Using AQUACROP to support climate change impact assessment in key agricultural sectors

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for the
Sixth Expert Group Meeting on the Regional Initiative
Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR)
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Cairo, Egypt
The population of the Arab Region has nearly tripled in 2014 since 1970, climbing from 128 million to 400 million.

It is expected to reach 600 million inhabitants by 2050.

But,
The available conventional water resources remain the same

Food demand is expected to increase 3X the current level
Arab Region is the largest grain importer (2010 million metric tons)

Global Trade: Net cereal imports (in million MT), by region, 2010

- Arab Countries: +16.1
- Europe: +17.5
- Sub-Saharan Africa: -18.0
- Latin America and the Caribbean: +6.3
- North America: +91.2
- Oceania: +18.6
- Asia: -58.8

Sources: adapted from USDA 2011
We need to do so with less water!

Source: OECD
Declining agricultural water

Southern Mediterranean

- Cubic meter per capita
- % Agriculture share of total
- Total available water per capita
- Agriculture share of water per capita

1990: 85
2000: 80
2025: 70
2050: 53

% of total water resources

Courtesy of Dr Theib Oweis, ICARDA
Increased certainty about the negative impact of it on all aspects of food security (availability, access, and utilization):

- Runoff will decrease by over 40% in many areas with an increase of severe drought and floods frequency and intensity and more extreme events (droughts, storms)
- Temp. increase is predicted to increase in the range of 4-7 °C by 2100
- Sea level rise of about 0.1-0.3m is expected by the end of 2050
The Water Scarcity Initiative (WSI)

What, Where?

WSI was initiated in 2013 by FAO in response to the FAO’s Strategic Framework:
– demands from the national governments of the NENA regions, and
– the prevailing water facts

Objectives
Support member countries in identifying and streamlining policies, governance, and best practices in agriculture water management, that can significantly contribute to boosting agriculture productivity, improving food security and sustaining water resources.
Build on?

- Arab Water Security Strategy 2010-2030
- The Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region” (RICCAR)
- Other relevant actions (i.e. several national/regional strategies)
WSI- Focus Areas of Work

1. **Strategic planning & policies**
2. **Strengthening/reforming governance at all levels**
3. **Improving water management, performances (efficiency) and productivity in major agricultural systems and in the food chain**
4. **Managing the water supply through the use of nonconventional waters**
5. **Climate change adaptations**
6. **Building sustainability with focus on salinity, groundwater, and livelihoods**
7. **Benchmarking, monitoring and reporting on water use efficiency and productivity**
WSI- Focus Areas of Work

1. Strategic planning & policies
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The Context:
NENA is one of the world regions most vulnerable to climate change (IPCC, 2014)

✓ An ‘adaptation assessment’ is carried out in support of the ‘Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region’ (RICCAR)
Title: Climate Change and Adaptation Solutions for the Green Sectors of Selected ‘Zones’ in the NENA Region

Partnership: the GIZ programme on Adaptation to Climate Change; ESCWA; ACSAD; and FAO

The ultimate objective: to increase the resilience and sustainability of the ‘green sectors’ under different climate scenarios.

Output 1: Improved assessment of climate change and design of adaptation measures of green sector in selected ‘zones’ of the Arab Region:

• North Delta of Egypt, Irrigated agriculture zone
• Karak governorate of Jordan, Rainfed agriculture
• Orontes Watershed- Lebanon, Mixed agriculture

Term: 17 months
Immediate Action:

Integrating FAO crop module (AquaCrop) into RICCAR Framework and generate maps of weather and hydrological-based water demand scenarios for three time horizons (baseline; 2030; and 2060)
Why AquaCrop Model?

Mathematical modeling to understand Climate Change

- **Simulate** complex and comprehensive compound interactions of many biophysical factors influenced by management practices to run for long time-scale to give clues to the long-term impact based on a short-term experiments
- computer simulation studies using comprehensive models/modules can provide *biophysical discoveries and predict smartly the impact of actions on the ground- smart management*
- The visual & real-time simulations can be powerful in making *informed decisions or implementing proactive interventions.*
Example:

the Modeling System for Agriculture Impacts of Climate Change

(MOSAICC)
Integrated package of models for assessing the impact of climate change on agriculture, including variations in crop yields and their effect on national economies.

MOSAICC

OUR PARTNERS:

The Modelling System for Agricultural Impacts of Climate Change (MOSAICC) is an integrated package of models for assessing the impact of climate change on agriculture, including the variations in crop yields and their effect on national economies.

MOSAICC has been developed by the Food and Agriculture Organization of the UN in the framework of the EC/FAO Programme on "Linking information and decision making to improve food security".

www.fao.org/climatechange/mosaicc
1. **Climate data processing tools**: statistical downscaling and interpolation tools

2. **Crop models**: simulate crop growth under climate change scenarios

3. **Hydrological model**: models the hydrology of river basins under climate change scenarios

4. **Economic model**: simulates the impact of yield variations due to climate change on national economies

These models are interconnected and were designed to facilitate the data flow from one to the other.
The models

The models integrated in FAO-MOSAICC are organized in four main components:

**Climate data processing tools**: statistical downscaling and interpolation tools aimed at preparing the data for the crop and the hydrology modelling tools

**Crop models**: simulate crop growth under climate change scenarios, using the data produced by the climate data processing tools

**Hydrological model**: models the hydrology of river basins under climate change scenarios, using the data produced by the climate data processing tools

**Economic model**: simulates the impact of yield variations due to climate change on national economies

These models are interconnected and were designed to facilitate the data flow.
AquaCrop conceptual framework

Atmosphere

Crop

Management

Soil

The Regional Initiative on Water Scarcity
AquaCrop – a tool for impact assessment on Agricultural crops - Project yields and water demand under CC

Biomass = WP \cdot \Sigma T

Evolution from FAO I&D Paper 33

The Regional Initiative on Water Scarcity
AquaCrop – a tool for impact assessment on Agricultural crops

Figure 2. Main processes included in AquaCrop.
**Field Management**

- **Fertility level** (non-limiting; moderate; poor)
- **Field-surface practices** (mulching; soil bunds)

**Water Management**

- **Rainfed**

**Irrigation**

- **User defined schedule** (timing and depth)
- **Model-generated schedule** (fixed interval; fixed depth; % of RAW)
- **Irrigation method** (drip; sprinkler; surface » basin; border; furrow)
AquaCrop - Tests

Wheat

The Regional Initiative on Water Scarcity
AquaCrop - Tests

Corn

- Texas
- Spain
- Quzhou
- California
- Florida
AquaCrop - Tests

Cotton

The Regional Initiative on Water Scarcity
AquaCrop - Validation

CC Assessment on Crop Production in Uzbekistan

The Regional Initiative on Water Scarcity
### AquaCrop – Example: CC Assessment on Crop Production in Uzbekistan

<table>
<thead>
<tr>
<th>Type</th>
<th>A: Crop types</th>
<th>B: Agro-Ecological Zones</th>
<th>C: Climate scenarios</th>
<th>D: CO2 fertilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Alfalfa</td>
<td>Desert &amp; Steppe, RB 2</td>
<td>Baseline</td>
<td>Yes</td>
</tr>
<tr>
<td>2.</td>
<td>Apples</td>
<td>Desert &amp; Steppe, RB 5</td>
<td>Low</td>
<td>No</td>
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<tr>
<td>3.</td>
<td>Cotton</td>
<td>Highlands, RB 3</td>
<td>Median</td>
<td></td>
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<tr>
<td>4.</td>
<td>Grassland</td>
<td>Piedmont zone, RB 1</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Potatoes</td>
<td>Piedmont zone, RB 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Tomatoes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Winter Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Spring Wheat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>8</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Total dimensions \((A \times B \times C \times D) = 400\)

[File](file:///C:/FKarajeh/FAO%20Office-FKarajeh/FAO-ESCWA/CropImpactAssessment_Uzbekistan.pdf)
## AquaCrop - Tests

Table 8. Impact on crop yields (ton/ha) of different adaptation options for the 6 AEZs

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Smart &amp; Shape</th>
<th>Smart &amp; Shape</th>
<th>Highlands</th>
<th>Piedmont area</th>
<th>Piedmont area</th>
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</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>Current</td>
<td>34.7</td>
<td>34.7</td>
<td>36.8</td>
<td>32.2</td>
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<tr>
<td></td>
<td>2050A</td>
<td>38.5 (+11%)</td>
<td>38.5 (+11%)</td>
<td>38.5 (+11%)</td>
<td>34.2 (+11%)</td>
</tr>
<tr>
<td></td>
<td>2050B</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>38.2 (+26%)</td>
</tr>
<tr>
<td></td>
<td>2050C</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>41.5 (+38%)</td>
</tr>
<tr>
<td></td>
<td>2050D</td>
<td>39.5 (+14%)</td>
<td>39.5 (+14%)</td>
<td>39.5 (+14%)</td>
<td>34.2 (+14%)</td>
</tr>
<tr>
<td></td>
<td>2050E</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>38.2 (+26%)</td>
</tr>
<tr>
<td></td>
<td>2050F</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>41.5 (+38%)</td>
</tr>
<tr>
<td></td>
<td>2050G</td>
<td>39.5 (+14%)</td>
<td>39.5 (+14%)</td>
<td>39.5 (+14%)</td>
<td>34.2 (+14%)</td>
</tr>
<tr>
<td></td>
<td>2050H</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>38.2 (+26%)</td>
</tr>
<tr>
<td></td>
<td>2050I</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>41.5 (+38%)</td>
</tr>
<tr>
<td></td>
<td>2050J</td>
<td>39.5 (+14%)</td>
<td>39.5 (+14%)</td>
<td>39.5 (+14%)</td>
<td>34.2 (+14%)</td>
</tr>
<tr>
<td></td>
<td>2050K</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>42.7 (+26%)</td>
<td>38.2 (+26%)</td>
</tr>
<tr>
<td></td>
<td>2050L</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>46.9 (+38%)</td>
<td>41.5 (+38%)</td>
</tr>
</tbody>
</table>

### Table 6: Impact on crop yields (ton/ha) of different adaptation options for the 5 AEZs

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Desert &amp; Steppe RB2</th>
<th>Desert &amp; Steppe RB5</th>
<th>Highlands RB3</th>
<th>Piedmont zone RB1</th>
<th>Piedmont zone RB3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alfalfa</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Current</strong></td>
<td>34.7</td>
<td>37.7</td>
<td>35.8</td>
<td>22.3</td>
<td>35.7</td>
</tr>
<tr>
<td><strong>2040’s Impact</strong></td>
<td>35.6 (+3%)</td>
<td>38.5 (+2%)</td>
<td>37.0 (+3%)</td>
<td>27.2 (+22%)</td>
<td>36.1 (+1%)</td>
</tr>
<tr>
<td>Increased Fertilizer Use</td>
<td>39.4 (+13%)</td>
<td>42.7 (+13%)</td>
<td>40.9 (+14%)</td>
<td>30.6 (+37%)</td>
<td>39.6 (+11%)</td>
</tr>
<tr>
<td>Increased Irrigation</td>
<td>38.8 (+12%)</td>
<td>42.0 (+11%)</td>
<td>40.3 (+12%)</td>
<td>29.9 (+34%)</td>
<td>39.4 (+10%)</td>
</tr>
<tr>
<td>Enhanced Varieties</td>
<td>39.5 (+14%)</td>
<td>41.9 (+11%)</td>
<td>40.7 (+13%)</td>
<td>30.2 (+35%)</td>
<td>40.2 (+13%)</td>
</tr>
<tr>
<td>Decreased Soil Salinity</td>
<td>38.4 (+11%)</td>
<td>41.7 (+11%)</td>
<td>39.9 (+11%)</td>
<td>29.7 (+33%)</td>
<td>38.7 (+9%)</td>
</tr>
<tr>
<td><strong>Current</strong></td>
<td>4.9</td>
<td>4.7</td>
<td>5.1</td>
<td>3.7</td>
<td>5.0</td>
</tr>
<tr>
<td><strong>2040’s Impact</strong></td>
<td>5.0 (+2%)</td>
<td>4.6 (-2%)</td>
<td>5.1 (-1%)</td>
<td>4.1 (+13%)</td>
<td>4.8 (-4%)</td>
</tr>
<tr>
<td>Increased Fertilizer Use</td>
<td>5.4 (+10%)</td>
<td>5.1 (+9%)</td>
<td>5.7 (+11%)</td>
<td>5.1 (+39%)</td>
<td>5.0 (-0%)</td>
</tr>
<tr>
<td>Increased Irrigation</td>
<td>6.7 (+38%)</td>
<td>6.3 (+34%)</td>
<td>6.6 (+28%)</td>
<td>4.6 (+25%)</td>
<td>6.7 (+35%)</td>
</tr>
<tr>
<td>Enhanced Varieties</td>
<td>5.7 (+18%)</td>
<td>5.3 (+13%)</td>
<td>5.9 (+15%)</td>
<td>4.8 (+31%)</td>
<td>5.5 (+10%)</td>
</tr>
<tr>
<td>Decreased Soil Salinity</td>
<td>5.2 (+6%)</td>
<td>4.9 (+4%)</td>
<td>5.4 (+5%)</td>
<td>4.6 (+26%)</td>
<td>4.9 (-2%)</td>
</tr>
</tbody>
</table>

*Source: FAO ESCWA Crop Impact Assessment_Uzbekistan.pdf*
Concluding remarks

**AquaCrop**

- is explicit and mostly intuitive, and maintains an optimum balance between simplicity, accuracy, and robustness
- is particularly suited for impact assessment under different climate change scenarios
- has been calibrated, validated, and applied for different crops and different climatic conditions, including high CO2
- has been utilized for different climate change impact assessments on agriculture: Mekong River, Latin America and Kenya + 2 main EU Projects -(Uzbekistan)
- will be incorporated into the RICCAR to provide the climate change impact assessment of Agriculture
Thank You

http://neareast.fao.org