Integrated Production Systems for Nutrition and Employment
In smallholders agriculture of the Dry Regions.

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Protected Production of Fruits and Vegetables for Nutrition Security in Urban and Peri-Urban Environments
Outline

1. Challenges for Agriculture in Dry Regions
2. Protected Agriculture in Arabian Peninsula
3. Way Forward
1. Challenges for Agriculture in Dry Regions

- Increasingly drier and hotter
- Food and nutrition insecurity
- Unemployment
- Fragile states
- Irrigation water is key
Efficient Use of Irrigation Water is Key for the Region

Many countries have chronic water scarcity problem

Water resources need to be protected

Climate change adds to the problem
More Yield, More Water Transpired

Wheat yield (t/ha)

![Chart showing wheat yield vs. water transpired](chart.png)

- Irrigated
- Rain-fed

\[ y = 0.016x - 2.4969 \]

\[ R^2 = 0.68 \]

Bread wheat

Water Transpired (mm)

More transpiration
less evaporation
or
less percolation?
Think Water Productivity (WP)

\[ WP = \frac{\text{Return}}{\text{Unit of Water Consumed}} \]

**What return?**
- Biomass, grain, fruit, meat, milk, fish (kg)
- Income ($)
- Social benefits (employment)
- Nutrition (calories, protein, carbohydrates, fat)
- Environmental benefits (C)

**What water?**
- Quality (EC)
- Location (GW depth)
- Time available

**Consumed (depleted)**
- Evaporation
- Transpiration
- Quality deterioration
Explore the Trade-Offs in Water Productivity

Keep the precious irrigation water in the dry areas for fruits and vegetables?
Protected Agriculture Strongly Improves Land and Water Productivity

UAE uses **20 million m^3** of water to produce **112,000 tons of Tomatoes**.

Photo: Peter Essick

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<table>
<thead>
<tr>
<th>Total Cost (AED/m^2)</th>
<th>Land Productivity (kg/m^2)</th>
<th>Total Income (AED/m^2)</th>
<th>Net Benefit (AED/m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooled GH</td>
<td>OF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.73</td>
<td>6.41</td>
<td>17.36</td>
<td>43.40</td>
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<tr>
<td>21.67</td>
<td>3.59</td>
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</tbody>
</table>

With **10%** of the water used in OF
2. Protected Agriculture in Arabian Peninsula

Achievements

Component-Based Research

• Development/improvement of a technology with components of the cropping/farming system (water, soil, plant, disease, etc.)
• Can be done in big farms in high-tech greenhouses

System-Based Research

• Innovation is in the interactions among components
• Conducted with smallholder farmers and low-cost plastic houses
• Has component of scaling out/scaling up

Capacity Building

Donors: AFESD, IFAD, OFID
2.1. Technological Developments

Donors: AFESD, IFAD, OFID
Introduced “Net House” to the Region

Results
• Better ventilation
• 8-9 months of year
• High yields
• Same net benefit as cooled greenhouse
  ← savings in water and electricity (for cooling)

Donors: AFESD, IFAD
Enhanced Cooling System, Using Solar Energy
with American University of Ras Al Khaimah (UAE)

Cooling uses 2-10 times more water than irrigation

Improved cooling system using solar energy saves up to 60% water

Donors: AFESD, IFAD
Adoption of Soilless-Production System

Increases Yield and Water Productivity by 50%

Donors: AFESD, IFAD, OFID
Average Productivity of 1 m³ of water in Protected Agriculture (PA) Vs. Open Field (OF)

Tomato
- PA 28.2 kg
- OF 2.8 kg

Pepper
- PA 16.7 kg
- OF 1.2 kg
Integrated Pest Management

Double doors

Insect-proof net

Aphid lion larvae feeding on aphids

Number of Pesticides Sprays

<table>
<thead>
<tr>
<th></th>
<th>IPPM</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>Downy Mildew</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Aphids</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Leaf Miner</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Spiders</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Dhamar, Yemen

Introduced by ICARDA, IPM is Widespread in All Seven Countries

Donors: AFESD, IFAD
Multi-criteria and Trade-Off analysis of Technologies

Land Productivity

Financial indicators of soil and soilless (Hydroponics) for cucumber grown under cooled greenhouse (US$/m²)

- Cost (US$/m²)
- Average annual income US$/m² (1.10 US$/kg in 2012)
- Profit (US$/m²)

<table>
<thead>
<tr>
<th></th>
<th>Soil</th>
<th>Soilless</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>34.45</td>
<td>33.58</td>
</tr>
<tr>
<td>Annual</td>
<td>14.45</td>
<td>10.15</td>
</tr>
<tr>
<td>Profit</td>
<td>20.73</td>
<td>13.43</td>
</tr>
</tbody>
</table>

Water Productivity

Economic Wp $/m³

- Beef: 0.1
- Lentil: 0.3
- Wheat: 0.1
- Potato: 0.6
- Olive: 3
- Dates: 1.6

Health and Biodiversity

Number of Pesticides Sprays

- IPPM
- Control

- Downy Mildew: 1
- Aphids: 1
- Leaf Miner: 0
- Spiders: 0
- Total: 19
2.2. Systems Design and Outreach for Smallholders

- Low cost
- Participatory Design
Results

• Reduction in **pesticide use** (e.g. 80% in Yemen)
• **Increase in yield** (e.g. 60% in Oman)
• **Increase in farmers’ income** (e.g. 45% in Yemen)
• **Water saving** (50% in Bahrain, Saudi Arabia, Oman, Qatar, UAE)
Introducing Protected Agriculture in Yemen’s Mountain Terraces

• 38 farmers implemented the system
• Increased yield (10 fold in cucumber; 5 fold in tomato) compared to open field
• Up to 400% additional income for farmers through the cultivation of cash crops
• Additional jobs, encouraging farmers to settle in rural areas
• Introduction of new techniques of cultivation and irrigation
• Intensification of the use of terrace lands

Donor:
French Government
(Food Aid Program, 2005-2007)
Introducing Protected Agriculture in Afghanistan

- **35 greenhouses** established at pilot farms
- **Additional 30** greenhouse established in Kunduz, where growers volunteered to pay 50% of costs
- ICARDA provides technical support and regular visits to the growers’ fields

- 12 specialized training courses
- 15 on job training courses
- 23 field days
- 500 farmers, extension agents, researchers trained

Donors: AFESD, IFAD, OFID
Greenhouse Manufacturing Workshop in Kabul 2005

• 15 local technicians
• 40% reduced in cost of the greenhouse structure

Donor: USAID
Technology Transfer in Arabian Peninsula 2014-2017

• 325 growers adopted the technology in all countries (12% higher than the project’s target)

• Benefited about 1,600 rural households (directly) and 5,500 indirectly

• Higher number of growers adopted the technologies through farmer-to-farmer extension and NARS efforts in Bahrain, Oman, and UAE

• Number of greenhouses equipped with soilless-production system reached 1,200 in UAE; 1,000 in Qatar

Donors: AFESD, IFAD
3. Way Forward:
Promote Irrigation for Integrated-Agricultural Systems in Dry Regions
Research Paradigm

**Efficiency and resilience** supported by **complexity** (number of components, circularity, managed interactions)

**Hypothesis to be tested** using systems experiments and farm models
Integrate Vegetable and Grain Crops

- Less weeds
- Less work
- More soil organic matter
- Less pests and disease
Integrate Crops and Fruit Trees in Multilayer Systems

Also in soil: subsurface irrigation
Integrate Crops and Livestock
Also, Why Not Fish?
Combine Food and Energy Production

Agrivoltaic System - Montpellier

- Same biomass (with the right variety)
- Less water used (up to 30%)
- Produce electricity

(Marrou et al. 2013. European Journal of Agronomy)
To open the discussion

- **Protected agriculture for smallholders** farming in Dry Areas.
- **Change the vision** in dry areas: “more nutrition and jobs per drop,” instead of “more crop per drop”
- **Sustainability** of irrigated agriculture should be grounded in **diversity**
- **Innovation is at interfaces** between agricultural and food systems
- **Move to farming systems design** from component-/sector-based design
- **Combine** research for smallholders and private sector (big farms, suppliers, food sector)