Impact of Climate Change on the Arab World

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About the Arab World

• The Arab region covers 10 million square kilometers of semi-arid and arid regions

• It is made up of 22 states

• Overall population of 370,989,000

• Population growth rate in past 20 years ~ 2.6%

• Proportion of total population in urban and coastal areas increased from 44% to 54% in past 20 years.
Arab World
# Countries in the Arab World

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<td>Somalia</td>
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<td>11</td>
<td>United Arab Emirates</td>
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Arab World

• Resource rich:
  ▫ Oil
  ▫ Gas
  ▫ Minerals
  ▫ Etc.

• Water poor
Internal water resources and per capita water availability (current)

Source: Droogers et al. 2012
Annual renewable water resources per capita

- Australia & New Zealand: 35,000 m³/year
- Latin America & Caribbean: 30,000 m³/year
- North America: 20,000 m³/year
- Europe & Central Asia: 15,000 m³/year
- Sub-Saharan Africa: 10,000 m³/year
- East Asia & Pacific (incl. Japan & Korea): 10,000 m³/year
- Western Europe: 7,000 m³/year
- South Asia: 3,000 m³/year
- Middle East & North Africa: 1,000 m³/year
Climate Change - Background

- **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.
Climate Change - Background

Climate versus Weather

What is Climate Change?

- the variation in the Earth's global climate or in regional climates over time
- caused by processes internal to the Earth, external forces (e.g. variations in sunlight intensity) or, more recently, human activities
- there is 90-95% likelihood that changes in modern climate have been in part caused by human action.
Climate Change - Background

• Intergovernmental Panel on Climate Change (IPCC) 4th Report:
  
  ▫ "Warming of the climate system is unequivocal."
  
  ▫ "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."
Climate Change - Background

What human activities are causing Climate Change?

- Fossil fuels: produce CO$_2$ and CH$_4$
- Aerosols: produce cooling – result in the plateau in the 20$^{th}$ Century temperature trend
- Cement manufacture: 3$^{rd}$ largest source of CO$_2$
- Land use: agriculture, deforestation, urban sprawl
- Livestock: responsible for 18% of the world’s greenhouse gas emissions as measured in CO$_2$ equivalents and 65% of human-induced nitrous oxide
IPCC Projections - Temperature

- A temperature rise of about 0.1 °C per decade would be expected for the next two decades, even if greenhouse gas and aerosol concentrations were kept at year 2000 levels

- Range of temperature increase of 1.8 °C to 4.0 °C
IPCC Projections - Temperature and Precipitation from 21 GCM Models
Major Climate Change Projections for the Arab World

• Overall decline in rainfall projected for
  ▫ Mediterranean North Africa, northern and western Sahara, eastern Mediterranean - up to 30%, higher over parts of Morocco (high confidence)
  ▫ Drier winters in central Sahara and Sahel (medium confidence)

• Overall increase in rainfall projected for
  ▫ Eastern and central Sahel, southern Arabian Peninsular, Somalia (lower confidence)
  ▫ Wetter summers in most of Arabian Peninsular (except central regions), parts of inland southwestern Asia (e.g. Iraq, Jordan) (lower confidence)

• Uncertainty regarding summer monsoon (Sahel, Arabian Peninsular)
  ▫ Regional models tend to predict increase in monsoon strength, higher summer rainfall, more robust monsoon, greening of parts of southern Sahara, for moderate increases in greenhouse gases (e.g. up to ~550ppm)
  ▫ Uncertainty greatest over western Sahel

Changes may be broadly characterized as northwards shift of Saharan climatic zone, expanding into Mediterranean coastal region and retreating to north in Sahelian region
Major Climate Change Projections for the Arab World

• Heatwaves
  ▫ Very likely to become more frequent and protracted, with higher maximum temperatures

• Fire
  ▫ Hotter, drier conditions likely to increase fire risk in scrub and forest in Maghreb and eastern Mediterranean region

• Dust and Sand Storms
  ▫ Reduction in vegetation cover and of soil moisture, in northern Sahara and peri-desert region may increase soil erodibility.
Major Climate Change Projections for the Arab World

- **Drought**
  - Likely to become more frequent, severe and protracted in Mediterranean region.
  - May still periodically affect Sahelian and southern Arabian regions even if monsoon intensifies and moves north - rainfall may become more variable and unpredictable.

- **Floods**
  - Any increase in rainfall in Saharan and Sahelian regions will increase risk of flash floods.
  - Risk of coastal flooding exacerbated by sea-level rise.
Vulnerability of the Arab Region

- The Middle East and North Africa most vulnerable to climate change impacts because of its water scarcity
  - Greater seasonal temperature variability
  - Increase in severe weather events (droughts and floods)

- Between 1980 and 2008 more than 37 million Arab people were affected and more than 20 billion dollars were lost due to natural disasters.
Water Scarcity

Water stress indicator (WSI) in major basins:

- Slightly exploited
- Moderately exploited
- Heavily exploited
- Over-exploited

Sources: Smakhtin, Revenga and Döll, 2004.
Poor Adaptive Capacity
What have we been witnessing?
2008 Drought

Source: MODIS http://earthobservatory.nasa.gov
Rains and Floods In Algeria (2001)

Heavy rainfall equivalent to an entire month of rain in several hours was recorded; this extreme event claimed 751 victims and caused damage estimated at US$300 million.
Rains and Floods In Morocco (2010)

Devastating floods, with substantive infrastructure damage and human losses. Estimated losses included 89 dead and missing, dozens wounded, more than 400 houses collapsed or flooded, and hundreds of hectares of agricultural land damaged or lost.
Floods in Egypt (2006)

Affected 118,000 individuals – and led to 600 flood-related deaths.
A Saudi man and a woman cross a flooded street following heavy rain in the Red Sea port city of Jeddah in January 2011. (Amer Hilabi, AFP)

Vehicles are piled up and tarmac torn up following heavy rains and floods in the city of Jeddah. (Amer Hilabi, AFP)
Rains and Floods in Qassim, Saudi Arabia (May 2013)
Rains and Floods in Palestine (January 2013)

More than $50 million in economic damages and several impacts on the agricultural sector.
Rains and Floods in Yemen (October 2008)

Approximately US$ 1.7 billion in total damages and losses, and increase in poverty rate from 28 to 51% between 2008-2010.
Gonu Cyclone in Oman (2007)

Fatalities 78 total, 37 missing Damage $4.4 billion
Flooding in Jordan (2013)
Torrential rains in Qatar (2013)
Flooding in Lebanon (2013)
## Some figures - Lebanon

<table>
<thead>
<tr>
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Some figures - Saudi Arabia

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Effects of Climate Change

- Health
- Agriculture and Food Supply
- Forests
- Ecosystems and Biodiversity
- Coastal Zones
- Water Resources
- Energy Production and Use
- Protected Areas, Outdoor Recreation and Tourism
Health Effects

- **Direct Temperature Effects:** affecting those with heart problems, asthma, the elderly, and the very young.

- **Extreme Events:** event-related deaths, injuries, infectious diseases, and stress-related disorders.

- **Climate-Sensitive Diseases:** increase the risk of some infectious diseases, especially in warm areas (e.g., malaria, dengue fever, yellow fever, and encephalitis).

- **Air Quality:** smog events (ozone is damaging to lung tissues) and particulate air pollution (particulates can reach to the deepest regions of the lungs).
Agriculture and Food Supply

• **Average temperature increase will:**
  ▫ lengthen growing season in regions with a relatively cool spring
  ▫ adversely affect crops in regions where summer heat already limits production
  ▫ increase soil evaporation rates
  ▫ increase the chances of severe droughts

• **Change in rainfall amount and patterns**
  ▫ precipitation will increase in high latitudes
  ▫ decrease in most subtropical land regions
  ▫ extreme precipitation events is predicted to increase
  ▫ higher soil erosion rates
  ▫ lower soil moisture
Rust Disease Infestation - 2010

Source: MODIS http://earthobservatory.nasa.gov
Forests

• Effects on forests are likely to include changes in:
  ▫ Forest health and productivity
  ▫ Geographic range of certain tree species.

• These effects can in turn alter:
  ▫ Timber production,
  ▫ Outdoor recreational activities,
  ▫ Water quality,
  ▫ Wildlife and
  ▫ Rates of carbon storage.
Ecosystems and Biodiversity

• An ecosystem is an interdependent, functioning system of plants, animals and microorganisms – found at any scale

• Effects on terrestrial species indicate a poleward and elevational range shifts of flora and fauna.

• If temperatures exceed 2-3 °C relative to pre-industrial levels 20% - 30% of species may be at risk of extinction

• Synchronicity between species will be lost

• Resilience of many ecosystems likely to be exceeded
Coastal Zones

Sea level rise:

• average sea level rise 0.18 to 0.60 m in the next century
• inundate wetlands and other low-lying lands,
• erode beaches, intensify flooding due to storm surges,
• and increase the salinity of rivers, bays, and groundwater

• Protection measures may have adverse effects on the environment and on public uses of beaches and waterways
Water Resources

Changes in temperature and precipitation will have an impact on:

- **Water availability**, 
  - Increase in net solar radiation or temperature ⇒ speed up hydrologic cycle processes ⇒ increase in precipitation in areas and reducing it in others
  - Increase in net solar radiation or temperature ⇒ evapotranspiration

- **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

- **Streamflow**
  - Streamflow may move from late spring to early spring/late winter
Energy Production and Use

• Energy Use - demand for energy will change:
  ▫ Rising air temperatures ⇒ increases in energy demand for air conditioning
  ▫ Energy consumed for other climate-sensitive processes could be impacted, e.g.:
    • pumping water for irrigation in agriculture
    • cooling of greenhouses
    • refrigeration (e.g. stored produce, medicine, etc.)

• Examples of potential impacts are:
  ▫ Hydropower generation will be affected due to variability in stream flows.
  ▫ Infrastructure for energy production, transmission and distribution could be affected by increasingly severe storms.
  ▫ Power plant operations can be affected by extreme heat waves.
  ▫ Some renewable sources of energy could be affected. Example:
    • Increased cloudiness may reduce solar power generation
    • Wind energy production
Protected Areas, Outdoor Recreation and Tourism

• Many protected areas are currently susceptible to events influenced by climatic variability, such as drought, wild fires, impaired air quality, and severe storms – this will increase.

• Tourism businesses, which usually are location-specific, have a lower potential than tourists themselves (who have a wide variety of options) to adapt to climate change
Consequences for 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
Consequences of 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.
Economic activities

Emissions

Concentrations

Climate Change

Impacts on physical and ecological systems

Impacts on (damages to) economies

Mitigation

Adaptation
Some Adaptation and Mitigation 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

- **Food supply:**
  - Roof top gardens, community gardens, etc.
  - Vertical/structural agriculture
  - Agreements with foreign suppliers

- **Air quality:**
  - Urban green spaces
  - Public transport
  - Renew transport fleet

- **Renewable energy**

- **Water quality:**
  - Wastewater treatment
  - Restriction on access to groundwater

- **Infrastructure failures:**
  - New technologies
  - Structural interventions (dikes, breakwaters, flap gates, etc.)
  - Zoning
A Little about Lebanon
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%.
What have we been witnessing?
**Some Current Numbers - Beirut, Lebanon**

### Annual Rainfall in Beirut

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<th>Rain (mm)</th>
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#### Linear Relationship

- **Max T:**
  - Observations
  - Linear Trend

- **Min T:**
  - Observations
  - Linear Trend
Choueifat - Hadath

Rmeyle  
Source: Moujaber and Bou samra, 2002
What are we doing a AUB/IFI

• Research on:
  ▫ temperature and precipitation trends
  ▫ climate change impact on drought occurrences and frequencies
  ▫ climate change impact on evapotranspiration
  ▫ developing climate change scenarios using GCMs
  ▫ adaptation measures and approaches
  ▫ impact of climate change on the Lebanese economy
THANK YOU FOR YOUR TIME AND PATIENCE

Falougha, Lebanon – ancestral hometown of Eduardo Haddad