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A DSS based approach for recommending best RMPs for sustained agricultural production from salt affected agricultural lands & irrigation waters

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Invited talk in a Technical Session on "*Harmonizing WFE Nexus: Strategies for Sustainable Water Resource Management*" at the Indo-Global Irrigation Summit 2025 on "*Best Irrigation Practices for Water and Food Security*" (Organizer ICID & Ministry of Jal Shakti, June 24 to 25 - 2025)

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Rationale

- Saline waters - a global threat to sustained irrigated agriculture as well as to biodiversity and ecosystem services
- Often overcome through combined use of good and poor quality irrigation waters
- However, when good quality water supplies are limited an appropriate crop rotation is the only means for managing salt affected soils and maintaining crop yields
- Environmental / agricultural impacts of any conjunctive water use/ crop rotation strategy are often not apparent until long after decisions are implemented
- Recommending appropriate conjunctive water use/ crop rotation plans requires the ability of a decision maker to assess their long term impacts on soil salinization/ sodification and crop yield reductions
- Long-term field experiments, lasting several years, are the conventional means for developing suitable conjunctive water use/ crop rotation plans.
- However, such experiments are unable to propose sustainable practices, when planned for shorter time durations (say 2-3 years) or become cost-ineffective and obsolete, when planned for longer time durations (say more than 15 years or so) : Ideal length of such long-term experiments has always been a debatable issue
- Long-term field experiments are site specific and expensive
- Available resources with the government not adequate to monitor all diverse areas
- Extrapolation from homogenous experimental plots to large heterogeneous areas is error-prone

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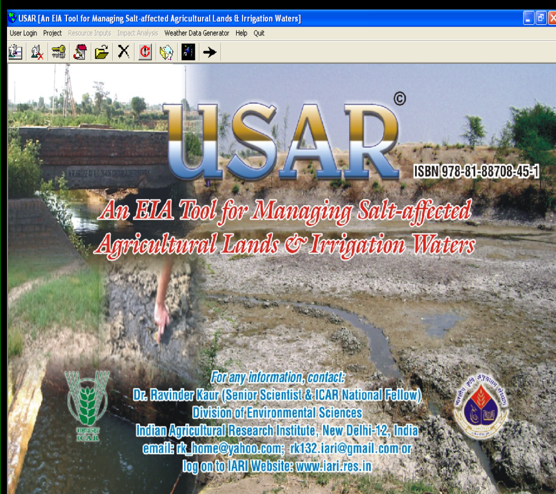
USAR

A Field Scale DSS for Managing Salt affected Agricultural Lands and Irrigation Waters



- Quantifying short/ long term impacts of a range of geo-hydrologic conditions and resource management strategies (eg. conjunctive water use & crop rotation plans) on field scale soil-water degradation
- Proposing appropriate adaptation strategies for managing salt -affected agricultural soils and waters
- Generate crop-specific irrigation schedules

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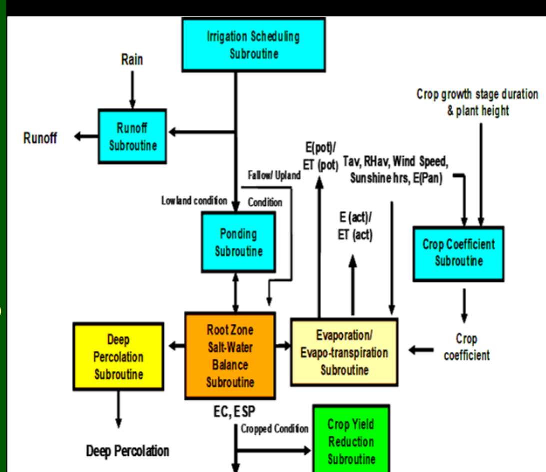
USAR

A Field Scale DSS for Managing Salt affected Agricultural Lands and Irrigation Waters



Incorporates algorithms for generating

- Realistic soil salinity/ sodicity specific soil hydraulic properties (such as moisture at sat., FC, WP, Ksat, f) from readily available basic soil data **[NO CALIBRATION REQUIRED]**
- Realistic weather–specific temporal Crop Coefficients (Kc) **[NO CALIBRATION REQUIRED]**
- Contains a set of default-soil/crop characteristics that can be selected and adjusted for **50** local **crop types** (ranging from cereals, pulses, and oilseeds to vegetables) and **12 soil types** (ranging from sand/loamy sand soils to silty- clay/ clay soils) in a menu driven environment.

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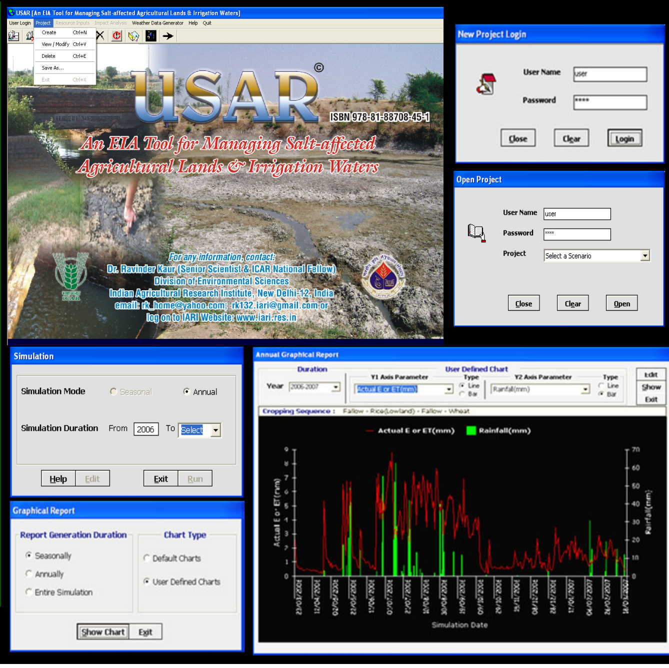
KEY COMPONENTS



PRE-PROCESSOR

Generating, Editing, Saving Scenarios

PROCESSOR

Executing Simulations

POST-PROCESSOR

Viewing outputs & temporal plots for the simulated scenarios

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TEST & VALIDATION ON FARMERS FIELDS - Primary Data Validation

Inputs for the test & validation of DSS:

- **Meteorological Data –** IMD, N. Delhi
- **Farm survey data** (comprising of information on irrigation source, cropping pattern, and agril. & water management practices followed for different crop types) **-** using questionnaires
- **Physico-chemical properties of soils** (s.a. texture, bulk density, moisture at saturation, field capacity and wilting point, saturated hydraulic conductivity, organic carbon, EC, pH, ESP) at the beginning of Kharif & Rabi seasons and
- **Physico-chemical properties of surface and sub-surface waters** (s.a. EC, pH, SAR, RSC) at the beginning of Kharif & Rabi seasons.

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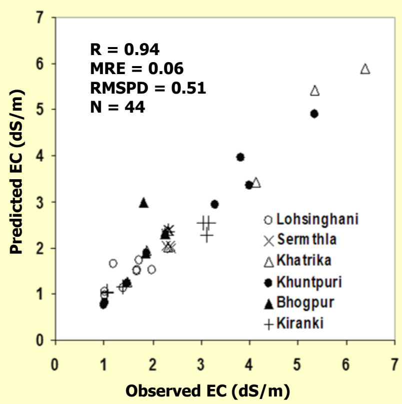
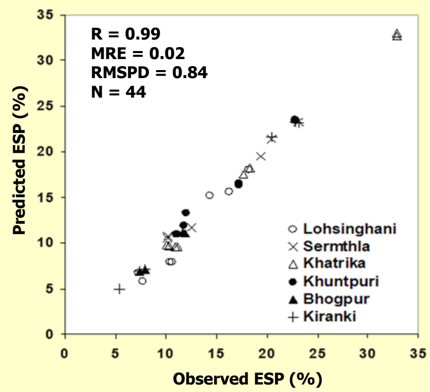
Validation of USAR on Farmers Fields





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RECOMMENDING
APPROPRIATE CONJUNCTIVE WATER USE STRATEGIES

for a rice-wheat growing salt affected (EC: 6.7 dS/m and ESP: 19%) field in Khatrika Village, Gurgaon

RABI SEASON
CONJUNCTIVE WATER USE PLANS :

Existing (CYCLIC) Practice:

2CW, TW, CW

Alternative Practices: (6)

CYCLIC MODES: (3)
CW:TW
1CW, 1TW, 2CW
2CW:2TW

BLENDING MODES: (3)
25% CW: 75% TW
50% CW : 50% TW
75% CW: 25% TW

KHARIF SEASON
CONJUNCTIVE WATER USE PLANS :

Existing (CYCLIC) Practice:

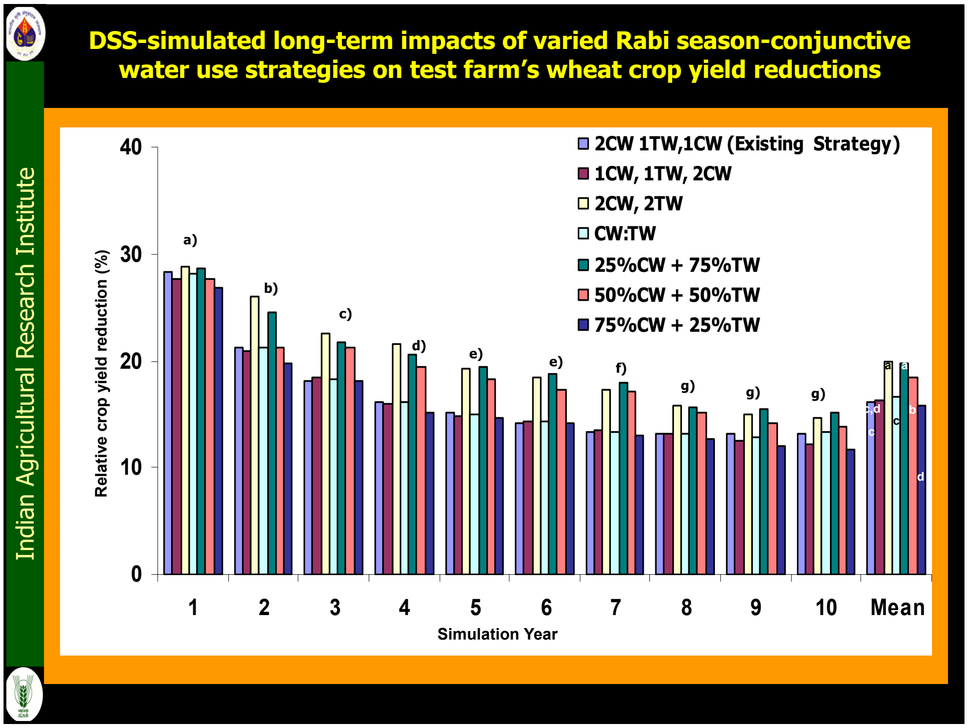
3TW,3CW,3TW

Alternative Practices: (6)

CYCLIC MODES: (4)
CW:TW
TW:CW
4CW:5TW
CW:2TW:3CW:3TW

BLENDING MODES: (2)
25% CW: 75% TW
50% CW : 50% TW

Results were subjected to 1- way classified ANOVA analysis (Dean and Voss 1999), with **conjunctive water use strategies (or treatments) as classificatory variables** and **simulation years as more than one observation for a particular treatment (or strategy)**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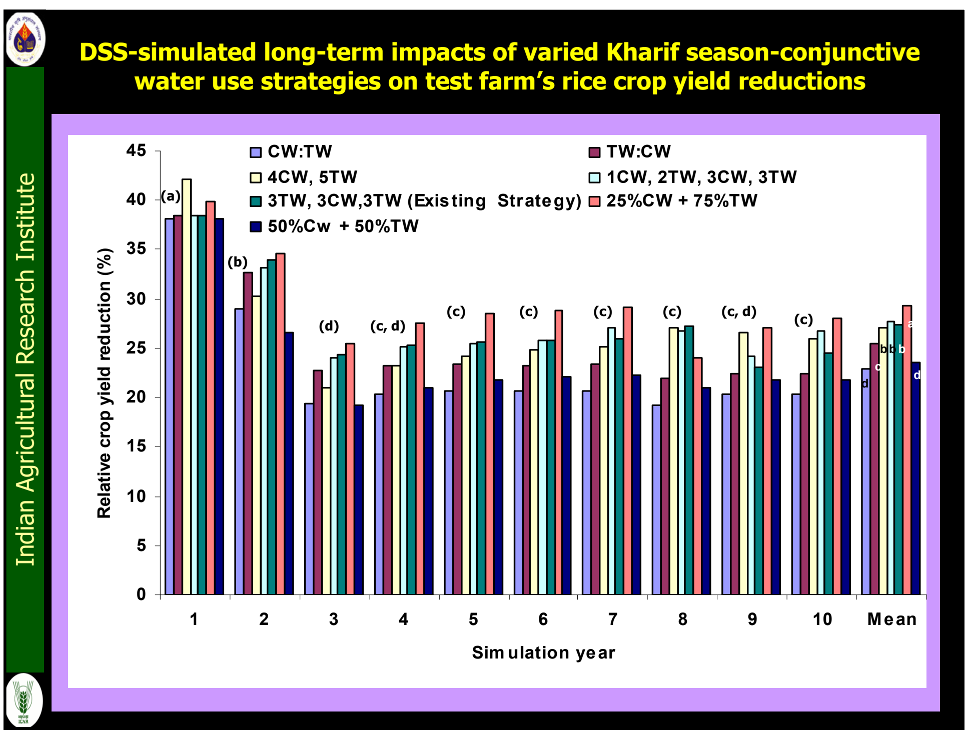
DSS-simulated long-term impacts of varied Rabi season-conjunctive water use strategies on test farm's wheat crop yield reductions
2CW 1TW,1CW (Existing Strategy)
1CW, 1TW, 2CW
2CW, 2TW
CW:TW
25%CW + 75%TW
50%CW + 50%TW
75%CW + 25%TW
Relative crop yield reduction (%)
0
10
20
30
40
a)
b)
c)
d)
e)
e)
f)
g)
g)
g)
1
2
3
4
5
6
7
8
9
10
Mean
Simulation Year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DSS-simulated long-term impacts of varied Kharif season-conjunctive water use strategies on test farm's rice crop yield reductions
CW:TW
TW:CW
4CW, 5TW
1CW, 2TW, 3CW, 3TW
3TW, 3CW,3TW (Existing Strategy)
25%CW + 75%TW
50%Cw + 50%TW
Relative crop yield reduction (%)
0
5
10
15
20
25
30
35
40
45
(a)
(b)
(d)
(c, d)
(c)
(c)
(c)
(c)
(c, d)
(c)
1
2
3
4
5
6
7
8
9
10
Mean
Simulation year

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RECOMMENDING ALTERNATIVE CROP ROTATION PLAN(S)

for a rice-wheat growing salt affected (EC: 6.7 dS/m and ESP: 19%) field in Khatrika Village, Gurgaon

Existing Crop Rotation:

Paddy-Wheat (P-W)

Alternative Crop Rotations:

Paddy-Barley (P-B)
Paddy-Mustard (M)
Paddy-Fallow (P-F)
Pearl millet-Fallow (PM-F)
Pearl millet-Wheat (PM-W)
Pearl millet-Mustard (PM-M)
Pearl millet-Barley (PM-B)
Fallow-Wheat (F-W)
Fallow-Mustard (F-M) &
Fallow-Barley (F-B)

Crop-specific local irrigation practices in the study area

CROP TYPE	IRRIGATION WATER DEPTH (mm)	NUMBER OF IRRIGATIONS	WATER USE PATTERN
Paddy rice	200	9	3TW, 3CW[a], 3TW
Pearl millet	70	1	TW[b]
Wheat	75	4	2CW,TW, CW
Barley	75	3	2CW,TW
Mustard	40	3	2CW,TW

[a]Good quality-canal water quality: EC: 0.9 dSm-1, SAR: 3.1 and RSC: 0.6 meqL-1;
[b]Poor quality-tube well water quality: EC: 4.3 dSm-1; SAR: 12.7 and RSC: 4.06 meqL-1

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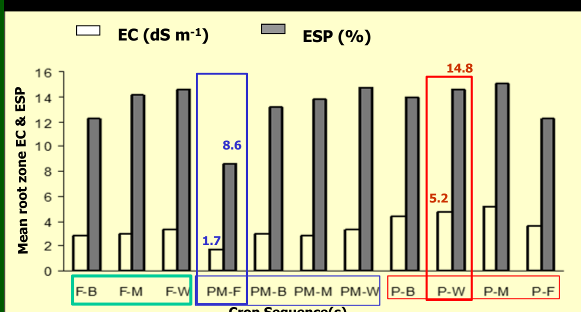
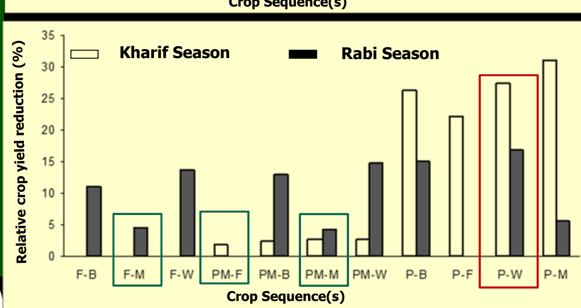
DSS-Simulated long term average root zone soil salinity and relative crop yield reductions under varied crop rotation plans





In contrast to the paddy-Wheat based crop rotation, the **fallow (F) and pearl millet (PM)-F Crop rotation was associated with about 67% and 42% less average root zone salinity and sodicity increase**.

Lowest average root zone salt increase in PM-F rotation was due to the application of no salt affected tube well waters during Rabi seasons.

Other (Kharif season) fallow, pearl millet and paddy based crop sequences were associated with application of about 40-75 mm of alkali tube well waters during Rabi seasons.

Paddy rice based crop rotations resulted in greatest average relative crop yield reductions during *Kharif* (26.7%) and *Rabi* (9.3%) seasons.

As expected Pearl millet based crop rotations, produced smallest average relative crop yield reductions during both *Kharif* (2.4%) and *Rabi* (8.0%) seasons.

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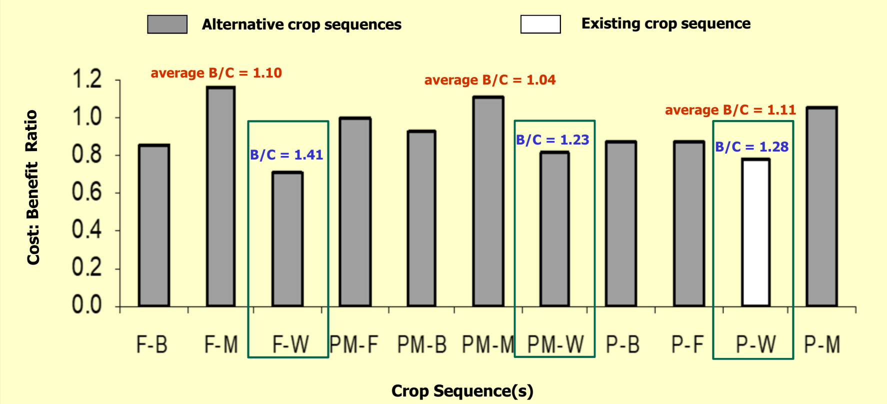
Cost/ Benefit Ratios for Varied Crop Rotation Plans



In contrast to the existing paddy-wheat crop rotation, **Fallow-wheat appeared to be economically the best crop rotation** as it was found to result in about 9.2% higher B/C ratio along with about 30% less root zone soil salinity.

Pearl millet-wheat crop sequence was also associated with almost the same (30% lower) long-term average root zone soil salinity. However, its economic feasibility was 13% and 4% less than the fallow-wheat and paddy-wheat rotations respectively