CONSIDERATIONS ON AGRICULTURAL WATER MANAGEMENT CHALLENGES IN CALIFORNIA

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Population is growing at fast rate

**IMPLICATION 1:**
increasing internal need for food to meet the demand of growing population

**IMPLICATION 2:**
Need to increase production of safe food on less fertile lands (more water & nutrients)

1984-2010 => ~ 1.1 M ac. of farmland lost to urbanization. 660,000 ac. was prime farmland (most was lost to urban development in the S.J.V.)
TREND 2 – WEATHER IS CHANGING

Clear implications both in water supply (≠ distribution) and crop water demand (peak concentrations in some months)
In the last 26 years (1990-2015) water districts received from the Central Valley Project and delivered to farmers:

- 100% of water rights only on 3 years/26 years (12%)
- 75% of water rights only on 8 years/26 years (30%)

due to combined impacts of dry conditions and environmental regulations
TREND 3
Irrigated Agriculture is concentrating & intensifying:
San Joaquin Valley, Sacramento-San Joaquin Delta, Imperial Valley

> 35% of the US table food on only ~1.2% of the US farmland

Cropping patterns are intensifying:
✓ Conversion from annual to perennial crops (fruit, nuts and vines)
✓ Higher planting densities & inputs
✓ Shift from surface irrigation to micro-irrigation (drip & micro-sprinkler)

ENCOURAGED BY FUNDING PROGRAMS
USDA-NRCS (EQIP), CDFA-SWEEP, ETC.
TRENDS IN IRRIGATED CROPS

- Water Agencies and Regulators pushing for a strong shift to micro-irrigation (sustainability) via financial incentives (SWEEP, EQIP, CEC)

- Farmers follow the push, but shift from annual to permanent crops and expand the cropped areas (max. net profit) and possibly the water use

more precise/frequent irrigation management needed by farmers

Irrigation Survey 2010

(Tindula, Orang & Snyder, 2013)
INVESTMENTS IN HIGH-TECH ON-FARM IRRIGATION

INCREASED/INTENSIFIED CROPPED ACREAGE

- Higher water & energy usage
- Inflexible (hardened) irrigation demand on existing cropped acreage
- Expanded acreage with high-value, water-demanding crops
- Cropping systems demanding higher irrigation frequency
- Larger GW extractions
- Salinity build-up
- Need for periodic leaching (hardly ever accounted for in water consumptive usage)
WATER SAVING/CONSERVATION VS. WATER PRODUCTIVITY

**Consumptive Use:**
Conversion of water into vapor

**Beneficial consumption**
Crop ET

**Non-beneficial consumption**
Soil and water evap.; ET weeds

**Recoverable Flows**
Water flowing back GW/Rivers

**Non-recoverable Flows**
Water flowing to sea/degraded

**Water Productivity**
Yield/Water diverted (Ton/ac-ft)
- Higher yield/ac-ft of water diverted/delivered
- Same water diverted/delivered but larger acreage => yield

**Water Saving/Conservation**
Yield/Water consumed (Ton/ac-ft)
- Less diversion from water sources
- Lower consumptive use

Linear relation of Yield vs. ET
Higher yield/area => higher ET/area

**Non-consumptive Use**
Water remaining in liquid state

Beneficial consumption
Crop ET

Non-beneficial consumption
Soil and water evap.; ET weeds

Recoverable Flows
Water flowing back GW/Rivers

Non-recoverable Flows
Water flowing to sea/degraded
Review of dozens of case studies: many examples of irrigation modernization projects that assume water will be saved and productivity increased, but very few examples that carefully document impacts of high-tech irrigation.

These few studies show that water consumption increased when irrigation systems were upgraded and that production per unity of water consumed was more or less constant.

The review concludes that restoring a balance bw. sustainable supply and water consumption requires:

- Physical control on water resources by management agencies
- Interventions to reduce water allocations

Introducing high-tech irrigation in the absence of controls on water allocation usually will make the situation worse:

- Consumption per unit area increases
- The area irrigated increases
- Farmers will tend to pump more water from deeper sources

The controlled access to water must precede incentives to high-tech irrigation.
Document comparative differences between Check Flood (CF) and SDI in:

- Actual Crop Evapotranspiration (ETa)
- Hay Yield (HY)
- Water Productivity (WP)
- Energy Usage (EU) and Energy Productivity (EP)
### MAIN FINDINGS

#### UC Davis - Russell Ranch
**Crop Season 2016**

<table>
<thead>
<tr>
<th></th>
<th>Check Flood</th>
<th>SDI</th>
<th>Difference SDI vs. CF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETa (ac-in/ac)</td>
<td>32.8</td>
<td>33.6</td>
<td>+2.5</td>
</tr>
<tr>
<td>YIELD (Ton/ac)</td>
<td>8.8</td>
<td>9.2</td>
<td>+4.5</td>
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<tr>
<td>AW (in)</td>
<td>46.3</td>
<td>42.1</td>
<td>-9.0</td>
</tr>
<tr>
<td>WP (Tons/ac-in)</td>
<td>0.19</td>
<td>0.22</td>
<td>+14.0</td>
</tr>
<tr>
<td>ENERGY (kWh)</td>
<td>97.2</td>
<td>188.0</td>
<td>+93.5</td>
</tr>
<tr>
<td>ENERGY Pr. (Ton/kWh)</td>
<td>0.09</td>
<td>0.05</td>
<td>-44.5</td>
</tr>
<tr>
<td>GHG (Ton-EqCO₂/ac)</td>
<td>0.04</td>
<td>0.07</td>
<td>+75.0</td>
</tr>
<tr>
<td>GHG Pr. (Ton/Ton-EqCO₂)</td>
<td>220.0</td>
<td>131.4</td>
<td>-40.2</td>
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</tbody>
</table>

#### UC Desert Research Center
**Crop Season 2013**

<table>
<thead>
<tr>
<th></th>
<th>Check Flood</th>
<th>SDI</th>
<th>Difference SDI vs. CF (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETa (ac-in/ac)</td>
<td>55.5</td>
<td>57.2</td>
<td>+3.0</td>
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<tr>
<td>YIELD (Ton/ac)</td>
<td>9.3</td>
<td>9.45</td>
<td>+1.6</td>
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<tr>
<td>AW (in)</td>
<td>69.3</td>
<td>58.5</td>
<td>-15.6</td>
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<tr>
<td>WP (Ton/in)</td>
<td>0.13</td>
<td>0.16</td>
<td>+21.0</td>
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<tr>
<td>ENERGY (kWh)</td>
<td>145</td>
<td>349</td>
<td>+141</td>
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<tr>
<td>ENERGY PR. (Ton/kWh)</td>
<td>0.06</td>
<td>0.03</td>
<td>-50.0</td>
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<tr>
<td>GHG (Ton-EqCO₂/ac)</td>
<td>0.055</td>
<td>0.121</td>
<td>+121</td>
</tr>
<tr>
<td>GHG PR. (Ton/Ton-EqCO₂)</td>
<td>186.0</td>
<td>73.0</td>
<td>-60.7</td>
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</tbody>
</table>
IS IRRIGATION EFFICIENCY STILL THE RIGHT TARGET TO PURSUE?

We have now irrigation systems and technology capable of achieving 90-95% Irrigation Efficiency

Long-standing problems seem not to be relieving:

- Groundwater overdraft and salinization
- Degradation of air, soil and water
- Pollution by over-use and leach-outs of fertilizers and pesticides

The old-school **Irrigation Efficiency/DU** concept is very limiting, whereas more comprehensive approaches have been tested, validated, and adopted by several Countries in their Water Policies.
NEED TO INTEGRATE THE ECONOMIC, ENVIRONMENTAL & EFFICIENCY COMPONENT OF WATER USE

\[
Eco-efficiency_{WATER} = \frac{\text{Agricultural Economic Output}}{\text{Demand on the Environment}} = \frac{\text{Value of production}}{(\text{Extracting resources & Emitting pollution})}
\]

There is the need to quantify 3 parameters and explore the relevant inter-linkages

1) The sectoral water use

2) The economic output

3) The environmental impacts

- Benefits measured in value, e.g. euro/impact
- Resource productivity measured in, e.g. euro/kg
- Resource use measured in amounts, e.g. kg, m³, km² etc.
- Eco-efficiency measured in, e.g. euro/impact
- Environmental impacts measured in potential impacts, e.g. CO₂-equivalent etc.
- Resource-specific impacts measured in, e.g. impact/kg
RELEVANT INDICATORS TO ASSESS ECO-EFFICIENCY

- Economic output of crop production (€/ha)
- Costs for achieving the economic output (€/ha)
- Environmental influence
  - Water used (ac-ft/ac)
  - Energy used (Kwh/ac-ft; Kwh/ac)
  - Wastes produced (Tons/ac; Tons/ac-ft)
  - GHG emission released (TonEq CO₂/ac; TonEq CO₂/ac-ft)
ECO-EFFICIENCY METRICS AND PERFORMANCE INDICATORS

1. **Environmental Productivity**: Production value per unit of environmental impact

2. **Environmental Intensity**: Environmental impact per unit of production value

3. **Improvement Cost**: Cost per unit of environmental improvement

4. **Environmental cost-effectiveness**: Environmental improvement per unit of cost

\[
EWP_{WATER} = \frac{\text{Added Value of Agricultural production (US$)}}{\text{Total water used (ac} - \text{ft)}}
\]

\[
EEP_{ENERGY} = \frac{\text{Added Value of Agricultural production (US$)}}{\text{Total energy used (Kwh)}}
\]

\[
EEP_{CO2} = \frac{\text{Added Value of Agricultural production (US$)}}{\text{Total CO}_2 \text{ released (Tons equivalent)}}
\]

EEIA > Weighted Average or Multi-Criteria Analysis
HOW TO FURTHER IMPROVE SWEEP

1. **Remove the emergency-response working mode**
   - More drought-preparedness/adaptation scope and less drought-response work
   - Best drought adaptation/resilience work should be conceived and planned during non-drought times

2. **Incentivize multiple irrigation methods/systems** on the farm to enable weather/supply-adaptive irrigation operation & management to cope with weather vagaries & variations

3. **Incentivize on-farm storage & compensation reservoirs** to buffer water supply operations and delivery (irrigation districts) with on-farm water demand and optimize/minimize energy costs

4. **Incentivize energy-smart upgrades** (retrofit to minimize energy/labor costs), larger system capacity to shorter irrigation sets)
5. **Bring back the integrated pilot projects (on-farm + IDs)**

- Incentivize upgrades to reduce the disconnect between on-farm water demand and water supply operations (see SSJID, NSJID, Oakdale ID, Pajaro Valley Water Management Authority, etc.)
- Match the frequency of supply with the frequency of demand

6. **Invest and implement a real Monitoring & Evaluation Program**

   to track impacts (water, energy and GHG) from improvement projects

   - Impacts from SWEEP are based on estimates from applications and technical reviews?

7. **Invest in Educational and Training Efforts**

   to help growers make the best use of the available technologies deployed in their field/farms.
THANK YOU !!

QUESTIONS OR COMMENTS?
✓ Warmer winter temperature
✓ More precipitation falls as rain instead of snow (less stored water)
✓ More flow from watersheds before the spring
✓ Flow between April and June declining during the last century (-10%)
Cumulative groundwater depletion in California’s Central Valley from USGS and GRACE (1962-2014)

After Faunt, 2009, USGS PP 1766
USGS data courtesy of Claudia Faunt
Water supply will be limited and regulated for all users (water rights and water tariffs need to be re-visited)

Larger quotas of water are being transferred from agriculture to urban areas and the environment.

Climate change and increased weather variability will worsen problems of water supply (drought & floods, frost and heat waves)

Need for cropping systems that:

- Use less water
- Adapt to lower-quality water
- Benefit from rainfall & flows capture during fall and winter months
The *growers’* and *regulators’* objectives are quite different:

- Can they be reconciled in a shared **Sustainable Water Management Strategy**?
- Are there **incentives** to make a **more productive** and **sustainable use** of the available water supplies?
Large efficiency gains + more careful water management

Agricultural expansion + intensification

California water use 1960-2015

Source: DWR, 2013
Economic Productivity of Water 2000-2010

680 $/AF => 910 $/AF (+34%)

(resulting from more efficient irrigation & more productive crops)

This economic performance indicator does not consider the costs and environmental influence.
Economic Productivity of Water per Crop ($/ac-ft)

MAIN CHALLENGE
Expansion of irrigated acreage & more permanent crops following irrigation efficiency and water productivity gains
CONFLICTING OBJECTIVES

REGULATORS: Water Savings, Water Conservation & Water Banking, Water Transfer Programs

AG. WATER DISTRICTS

✓ Must deliver & sell water to users (stay in business)
✓ Pay-back their infrastructure, operational & maintenance costs
✓ **USE-IT-OR-LOOSE-IT** (must document they need and water usage not to reduce/loose the water rights)

**BUT**

✓ Must maintain conditions & incentives for successful agricultural businesses
✓ Must comply with environmental/water regulations

FARMERS: Yield & Productivity ($$/land, $$/water, $$/energy)
CAN WE CONSIDER DROUGHT STILL AN EMERGENCY?

☆ Wet and Dry cycles have been alternating in California since the 60s’

☆ Droughts are re-occurring in California and are part of our climate