Holistic Pressurized Irrigation Development

by
Jack Keller

Pressurized Irrigation Development

- Uniform pre-watering for germination and then uniformly, timely, and efficient replacement of the water depleted by crop ET is the basic objective of irrigation
- Pressurized irrigation development involved a sequence of iterative steps, like a dance, led by technology innovations -- followed by design procedures and criteria for efficiently employing them

Three Levels of Pressurized Irrigation Development

1. Development of the “pressurized irrigation technologies” (PITs)
2. Design, instillation, and management of various PITs serving individual fields
3. Development, management, and rejuvenation of projects serving many fields with the various PITs

Holistic Development

- Strives to optimize the use of all the available resources
  - Human, societal, economic, and knowledge
  - Natural and biological
  - Physical and technological
- While minimizing adverse environmental consequence from
  - Over-use of any resources
  - Pollution of the natural resources

Being Holistic Requires Considering Many Variables

- Soil, topography, field size and layout
- Crop's sensitivity to water and salinity stresses
- Water cost, availability, quality, & supply reliability
- Quality and destination of return flows
- PITs' costs and their water application uniformity
- Energy cost and reliability
- Cost, quality, availability, and reliability of irrigator, management, and technical services
- Financial ability and capacity
- Net cropping system returns to irrigation water

So Many Variables Looks Scary (but it need not be because)

- We do the best we can with the knowledge we have
- As development proceeds we learn how to handle many of the variable parameters on a regional basis
- But always remember -- many parameters will evolve over time as irrigation and the consequential human and economic development proceed

Pressurized Irrigation Technologies (PITs)

Pressurized Irrigation Technologies (PITs)

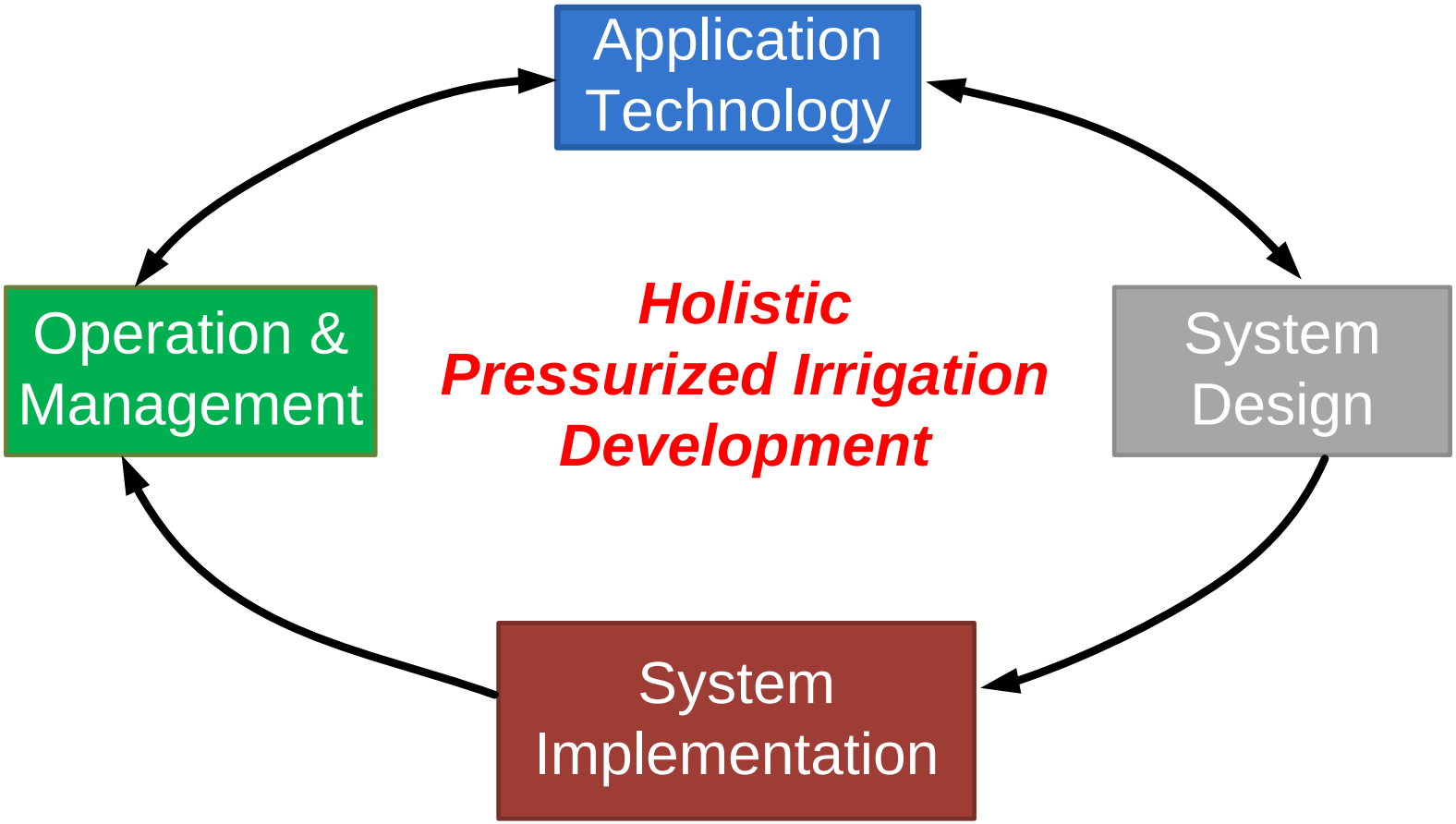
- Have networks of pipe (or tubing) that deliver water under pressure to their emission devices
- Are defined by their water emission devices
  - Drip has drip-emitters (drippers)
  - Sprinkle has sprinklers
  - Surface has gates (controlled orifices)

Main PITs Water Emission Device Characteristics

- Drip – small flows (0.2 to 2+ liters/hour) from drip-emitters at or below ground level near each plant
- Sprinkle – medium flows (2 to 30 liters/min) from sprinklers ejecting water into the air to many plants from fixed or moving pipelines
- Surface – medium flows (0.2 to 5 liters/sec) from gates (controlled-orifices) into furrows or basins to serve many plants

Sequence of Holistic Irrigation Development

- Begin with the available PITs
- Consider the above elements and design a field system using each of these PITs
- Implement the most promising PIT systems
- Get operational and management feedback to inform needs for modifications of the PITs themselves or the PIT system design protocols


Application Technology
System Design
System Implementation
Operation & Management
Holistic
Pressurized Irrigation
Development

Field Irrigation System Design Using PITs

DAVID KARMELI Ph.D.
JACK KELLER Ph.D.

PAIN BIRD

TRICKLE IRRIGATION DESIGN

$$d_m = \frac{d\sqrt{q_m}}{\sqrt{q}} = d\sqrt{n}$$

$$P = \frac{100\, n\, S_{ep}\, S_w}{S_t\ S_r}$$

Drip Irrigation Systems apply water directly to the plants' bases, so their Emission and Application Uniformities are the same

- Drip Design Emission Uniformity, *EU:*

$$EU = 100(1 - 1.27\, v_a/Np^{0.5})q_n/q_a$$

v_a is the manufacturers coefficient of variation
Np is the number of emission points per plant
q_n is emission rate at minimum system pressure
q_a is system's average or design emission rate


SPRINKLE
AND
TRICKLE
IRRIGATION
JACK KELLER
RON D. BLIESNER

Sprinkle Irrigation Systems' water is airborne in route to the plants' bases, so Emission and Application Uniformities are different

- *Sprinkle Emission Uniformity, EU_S:*

$$EU_S = (1 - 1.27\, v_a / N'^{0.5}_S) q_n / q_a$$

v_a is sprinkler discharge variation coefficient

N_S is number of sprinklers overlaps per plant

q_n is computed sprinkler discharge rate at system's minimum pressure location

q_a is system's design sprinkler discharge rate

Sprinkle Irrigation Systems' Application Uniformity is the product of the EU_S and Tested Cup-catch Uniformity

- Cup-catch Coefficient of variation Uniformity, *CvU:*

$$CvU = 1.0 - (sd/q_a)_{(cup\text{-}catch)}$$

q_a is the average cup-catch for the population
sd is the standard deviation of cup-catches for the population

Drip and Sprinkle System Application Efficiency Ratios (AERs)

(With no leaks and optimum scheduling including salinity management)

- Drip AER ≈ CvU_D

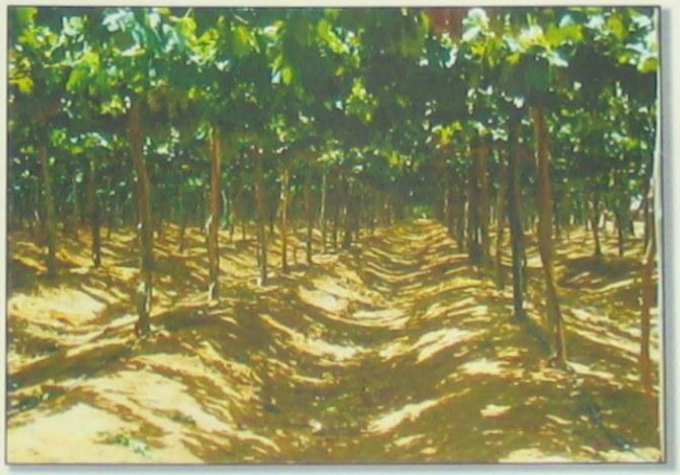
  CvU_D is the Field Drip Emission Uniformity

- Sprinkle AER= (EU_S) x (CvU) x R_e

  R_e is the effective portions of water emitted from sprinklers, which is a function of drop size, wind speed, and reference *ET*

Sprinkle & Trickle Irrigation

Lecture Notes



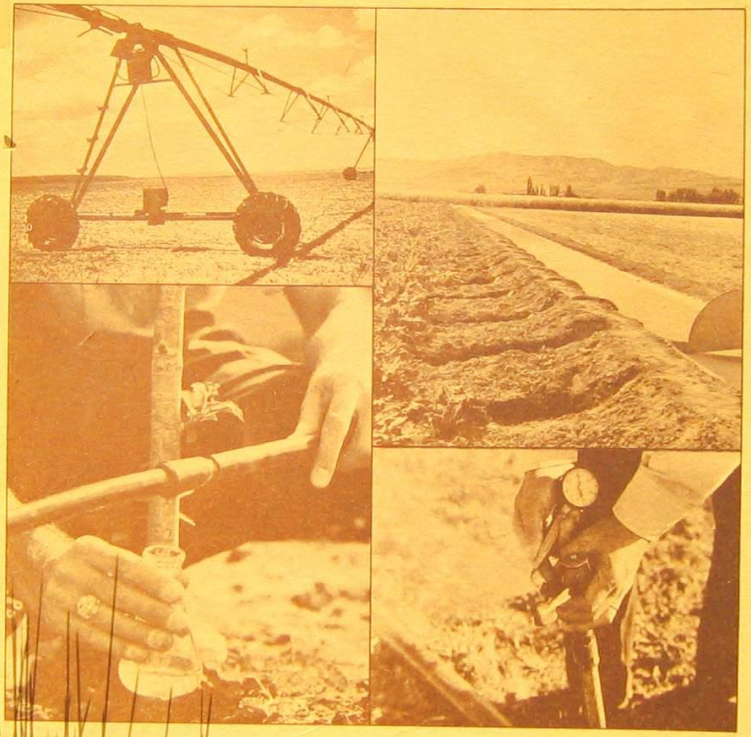
BIE 5110/6110

Fall Semester 2010

Civil and Environmental Engineering Department
Utah State University, Logan, Utah

Farm Irrigation System Evaluation: A Guide for Management

(Third Edition)



By: John L. Merriam
Jack Keller

Utah State University
Logan, Utah
1978

Purposes of Improving Irrigation Efficiency

- Commercial farming

"more crop production per m^3 water consumed"

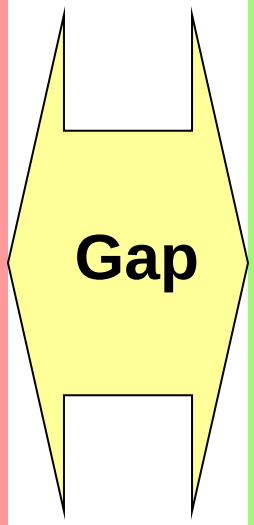
- Family farms

"better nutrition and more poverty reduction per m^3 water consumed"

The Irrigation Technology Gap

Modern technologies:

- *Intended for large fields and favorable lands*
- *Focused on saving labor by trading capital for labor*
- *Complex hardware requiring skilled maintenance*
- *Energy and capital intensive*



Small farm needs

- *Suitable for small plots and marginal lands*
- *Focused on low-cost and trading labor for capital*
- *Simple hardware that is easy to maintain and repair*
- *Low energy inputs, rapid capital return*

Most modern PITs needed to be reengineered to be affordable and suitable for small-plot farmers

Design Criteria for Small Farm Irrigation PITs and Systems

- Easy to understand, operate and repair
- Return on investment in one season
- Sales, installation, and service compatible with local small businesses
- Available in small packages: 20 m^2 to 20,000 m^2
- Low pressure: 1 to 12 meters of inlet pressure head

Center-Pivot Sprinkle System for 30-ha Half-Circular Irrigated Area

Electric Turbine Pump and Pivot

500 m of Sprinkler System Spans

Inlet pressure head: 25 m --- Cost : US $3,000/ha

Mini-Sprinkler Components and Instillation

Mini-Sprinklers Operating

(Sprinkler Spacing: 4 m x 5 m)

Inlet pressure head: 10 m – Cost: US$ 750/ha

Simple Cup Used to Estimate ET_O
(±10 cm diameter by ±10 cm deep)

Based on practical ET_O monitoring suggestions from David Seckler

DESIGN AND EVALUATION OF SMALL PLOT IRRIGATION FOR AGRICULTURAL DEVELOPMENT

By:
Jack Keller and Andrew A. Keller

FIRST EDITION

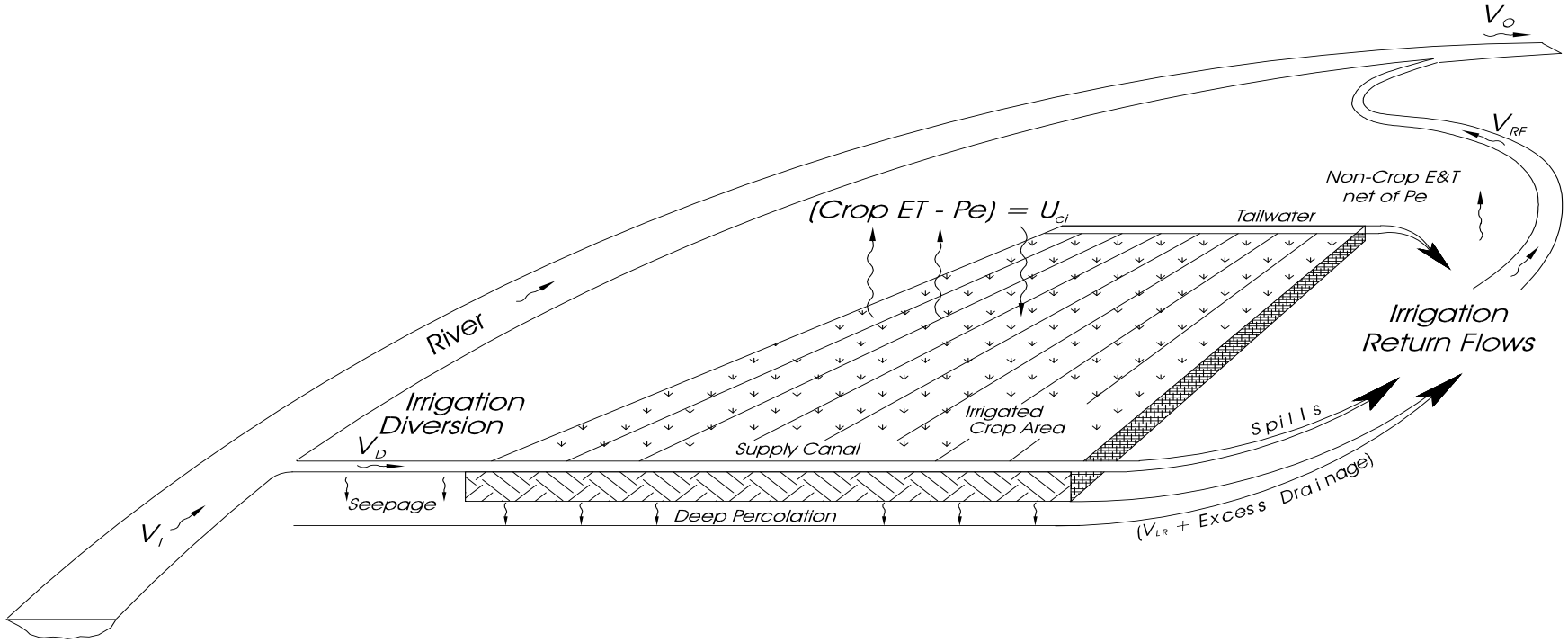
Final February 2011
(First Draft October 2010)

Irrigation System Design, Management, and/or Rejuvenation for Projects with Fields Using PITs

IRRIGATION EXPERIENCE TRANSFER: INTERDISCIPLINARY PERSPECTIVES

USAID / WATER MANAGEMENT
SYNTHESIS PROJECT
WMS REPORT 88

Pictorial Vies of Diversion Project and Term Necessary for Defining E_e

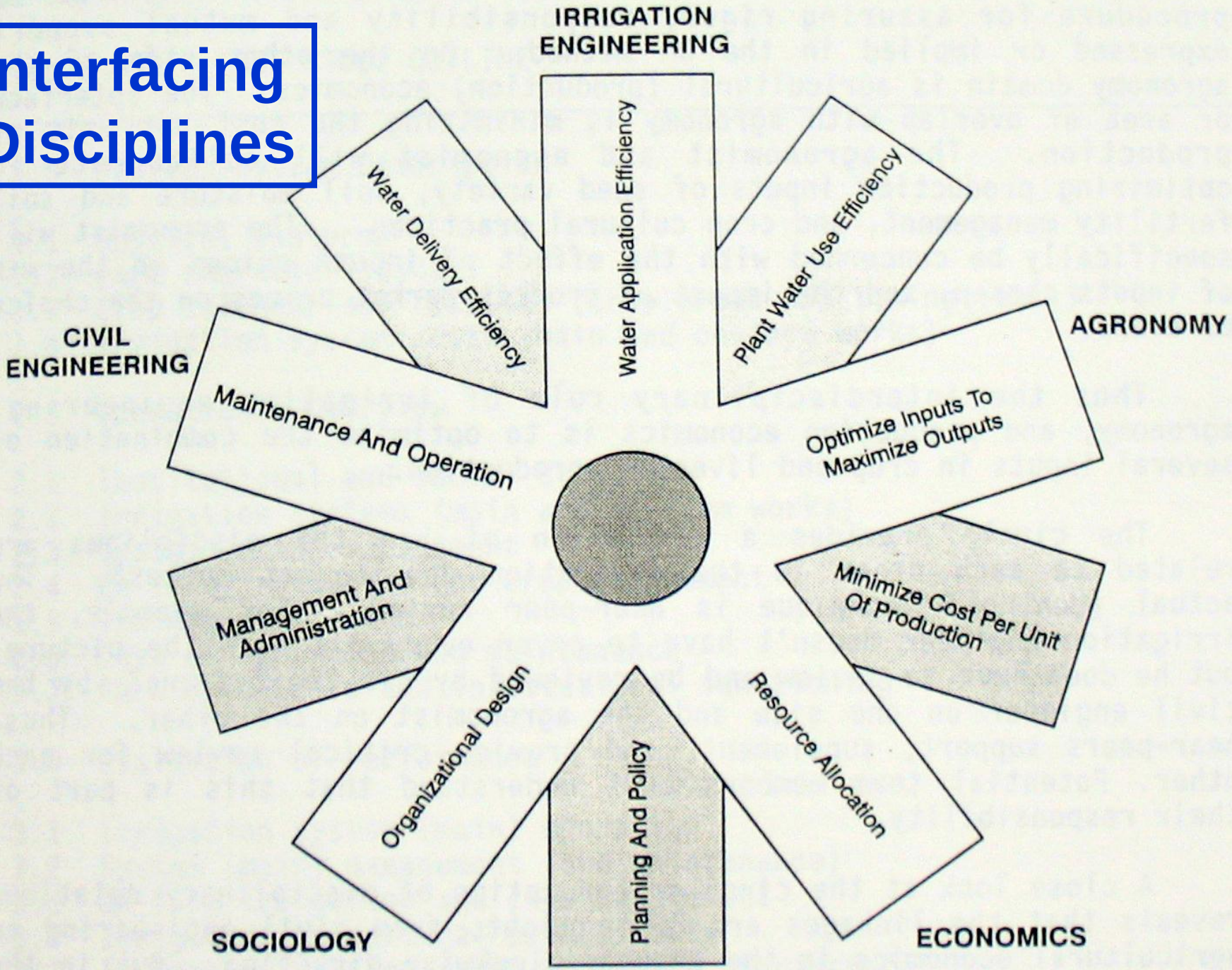


Effective Irrigation Efficiency E_e [accounts for return flows and the consequential water quality changes]

$$E_e = \frac{Crop\ ET\ of\ \ Irrigation\ Water}{Total\ Effective\ Use}$$

$$= \frac{U_{ci}}{U_e} = \frac{U_{ci}}{V_{eI} - V_{eO}} = \frac{Crop\ ET - P_e}{(1 - LR_I)V_I - (1 - LR_O)V_O}$$

Interfacing Disciplines



Performance/Opportunity Analysis

- Focuses on what is happening and assumes it is rational in the context of the local people and their social, economic, natural, and physical environment
- Searches for what is successful and takes a performance view, coaching stakeholders to expand success to improve performance
- Uses an integrated framework that leads to interdisciplinary action, which is in the domain of consultation

All Creative Work Requires Some Kind of Meditation

When you approach a design and are stuck, realize being stuck and a blank mind precede inventiveness. Don't try to avoid being stuck because you will find that the harder you try to hold on to it, the faster your mind will naturally and freely move toward finding a good design.

So just concentrate on what you want to accomplish - live with it for a while. Study it like you study a line when fishing and before long, you will get a little nibble, a design idea asking in a timid way if you am interested……


Thank You for your Visit to our
home and invitation To this
wonderful gathering