Increasing the Value of Water in Agriculture in marginal environments

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What is value of water in agriculture?

- Value of water is defined by its price, serve as a guide to allocate resources into uses in which they yield the greatest total economic return.
- The marginal value of irrigation water is the increase in crop yield in irrigated agriculture compared to rainfed agriculture.
Challenges in measuring value of water in agriculture

• The valuation of water in agriculture remains a challenge because it is rarely traded like other uses (Municipal and industry)

• In water-scarce regions, agricultural commodities are but the value of the associated “virtual” water is seldom accounted for.

• While there are well-established methods to calculate the virtual water, its economic value remains difficult to assess.

• Information on the value of water in agriculture is important for investing in irrigation development by governments and individual farmers.
Value of water in different regions

- Four major staple crops (≈60% of global food production), the global mean water values are $0.05, $0.16, $0.16, and $0.10/m³ for wheat, maize, rice, and soybean, respectively

(for industry and domestic uses (0.30-2.25 US$/m³))
Crop specific value of irrigation water (US$/m³)

- Availability of water
- Crop yields
- Market price of the produce
Value of water in marginal environments

- Water is more valuable when its supply is limited relative to demand both in quality and quantity.

- Value of water in agriculture is directly linked to water use efficiency. Selecting innovative irrigation technologies can help save water and increase WUE.

- In marginal environments, an important agricultural policy objective is to grow salt and drought tolerant crops using alternate water resources.
Sustainable agricultural development – challenges in UAE

**Decreasing water quantity and quality**
*Changing rainfall patterns, excessive GW pumping*

**Poor soil health**
*Low organic matter, low fertility & poor soil structure*
Soil health in UAE

• 75% are sandy soils - limited capacity to support biological activity.
• Low water and nutrient holding capacity - nutrient loss and pollution
• Soil degradation in UAE require special management practices to improve soil health
More than 85% of UAE water supply is from ground water and desalinated water.

Water supply – Key sources\(^1\) for all types of usage (2013, % of total water supply)

- **Groundwater** (~44%)
  - Trend: \(\downarrow\)
  - Characteristics:
    - Groundwater is the water located in the surface of the earth and can be obtained through wells.
    - Groundwater has been depleted over the last decades.

- **Desalinated water** (~41.7%)
  - Trend: \(\uparrow\)
  - Characteristics:
    - Supplies predominantly the domestic (drinking) and industrial sectors.
    - Production increased by 3% per year to 2016 to cater for increased demand.

- **Treated wastewater** (~13.9%)
  - Trend: \(\uparrow\)
  - Characteristics:
    - 64% used in irrigation of gardens, and reforestation trees.
    - 32% disposed in the sea.
    - Remaining 4% is stored.
    - 86 plants in 2016 (39 in Abu Dhabi and 47 in Ras Al Khaimah).
    - Treated wastewater increased by between 2011 and 2016.

- **Surface water** (~0.4%)
  - Trend: \(\downarrow\)
  - Characteristics:
    - Includes any water that collects on the surface of earth and is maintained through natural processes.
    - UAE has arid climatic conditions; rainfall levels have dropped 80 mm to 2013\(^2\).
Groundwater Use in UAE

- **Agriculture**: 77%
- **Forestry**: 11%
- **Amenity**: 9%
- **Domestic & Industrial**: 3%

Bar chart showing groundwater use in Million m$^3$ for different emirates:
- Abu Dhabi: 71%
- Dubai: 8%
- Sharjah: 7%
- Ajman: 4%
- UAQ: 4%
- RAK: 4%
- Fujairah: 1%
UAE Groundwater reserves by quality

Groundwater resources are of a poor quality

- Fresh: 3%
- Slightly Brackish: 26%
- Brackish: 21%
- Slightly Saline: 30%
- Saline: 20%

Recharge is negligible
Potential solutions

- Improve soil health (stability, fertility, and salinity, etc.)
- Use alternative resources of water
- Increase WUE in all sectors; using more water-efficient technologies and water-efficient crops
- Manage water demand i.e., reduce per capita water use
ICBA Interventions

Soil improvement - effect of compost on crops

Compost increases fresh biomass up to 30-40 percent

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>Control</th>
<th>ICBA Com@20tons/ha</th>
<th>Sharjah Com@20tons/ha</th>
<th>Biofertilizer 5 L/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>Cowpea</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2015</td>
<td>Cowpea</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>2014</td>
<td>Sesbania</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>4</td>
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<tr>
<td>2015</td>
<td>Sesbania</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>2014</td>
<td>Lablab</td>
<td>3</td>
<td>7</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>2015</td>
<td>Lablab</td>
<td>4</td>
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<td>9</td>
<td>7</td>
</tr>
<tr>
<td>2014</td>
<td>Pigeon pea</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>4</td>
</tr>
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<td>4</td>
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<td>5</td>
</tr>
</tbody>
</table>
Biochar to improve soil fertility

- Effective to regain soil fertility, save water and soil nutrients, reduce GHG.

- In greenhouse maize, biochar @ 5 tons/ha increased fresh biomass by 29% and 50% reduction in fertilizer application.

- Field trials on pearl millet increased fresh biomass by 46% and water retention by 40%.
ICBA Interventions

Improving irrigation water use efficiency (WUE)

WUE of crop species

Cereals = 2.37 kg/m³
Oilseeds = 0.69 kg/m³
Fiber crops = 0.45 kg/m³
Legumes = 0.42 kg/m³

Water-Intensive Crops

Some of the most popular crops are highly water-intensive. These crops include:

• Rice
• Soybeans
• Wheat
• Sugarcane
• Cotton
• Alfalfa
• Pasture
ICBA Interventions

Improving irrigation water use efficiency (WUE)

- Produce daily land surface temperature and climate data
- Calculate crop water requirements
- Calculate actual crop water use
- Produce Agricultural Water Productivity maps
- Estimate irrigation water use and groundwater abstraction
### Growth of water-intensive crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>WR (m³/ha)</th>
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<th>WR (m³/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>15,700</td>
<td>Watermelon</td>
<td>5,500</td>
</tr>
<tr>
<td>Rhodes</td>
<td>15,000</td>
<td>Sunflower</td>
<td>4,830</td>
</tr>
<tr>
<td>Date Palm</td>
<td>14,800</td>
<td>Tomato (GH)</td>
<td>4,050</td>
</tr>
<tr>
<td>Lemon/Citrus</td>
<td>10,200</td>
<td>Sweet melon</td>
<td>3,100</td>
</tr>
<tr>
<td>Tomato (field)</td>
<td>6,500</td>
<td>Onion</td>
<td>2,500</td>
</tr>
<tr>
<td>Okra</td>
<td>6,400</td>
<td>Potato</td>
<td>2,500</td>
</tr>
</tbody>
</table>
Improving irrigation water use efficiency

Water saving for date palm

• Present water application is 280 l/tree/day
• Trees are using 50-75 l/day (winter) and 200-250 L/day (summer)
• New technologies have saved about 35% of water

Testing of water-efficient technologies

• Sub-surface drip irrigation systems
• Deficit irrigation
• HydroRock irrigation system
• Use of poor-quality irrigation water

• Annual ET > 1900 mm/yr
• Annual rainfall < 60 mm/yr
Treated wastewater use for vegetables in UAE

• Most TWW in UAE is used for landscape and not for food crops.

• To evaluate uptake of heavy metals (i.e., Cu, Fe, Zn and Cr) and microbial loading by 6 vegetables grown with TWW.

• To quantify the associated health risks for humans.
Managing high to extreme water and land salinity

Conserve fresh water for domestic, industrial and agriculture purposes (for crop cultivation)

Use marginal saline land and water for growing:
- Salt tolerant crops
- Forage/Fodder crops
- Timber value trees

Use highly saline/sea water for growing halophytes for:
- Forage/Fodder species
- Timber value trees
- Oil producing species
- Landscaping
**Crop management for salt-affected soils**

<table>
<thead>
<tr>
<th>Salinity Type</th>
<th>Salinity Levels</th>
<th>Production system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slightly saline</td>
<td>$&lt;5 \text{ dS/m} (&lt;3500 \text{ ppm})$</td>
<td>Salt tolerant crops</td>
</tr>
<tr>
<td>Moderately saline</td>
<td>$5-15 \text{ dS/m}$&lt;br&gt;$(3500-10,500 \text{ ppm})$</td>
<td>Salt tolerant crops</td>
</tr>
<tr>
<td>Highly saline</td>
<td>$15-25 \text{ dS/m}$&lt;br&gt;$(10,500 – 17,500 \text{ ppm})$</td>
<td>Salt-tolerant and halophyte crops</td>
</tr>
<tr>
<td>Very highly saline</td>
<td>$&gt;25 \text{ dS/m}$&lt;br&gt;$(&gt; 17,500 \text{ ppm})$</td>
<td>Salt-tolerant and halophyte crops</td>
</tr>
<tr>
<td>Seawater</td>
<td>$40-60 \text{ dS/m}$&lt;br&gt;$(28,000-42,000 \text{ ppm})$</td>
<td>Halophyte crops</td>
</tr>
</tbody>
</table>
Developing water and salinity tolerant crops

- Date Palm
- Sunflower
- Quinoa
- Amaranth
- Barley
- Sorghum
- Pearl millet
- Forages
- Safflower
- Mustard
- Lablab
- Sporobolus
- Moringa
- Salicornia
- Cowpea
### Other crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sporobolus</td>
<td>15-30 dS/m</td>
</tr>
<tr>
<td>Moringa</td>
<td>10 dS/m (max)</td>
</tr>
<tr>
<td>Sunflower</td>
<td>5-8 dS/m (Max)</td>
</tr>
<tr>
<td>Safflower</td>
<td>5-10 dS/m (Max)</td>
</tr>
<tr>
<td>Mustard</td>
<td>(5-8 dS/m)</td>
</tr>
<tr>
<td>Lablab</td>
<td>5-8 dS/m</td>
</tr>
<tr>
<td>Cowpea</td>
<td>6-10 dS/m</td>
</tr>
<tr>
<td>Quinoa</td>
<td>10-15 dS/m</td>
</tr>
<tr>
<td>Barley (fodder)</td>
<td>6-10 dS/m (grain); 8 – 12</td>
</tr>
<tr>
<td>Sorghum</td>
<td>5-8 dS/m</td>
</tr>
<tr>
<td>Pearl Millet</td>
<td>5-8 dS/m</td>
</tr>
</tbody>
</table>

### Date Palm:
- Up to 15 dS/m (some varieties) but 10 is max for better growth and fruiting.

### Forages:
- 15 dS/m (Buffle grass, Blue Panicum, Guinea grass);
- 15-30 ds/m (Distchilis, Sporobolus, Paspalum etc.
- 30 ds/m to seawater salinity (Salicornia)

**Biosaline Agriculture**

ICBA has introduced drought and salinity tolerant crops
Where Biosaline agriculture can be practiced?

- Salt-affected irrigated agricultural lands
- Only marginal quality irrigation water is available.
- Marginal lands (abundant saline soils in dry regions).
- Sub-coastal saline lands (20,000 – 25,000 ppm).
- Coastal lands with salinity up to sea levels.
Conclusions

• Agriculture plays an important role in the global economy; therefore its sustainability needs priority.

• There is a large scope for increasing value of water in agriculture.

• This can be achieved by improving WUE and introducing drought and salt-tolerant crops.

• Precision farming using data driven agricultural approaches can help increase water and land productivity.
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