Comprehensive Water Resources Development and Utilization in Agriculture

T. B. S. Rajput, Emeritus Scientist
Water Technology Centre,
Indian Agricultural Research Institute, New Delhi 110012
Evolution of Indian Irrigation:

Era of adaptive irrigation - up to 1830

COMMUNITY

Era of canal construction - 1830-1970

STATE

Era of atomistic pump irrigation - 1970-todate

INDIVIDUAL FARMER
Irrigation Development in India after Independence

Irrigation potential created
GAP
Irrigation potential utilized

1951 (Food grain 51 Mt)
2006 (201 Mt)

Five year plan periods

Irrigation potential, Mha

I I II III IV VI VI VII VIII IX X
Irrigation efficiency

Overall irrigation efficiency in India – 38%

27% in Krishna Godavari, Kaveri and Mahanadi river systems

43 to 47% in Indus and Ganga river systems

70 to 80% in 55% area irrigated by groundwater
## Water losses in conveyance

<table>
<thead>
<tr>
<th>Sources of losses</th>
<th>Seepage</th>
<th>Evaporation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main canal &amp; Branches</td>
<td>13.6</td>
<td>3.4</td>
<td>17.0</td>
</tr>
<tr>
<td>Distributaries</td>
<td>6.4</td>
<td>1.6</td>
<td>8.0</td>
</tr>
<tr>
<td>Field &amp; Water Courses</td>
<td>16.0</td>
<td>4.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Field application losses</td>
<td>13.2</td>
<td>3.3</td>
<td>16.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>49.2</strong></td>
<td><strong>12.3</strong></td>
<td><strong>61.5</strong></td>
</tr>
</tbody>
</table>
Rehabilitation of Irrigation System

Before

After

Notana Mr. 1 RD 9500 (Kishanpura Sub Branch System)
Operation and maintenance

• New management requirements

• Monitoring and evaluation

* Re-training of engineers and managers in irrigation agencies

* Farmers participation in planning and maintenance work

* Pricing of water
Water management in distribution network

(a) Drawing up the schedule of irrigation water diversion.
(b) Supplying water according to farmers’ demand.
(c) Scientific operation and rational distribution.
(d) Flexible, stable and sufficient water supply.
New or upgraded structures:
Automated gate and check structures:

- Remote monitoring and actuation.
- Radio communication.
- Solar powered.
A - Improvement of the irrigation network management

CANALS FLOW SIMULATION MODEL

IMPROVEMENT OF THE IRRIGATION NETWORK DISTRIBUTION EFFICIENCY
A - Improvement of the irrigation network management

WATER DEMAND ANALYSIS

WEATHER STATIONS

TRANSMISSION BY RADIO
- TEMPERATURE
- ETP
- HUMIDITY
- PRECIPITATION

ESTIMATION OF CROP WATER REQUIREMENTS
Water management strategies in distribution network
3. Canal Water Distribution Methods

- Warabandi
- Shejpali
- Block system
- Zonal system
- Localized system

Integrated Canal Scheduling Model

Supply based

Demand based
Through balancing reservoirs
Drip system Coupled with solar pumping
On – farm
Water management strategies
On farm water management

- Optimal water conveyance network
- Equitable distribution of water
  - Conjunctive use of surface water and ground water
  - Precision land leveling
  - Measurement of water in the farm
  - Choice of irrigation method
- Choice of cropping pattern
- Development of land drainage
- Canal automation
# Maintenance of water courses

Conveyance losses in per cent per 100 meter of water course

<table>
<thead>
<tr>
<th></th>
<th>Unlined</th>
<th></th>
<th>Lined</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Un-maintained</td>
<td>8.6</td>
<td>4.7</td>
<td>3.2</td>
<td>1.5</td>
</tr>
<tr>
<td>Maintained</td>
<td>4.7</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- **Unlined**: Water courses without lining
- **Maintained**: Water courses that have been maintained
- **Lined**: Water courses with lining
Water course alignment

The water course should follow the main ridges, and

The water course should also follow general conditions:

- Watercourse should be aligned along the sides of rectangles
- No watercourse should be near to the canal boundary or an inspection road than half the width of the killa.
- Watercourse should be aligned entirely within one rectangle
- Whenever possible, watercourse should irrigate on both sides.
- Ordinarily, only one nakka is sanctioned for each square, but a second nakka may occasionally be given
1. Optimal layout of watercourses network

Desirable
A least length network of channels connecting all the fields with water source/ canal outlet

Modified Minimal Spanning Tree model

Step 1 - Prepare a table of different possible segments of the water course
Step 2 - Start from the outlet select minimal possible segment & everytime keep selecting smallest possible segments
Step 3 - Take a precaution that no looping is done
Step 4 - All segments, before selection may be checked for positive gradient.
Step 5 – Stop when the layout plan covers the entire command connecting all the fields

List Of Possible Layout Paths

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD = 64.4</td>
<td>BF = 54.3</td>
<td>CG = 52.5</td>
<td>DA = 64.4</td>
</tr>
<tr>
<td>AB = 95.5</td>
<td>BC = 54.6</td>
<td>CB = 54.6</td>
<td>DE = 124.8</td>
</tr>
<tr>
<td></td>
<td>BA = 90.5</td>
<td></td>
<td>DB = 180.1</td>
</tr>
<tr>
<td>F</td>
<td>G</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>FE = 14.2</td>
<td>GF = 50.4</td>
<td>HM = 45.0</td>
<td>IH = 45.5</td>
</tr>
<tr>
<td>FG = 50.4</td>
<td>GC = 52.2</td>
<td>HI = 45.5</td>
<td>IN = 50.0</td>
</tr>
<tr>
<td>FB = 54.3</td>
<td>GH = 52.3</td>
<td>HG = 52.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GL = 56.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. Field rectangulation-

Consolidation and rectangulation of fields by minimum dislocations of properties reduces total length of water courses. It will save water losses besides increased efficiency in use of machinery.

<table>
<thead>
<tr>
<th>Layout Plan Option</th>
<th>Length, m</th>
<th>Savings, m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>1260</td>
<td>-</td>
</tr>
<tr>
<td>Optimized (M ST)</td>
<td>1085</td>
<td>175</td>
</tr>
<tr>
<td>Field Rectangulation</td>
<td>925</td>
<td>335</td>
</tr>
</tbody>
</table>
INTERACTIVE, USER FRIENDLY MODEL (OUTLET) FOR PREPARATION OF ROSTER FOR WATER DISTRIBUTION
4. EQUITABLE WATER DISTRIBUTION TO ALL BENEFICIARIES

ACHIEVABLE LEVELS OF EQUITY

TIME EQUITY  Distribution of outlet operation time in proportion to the size of holdings of beneficiaries.

VOLUME EQUITY  Distribution of volume of water in proportion to the size of holdings of beneficiaries.

REQUIREMENT EQUITY  Distribution of volume of water in proportion to the actual requirements.

SOCIAL EQUITY  Distribution of equal volume of water to different beneficiaries in the command.

INTERACTIVE, USER FRIENDLY MODEL (OUTLET) FOR PREPARATION OF ROSTER FOR WATER DISTRIBUTION
Laser land leveling

Surface application methods such as check basin, border strip and furrow irrigation.

Application efficiency - 30 to 50 %

Farmers traditionally have been practicing land leveling in their fields using animal drawn or tractor drawn levelers.

Minimizes chances of GW pollution

Increases water application efficiency by 50%

40 % increase in cropping intensity

Increase in yield of crops (wheat-15%, sugarcane-42%, rice- 61% & cotton- 66 %)

Nitrogen use efficiency in kg grain kg\(^{-1}\) nitrogen

45.11 to 48.37 in rice & 34.71 to 36.90 kg in wheat
Irrigation Efficiency

Irrigation Methods

- Flood: 40%-60%
- Furrow: 50%-70%
- Sprinkler: 70%-85%
- Center Pivot: 80%-90%
- Drip: 90%-95%
1. Maintenance and upkeep of conveyance channels
3. Flow measurement at farm

Auto- Flow Recorder

Wheel Flow Meter

Pipe Flow Meter

Flow Metering Siphon
7. Efficient surface method
(Surge Irrigation)

* The concept of surge irrigation is in use since 1979
* Initiated surge irrigation studies in India in 1986.
* Developed a kinematic wave model for its design

Surge irrigation is the intermittent application of water flow to furrows/basins in a series of “on” and “off” periods of constant or variable duration.
In situ soil and Water Conservation in Rainfed Agriculture

Contour Guideline

Contour cultivation

Protection to Farm pond inlet

Clean water in Farm pond
## Effect of mulching for water conservation

<table>
<thead>
<tr>
<th>Crop</th>
<th>Weed control, %</th>
<th>Yield increase, %</th>
<th>Water saving, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinnow</td>
<td>55</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>Amla</td>
<td>40</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Lemon</td>
<td>51</td>
<td>14</td>
<td>30</td>
</tr>
<tr>
<td>Guava</td>
<td>40</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Cotton</td>
<td>60</td>
<td>25</td>
<td>46</td>
</tr>
<tr>
<td>Ginger</td>
<td>99</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Turmeric</td>
<td>94</td>
<td>21</td>
<td>25</td>
</tr>
</tbody>
</table>

- **Water saving**: 30 to 70%
- **Increase in yield**: 10 to 60%
- **Control of weeds**: 30-90%
AQUA – FERTI-SEED-DRILL
Waste water use through subsurface drip

Subsurface drip (SSD) reduced risk of infection of farm workers and reduced odor.

In SSD, soil microbes rapidly destroy most, if not all pathogens. This is known as "filtrigation".

In SSD, a lower level of wastewater treatment may be acceptable resulting in a reduction of pollution.

SSD reduced the use of nematicides by 83%. (Ferrell, 1990).
9. Crop improvement/ better cultivation practices

- **Reduction in crop duration**
  - Graph showing time duration vs. yield
- **Elaborate root network**
- **Raised bed cultivation**
- **Evaporation reduction**
- **Low water requiring crops**
8. Sensor based irrigation scheduling

Saving of irrigation water in vegetables (bottle gourds and potato) up to 40% by appropriate
9. Phytomonitoring Applications
Conclusion

Institutional, organizational and technological improvements are needed at all operational levels of irrigation schemes from water supply and conveyance to the distribution and application at farm level for increasing water productivity.
thanks
for your kind attention