9th India International Water Week 2026

Smart Irrigation Management for Resilient Water Systems:

with a Water–Energy–Food Lens

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Water and Energy Intensive South Asian Agriculture

1. **About 40% of cultivated land is irrigated**, with agriculture consuming over 90% of water — achieving food security

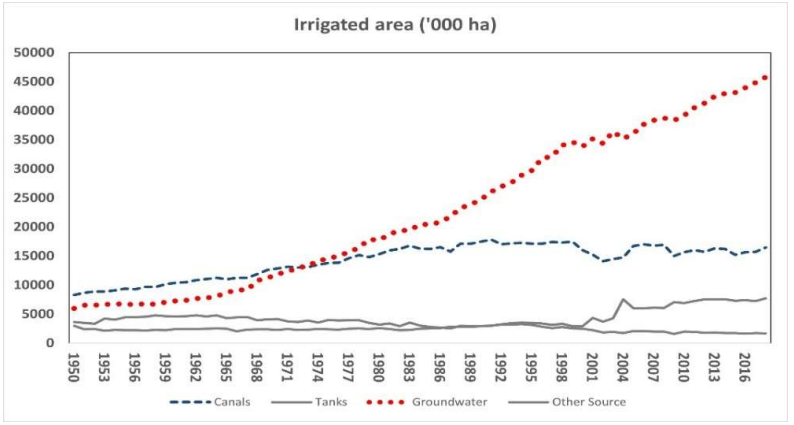
2.
   - About **60–80% of irrigated area is serviced by groundwater** in India, Bangladesh and Pakistan
   - **Ageing irrigation systems** and **low water use efficiency**

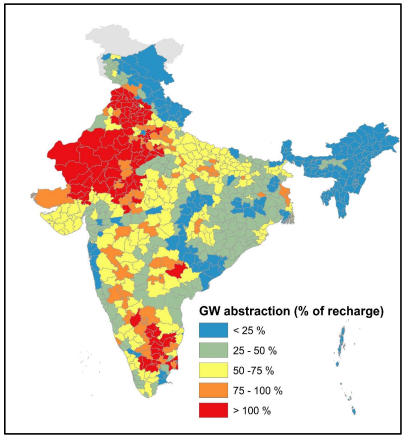
3. Over **30 million groundwater pumps abstract** about 350 billion cubic metres of groundwater annually

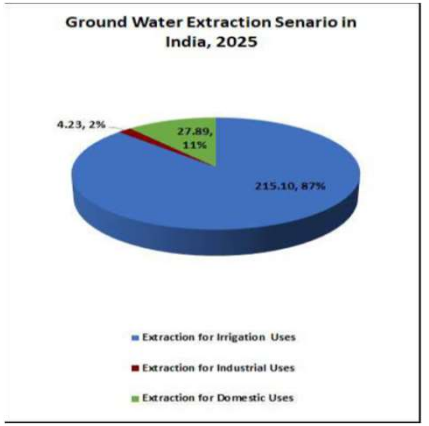
4. Increasing energy demand — India alone consuming **20% of energy in agriculture** (largely groundwater pumping and lifting)

Smart irrigation is a MUST for resilient water systems under growing climate change and a widening water supply–demand gap

Irrigated area ('000 ha) by source





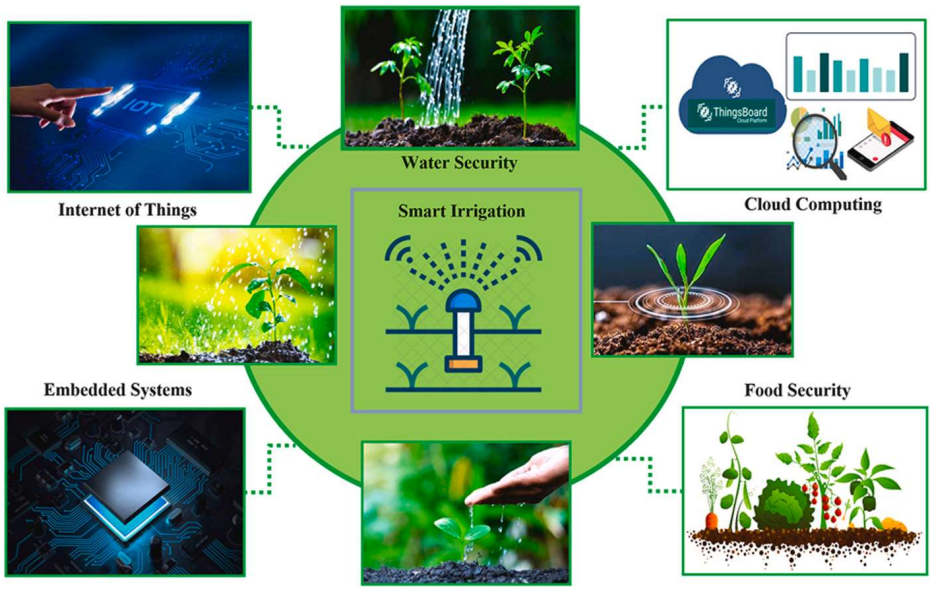


Smart Irrigation: Building Resilient Systems

Smart irrigation uses sensors and weather with real-time analytics to deliver a precise amount of water to:

- Reduce non-beneficial losses
- Lower the energy use required for pumping / lifting water
- Maximize crop yields and enhance water productivity

1. Functions as digital water allocation infrastructure integrating sensors, data analytics and automated controls
2. Monitors soil moisture, weather conditions and crop water requirements in real time, for precise irrigation scheduling and distribution
3. Data-driven demand assessment & management reduces over-irrigation and improves water use efficiency
4. Integration with artificial intelligence refines irrigation decisions, aligning water delivery with dynamic conditions



Smart Irrigation: Combining Sensors, Space Technology & ICT

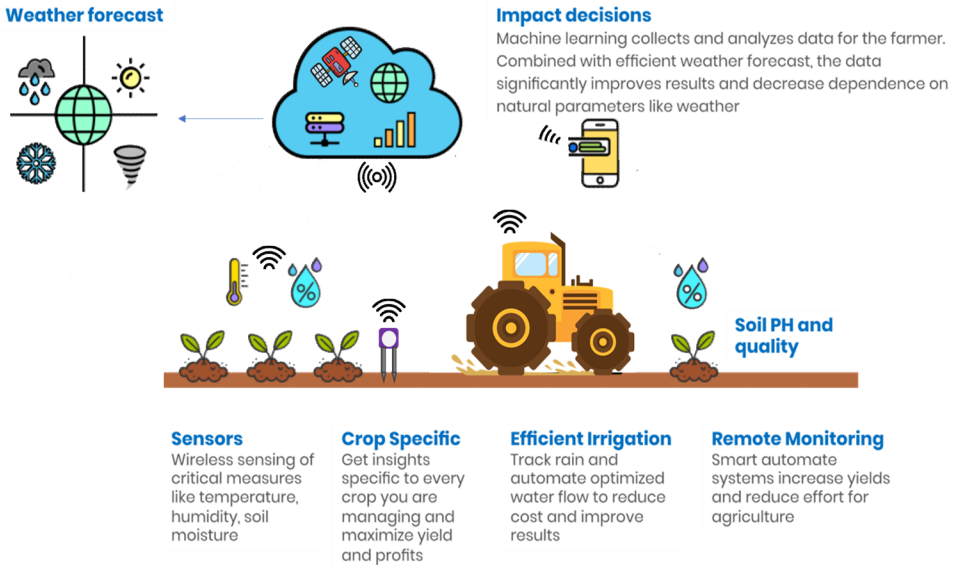
Ground Sensors
Soil moisture · Relative humidity

Crop-Specific Monitoring
Minimize efforts and increase yield

Remote Sensing & Forecasts
Satellite and weather-forecast inputs

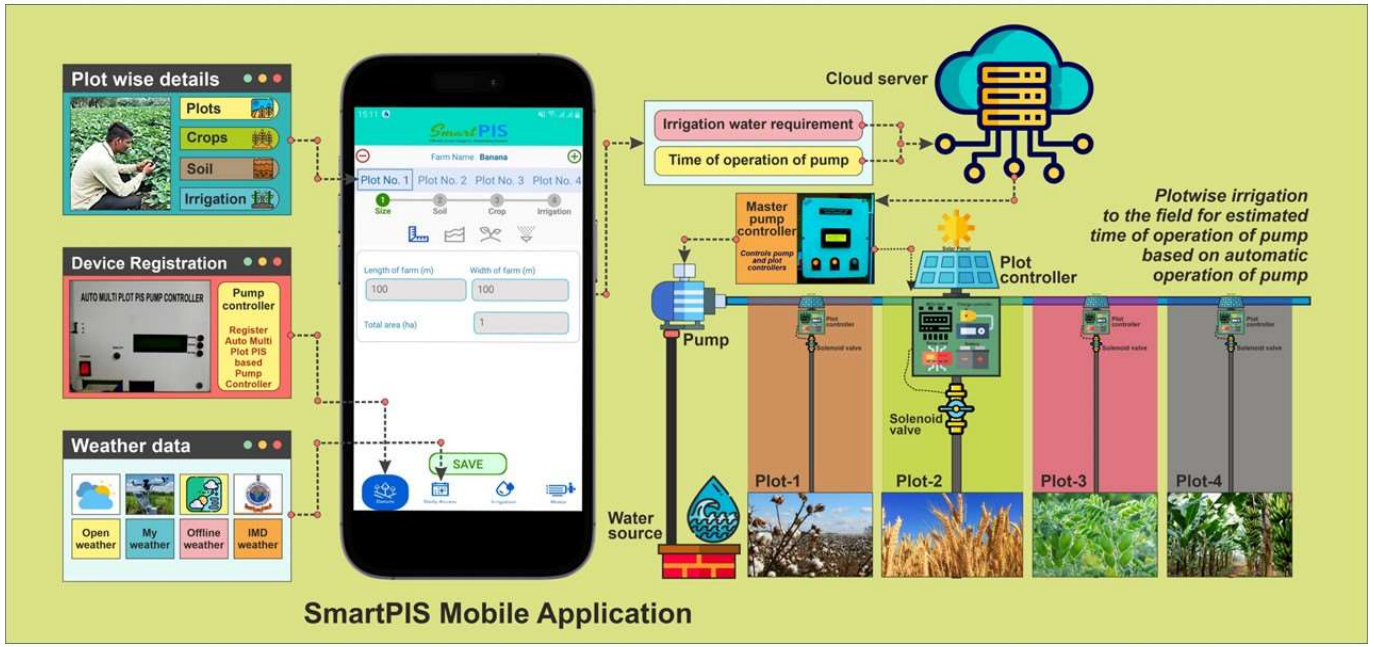
IoT
Drones · Satellites · Analytics · AI

Smart Irrigation
Crop registration · Sensing technology · Plan of watering the crops



SmartPIS: Plot-wise Smart Irrigation Application

From plot, device and weather data to automatic, plot-wise pump operation



Submitted-registration of under copyright Diary No. 6394/2022-CO/SW (Ref: Gorantiwar *et al.*, 2020 & Gorantiwar *et al.*, 2021)

How it works

- Plot-wise details: plots, crops, soil, irrigation
- Device registration: auto multi-plot pump controller
- Weather data: open, my, offline and IMD weather
- Cloud server computes irrigation water requirement and time of operation of pump
- Master pump controller and plot controllers operate solenoid valves plot by plot

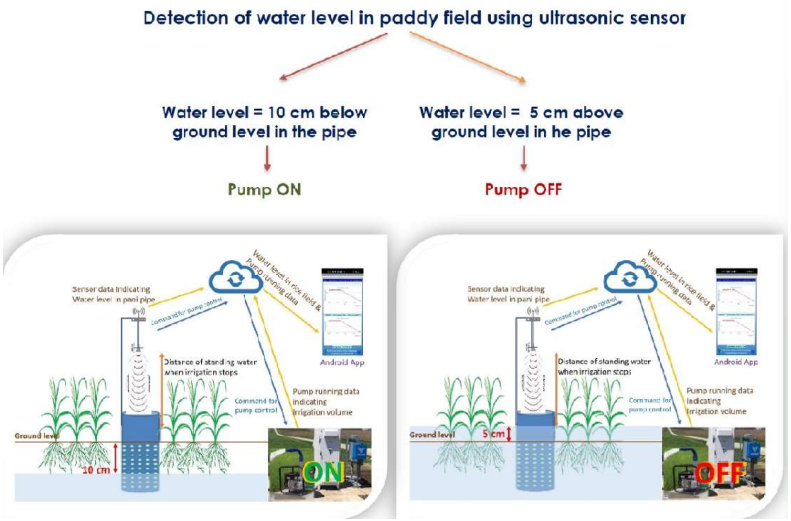
Plot-wise irrigation delivered for the estimated time of pump operation, based on automatic operation of the pump.

IoT-enabled AWD-based Irrigation for Transplanted Rice

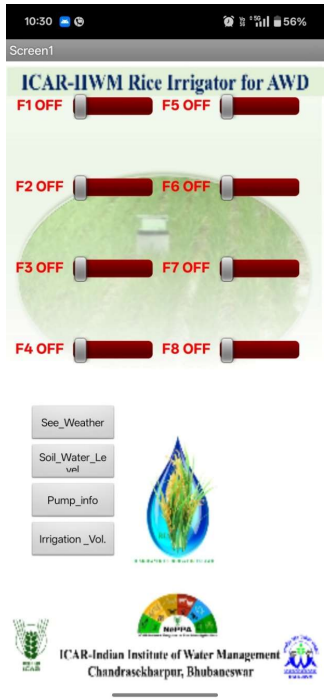
- IoT-enabled smart irrigation scheduling in the paddy field, based on water level below ground level
- Saves 20% of water in rice farming with a minimal yield loss of 5%
- Low-cost, farmer-friendly device (₹10,000; US$115) — a sensing unit, a pump controller and a mobile app for irrigation automation







Pump ON at 10 cm below ground level; pump OFF at 5 cm above ground level in the pipe.



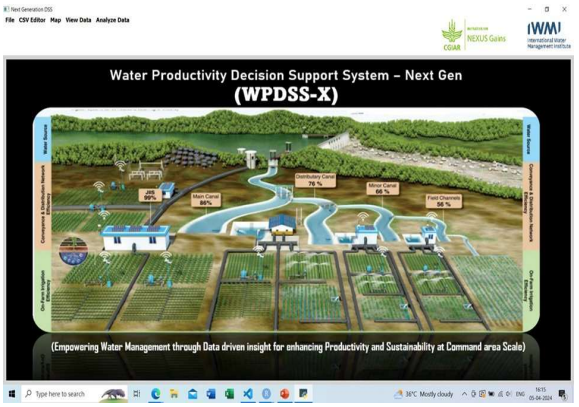
ICAR-IIWM Rice Irrigator for AWD — mobile app

Smart AWM: Building On-farm Resilience in Water Systems

Agri Water Management Solutions

- Laser land levelling
- Micro irrigation (Drip, sprinkler, raingun)
- Smart Irrigation Scheduling (sensors- based)
- Direct-seeded rice (DSR), Conservation agriculture
- Alternate wetting & Drying (AWD) in rice
- Crop diversification
- Pressurized piped distribution
- Participatory water management

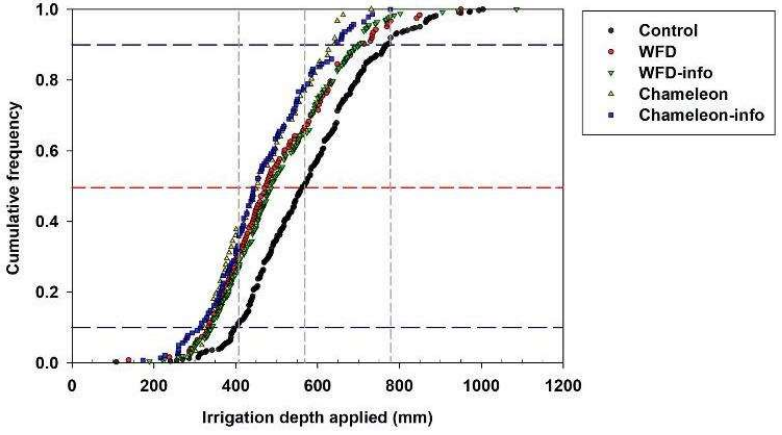
DSS Linking Canal Operation & OFWM



Chameleon Soil Moisture Sensor



Reduced water use by **20-25%**

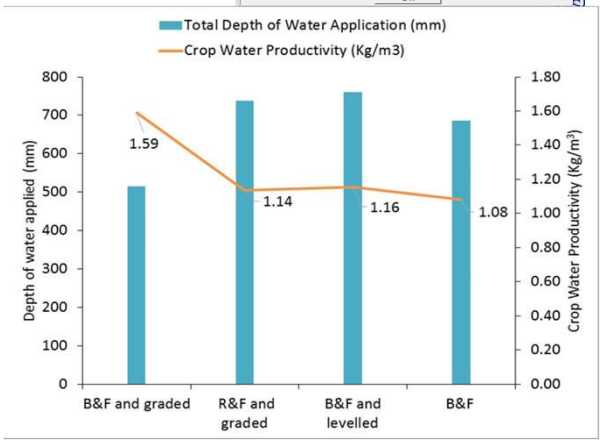


Significant reduction of 21% when WUGs build information networks using chameleon sensors

WinSRFR -a software for the hydraulic analysis of surface irrigation systems- for designing and evaluating performance of irrigation systems

Precision surface irrigation with SIP (Kharif Maize)





Recent Irrigation Modernization Developments- India

Narmada Canal Project, Rajasthan: An Efficient Canal fed pressurized Irrigation System



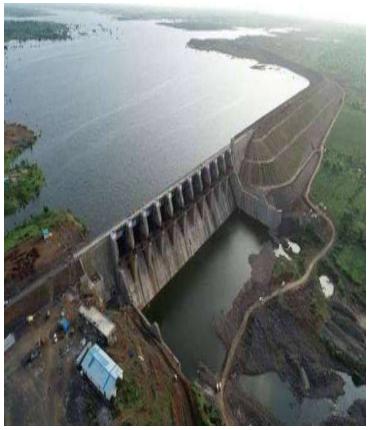
- Canal water stored in diggies, lifted and conveyed to on-farm micro-irrigation through a buried pipe network
- 78% increase in CCA, water saving 49%

Ramthal (Marol) Lift Irrigation Project

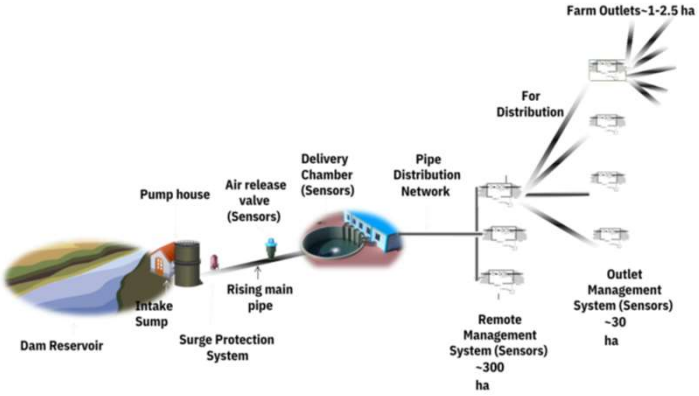


- 90% increase in area served
- Doubling of project beneficiary count
- Improved water use efficiency

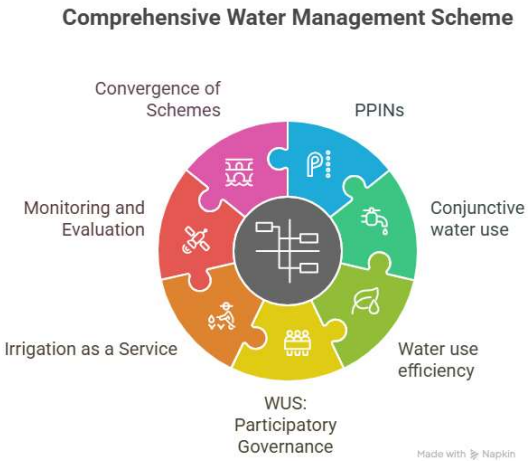
Madhya Pradesh Irrigation Efficiency Improvement Project (MPIEIP)-ADB Supported Smart Irrigation Project

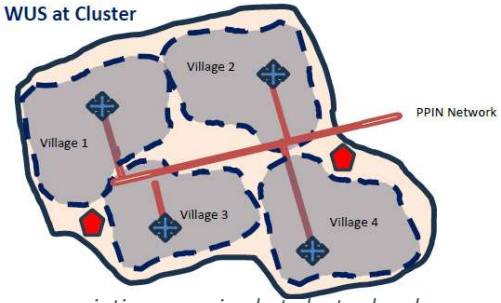






Modernization of Command Area Development (MCAD), MoJS





Water user societies organised at cluster level across villages, linked by the PPIN network

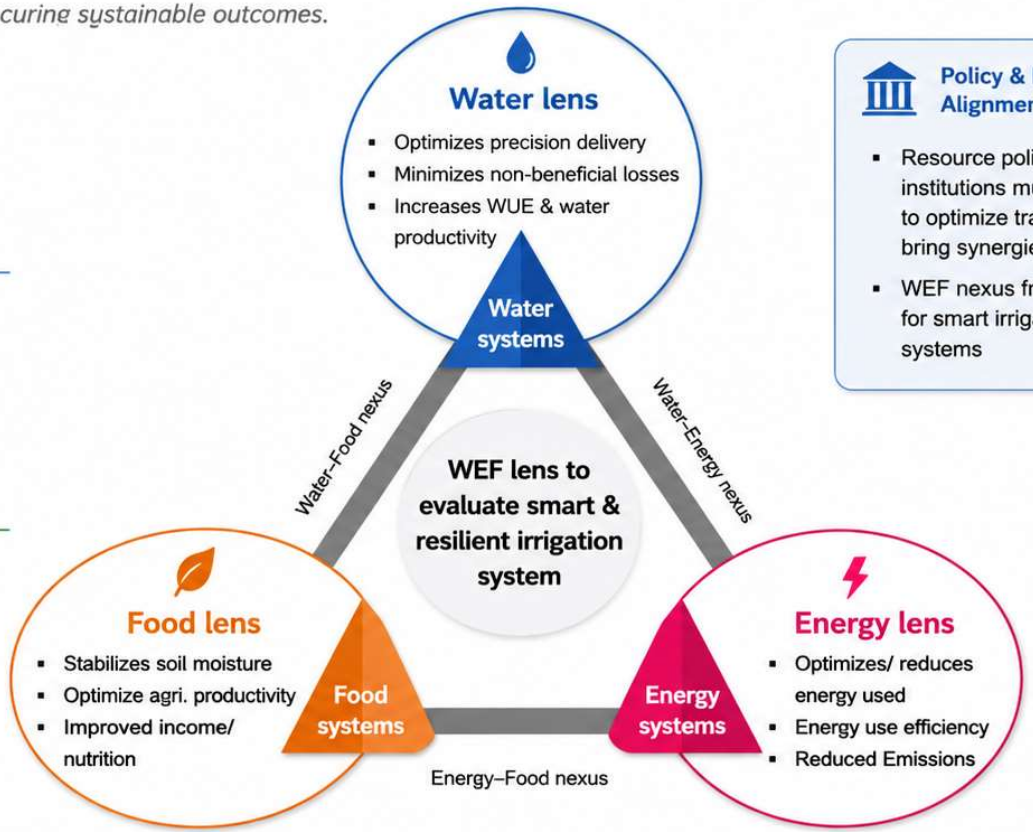
Smart Irrigation: with Water-Energy-Food Lens

Optimizing synergies. Managing trade-offs. Securing sustainable outcomes.

Smart irrigation systems operate at the intersection of **Water-Energy-Food (WEF) Nexus** loop.

WEF nexus lens to optimize the water savings plus energy used for pumping & conveying water and secure sustainable agricultural yield.

Trade-offs and synergies including environ-economics of water saved, energy used and food produced.



Policy & Institutional Alignment

- Resource policies, and institutions must overlap to optimize trade-offs and bring synergies
- WEF nexus framework for smart irrigation systems

Smart irrigation systems must optimize the WEF nexus

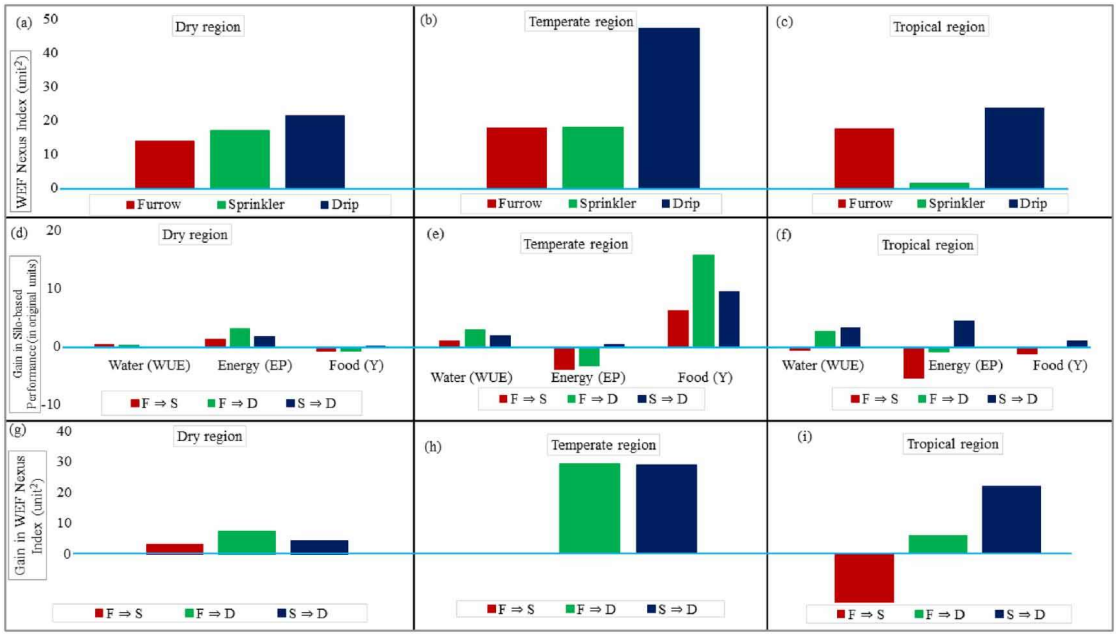
More crop per drop | Less energy per yield | Better lives, sustainably

Assessing the WEF Nexus in Irrigation Water Management

1. Integrated modelling frameworks
2. Composite / integrated WEF indices as an aggregation of indicators
3. Sustainability polygons / radar charts / spider diagrams

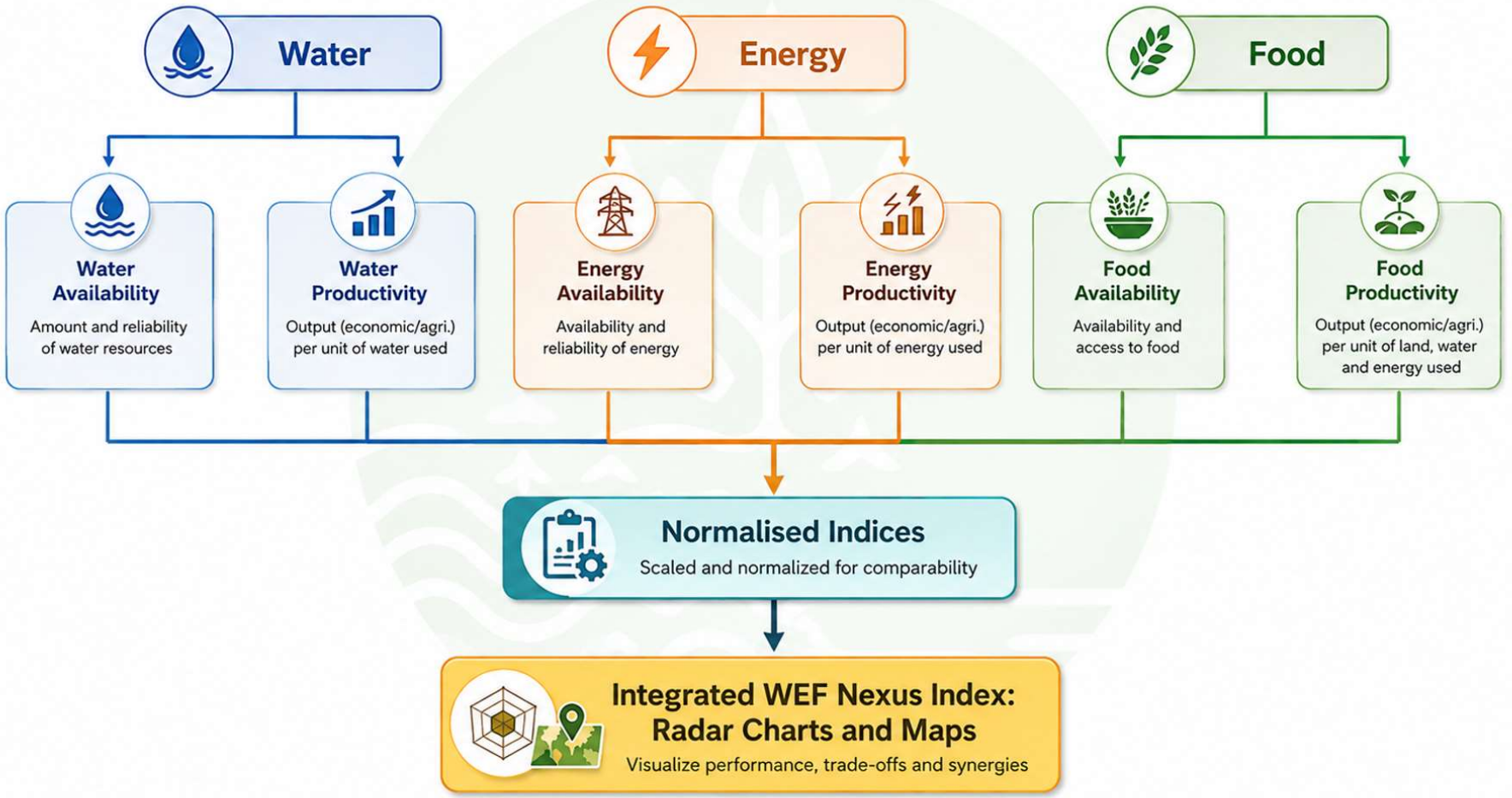
Sustainable irrigation technologies: a water–energy–food (WEF) nexus perspective towards achieving more crop per drop per joule per hectare

Tagata, Dirwai, Senzanje, Sikka & Mabhaudhi — Environmental Research Letters 17 (2022) 074009, IOP Publishing (topical review, open access)



Integrated WEF nexus performance of irrigation systems in (a) dry, (b) temperate and (c) tropical climates; impacts of irrigation modernisation on water, energy and food performance from a silo approach in (d) dry, (e) temperate and (f) tropical climates; and impacts of irrigation modernisation on the WEF nexus in (g) dry, (h) temperate and (i) tropical climates.

WEF Nexus Composite Index: Framework



WEF NEXUS INDEX — MOHANPURA–KUNDALIA IRRIGATION PROJECT

MORE WATER | CLEANER ENERGY | HIGHER PRODUCTION | A STRONGER, MORE RESILIENT FUTURE

WATER

More water, higher productivity



Efficient irrigation for prosperous farms

Kundalia Dam. Madhya Pradesh

Indicator	Pre-project	Post-project	Unit
Water use efficiency	38	80	%
Irrigation Water Duty (ha irrigated / Mm³ live storage)	220	495	ha irrigated / Mm³ live storage
Command area under assured irrigation	60,000	290,000	ha
Water sub-index	0.316	0.896	–

2.8× gher water sub-index

Greater water efficiency and expanded irrigated area

ENERGY

Efficient, reliable and cleaner energy



Reliable energy for sustainable irrigation

Indicator	Pre-project	Post-project	Unit
Pumping system efficiency	46	80	%
Energy productivity	1,782	3,098	ha / million kWh
Carbon productivity	7.65	13.29	ha / t CO_2
Energy sub-index	0.492	0.856	–

1.7× higher energy sub-index

More productive and lower-carbon irrigation

FOOD

Higher production, stronger food security



Healthy crops for a food secure tomorrow

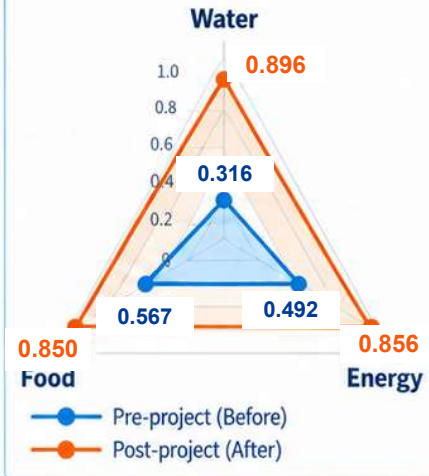
Indicator	Pre-project	Post-project	Unit
Wheat yield, Rajgarh district (period mean)	3,096	3,213	kg/ha
Wheat production, Rajgarh district (period mean)	636,917	1,036,056	t
Vegetated / cropped extent (NDVI > 0.35)	139,734	277,817	ha
Food sub-index	0.567	0.850	–

1.5× gher food sub-index

Higher production and larger cropped area

WEF NEXUS SUMMARY

WEF Nexus Triangle



Composite WEF-NI Score

Pre-project	Post-project
0.445	0.867

+95% improvement

(1.95× higher)

Food panel includes observed Raigarh wheat yield and production, plus NDVI-based cropped extent.

Mohanpura-Kundalia Irrigation Project Report

INTEGRATING WATER | ENERGY | FOOD FOR A SUSTAINABLE TOMORROW

Key Takeaways

1. The WEF nexus is important to assess the **trade-offs and synergies of smart irrigation** systems — **maximizing yields while optimising water, land and energy use**

2. The WEF nexus framework demonstrates how digital and integrated resource systems can function to optimize water allocation and use, and reduce cross-sector pressures

3. When aligned through **coordinated planning and governance**, it **strengthens resilience and supports long-term sustainability** by ensuring resources are managed within interconnected and resource-constrained environments

4. **Smart irrigation systems must be examined with a WEF lens for Nexus Gains**

Thank You

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Alok K Sikka, IWMI · D. R. Sena, ICAR-IARI, Delhi · IIWW-26, 23 September 2026