Irrigation of Agricultural Crops in California

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What percentage of California’s water is used by agriculture?

- 80 %: based on the developed water supply
- 52 %: based on the total water supply of a dry year
- 29 %: based on the total water supply of a wet year
Why irrigate?
How much water does agriculture need?
What is evapotranspiration (ET)?

- Evapotranspiration: crop water use
  - Water evaporation from plant leaves (transpiration)
  - Water evaporation from soil surface
  - More than 95% of the water uptake by plants is evaporated

- Factors
  - Climate: solar radiation, temperature, humidity, wind
  - Plant: crop type, stage of growth, health
  - Soil moisture content
Units of evapotranspiration (ET)

- **Volume of water**
  - One acre-inch = 27,160 gallons
  - One acre-foot = 325,900 gallons

- **Depth of water (inches, feet, cm, mm)**
  - Standardized water use (independent of field size)
  - One inch of water = 1 acre-inch per acre = 27,160 gallons per acre
Measuring evapotranspiration (ET)

- Difficult and expensive to measure
- Methods
  - Lysimeter – very expensive, restricted to ag field stations
  - Meteorological methods – moderately expensive, portable
  - Soil moisture measurements – inexpensive, can be inaccurate
- California Irrigation Management Information System (CIMIS)
  - Network of weather stations Installed and maintained by the University of California and California Department of Water Resources
  - Weather data used to calculate a reference crop ET (ET of grass or alfalfa)
  - Crop coefficients (Kc) used to relate reference crop ET to actual crop ET
  - $ET = Kc \times \text{Reference crop ET}$
Lysimeter
Meteorological Methods
Soil moisture measurements
CIMIS weather station – data and complex equations are used to calculate a reference crop ET

Crop ET = crop coefficient \times \text{reference crop ET}
Evapotranspiration of selected crops

- Wheat: 16 inches
- Tomatoes: 25 inches
- Almonds: 38 inches
- Almonds (cover crop): 51 inches
- Alfalfa: 55 inches
- Lettuce: 8 inches
- Rice: 37 inches
- Corn: 27 inches
- Citrus: 35 inches
- Strawberry: 25 inches
Where do dairy products come from?

- Dairy products: ice cream, cheese, milk, yogurt, butter
- Dairy cows produce the milk used to make these products
- Dairy cows eat about 70% of the alfalfa produced in California
Alfalfa

- Products: ice cream, milk, cheese, yogurt, butter
- Seasonal ET of alfalfa = 55 inches of water = 55 acre-inches per acre = 1,500,000 gallons per acre
- 160 acres: ET = 160 acres x 1,500,000 gallons per acre = 240,000,000 gallons of water per year (does not include irrigation system inefficiencies)
- Are we wasting water growing alfalfa?
Grain

- Products: bread products, rice, cereal, chicken, eggs, steak
- Seasonal ET of wheat = 16 inches of water = 16 acre-inches per acre = 435,000 gallons per acre
- 160 acres: ET = 160 acres x 435,000 gallons per acre = \textbf{69,600,000} gallons of water per year (does not include irrigation system inefficiencies)
What crops should be grown in California?
Maximize dollar returns?

- Only high cash value crops should be grown
  - Tree crops
  - Vegetable crops
  - Tomatoes

- Low cash value crops should not be grown
  - Wheat
  - Corn
  - Cotton
  - Alfalfa?
Maximize human health?

Anatomy of MyPyramid

One size doesn’t fit all
USDA’s new MyPyramid symbolizes a personalized approach to healthy eating and physical activity.
The symbol has been designed to be simple. It has been developed to remind consumers to make
healthy food choices and to be active every day. The different parts of the symbol are described below.

Activity
Activity is represented by the steps and
the person climbing them, as a reminder
of the importance of daily physical activity.

Moderation
Moderation is represented by the narrowing
of each food group from bottom to top.
The wider base stands for foods with
little or no solid fats or added sugars.
These should be selected more often.
The narrower top area stands for foods
containing more added sugars and solid
fats. The more active you are, the more of
these foods can fit into your diet.

Proportionality
Proportionality is shown by the different
widths of the food group bands. The widths
suggest how much food a person should
choose from each group. The widths are
just a general guide, not exact proportions.
Check the Web site for how much is
right for you.

Variety
Variety is symbolized by the 6 color bands
representing the 6 food groups of the
Pyramid and oils. This illustrates that
foods from all groups are needed each
day for good health.

Personalization
Personalization is shown by the person on
the steps, the slogan, and the URL. Find
the kinds and amounts of food to eat each
day at MyPyramid.gov.

Gradual Improvement
Gradual improvement is encouraged by
the slogan. It suggests that individuals can
benefit from taking small steps to improve
their diet and lifestyle each day.
Protein

grams/m³

- wheat
- rice
- maize
- potatoes
- sugar (beets)
- pulses (beans)
- treenut
- groundnut
- soybean oil
- cottonseed oil
- tomatoes
- onions
- carrots
- orange
- lemon
- grapefruit
- banana
- apple
- pineapple
- date
- grape
- fruit other
- bovine meat
- pork meat
- poultry meat
- eggs
- milk
- butter

W. W. Wallender, UC Davis
The situation

- Agriculture cannot compete economically with the urban/industrial sector for water.
  - Uses a large amount of water per unit of production
  - We do not pay very much for the agricultural products
- Regardless of the economics, if we want food we will have to pay the price in terms of water and land for producing the agricultural products used to produce our food. There is no other choice if we want food!
- Lower-cash value crops provide a major part of our diet
Irrigation methods in California
Irrigation efficiency

- Definition: ratio of water beneficially used to amount applied
- Beneficial uses
  - ET – major use
  - Salinity control
  - Frost protection
  - Drip system maintenance
- Losses affecting the irrigation efficiency
  - Surface runoff – water that runs off the lower end of gravity irrigated fields
  - Deep percolation – water that percolates through the soil below the root zone
  - Evaporation
- Different numbers for farm, irrigation district, regional irrigation efficiencies
Furrow irrigation (gravity)
Flood or border irrigation (gravity)
Wheel-line sprinkle system
Hand-move sprinkle system
Portable solid-set sprinkler system
Center-pivot sprinkler system – inappropriate for many California soils
Linear-move sprinkler system
Microsprinklers – tree crops

Microsprinkler
Drip irrigation – vineyards, tree crops
Drip irrigation – row crops

Surface drip irrigation

Subsurface drip irrigation

Drip tape
Which irrigation method is the best?

- **Gravity irrigation**
  - Low capital cost
  - Low labor cost to operate
  - Difficult to manage efficiently – trial and error approach
  - Surface runoff can cause water quality problems

- **Sprinkler irrigation**
  - Moderate capital cost
  - Low to moderate labor costs to operate
  - Easy to manage
  - Efficiency limited by wind effects

- **Microirrigation**
  - High capital costs (up to $1,000 per acre)
  - Precise application of water throughout a field
  - Moderate labor costs
  - Easy to manage
  - Highly susceptible to emitter clogging
# Maximum potential irrigation efficiencies

<table>
<thead>
<tr>
<th>Irrigation method</th>
<th>Irrigation efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity (furrow, flood)</td>
<td>70-85</td>
</tr>
<tr>
<td>Sprinkle</td>
<td></td>
</tr>
<tr>
<td>Hand-move, wheel-line, solid set</td>
<td>70-80 (low wind)</td>
</tr>
<tr>
<td>Center pivot, linear-move</td>
<td>80-90</td>
</tr>
<tr>
<td>Microirrigation</td>
<td>80-90</td>
</tr>
</tbody>
</table>
Will increasing the farm irrigation efficiency save water that can be used elsewhere?

- Numerous studies have attempted to answer this question
  - Many researchers are not very familiar with irrigated agriculture
  - Some ignore reality
  - Questionable assumptions, results, and conclusions
- Problem – losses from one farm frequently are used by downstream water users
  - Difficult to track where the water goes
  - Little or no real water savings
Two farm irrigation district

ET = 25 ac-ft
IE = 50 %
Surface runoff = 25 ac-ft

Surface runoff = 0 ac-ft

ET = 25 ac-ft
IE = 100%
Surface runoff = 0 ac-ft

ET = 25 ac-ft
IE = 50 %
Surface runoff = 25 ac-ft
Estimates of potential water savings from increased irrigation efficiency

- **University of California study** – 843,000 acre-feet
  - University, state and federal agencies, irrigation districts, grower organizations
  - Considered reuse of water
  - Estimate based on amount of water not reused downstream

- **Consultant study** – at least 4,400,000 acre-feet
  - Did not consider reuse of water

- **Improved water quality may be the primary benefit of increased irrigation efficiency rather than water savings** – reduced surface runoff (sediments, pesticides, nutrients)
Where will the water come from?

- No more dams for water storage
- Water conservation from increased irrigation efficiency?
- Removal of agricultural land from production – most likely source of water for satisfying the increased urban/industrial and environmental water demands
  - DWR water transfer program
  - MWD program of removing alfalfa fields from production on a rotating basis in the Palo Verde Valley – water is transferred to the LA area
- Deficit irrigation of agricultural fields
  - Regulated deficit irrigation – trees and vine crops (UC Davis)
  - Mid-summer deficit irrigation - alfalfa (UC Davis)
- Reduced urban/industrial and environmental demands
Summary

- Agriculture is California’s largest user of water.
- It takes a lot of water to produce a crop.
- The price that society has to pay for food is the water and land required to produce the crops needed for food. There is no other choice.
- It is unlikely that increasing irrigation efficiency will have a large impact in supplying the predicted future water needs of the urban/industrial and environmental sectors.
- Agricultural land will need to be removed from production to supply the needed water.
Have a good day!