Vulnerability of Water Available for Crops

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The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD)
The integrated Assessment model

Representative Concentration Pathway (RCP) → GCM → RCM → RHM → VA → IM

IMPACT ASSESSMENT

VULNERABILITY ASSESSMENT

THE ARAB REGION
Components of vulnerability

EXPOSURE (0.50)

SENSITIVITY (0.50)

POTENTIAL IMPACTS (0.50)

ADAPTIVE CAPACITY (0.50)

VULNERABILITY
<table>
<thead>
<tr>
<th>SECTORS</th>
<th>SUBSECTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Water availability</td>
</tr>
<tr>
<td>Biodiversity and Ecosystems</td>
<td>Area covered by forests</td>
</tr>
<tr>
<td></td>
<td>Area covered by wetlands</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Water available for crops</td>
</tr>
<tr>
<td></td>
<td>Water available for livestock</td>
</tr>
<tr>
<td>Infrastructure and Human Settlements</td>
<td>Inland flooding area</td>
</tr>
<tr>
<td>People</td>
<td>Water available for drinking</td>
</tr>
<tr>
<td></td>
<td>Health conditions due to heat stress</td>
</tr>
<tr>
<td></td>
<td>Employment rate for the agricultural sector</td>
</tr>
</tbody>
</table>
The water availability study area represents 22% of the Arab Region and is defined by:

- rainfed cropland Area
- and
- irrigated cropland areas
Impact chain of Water Available for Crops

CHANGE IN THE WATER AVAILABLE FOR CROPS – IMPACT CHAIN

**Exposure (0.56)**
- RCM: Change in temperature (0.17), Change in precipitation (0.17)
- RHM: Change in runoff (0.17), Change in evapotranspiration (0.17)

**Extreme ClimateIndices (0.16)**
- Change in number of days > 35 °C
- Change in maximum length of dry spell

**Sensitivity (0.50)**
- Population (0.56)
  - Population density (0.12)
  - Share of agricultural labor force in total labor (0.12)
  - Total renewable water available per capita (0.13)
  - Share of water consumption in agriculture (0.52)
  - Share of agriculture in GDP (0.13)

- Natural (0.26)
  - Soil storage capacity (0.34)
  - Degradation of vegetation cover (0.32)
  - Rainfed areas (0.34)

- Mainstream (0.24)
  - Floodprone areas (0.46)
  - Irrigated areas (0.54)

**Adaptive Capacity (0.56)**
- Knowledge & Awareness (0.11)
  - E-government development (0.34)
  - Tertiary enrollment (0.33)
  - Adult literacy rate (0.33)

- Technology (0.11)
  - Number of scientific and technical journal articles (0.45)
  - Information and communication technologies index (0.55)

- Infrastructure (0.56)
  - Water & sanitation (0.56)
    - Areas served by dams (0.17)
    - Installed desalination capacity per capita (0.17)
    - Fossil groundwater (0.17)
    - Access to improved water (0.17)
    - Access to improved sanitation (0.16)
    - Area equipped for irrigation (0.16)
  - Environment (0.17)
    - Environment performance index (1.0)

- Institutions (0.10)
  - Governance index (0.53)
  - Disaster risk reduction committees (0.47)

- Energy (0.17)
  - Access to electricity (0.50)
  - Energy consumption (0.50)

- Transport (0.16)
  - Density of road network (1.0)

- Economic Resources (0.10)
  - GDP per capita (0.35)
  - ODA (0.28)
  - Food imports as % of merchandise exports (0.37)

- Equity (0.08)
  - Female-to-male literacy ratio (0.52)
  - Migrants/refugees index (0.48)
### Exposure

#### AGRICULTURE: WATER AVAILABLE FOR CROPS

**EXPOSURE:** RCP8.5 END-CENTURY (2081-2100)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Percentage of study area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low EX</td>
</tr>
<tr>
<td>RCP 4.5 Mid-century</td>
<td>7%</td>
</tr>
<tr>
<td>RCP 8.5 Mid-century</td>
<td>1%</td>
</tr>
<tr>
<td>RCP 4.5 End-century</td>
<td>6%</td>
</tr>
<tr>
<td>RCP 8.5 End-century</td>
<td>1%</td>
</tr>
</tbody>
</table>

#### EXTREME CLIMATE INDICES

- Change in temperature (0.17)
- Change in precipitation (0.17)
- Change in runoff (0.17)
- Change in evapotranspiration (0.17)
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Percentage of study area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low SE</td>
<td>28%</td>
</tr>
<tr>
<td>Moderate SE</td>
<td>66%</td>
</tr>
<tr>
<td>High SE</td>
<td>7%</td>
</tr>
</tbody>
</table>

Legend:
- **Low Sensitivity**
- **Moderate Sensitivity**
- **High Sensitivity**

### Sensitivity Indicators
- **Population (0.56)**
  - Population density (0.12)
  - Share of agricultural labor force in total labor (0.12)
  - Total renewable water available per capita (0.13)
  - Share of water consumption in agriculture (0.50)
  - Share of agriculture in GDP (0.13)

- **Natural (0.36)**
  - Soil storage capacity (0.34)
  - Degradation of vegetation cover (0.32)
  - Rainfed areas (0.34)

- **Manmade (0.24)**
  - Flood prone areas (0.46)
  - Irrigated areas (0.54)
Components of vulnerability

- **EXPOSURE (0.50)**
- **SENSITIVITY (0.50)**
- **POTENTIAL IMPACTS (0.50)**
- **ADAPTIVE CAPACITY (0.50)**

**VULNERABILITY**
### Scenario Analysis

<table>
<thead>
<tr>
<th>Scenario</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low PI</td>
</tr>
<tr>
<td>RCP 4.5 Mid-century</td>
<td>3%</td>
</tr>
<tr>
<td>RCP 8.5 Mid-century</td>
<td>0%</td>
</tr>
<tr>
<td>RCP 4.5 End-century</td>
<td>2%</td>
</tr>
<tr>
<td>RCP 8.5 End-century</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Areas with highest potential impact:**
- The lower Nile River valley
- The eastern ME cost

**Areas with lowest potential impact:**
- Tigris-Euphrates Basin
Adaptive capacity

Areas with lowest adaptive capacity:

- the Horn of Africa
- The southern of Sudan,
- The southern of Mauretania and
- the southwestern Arabian Peninsula.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Percentage of study area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low AC</td>
</tr>
<tr>
<td>All climate scenarios</td>
<td>28%</td>
</tr>
</tbody>
</table>
Components of vulnerability

- EXPOSURE (0.50)
- SENSITIVITY (0.50)
- POTENTIAL IMPACTS (0.50)
- ADAPTIVE CAPACITY (0.50)

VULNERABILITY
### Vulnerability

**Areas with highest vulnerability:**
- the upper Nile Valley,
- the southwestern Arabian Peninsula, and
- **Areas with lowest vulnerability:**
  - the Mediterranean coast of the Maghreb,
  - parts of the Levant, the Tigris-Euphrates Basin, and the central eastern Arabian Desert.

#### Table: Percentage of study area

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Low Vul</th>
<th>Moderate Vul</th>
<th>High Vul</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 4.5 Mid-century</td>
<td>0%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>RCP 8.5 Mid-century</td>
<td>0%</td>
<td>33%</td>
<td>67%</td>
</tr>
<tr>
<td>RCP 4.5 End-century</td>
<td>0%</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>RCP 8.5 End-century</td>
<td>0%</td>
<td>16%</td>
<td>84%</td>
</tr>
</tbody>
</table>
Vulnerability hotspots:

- sub-Saharan Africa,
- the Horn of Africa, and
- the southwestern Arabian Peninsula
Vulnerability to inland flooding
Inland flooding areas:
Study area

Study area based on areas with low flood potential or greater
Impact chain: Inland flooding area

**Exposure (0.50)**
- RHM
  - Change in run-off (0.34)*
- Extreme events indices
  - Change in annual count of 10 mm precipitation days (0.33)*
  - Change in annual count of 20 mm precipitation days (0.33)*

**Sensitivity (0.50)**
- Population (0.25)
  - Population density (0.21)
  - Share of agricultural labor force (0.14)
  - Share of children and elderly of the population (0.14)
- Natural (0.25)
  - Landuse - land cover (0.23)*
  - Soil erodibility (0.21)
  - Degradation of vegetation cover (0.22)
- Manmade (0.50)
  - Flood prone areas (0.50)
  - Urban extent (0.15)
  - Road network (0.13)
  - Areas under cultural heritage protection (0.11)
  - Wastewater treatment (0.11)

**Adaptive Capacity (0.50)**
- Knowledge & Awareness (0.10)
  - E-Government development (0.38)
  - Tertiary enrollment (0.31)
  - Adult literacy rate (0.31)
- Infrastructure (0.12)
  - Water & sanitation (0.32)
    - Areas served by dams (1.0)
  - Environment (0.32)
    - Environment performance index (1.0)
- Transport (0.36)
  - Density of road network (1.0)
- Institutions (0.10)
  - Governance index (0.34)
  - Areas under nature protection (0.31)
  - Disaster risk reduction committees (0.35)
- Economic resources (0.50)
  - GDP per capita (0.50)
  - ODA (0.50)
EXPOSURE (0.50)

RHM
- Change in runoff (0.34)*

EXTREME EVENTS INDICES
- Change in annual count of 10 mm precipitation days (0.33)*
- Change in annual count of 20 mm precipitation days (0.33)*
### SENSITIVITY (0.50)

#### POPULATION (0.25)
- Population density (0.21)
- Share of agricultural labor force (0.14)
- Share of children and elderly of the population (0.14)
- Share of agriculture in GDP (0.15)
- Refugee population (0.18)
- Migrant population (0.18)

#### NATURAL (0.25)
- Land use - land cover (0.23)*
- Soil erodibility (0.21)
- Degradation of vegetation cover (0.22)
- Livestock density (0.15)
- Wetlands areas (0.19)*

#### MANMADE (0.50)
- Floodprone areas (0.50)
- Urban extent (0.15)
- Road network (0.13)
- Areas under cultural heritage protection (0.11)
- Wastewater treatment (0.11)

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16 indicators
Exposure

**EXPOSURE (0.50)**

**RHM**
- Change in runoff (0.34)*

**EXTREME EVENTS INDICES**
- Change in annual count of 10 mm precipitation days (0.33)*
- Change in annual count of 20 mm precipitation days (0.33)*

**Scenario**

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<tr>
<td></td>
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</tr>
<tr>
<td>RCP 4.5 Mid-century</td>
<td>5%</td>
</tr>
<tr>
<td>RCP 8.5 Mid-century</td>
<td>5%</td>
</tr>
<tr>
<td>RCP 4.5 End-century</td>
<td>4%</td>
</tr>
<tr>
<td>RCP 8.5 End-century</td>
<td>7%</td>
</tr>
</tbody>
</table>
sensitivity

- **Scenario**
  - **Percentage of study area**
    - **Low SE**
    - **Moderate SE**
    - **High SE**

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<thead>
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<th>Moderate SE</th>
<th>High SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>All climate scenarios</td>
<td>89%</td>
<td>11%</td>
<td>0%</td>
</tr>
</tbody>
</table>
### Areas with highest potential impact:
- Middle valley of the Senegal River
- Jubba–Shabelle river floodplains
- Bahr el Arab floodplain (eastern Sahel)

### Areas with lowest potential impact:
- Atlas Mountains and coastal plain
- Jafara Plain
- Green Mountains
- Coastal Levant
- Zagros Mountains

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<tr>
<td></td>
<td>Low PI</td>
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<tr>
<td>RCP 4.5 Mid-century</td>
<td>17%</td>
</tr>
<tr>
<td>RCP 8.5 Mid-century</td>
<td>27%</td>
</tr>
<tr>
<td>RCP 4.5 End-century</td>
<td>21%</td>
</tr>
<tr>
<td>RCP 8.5 End-century</td>
<td>23%</td>
</tr>
</tbody>
</table>
**Areas with lowest adaptive capacity:**

- Wadis and streams in sub-Saharan Africa
- Wadis and streams in south-western Arabian Peninsula

### Percentage of study area

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Low AC</th>
<th>Moderate AC</th>
<th>High AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>All climate scenarios</td>
<td>25%</td>
<td>73%</td>
<td>2%</td>
</tr>
</tbody>
</table>
### Areas with highest vulnerability:
- Sub-Saharan Africa

### Areas with lowest vulnerability:
- North Africa and Levantine coastal areas

#### Percentage of study area

<table>
<thead>
<tr>
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<th>Low Vul</th>
<th>Moderate Vul</th>
<th>High Vul</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 4.5 Mid-century</td>
<td>2%</td>
<td>94%</td>
<td>4%</td>
</tr>
<tr>
<td>RCP 8.5 Mid-century</td>
<td>3%</td>
<td>93%</td>
<td>4%</td>
</tr>
<tr>
<td>RCP 4.5 End-century</td>
<td>2%</td>
<td>94%</td>
<td>4%</td>
</tr>
<tr>
<td>RCP 8.5 End-century</td>
<td>4%</td>
<td>89%</td>
<td>7%</td>
</tr>
</tbody>
</table>
Vulnerability hotspots:

- Western Sahel
- Eastern Sahel
- Horn of Africa (particularly the Jubba and Shabelle river floodplains)
- Isolated areas—southern Arabian Peninsula