- Algal blooms and increase in bacteria, fungi > toxins
- Less oxygen

Impact on ecosystems

- Climate change will influence integrity and functions of aquatic ecosystems.
- Decreasing precipitation and runoff will alter environmental flows and lead to drying of streams, lakes, wetlands for extended periods
- This could dramatically reduce productivity and irreversibly affect key water supporting functions provided by ecosystems as natural infrastructures (regulation, storage, purification, natural buffers, etc.)
- Ecosystems respond to changes in hydrology in complex and often non-linear ways.
- Tipping points and feedback loops leading to abrupt hydro-ecological shifts likely to occur

Impacts on water demand

- Demand for agricultural and domestic water (including tourism) in particular increases significantly at hotter and drier times of the year.

- Agriculture has always been the largest user of water in the SWIM region (80% of the total demand)

- This will intensify with increasing needs for irrigation brought on by higher temperatures, evapotranspiration and reduced precipitation and soil moisture,
  - Maghreb, Egypt : +2-4% for maize, 6-10% for potatoes

- Impacts on agricultural water demand will vary greatly in space

Climate change impacts are superimposed on current water sector vulnerabilities

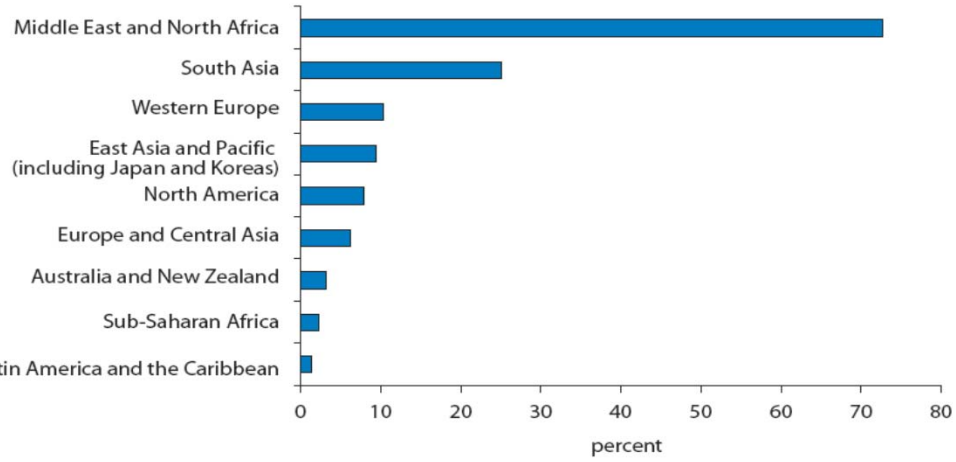
- Climate change impacts on water cannot be viewed in isolation from other drivers of changes
- Water management in the region is already facing a multitude of non-climatic constraints & challenges that increase its vulnerability to and excerbate the potential impacts of climate change

- Vulnerability factors are:
  - Environmental
  - Economic
  - Social
  - Political
  - Institutionnal
  - Etc…

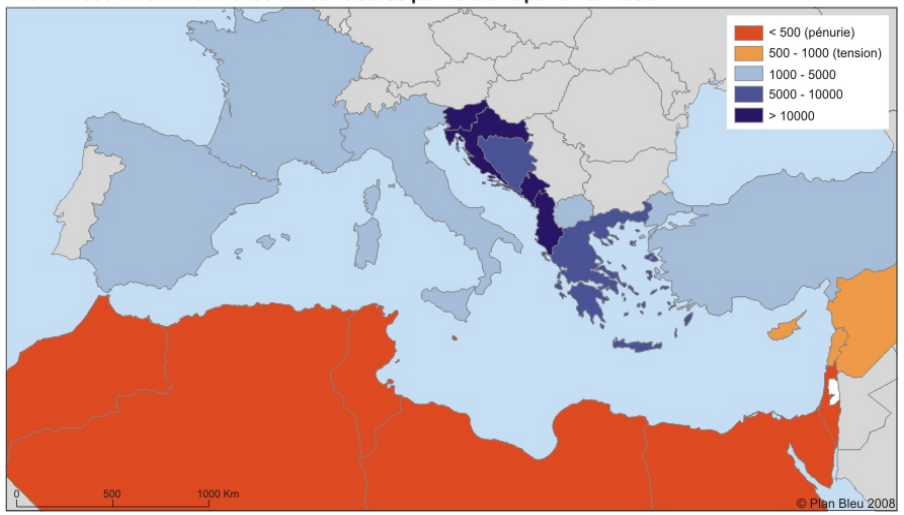
Dominant water stress and growing water scarcity

- Natural aridity
  - SWIM countries are the most water scarced region in the world
  - account for 10% of the global surface but only for 0,1% of global precipiation
  - PCs receive only 10% of the total precipitation for the Med. basin
- Escalating water demand and high withdrawal due to rapid population growth, urbanization and accelerated socio-economic development (agriculture = 82% of total demand)
- Overexploitation of major river basins and depletion of strategic ground water reserves
- Escalating water scarcity
  - People living in water poverty (<500 m3/pers./y): 60 million in 2005 → 258 million in 2050 (without CC)

Percentage of Total Renewable Water Resources Withdrawn, by Region

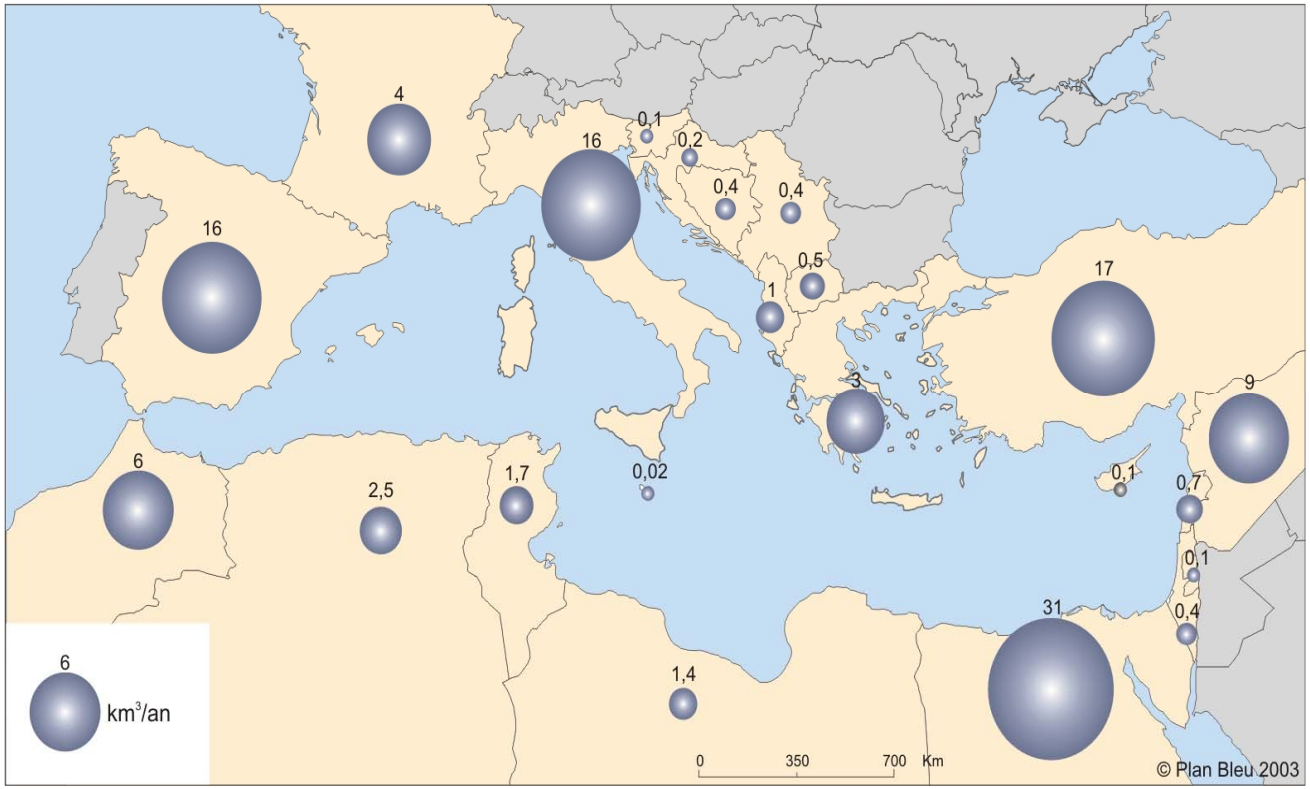


Ressources en eau naturelles renouvelables par habitant par an en 2050



Unefficiency of water uses

Amount of water lost or unused (Source: Plan Bleu)



- Irrigation : 20% lost during transfer, 60 % efficiency
- Drinking water : 30% lost during transfer, 20% leakages
- **Today, 110 km³/an lost or unused (≈ 40% of total water demand)**

Rapid degradation of water quality and ecosystems

- Water quality is deteriorating rapidily rendering imporant resources of water unusable
- Drivers of deterioration include growing urbanization, industrialization, tourism, salinization ,etc.
  - In SMCs, 80% of wastewater are untreated
- Ecological flows poorly applied
- Wetlands and estuaries are being disrupted and even destroyed as a result of water diversion and pollution from domestic, industrial and agricultural sectors.
- Degradation of forested watersheds leading to loss of key supporting services, as well as increased erosion and silting processes in reservoirs

Chronic polution of the Litani river (Lebanon)

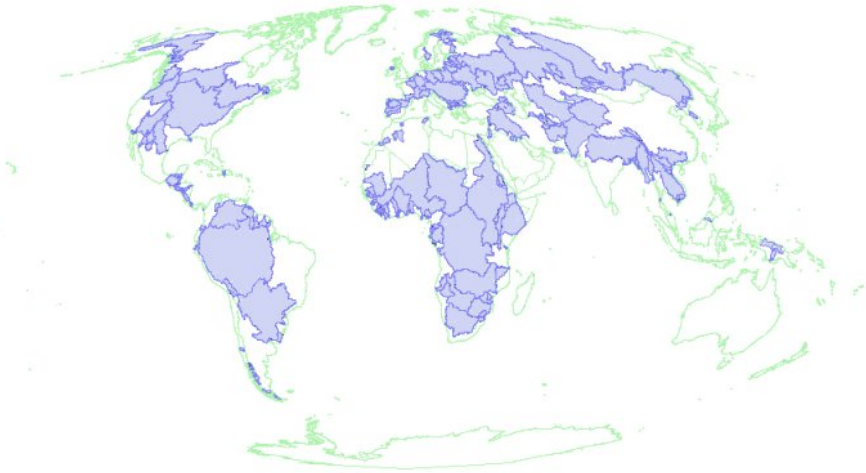
Destruction of the Moulouya wetlands (Morocco)

High dependency on shared water resources

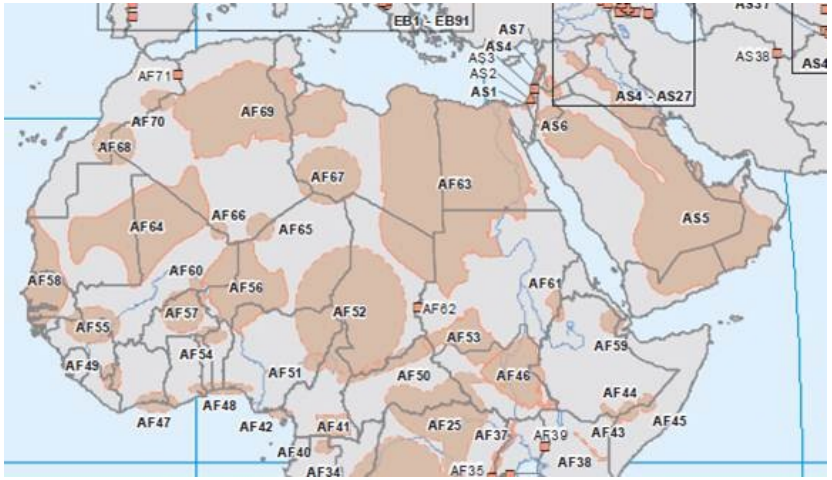
- Around 60 % of the annual renewable resources of the region is transboundary and come from countries situated outside the region that are alsc likely to be impacted by CC in huge proportions

- Lack of formalized transboundary agreement and adequate arrangements and capacities for the joint and management of international waters in the face of increasing water scarcity and variability

International river basins

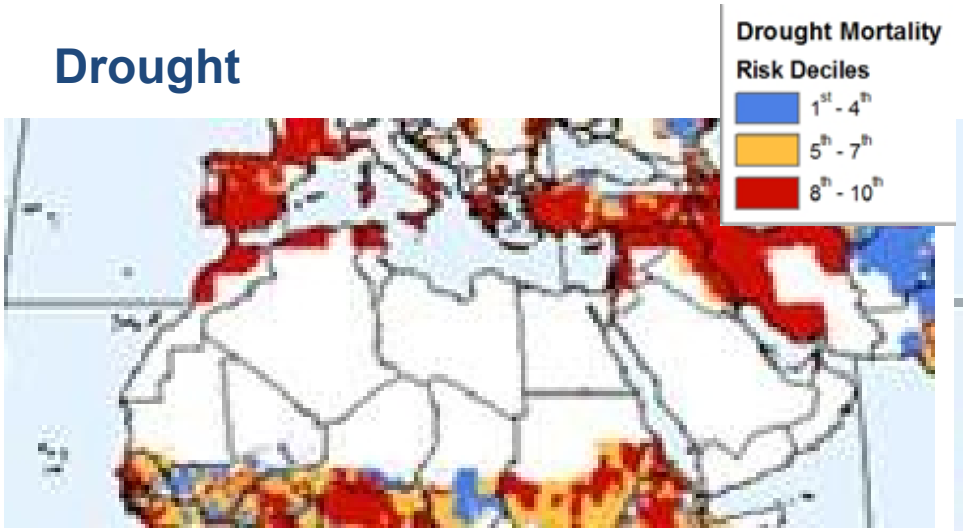


Transboundary aquifers

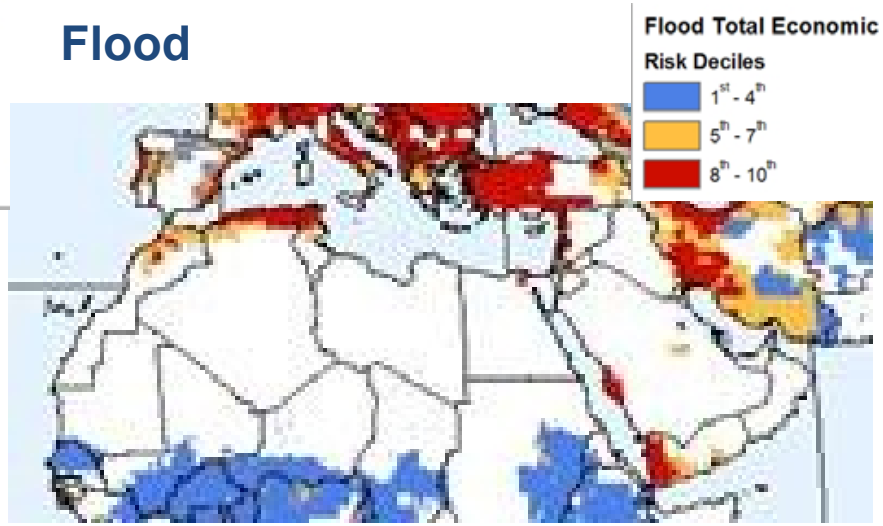


Increasing loss of life and damages from extreme drought and flooding events

Drought



Flood



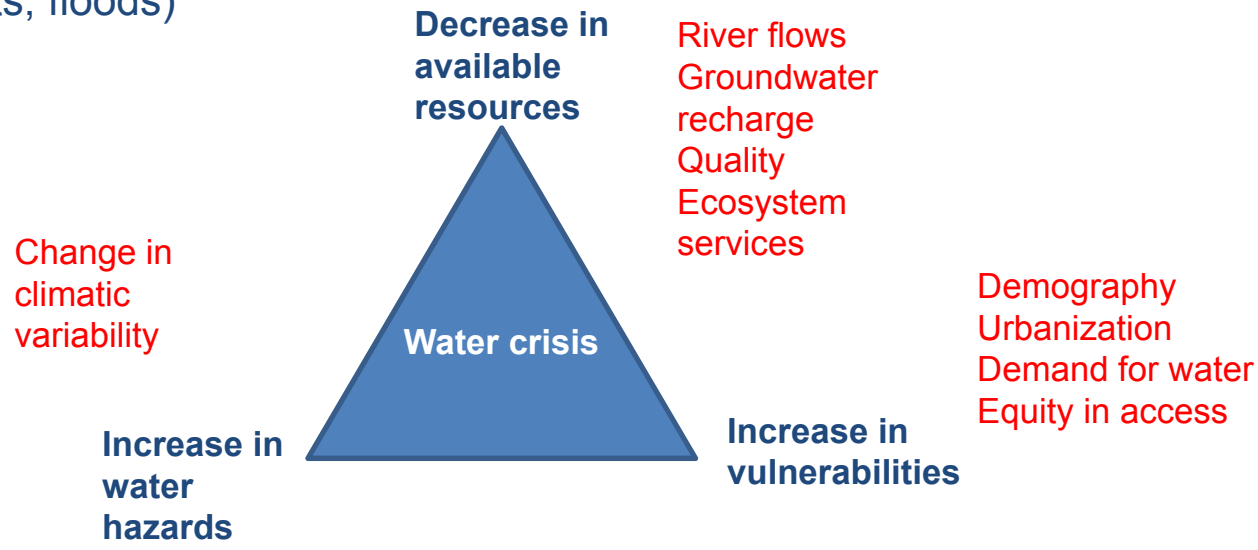
- Populations and assets are increasingly exposed to hydro-meteorological hazards
- Population growth and accelerating urbanization are key drivers of exposure
  - Arab countries have higher level of urbanization than the world average (60% vs 50%)
  - Significant development and urban settlements along the coastline in low elevation areas
- Rural out migration to cities and development of tourism are also increasing exposure

Other non-climatic vulnerability factors

- Heavy reliance on water-sensitive economic sectors such as tourism, agriculture, livestock, etc.;
- Water governance gaps
  - Insufficient implementation of IWRM strategies and plans
  - Institutional fragmentation, lack of inter-sectoral and multi-level coordination,
  - Limited technical, financial & human capacities
  - Inadequate mechanisms for collection, sharing and analysis of climate and hydrological data and information to inform policy making and operational management
  - Insufficient empowerment and participation of water stakeholders
  - Barriers to sustainable water sector financing & cost-recovery
- Political instability & conflicts undermining good water management and climate change adaptation;

Key messages

- Mediterranean & Middle East region is one of the most vulnerable region in the world to climate change
- Combined effect of climate change and development will:
  - worsen the regional gap between water supply and demand, thereby intensifying water scarcity (16-37% of the projected gap in 2050 could be attributed to CC)
  - exacerbate frequency and intensity of extreme water events and related disasters (droughts, floods)



CC will require in PCs more stringent adjustment of water resources management than in any other region


شكرا لانتباهكم
Thank you for your attention

Q&A, Discussion

- Needs for clarification ?
- How does climate change look like in your country?
- What are the observed changes in hydrology?
- How are they affecting water management?