Exploring the Role of Biosaline Agriculture in GCC's Water Management Landscape

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Overview

- Global and local challenges
- Implications for water in marginal environments
- ICBA work on Biosaline agriculture: Solutions for water and crop management
  - Decision support tools
  - Salt-, heat-, and drought-tolerant crops
  - Innovative production systems and practices

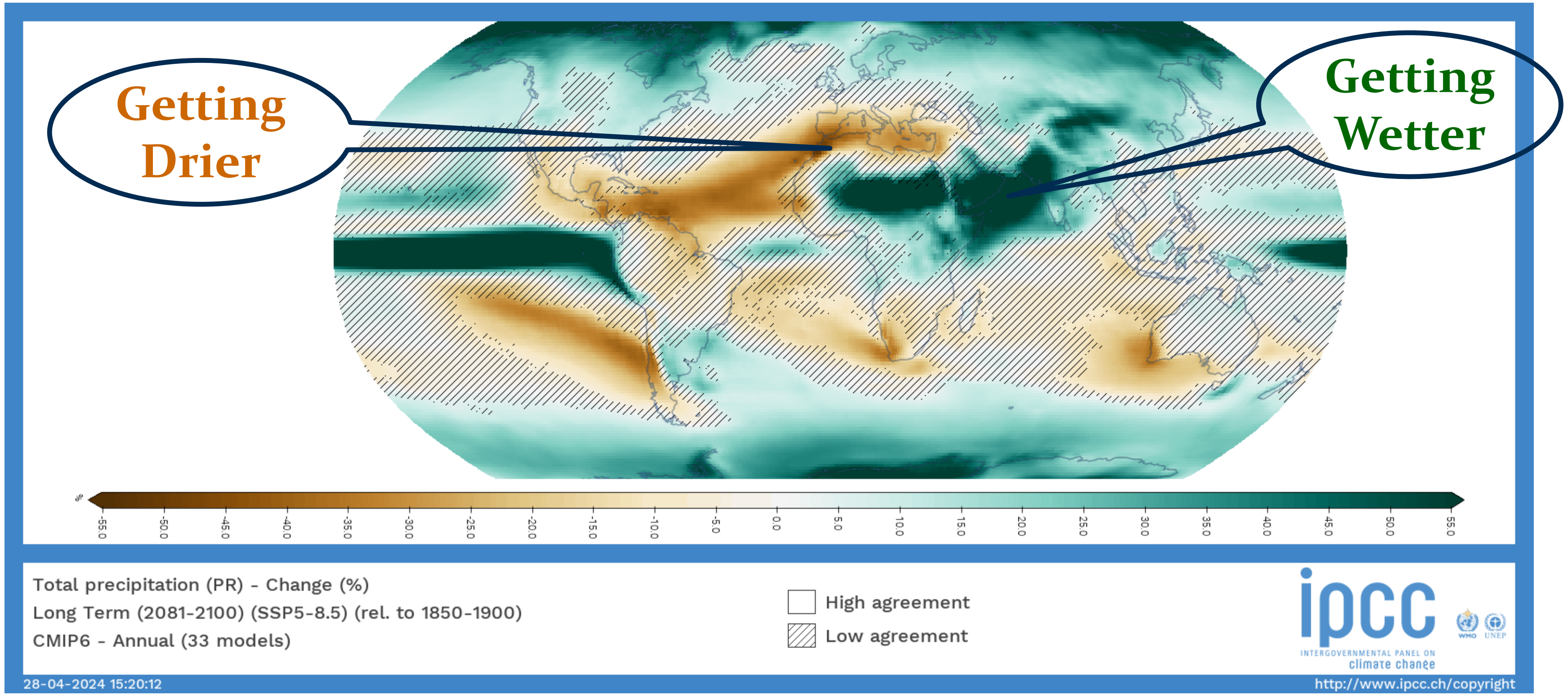
Global challenges

Global population: To grow from 8.1 billion currently to 9.7 billion in 2050.

Climate change: 2023 warmest year since 1850. Changing weather patterns, rising sea levels, and more extreme events.

Poverty: 712 million people globally were living in extreme poverty in 2022. An increase of 23 million people compared to 2019.

Local challenges: drought and flood



- Severe, extended and more frequent droughts in North Africa
- Extreme rainfall events in GCC countries

Local challenges: heat waves

npj Climate and Atmospheric Science

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Impact Factor

8.372

Scopus

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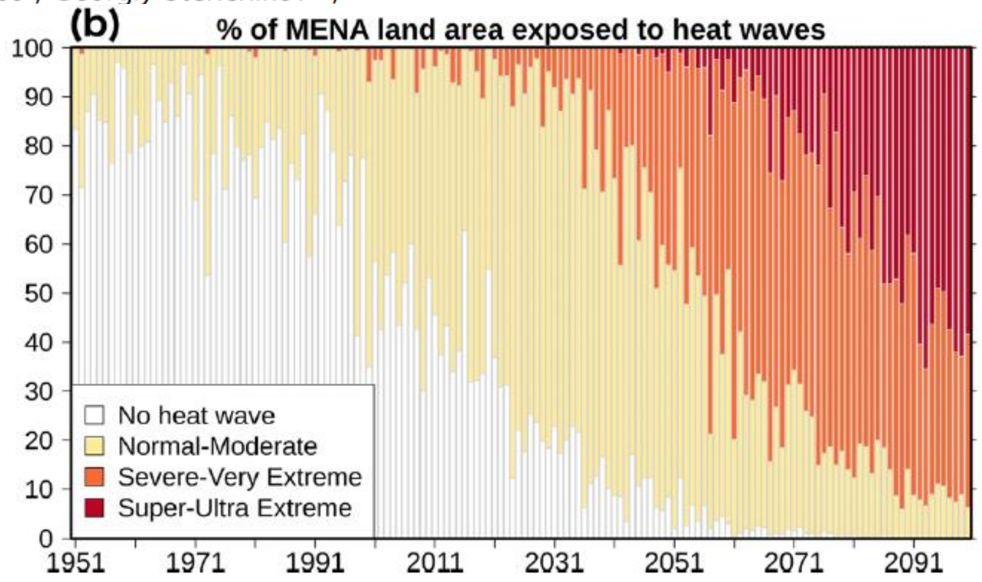
Business-as-usual will lead to super and ultra-extreme heatwaves in the Middle East and North Africa

George Zittis[1] ✉, Panos Hadjinicolaou[1], Mansour Almazroui[2], Edoardo Bucchignani[3,4], Fatima Driouech[5], Khalid El Rhaz[6], Levent Kurnaz[7,8], Grigory Nikulin[9], Athanasios Ntoumos[1], Tugba Ozturk[10], Yiannis Proestos[1], Georgiy Stenchikov[11], Rashyd Zaaboul[12] and Jos Lelieveld[1,13]

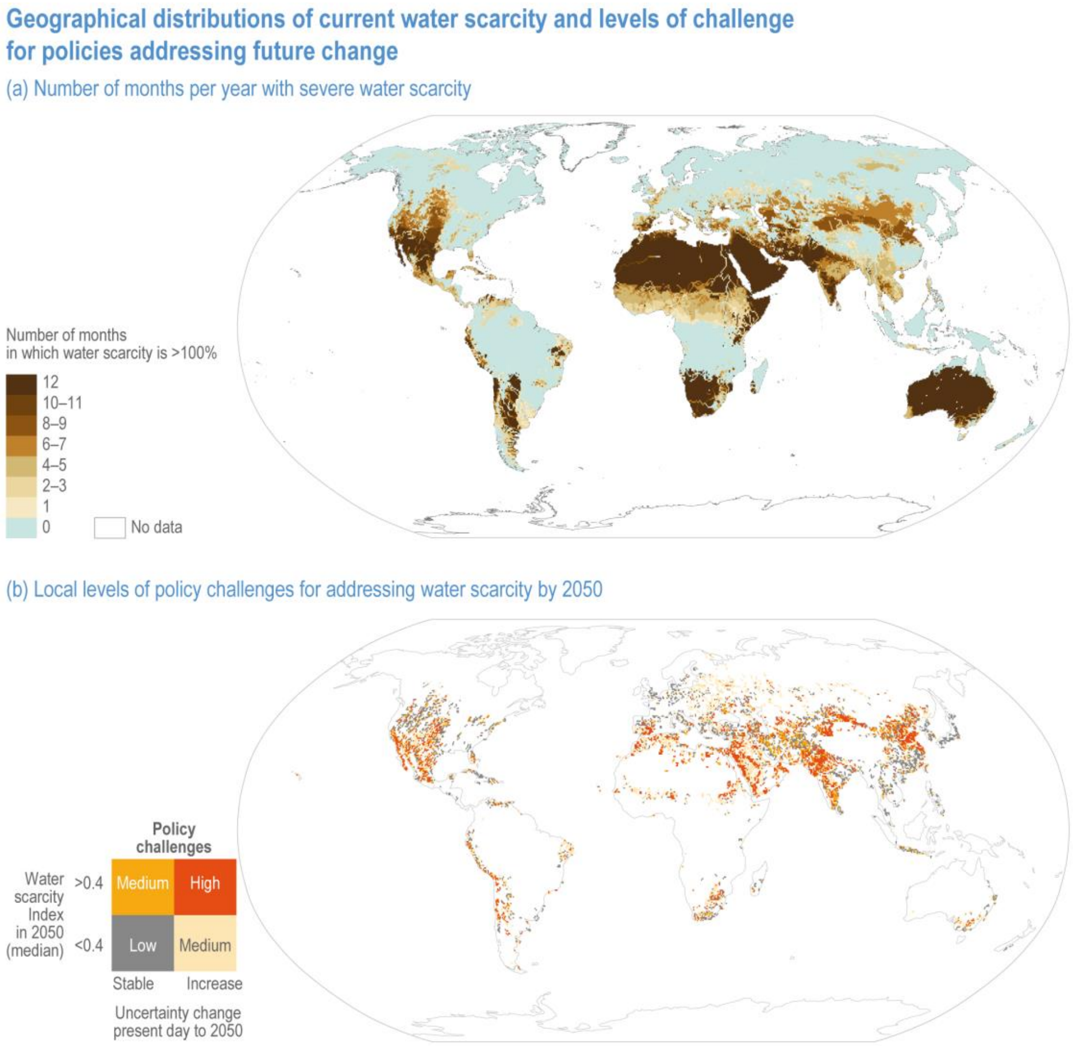
By 2100, about 50% of the MENA population could be exposed to annually recurring super- and ultra-extreme heatwaves (up to 56 °C and higher).

npj Climate and Atmospheric Science (2021) 4:20 ;
https://doi.org/10.1038/s41612-021-00178-7



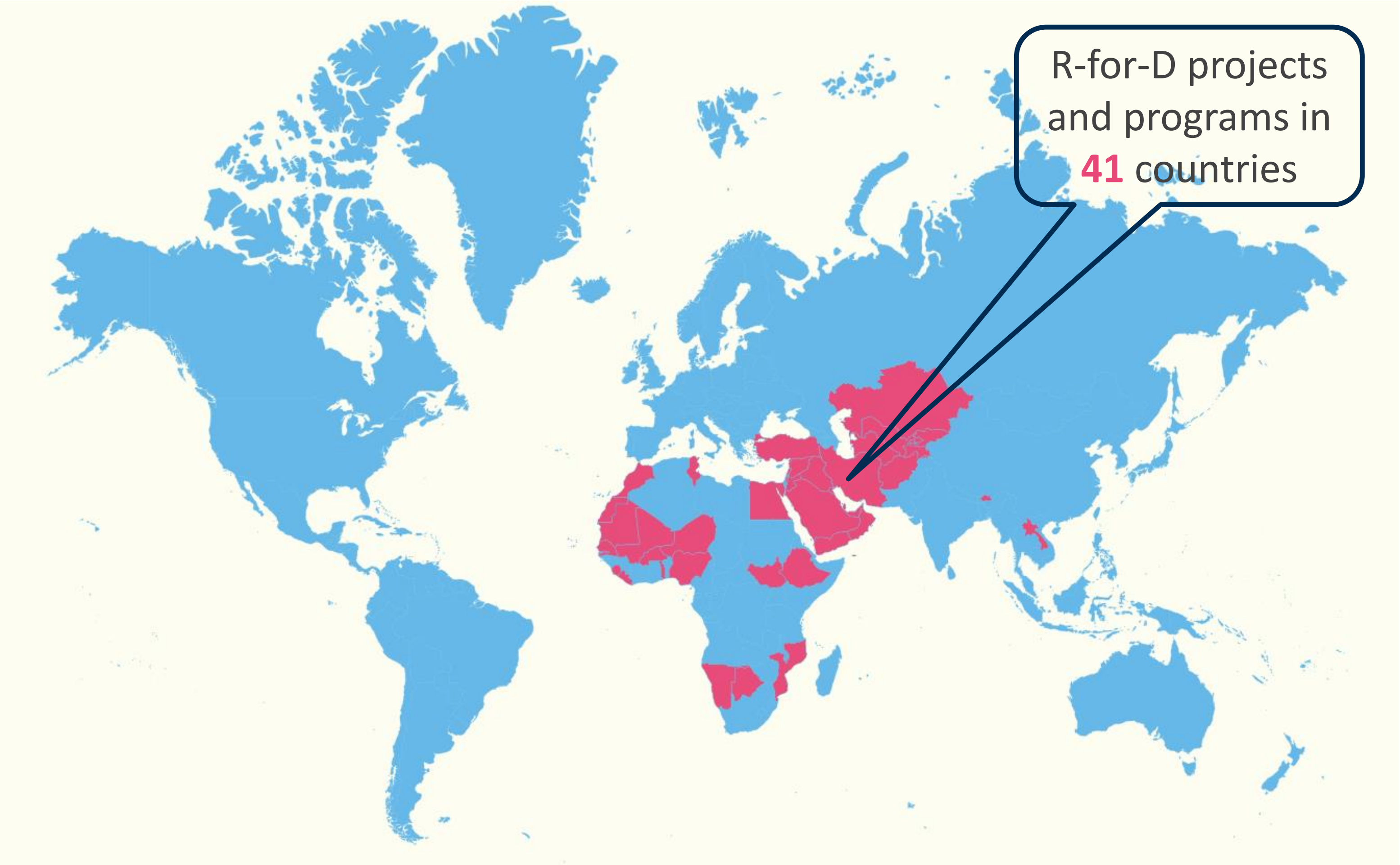
Water-related issues

- **Water scarcity:** Less precipitation, limited access to freshwater sources.
- **Soil salinity:** Caused by evaporation of irrigation water or from agricultural practices.
- **Water quality:** Contaminated water (industrial activities, sea water intrusion, agriculture).
- **Climate change:** Exacerbates water issues (heat, drought, floods).



Source: IPCC, AR6-WG2, Chapter 4

ICBA Research and Development Work



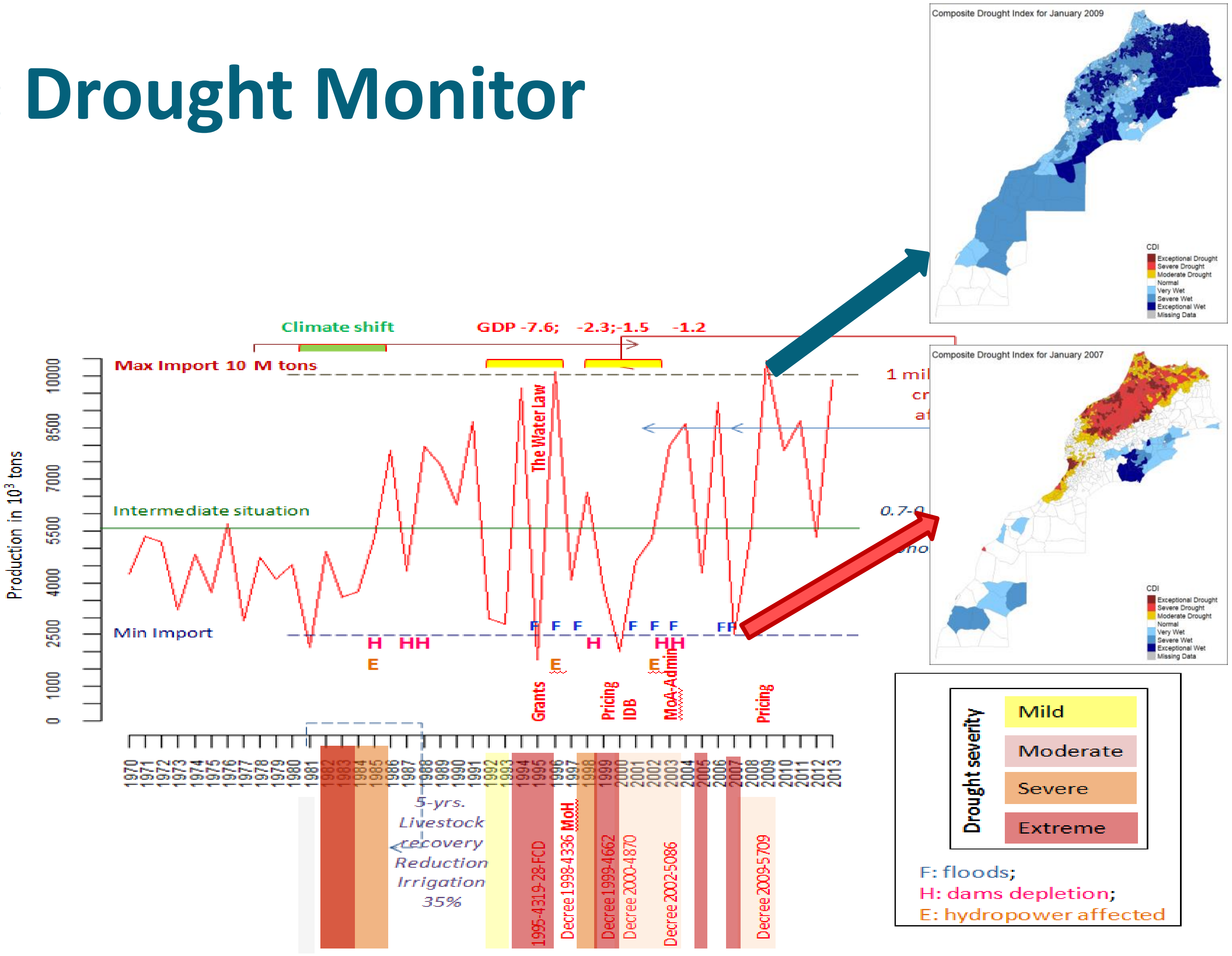
Decision support tools: Water and crop management

Climate-Smart crops: Salinity, heat, and drought tolerant crops

Soil management: Physics, chemistry, fertility, and conservation

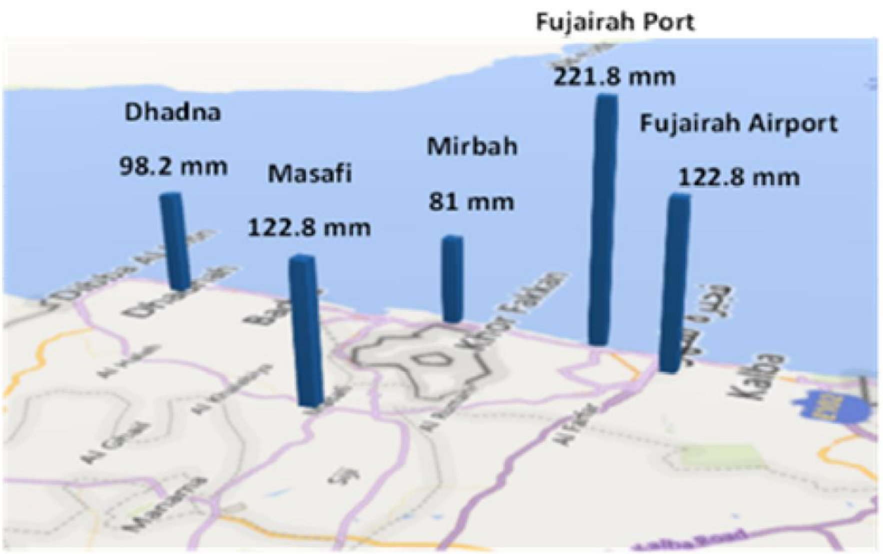
Decision support tools: Drought Monitor

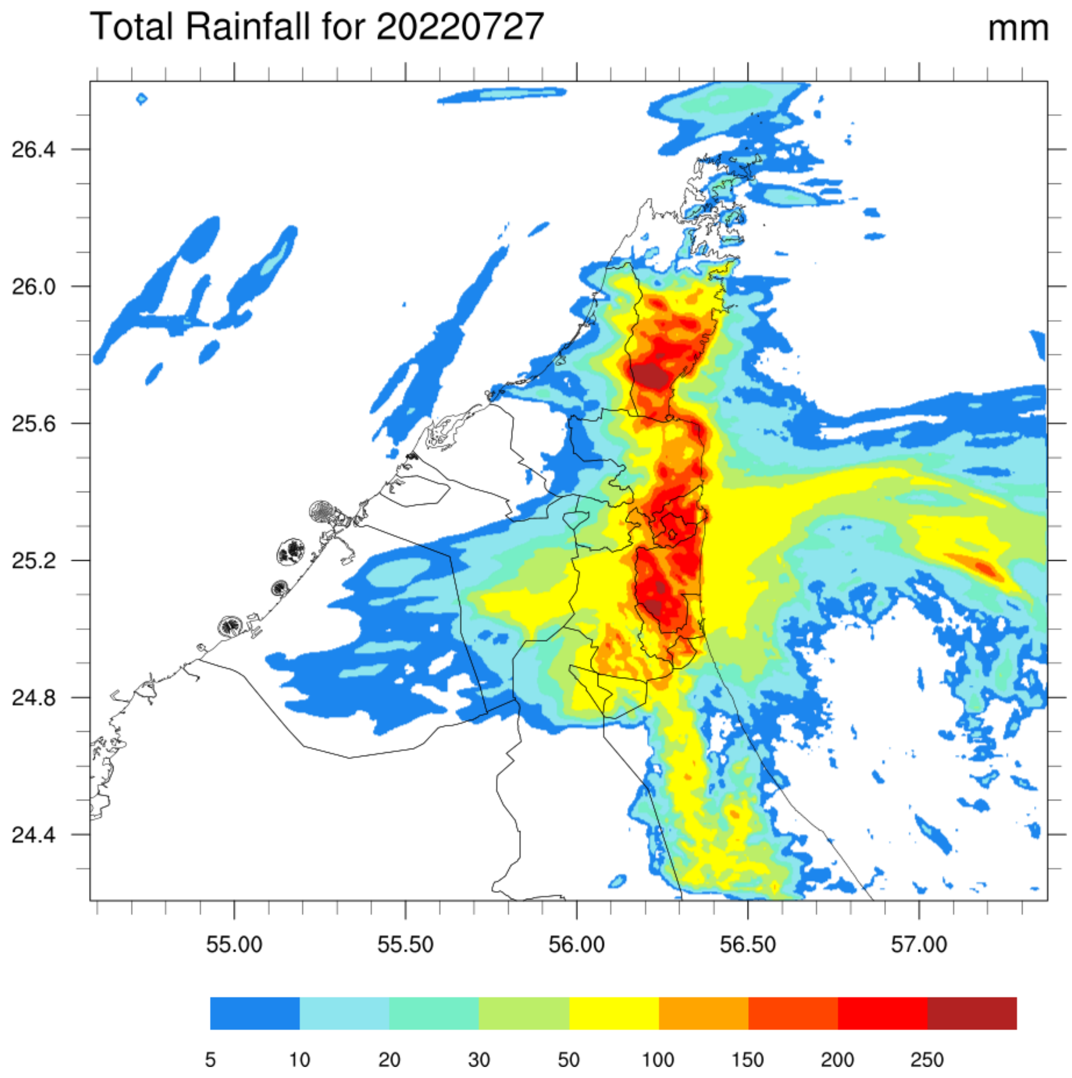
- Drought monitoring system: In partnership with University of Nebraska Lincoln
- National systems: Morocco, Tunisia, Lebanon, Jordan
- Regional system: MENA



Decision support tools: Flood Predictor

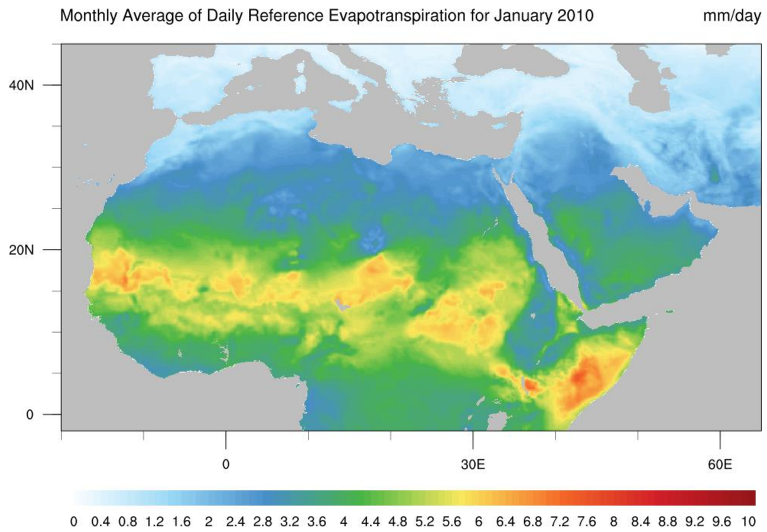
- Weather prediction system: In partnership with Fujairah Research Centre (FRC) and Fujairah Environment Authority (FEA)

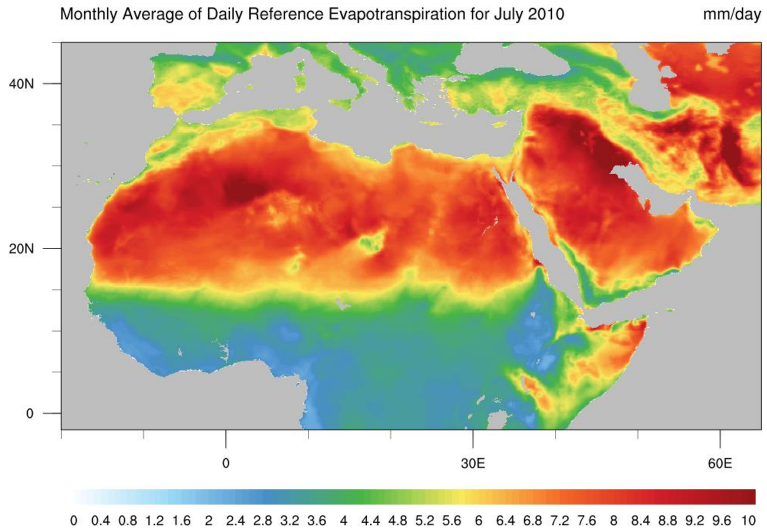




Decision support tools: ET Calculator

- ET_{ref} calculator: daily at 10 km resolution for MENA region (based on ERA5)
- 7 days prediction for UAE (based on WRF)
- Being customized for Crop Water Requirement (CWR) prediction (selected crops in UAE)





ICBA targeted crops: Crop salinity thresholds

Date Palm

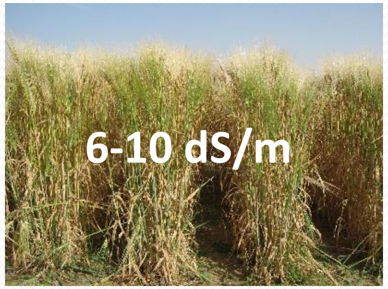
Quinoa

Forages

Sporobolus

Salicornia

Barley



Moringa

Safflower

Cowpea

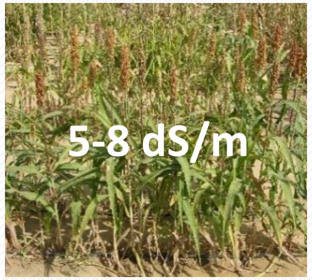
Lablab

Sunflower

Mustard

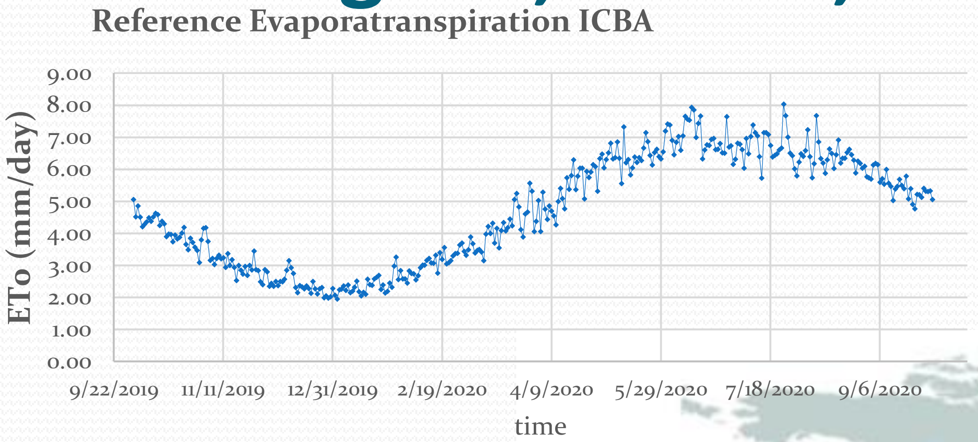
Pearl millet

Sorghum



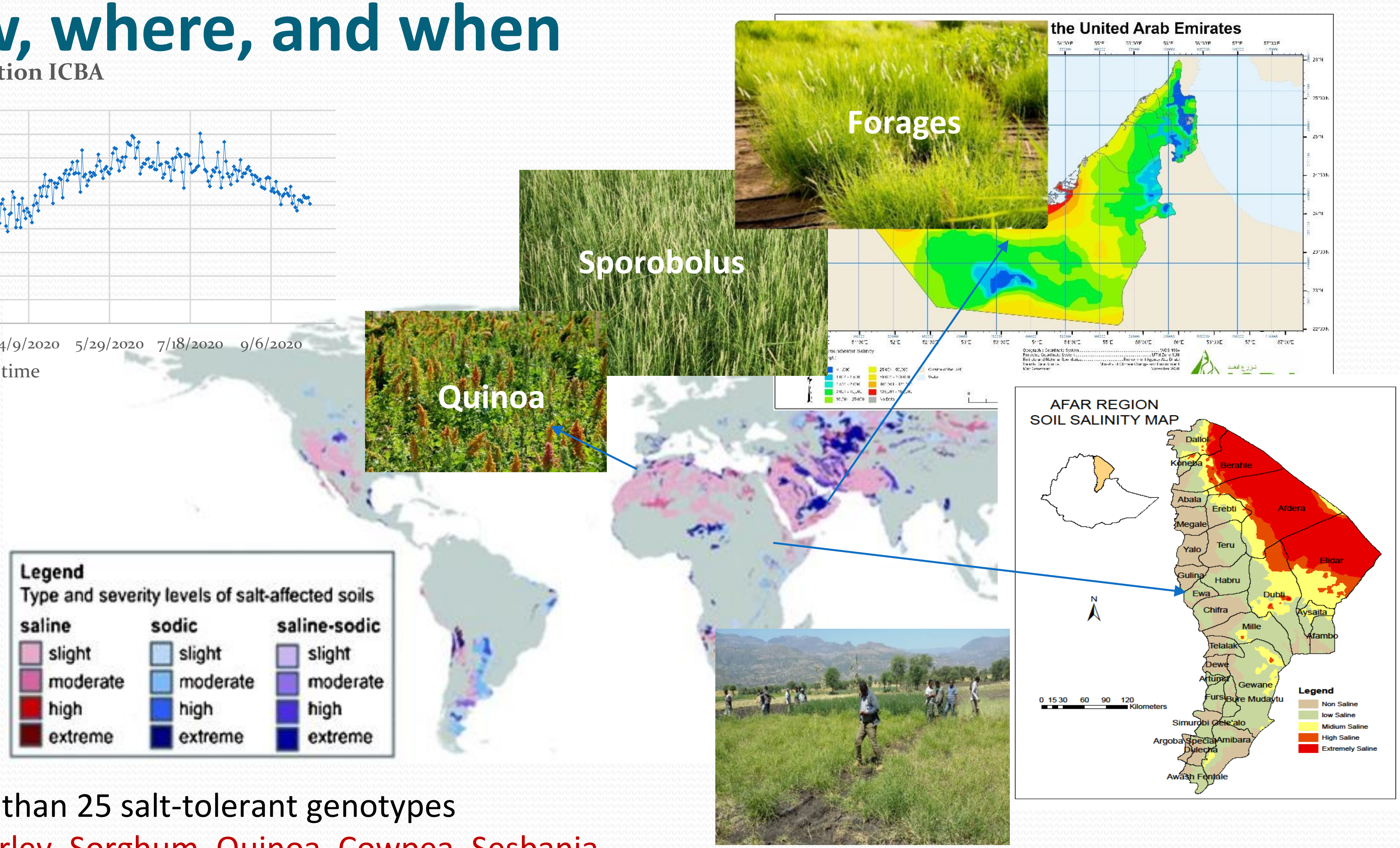
Amaranth

What to grow, where, and when



- LULC maps
- Crop mapping
- Groundwater

quality zoning for agricultural use



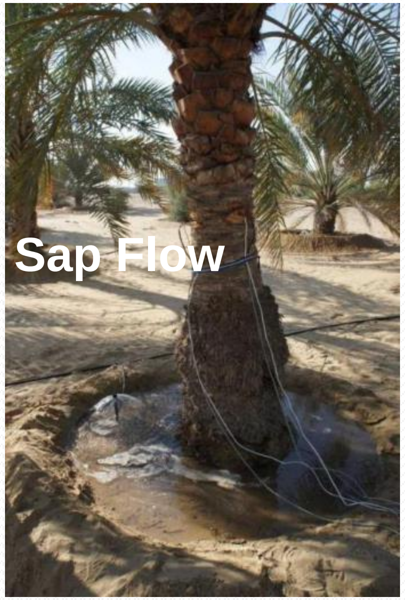
Ethiopia: More than 25 salt-tolerant genotypes introduced. (Barley, Sorghum, Quinoa, Cowpea, Sesbania, Pearl Millet, Rhodes grass, Panicum and Cenchrus).

Ethiopia: 20-30% higher yields in saline areas.

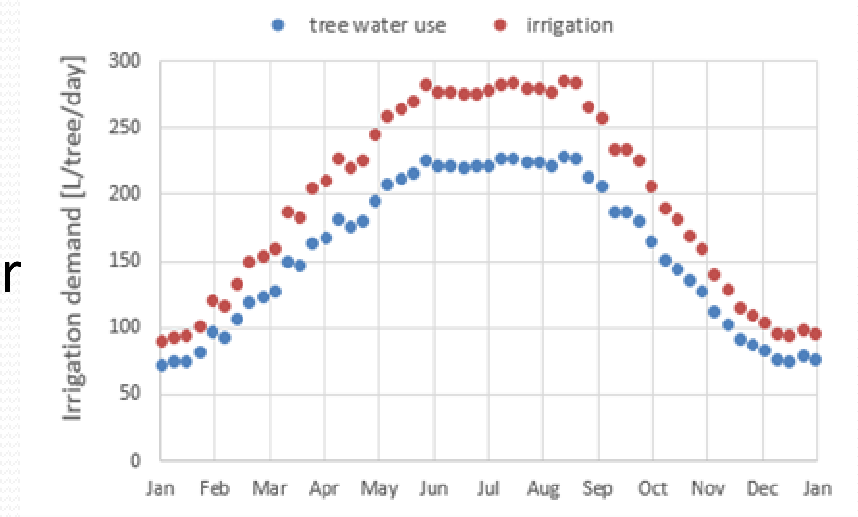
Better estimates of crop water requirements - UAE

Sensors and Lysimeters

- Saving is about 35%
- Present tree Irrigation Water Application is about 280 L / day
- Trees are using 50 -75 L/day (winter) and 200-250 L/day (summer)



- Crop water calculator experiment
- Open field, greenhouse, shade house
- Water use efficiency (kg/m3) was similar between Greenhouse and shade house (taking out the cooling water)



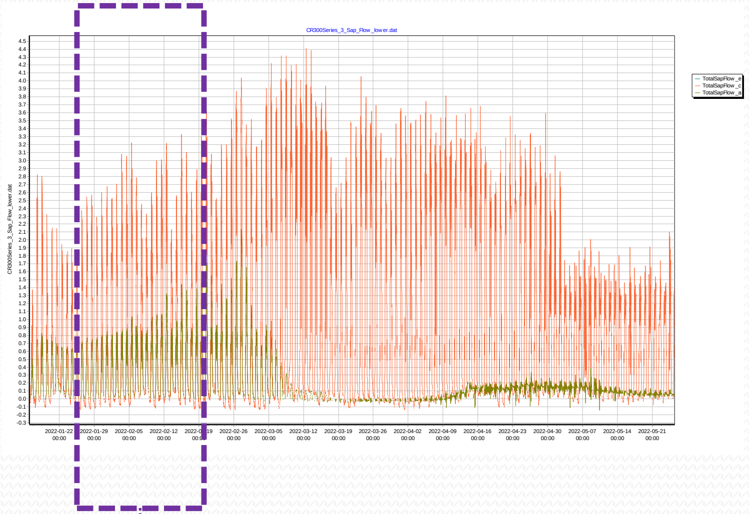
Source: Joint experiment between ICBA, EAD, Plant and Food Research, Maven

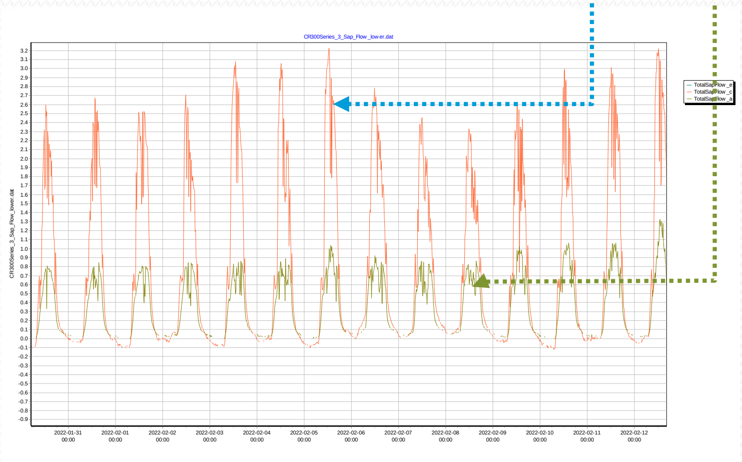
Crop water uptake during the day

Moringa water use at ICBA research station

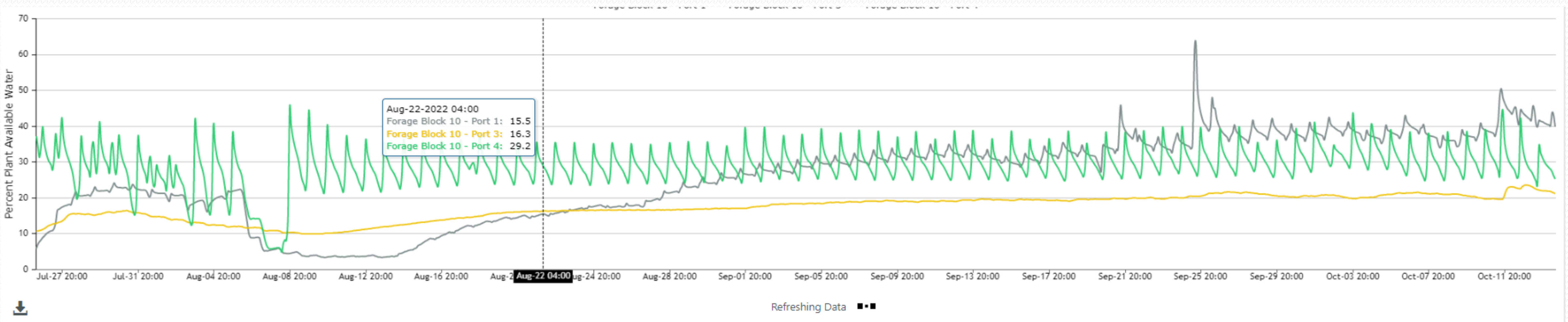
Moringa- fresh water

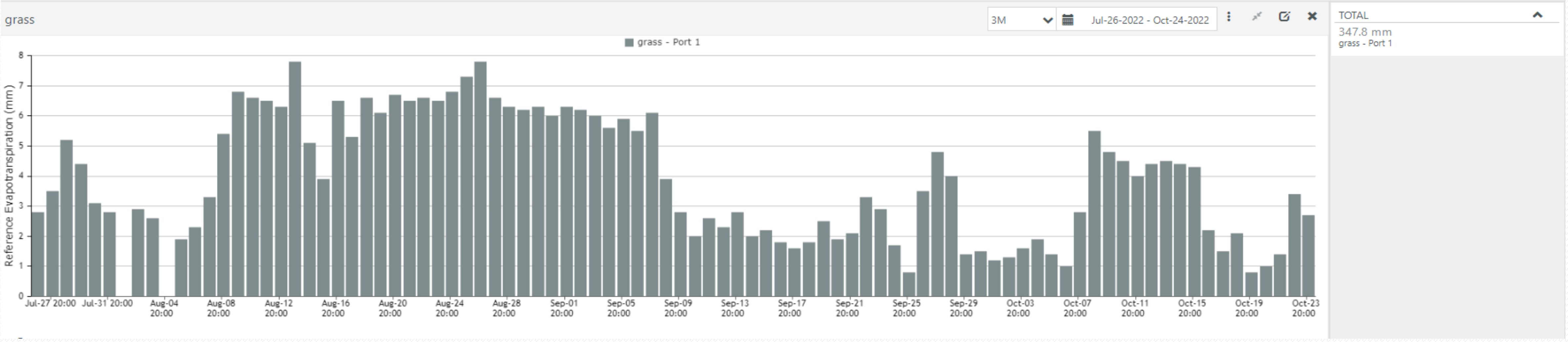
Moringa-saline water





Irrigation scheduling using soil moisture measurement

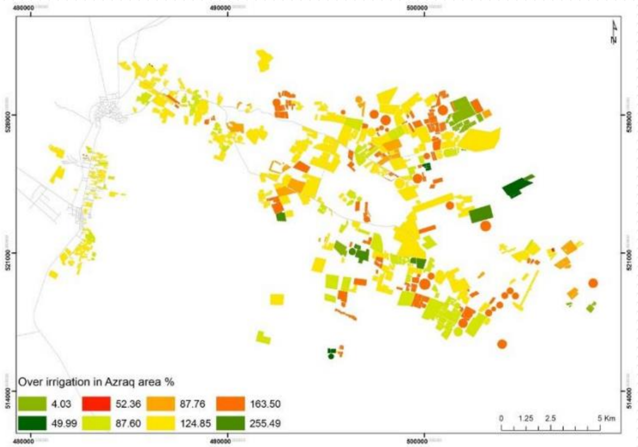


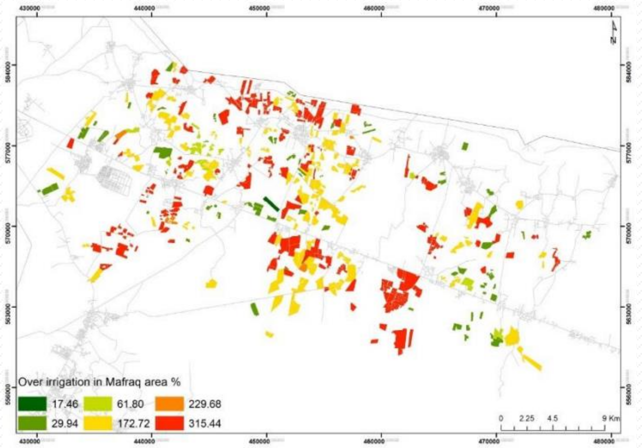


Water auditing to improve irrigation water efficiency and crop yield - Jordan

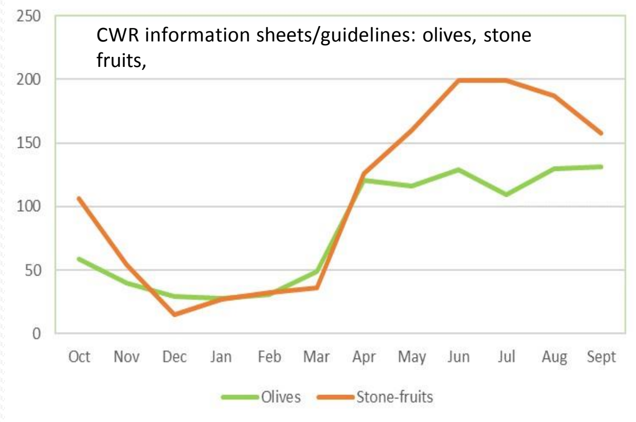
Challenges

Over-pumping in many farms





Enhanced knowledge about the seasonal actual crop water requirements



Solutions

- Market System Development Approach - Training suppliers on crop water requirements and irrigation scheduling
- Water auditing on the farms

<u>Results: Saving of water, fertilizers, energy, and money</u>

Novel production systems for marginal environments

Novel production systems for marginal environments

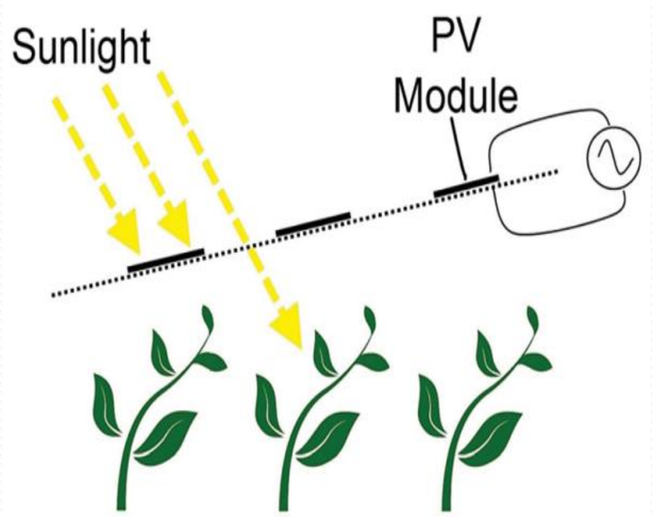
High tech greenhouses

- Precise regulation of climatic and nutritional needs of the plants.
- Climate parameters are regulated through passive cooling by operating fan and pad systems and sensor-based controlled systems.
- Use of hydroponic growing methods.

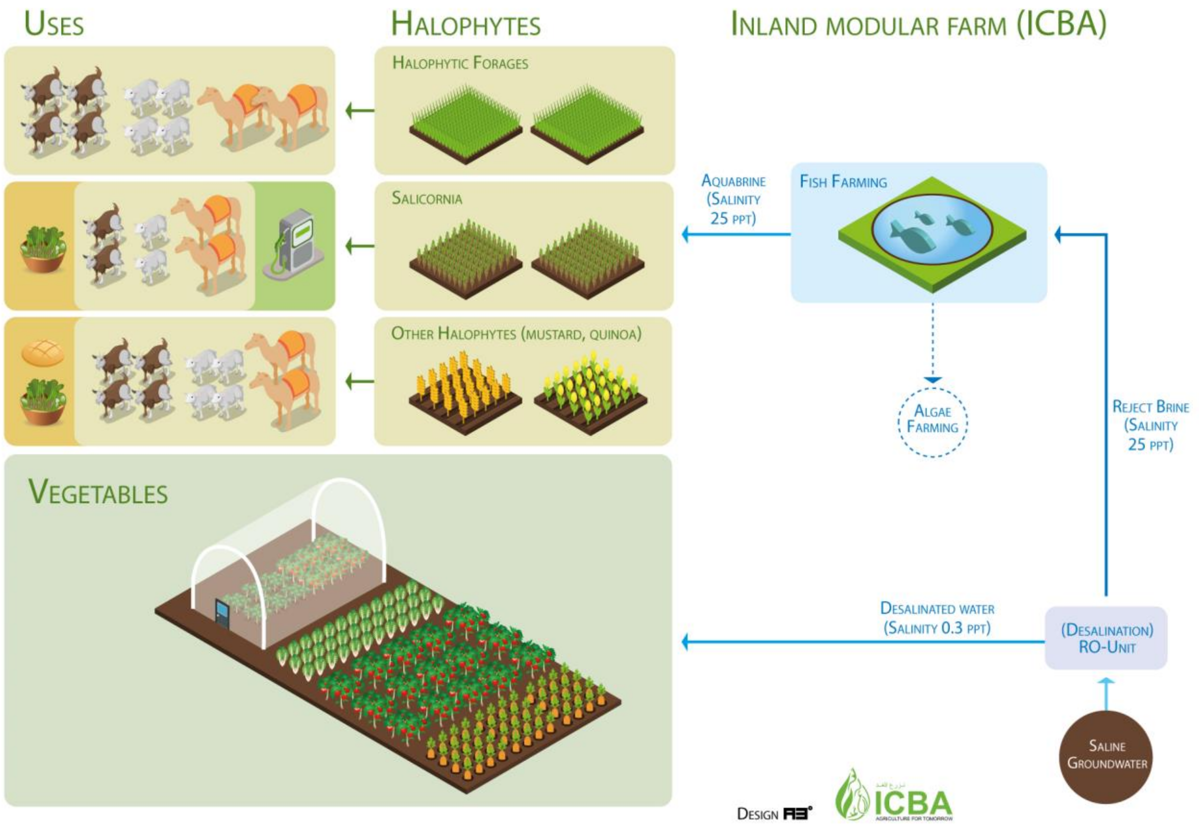
Novel production systems for marginal environments

Photovoltaic greenhouse

- Greenhouse with **photovoltaic panels** integrated in the structure
- Produce both **clean electricity** & **food crops** on the same surface
- Sharing of photons between PV panels and crops
- Reduce crop stress in areas with strong solar radiation
- Clean Energy, self-sufficient energy system



Integrated Aqua-Agriculture System (IAAS)



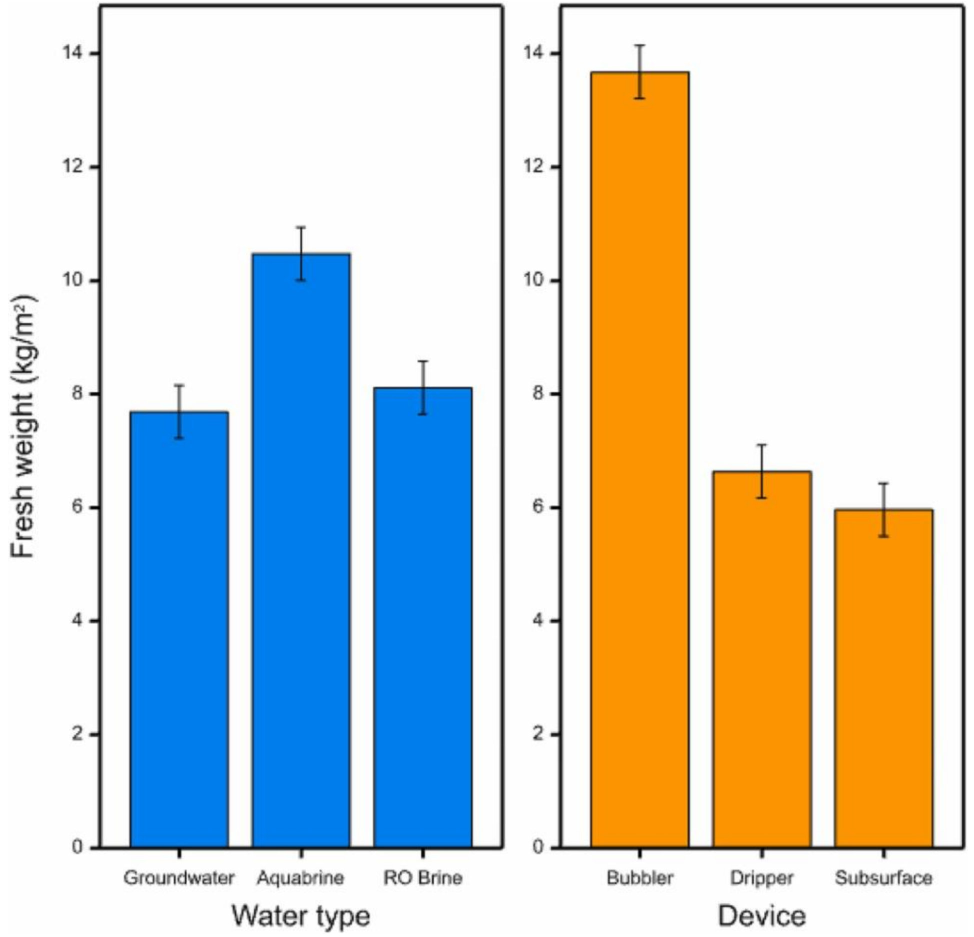
- Maximum seed yield: **3 t/ha @ 40 dS/m** (irrigated with aquaculture effluents)
- Maximum green biomass yield (6 months after sowing): **140 t/ha @ 20 dS/m**

Halophyte plants: Less pressure on fresh water + exploring new crops for food and feed

Salicornia: water quality and irrigation methods

- Salicornia irrigated with reject-brine from aquaculture tanks yielded up to 16 kg m^{-2}.
- Gross economic water productivity (GEWP) was highest for aquabrine and drippers.
- GEWP for desalinated waters at 1.5–6.2 $ kg^{-1} were 1–4 times desalination costs.

The greatest economic benefit for halophyte production, balanced for water usage, would come from fresh tips grown with aquabrine applied through either drippers, or subsurface irrigation.



Source: AL-Tamimi et al., 2023
EAD, ICBA, The New Zealand Institute for Plant and Food Research, and Massey University

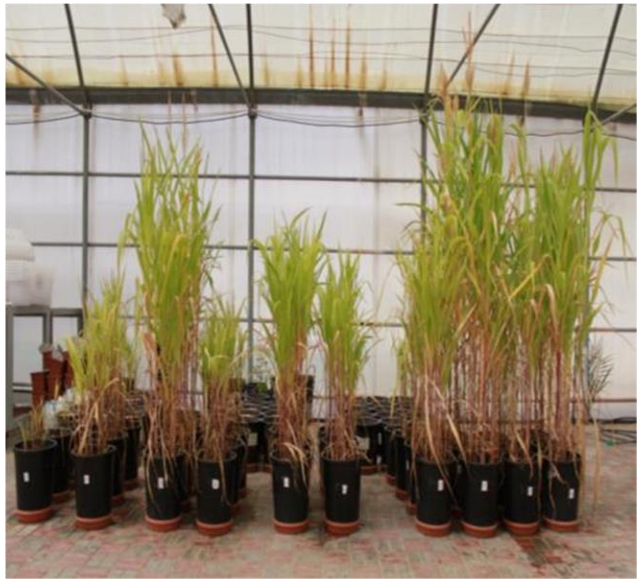
Biochar for Soil Quality Enhancement & Carbon Sequestration

- Study the use of biochar, compost, and bio-fertilizers for maize crops in the sandy soils of UAE.
- Long-term Biochar Application rate on field crops irrigated with saline water

Main results

- Increased fresh biomass (29%), reduced rate of fertilizer application (50%) (Biochar + bio-fertilizer)
- Increased biomass (19%) (Biochar vs conventional Fertilizer)
- Increased organic carbon and Cation-exchange-

capacity 15-9% and 48-52 % respectively (Biochar + compost)



Conclusion and Recommendations

- Biosaline agriculture contributes to ease the pressure on fresh water in water scarce regions.
- Investing in climate-smart crops, biosaline agriculture, decision-support tools, and new technologies.
- Exploring alternative crops for food and feed including halophytes.
- Exploring innovative production systems such as the photovoltaic greenhouses.

Acknowledgement

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Thank you

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