Training for Asian Young Professionals on Performance Assessment of Irrigation Systems
(9th to 13th April 2018 in Beijing, China)
Modernization of irrigation scheme through the MASSCOTE approach - a case study

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The objectives of the Workshop

• Produce insights on the performance of management in Narayanpur irrigation systems
• Increase capacity on techniques and modern approaches of management and operation (60 participants).
• Produce some recommendations for the follow-up of irrigation modernization development plans at state level.

Tools used: MASSCOTE & RAP
MASSLIS & MASSMUS

Mapping System & Services for Canal Operation Techniques and Rapid Appraisal Procedure

MASSCOTE Objective = Mapping the serviced area into manageable cost-effective units to better serve users.

MASSLIS = Module for Lift Irrigation System
MASSMUS = Module for Multiple Uses-Services.
STEP 1 RAP: Objectives

- Provide a basis for making specific recommendations for modernization and improvement of water delivery service, identifying weaknesses and changes
- Provide a baseline for comparison of future performance after modernization
- Benchmarking for comparison against other irrigation projects
RAP Outputs

- **External indicators**
  - Examine inputs and outputs of the whole project (and constraints)
- **Internal indicators**
  - Identify key factors related to water control throughout a project.
  - Define level of water delivery service provided to users at all levels of the system
  - Managers, operators, WUCS, farmers
  - Examine specific hardware and management techniques and processes used in the control and distribution of water

RAP Process

- We divided into 7 groups
  - Group 1: RLIS and NRBC
  - Group 2: IBC 0 to 80 KMs
  - Group 3: NLBC 77 KMs
  - Group 4: SBC 76 KMs
  - Group 5: JBC 78 KMs and MBC 51 KMs
  - Group 6: IBC 80 to 172 KMs
  - Group 7: ILC 0 to 97 KMs
- We spent 3 days on the field
- We gave ratings to all internal indicators
- We reviewed and finalized the results in plenary

Our ratings, given, validated and endorsed by all participants

Common findings (1)

- Huge water infrastructure: should be well managed to serve generations to come, avoid food shortage and generate good incomes for rural people.
- Management shift from construction phase to water management has not yet happened.
- Distortion of reality at management and users levels
- Measurements, assessment and monitoring not given priority

Common findings (2)

- Involvement of all users and stakeholders should be increased in water management.
- Spreading water all over is good for easy access to water services, but shallow water stagnation is seen in several pockets of command with invasive vegetation.
- Drainage flow important (Nala): Water losses!
- Water Services should thus include drainage.
Common findings (3)

- In some subsystems about 50% rice cultivation
- Water distribution not well controlled
- Rotation not followed leading to shortage of water at tail.
- Lack of gates below disty heads making rotation impossible
- Low flow spreading all around ➔ low efficiency of transport
- Seepage losses as canal lining deteriorated
- Too much water flows in upstream distys.
- Inequity ➔ Tail-enders deficit within Disty

Specific findings (1)

NLBC:
- Vulnerable reaches in banking in km.61 to 63 needs special attention for stabilization.
- Aqueducts need restoration

NRBC:
- Transitions between cutting and banking reaches of canal need stabilization
- Sensitive off-takes need immediate attention

Specific findings (1)

ILC (Lift):
- Bank slides in intake channel is a serious problem

RLIS (Lift):
- Butterfly Valve required to throttle the discharge
- Capacitor to improve Power Factor

IBC (Branch Canal):
- Slippage of CC lining to be rectified in many reaches

Specific findings (1)

SBC (Branch Canal):
- Excess drawal leads to drainage problem in initial reaches

MBC (Branch Canal):
- Substantial leakage in head regulator (diversion). Need proper structure to automate operation to avoid vandalism
- Restoration of aqueduct in km.40 is required

JBC (Branch Canal):
- Deteriorated lining in initial 20 km stretch to be rectified
Social order

Social "Order" in the Canal System operated by paid employees

<table>
<thead>
<tr>
<th></th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches*</th>
<th>Lifts**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree to which deliveries are NOT taken when not allowed, or at flow rates greater than allowed</td>
<td>0.8</td>
<td>0.8</td>
<td>1.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Noticeable non-existence of unauthorized turnouts from canals</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
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<tr>
<td>Lack of vandalism of structures</td>
<td>1.0</td>
<td>1.0</td>
<td>2.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

*Branches: SBC, JBC, MBC & IBC  **Lifts: RLIS & ILC

Service to farmers (canal)

<table>
<thead>
<tr>
<th>Actual Water Delivery</th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches*</th>
<th>Lifts**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service to Individual Ownership Units (e.g., field or farm)</td>
<td>1.7</td>
<td>1.1</td>
<td>0.6</td>
<td>1.1</td>
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</table>

Measurement of volumes

<table>
<thead>
<tr>
<th>Flexibility</th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches*</th>
<th>Lifts**</th>
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<tbody>
<tr>
<td></td>
<td>0.0</td>
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<table>
<thead>
<tr>
<th>Reliability</th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches*</th>
<th>Lifts**</th>
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<tbody>
<tr>
<td></td>
<td>2.0</td>
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<table>
<thead>
<tr>
<th>Apparent equity</th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches*</th>
<th>Lifts**</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2.0</td>
<td>2.0</td>
<td>1.0</td>
<td>1.0</td>
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</tbody>
</table>
Actual and Stated Water Delivery Service to Individual Ownership Units

Actual and Stated Water Delivery Service at the most downstream point in the system operated by a paid employee

Service to field channels (most downstream point operated by paid employee)

<table>
<thead>
<tr>
<th>Project</th>
<th>Actual / Stated</th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches</th>
<th>lift</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1</td>
<td>Water Delivery Service at the head of field channel</td>
<td>0.9 / 0.9</td>
<td>1.2 / 0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of fields downstream of this point</td>
<td>0.00 / 0.00</td>
<td>0.0 / 0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Measurement of volumes</td>
<td>0.0 / 0.0</td>
<td>0.0 / 0.0</td>
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<tr>
<td></td>
<td>Flexibility</td>
<td>1.0 / 0.0</td>
<td>2.0 / 1.0</td>
<td>1.0 / 0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reliability</td>
<td>1.0 / 1.0</td>
<td>2.0 / 2.0</td>
<td>1.0 / 0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Apparent equity</td>
<td>2.0 / 2.0</td>
<td>1.0 / 1.0</td>
<td>1.0 / 0.0</td>
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Service by main canal

<table>
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<tr>
<th>Project</th>
<th>Actual / Stated</th>
<th>NRBC</th>
<th>NLBC</th>
<th>Branches</th>
<th>lift</th>
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<tbody>
<tr>
<td>I-3</td>
<td>Actual Water Delivery Service by Main Canal to the Second Level Canals</td>
<td>1.3 / 2.4</td>
<td>2.4 / 1.6</td>
<td>1.6 / 1.0</td>
<td></td>
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<tr>
<td></td>
<td>Flexibility</td>
<td>1.6 / 2.4</td>
<td>1.0 / 1.0</td>
<td>1.0 / 1.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reliability</td>
<td>1.0 / 2.4</td>
<td>3.0 / 3.0</td>
<td>3.0 / 3.0</td>
<td></td>
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<tr>
<td></td>
<td>Control of flow ratios to the submain as stated</td>
<td>1.6 / 3.0</td>
<td>3.0 / 3.0</td>
<td>1.0 / 1.0</td>
<td></td>
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**Water User Associations**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mada</th>
<th>Kerian Kump</th>
<th>Penang</th>
<th>Muda*</th>
<th>Kemubu*</th>
<th>Lampao*</th>
<th>Nam Oon</th>
<th>Lodoyo</th>
<th>Lak Bok</th>
<th>MARIIS**</th>
<th>Dau Tieng</th>
<th>Cau-Son, Cam-Son</th>
<th>West Krishna</th>
<th>Audhra Pradesh</th>
<th>Majalgaon*</th>
<th>Dantiwada*</th>
<th>Bhakra*</th>
<th>SMIP</th>
<th>Narayani</th>
<th>AkramWah</th>
<th>Fuleli-Guni</th>
<th>Ghotki</th>
<th>Dez*</th>
<th>Benl Amir*</th>
<th>Office du Niger*</th>
<th>Rio Yaqul*</th>
<th>Coello*</th>
<th>Saldana*</th>
<th>Cupatitzio*</th>
<th>Rio Mayo*</th>
<th>Sehan*</th>
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<tbody>
<tr>
<td>Percentage of all project users who have a functional, formal unit that participates in water distribution</td>
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<td>0.0</td>
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<tr>
<td>Actual ability of the strong Water User Associations to influence real-time water deliveries to the WUA</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
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<td>Ability of the WUA to rely on effective outside help for enforcement of its rules</td>
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<td>Legal basis for the WUAs</td>
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<tr>
<td>Financial strength of WUAS</td>
<td>0.0</td>
<td>0.0</td>
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</table>

**Objectives:** Assessing the physical capacity of irrigation structures to perform their function of conveyance, control, measurement, etc.

Assessing the sensitivity of irrigation structures (offtakes and cross-regulators), identification of singular points. Mapping the sensitivity of the system.
Sensitivity characterizes the way structures respond when they are operated or stimulated by an external cause.

**Hydraulic behavior: Sensitivity of irrigation structure**

A variation of water level in the MC ➔ variation of head at near by offtake ➔ variation of the offtaking discharge

This is an alternative way of looking at fluctuations in irrigation systems without having to resort to the difficulty of unsteady flow.

It is a simple “What-If” analysis, i.e. what would be the change of the output if the input change is so much.

**Offtake Structure sensitivity**

The discharge sensitivity to water depth at any structure is defined as the ratio of the relative variation of discharge through the structure ($\Delta Q/Q$) and water depth deviation ($\Delta H$) upstream of the structure.

$$ S = \frac{\Delta Q/Q}{\Delta H} $$  

Unit = m$^{-1}$

Example: A sensitivity indicator of '1' indicates that a change of 0.1 m in water level in the parent canal generates a discharge variation (q) through the structure of 0.1 or 10%.

**Sensitivity**

- By design sensitivity of offtake is low (<1) when canals are run at FSD
- Only tail end offtakes are facing harsh problems of sensitivity and supply limitations due to low discharge in canals.
Perturbations analysis: causes, magnitudes, frequency and options for coping with

**CAUSES:**
- Unauthorized off-takes (siphons) and lifting of water from canal
- Temporary constructed obstructions (walls) to raise water level at offtake
- Lack of proper gate to close offtake
- Inaccuracy in management

**MAGNITUDE:**
- It is significant in case of pump operation and illegal withdrawals from pump sets.

**Options to cope with:**
1. Share the surplus / deficit equally among the users.
2. The CRs to be operated
3. Surplus to be stored … option to be explored

**Mapping water streams and bodies = a key feature of the management.**
### MASSCOTE STEP 5
**COST of O & M**

**Objective:**

Mapping the costs associated with current operational techniques and resulting services, disaggregating the different cost elements; cost analysis of options for various level of services with current techniques and with improved techniques.
Management Operation Maintenance

Comparison amongst zones

BUDGET OF CANAL ZONE-II, KEMBHAVI (2007-08)

- SALARIES: 63%
- TRAVEL EXPENSES: 2%
- MAINTENANCE & REPAIRS: 3%
- MACHINERY & EQUIPMENTS: 2%
- OFFICE EXPENSES: 1%

BUDGET OF O & M ZONE, NAYARANPUR (AVERAGE 2003-04 TO 2007-08)

- SALARIES: 50%
- TRAVEL EXPENSES: 3%
- MAINTENANCE & REPAIRS: 5%
- MACHINERY & EQUIPMENTS: 5%
- OFFICE EXPENSES: 1%

Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Cost per Ha. in Rs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy charges</td>
<td>715.00</td>
</tr>
<tr>
<td>Operation &amp; Maintenance of pumps</td>
<td>400.00</td>
</tr>
<tr>
<td>Administration charges</td>
<td>791.75</td>
</tr>
<tr>
<td>Maintenance of canal net work</td>
<td>225.65</td>
</tr>
<tr>
<td>Total</td>
<td>2132.40</td>
</tr>
</tbody>
</table>

Mapping the maintenance and operation cost of the system
Too Low Cost for MOM

Cost per hectare = Rs.2130

STEP 6: SERVICES and VISION

- Flexibility in main canal discharges (+5 - 10% depending on discharge)
- Flexibility in 2nd level canals (+20% of discharge)
- Reliability: highly reliable during rabi, varied reliability during kharif
- Equity: equity during rabi and less equity in kharif due to system constraints (delayed response during rains)
- Cost: high cost (Rs 2130/ha)

MASSCOTE STEP 6
SERVICES and VISION

<table>
<thead>
<tr>
<th>Service component</th>
<th>Target</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>q lit/sec</td>
<td>+/- 5% (Kharif) +/- 5% (rabi)</td>
</tr>
<tr>
<td>Timeliness</td>
<td>At the hour</td>
<td>+/- 3 day (Kharif) +/- 1 days (rabi)</td>
</tr>
<tr>
<td>Duration</td>
<td>6 hr</td>
<td>+/- 30 min (K&amp;R)</td>
</tr>
<tr>
<td>Flow characteristics</td>
<td>Stable flow</td>
<td>+/- 5% (Kharif) +/- 10% (rabi)</td>
</tr>
<tr>
<td>Compensation when at fault</td>
<td>Direct compensation of water</td>
<td>Max. 3 days periods</td>
</tr>
</tbody>
</table>

What mandate for main agency?

- Service Oriented Management (SOM)
**USERS**

**Principal user:** Farmers

**Other users:** Industries, rural population/cattle (drinking/domestic water supply), Fishery, tourism

**Rationale of partitioning Management:**

- 500 Ha or Lateral level WUCS (depending upon size of the system)
- 1000 Ha or Disty level LMU
- Each subsystem level Federation
- System level - PRESIDENT of federation

**Step 7**

**PARTITIONING/MANAGEMENT**

**MANAGEMENT & OPERATION**

- **Main System Agency**
- **Local Management Agency**
- **Water Societies**

**GOVERNANCE & POLICY**

- **KBJNL**
- **Federation of LMA AT SCHEME LEVEL**

**MASSCOTE STEP 7**

**PARTITIONING/MANAGEMENT**

**EXISTING UNIT**

- Sub-division: 52

**PROPOSED UNITS**

- Sub-division: 40
- AEE-1, AE/JE – 2 +2,
- FDC/SDC = 2+2
- Comp Operator-1,
- Work Inspector – 5,
- Sawadi-20

- Divisions: 12
- Circle: 4
- Zone: 3

- Divisions: 10
- Circle: 3
- Zone: 1
Partitioning Of management for INDI LIS

- One division + Subdivision
- WUCS: 500Ha each
- LMUs: 5000Ha (3-4 LMUs/Subdivision)
- Federation: 10 LMUs (Division)
- Main canal maintained by KBJNL
- WUCS look after maintenance of Dy & below in coming years

Water management strategy:

Kharif:
- Main canal: Continuous flow, tolerance: +/-5%, flow varied during rain fall
- Distributary: Within the Dy rotation to 3rd level canal, tolerance: +/-10%

- In lift schemes main canal should be used for storing water as buffer storage (online) to combat voltage fluctuation and also, preferably, within CA buffer storage during rains for optimum utilisation of water and as an energy saving technique.

- Rain: Main canal: Continuous flow, tolerance: +/-5%
- Distributary: Within the Dy rotation to 3rd level canal, tolerance: +/-10%
- Allow better service to areas without ground water potential.
- Recycling facilities to be made use of by the users.
- Conjunctive use to be encouraged.

Service strategy:

1) Allocation of water to farmers:
   - Allocation to WUAs
   - Allocation varies for Kharif because of contribution of rain fall
   - Allocation for rain is fixed
   - Deficit to be shared equally

2) Schedule of watering: Rotation among distributaries for both Kharif and Rabi
3) Deliveries: Tolerance of 1 day for Rabi and 3 days for Kharif
4) Special rules for services to downstream users:
   - Water to be fed from tail end to upwards at the beginning of seasons
   - Within the distributary quantum delivery starts from tail end
   - It is the responsibility of tail enders not to waste water

Information system:

- Manual SCADA, digitization of data
- Operation rules at various levels:
  - Main canal: Kharif: 120 days, Rabi: 90 days
  - CR operated to maintain Water level at FSO.
- New structures to be added:
  - CRs (rainfed) and escapes, duck bill weirs in Dy.
WATER DISTRIBUTION:
➢ Assessment of water level control and sensitivity of MC and Disty, reduction of high sensitive structures
➢ Allocation based on availability
➢ Assessment and repairs to CC lining, removal of silt in MC/Disty
➢ Provide off-take gates on Disty

DRAINAGE:
➢ Mapping of drainage system (bandharas, re-cycling, well)
➢ Interlinking ponds
➢ Monitoring of water quality
➢ Outflow of the Catchment Area

STEP-9: CANAL OPERATION IMPROVEMENTS

MEASUREMENTS:
➢ Phase-I: MC/Disty/Lateral - rated gauge
➢ Phase II:
➢ Automatic data recorder and communication
➢ Separate monitoring unit for KBJNL
➢ Database system for KBJNL

INFORMATION SYSTEM:
➢ Information - Remote Sensing - GIS

VISION
“A very efficient environmentally sustainable agriculture oriented towards high value production and value addition. An overall reliable cost effective water management targeting equity in water access, multiple uses throughout the command areas with high capacity professionals. Farmers active and responsible in water resource management progressively taking over management and cost recovery with other stakeholders.”

FOLLOW-UP
• Actual assessment of CCA
• Spatial units for management (KBJNL, WUFs, WUAs)
• Assessment of WUA’s ability in Integrated Management (Progressive transfer)
• Re-location of office management (with shift from construction to management focus)
• Design of capacity development programme (Staff / Users)
• Need of separate security force for Law and order ...
• Assessment of silt in MC, disty and laterals
• Assessment of gates on disty
FOLLOW-UP

- Policy decision regarding modernization/repairs of laterals and FTGs (as they are handed over to the WUAs)
- Calibration of rated section - MC and Disty
- Installation of FLUMES – project to be developed
- Drainage
- Escapes (assessments of leakage)
- Repairs to arrest leakage in escapes and Undertunnels
- Multiple uses
- Database management
- Telemetry and sensors
- Water balance at local level
- Outsourcing of RS and GIS activity in investment phase and training staff to operate the system

Thank YOU