International Water Management Institute

Water-Energy-Food Nexus for Asia's food security

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Innovative water solutions for sustainable development

Food · Climate · Growth

Asia Food security hinges on Irrigation

- **Asia's Challenge**: With **36% of global freshwater**, Asia supports **60% of the world's population**.

- Over **75% of Asia is water insecure**, countries > 90% of population already facing water crisis

- **Irrigation in Asia was** critical to usher in the Green Revolution, lifting millions out of poverty and ensuring food security.
  - 90 % of water withdrawals
  - Agriculture is the biggest consumer of water- many countries rely heavily on groundwater
  - South Asia has the largest share of agricultural water use (91%)
- 570 million ha is cultivated, of which 216 million ha equipped with irrigation (~ 41 %)
  - India and China combined > 50 % of cultivated and irrigated land

- South Asia is where WEF nexus is most dominant, **High intensity agriculture, high population density**

	% of country area cultivated	% of area irrigated	% of groundwater irrigation	% of total water withdrawal	Population density
Central Asia	7.8	67.4	2.4	76.7	38.8
East Asia	12.6	48.6	21.4	63.9	242.9
South Asia#	29.9	42.7	32.4	81.2	527.4
South East Asia	21.0	18.7	3.8	70.4	140.0
Western Asia	13.0	55.2	48.4	63.8	299.6

#Exlcude Island country Maldives

Centrality of Groundwater to South Asian Agriculture

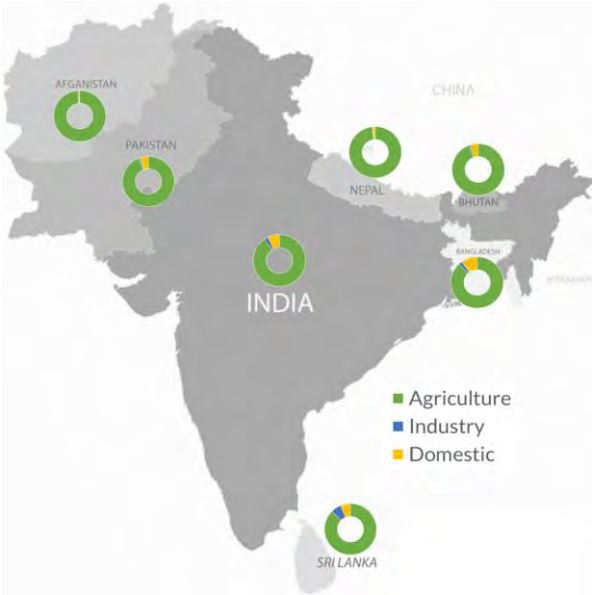
SA supports **25% of the world's population** with just **4.6% of the world's water resources**

About 40% of cultivated land is irrigated, with agriculture consuming over 90% of water use-achieving food security through ground water irrigation

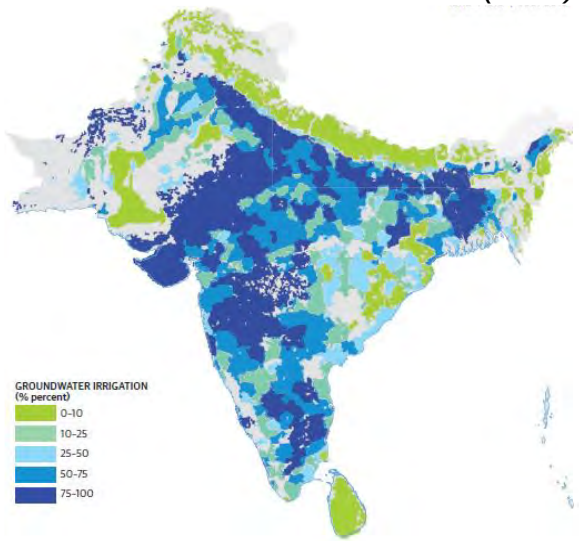
About **60-80 % of irrigated area is serviced by groundwater** in India, Bangladesh and Pakistan

Over **30 million groundwater pumps abstract** about 350 billion cubic meters of groundwater annually

Increasing energy demand-India alone consuming **20% of energy in agriculture** (largely GW pumping)



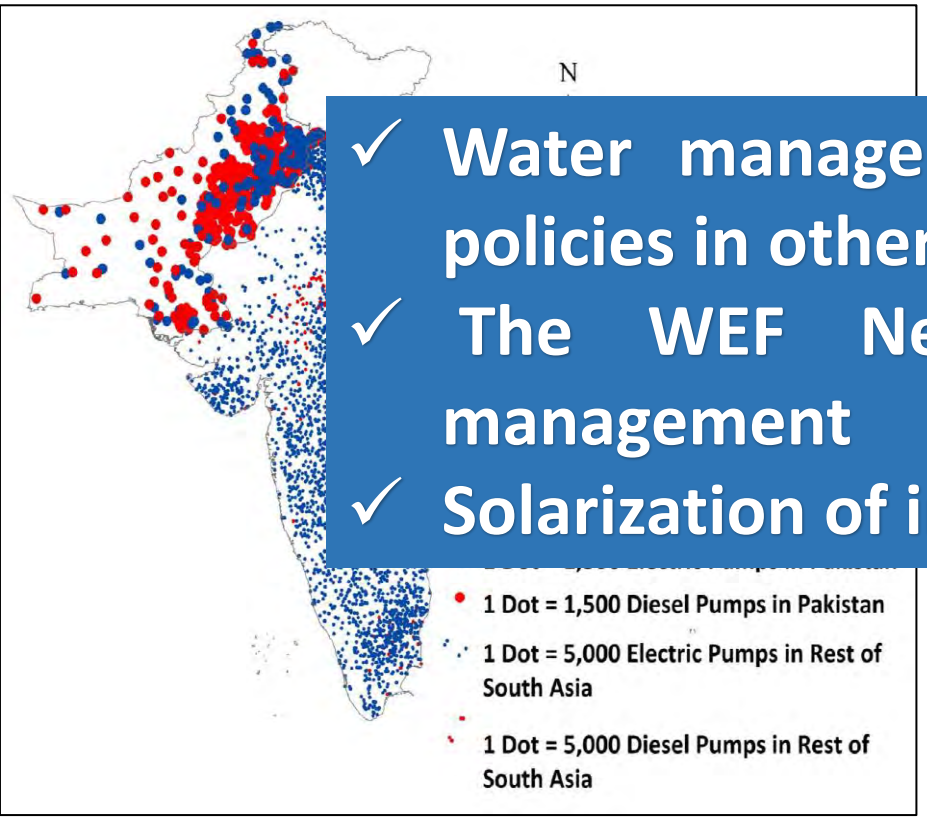
Shah and Verma (2017)

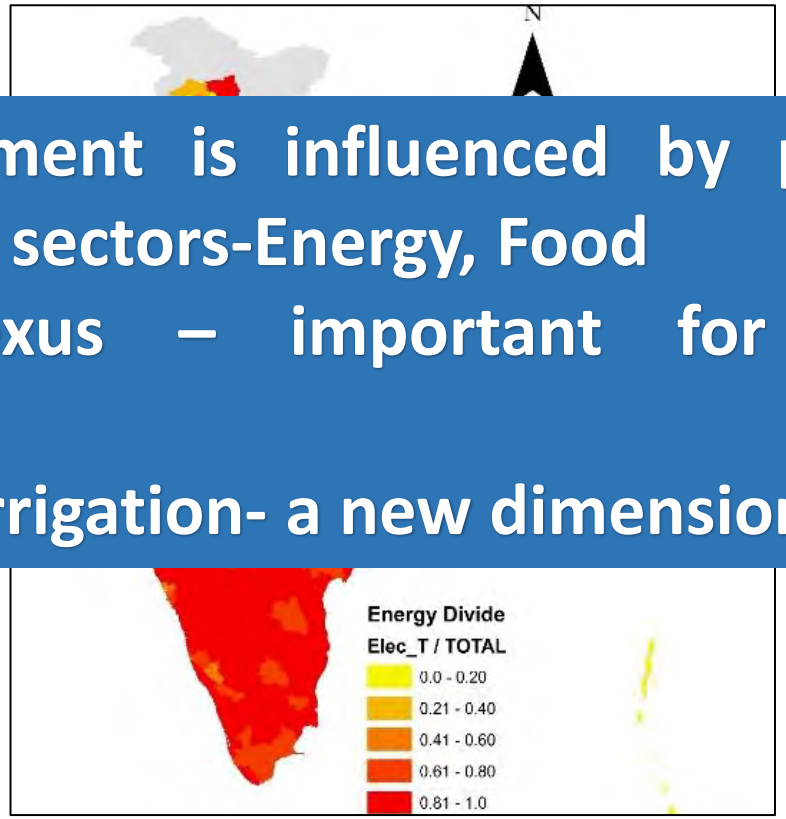


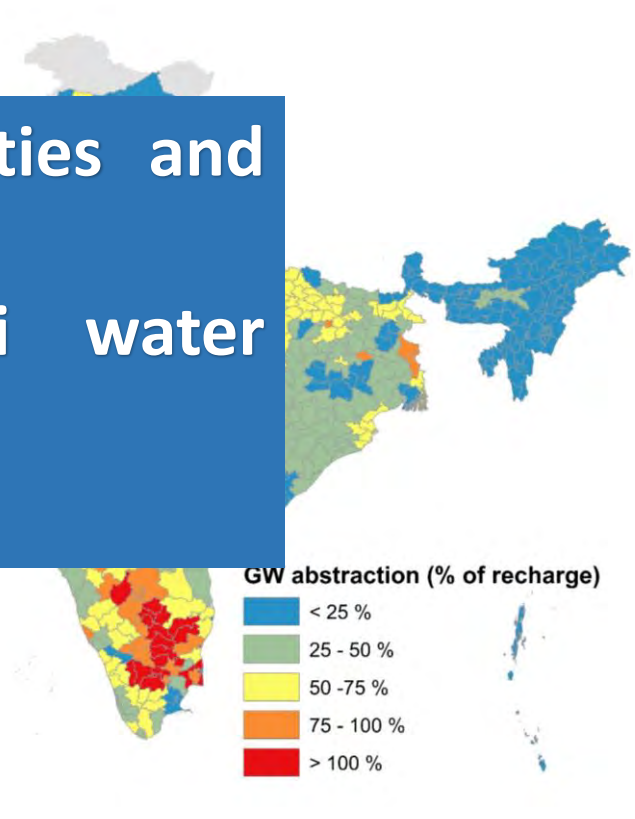
World Bank (2020)

GW Irrigation-Energy Nexus

- Free / subsidized farm power (India)+ water intensive crops → GW depletion in western and Southern India; Pakistan, NW Bangladesh
  - Unsustainable groundwater abstraction produces enough food to feed 173 million people.
  - Wells going dry/deeper entails more energy use and pumping more expensive
- Lack of farm power → Under-irrigation and low productivity in some parts-ex. eastern India, parts of BD, Pakistan



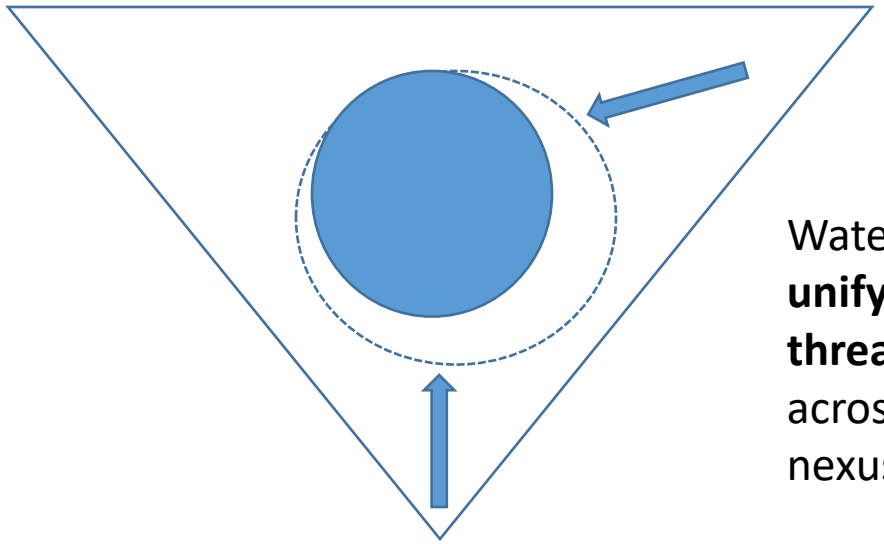




- ✓ **Water management is influenced by priorities and policies in other sectors-Energy, Food**
- ✓ **The WEF Nexus – important for Agri water management**
- ✓ **Solarization of irrigation- a new dimension**

Sectoral "nexus Gains"

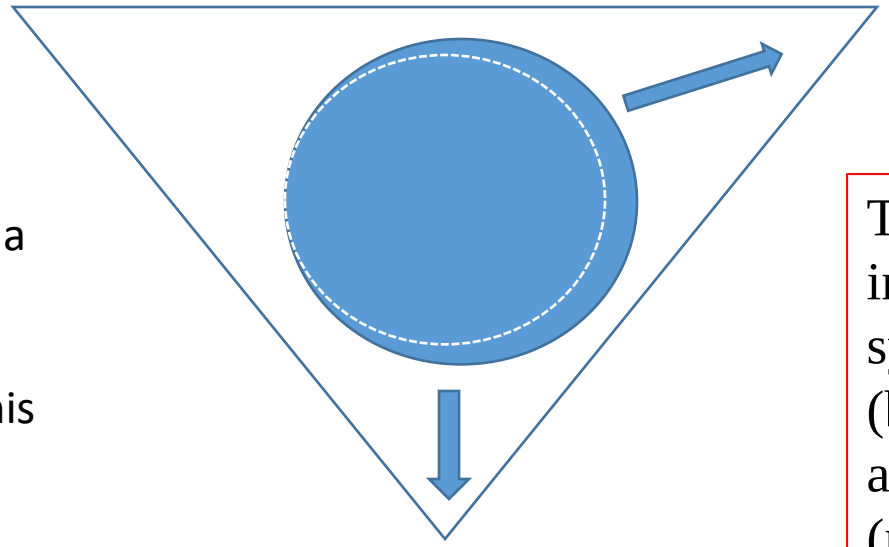
Agricultural water productivity gains reduce water and energy consumption



Energy efficiency measures can reduce water footprint

Sectoral "nexus losers"

Subsidy on electricity for groundwater pumping for irrigation



Shift to more water intensive energy mix, e.g. fracking

Water is a **unifying thread** across this nexus

These objectives are interconnected either synergistically (beneficial) or antagonistically (negatively, trade-offs)

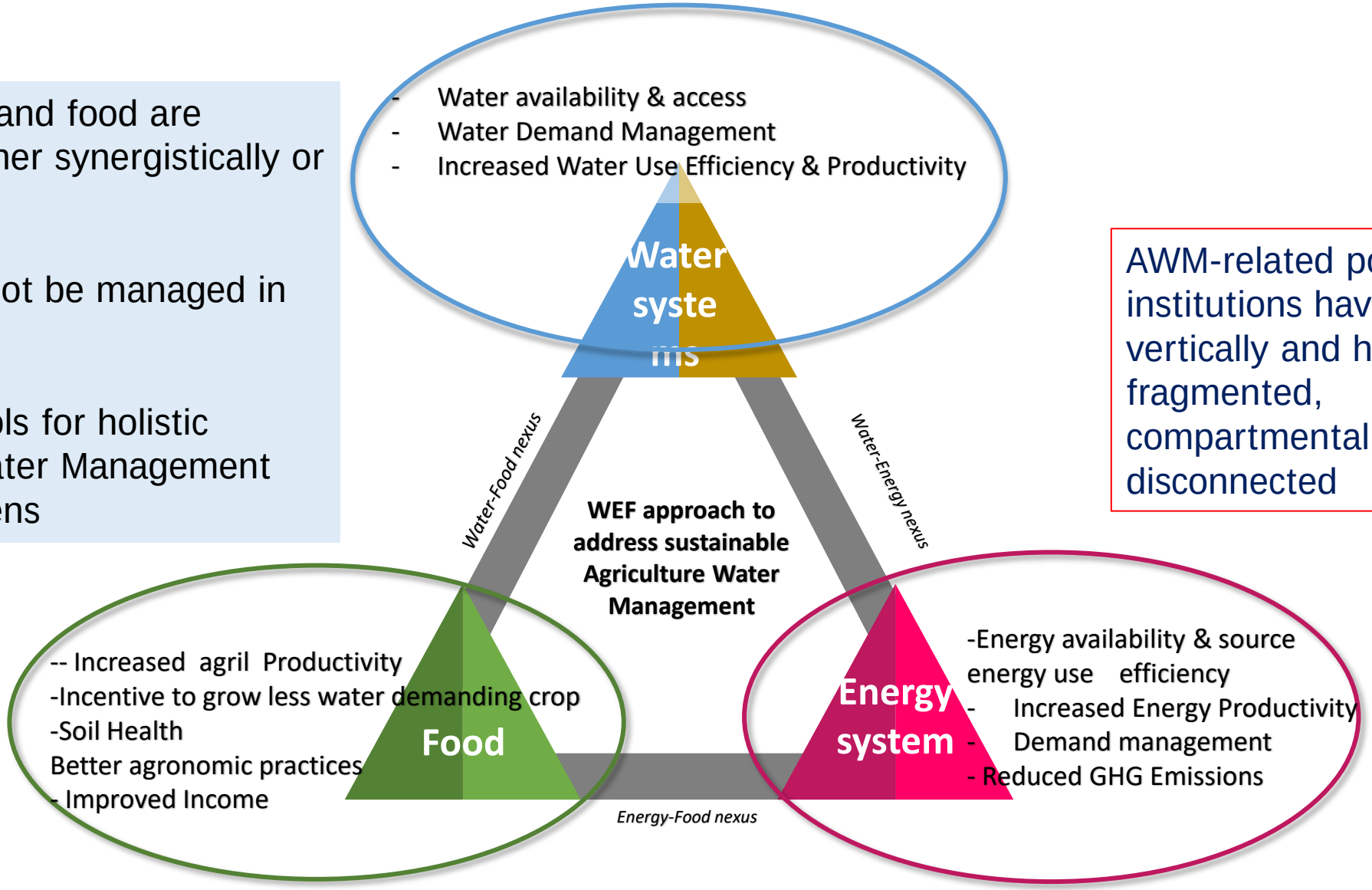
The AWM system consists of multiple subsystems at multiple levels with multiple components with inherently complex feedback-with water, energy & food intrinsic relationship.

WEF Nexus approach for sustainable AWM

Water, energy and food are interlinked, either synergistically or adversely

So, water cannot be managed in isolation

Framework/tools for holistic Agricultural Water Management with a nexus lens



AWM-related policies and institutions have remained vertically and horizontally fragmented, compartmentalised and disconnected

Some common methods for assessing WEF nexus in Water Management

- Integrated modelling frameworks e.g., Agricultural Water-Energy-Food Sustainable Management (AWEFSM) model, Integrated Hydrologic Modelling
- Composite/integrated WEF indices as aggregation of indicators
- sustainability polygons / radar charts / spider diagrams

WEF nexus performances of different irrigation technologies-Meta review

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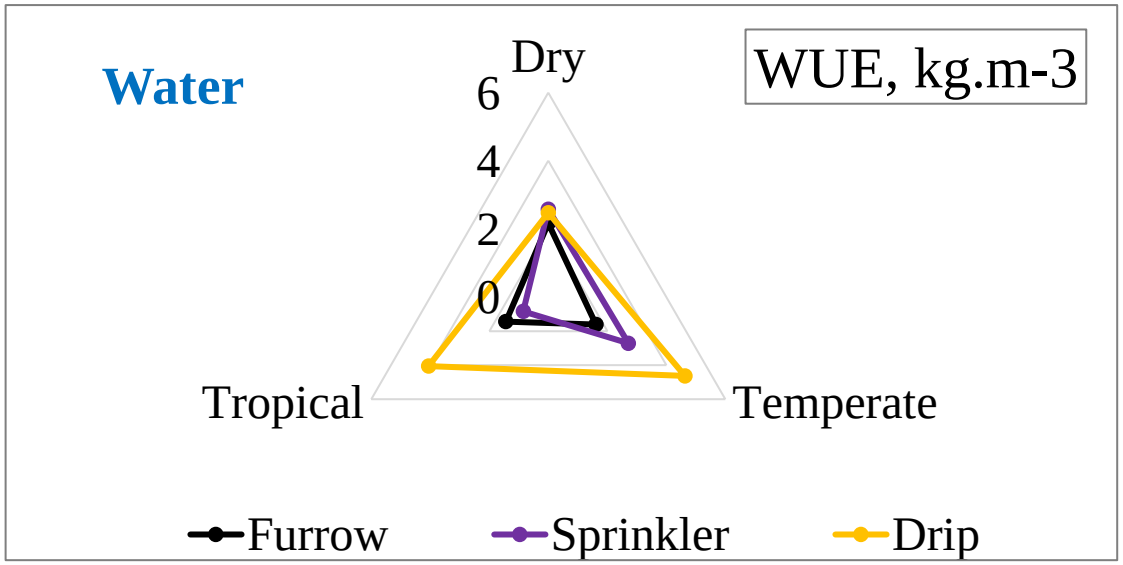
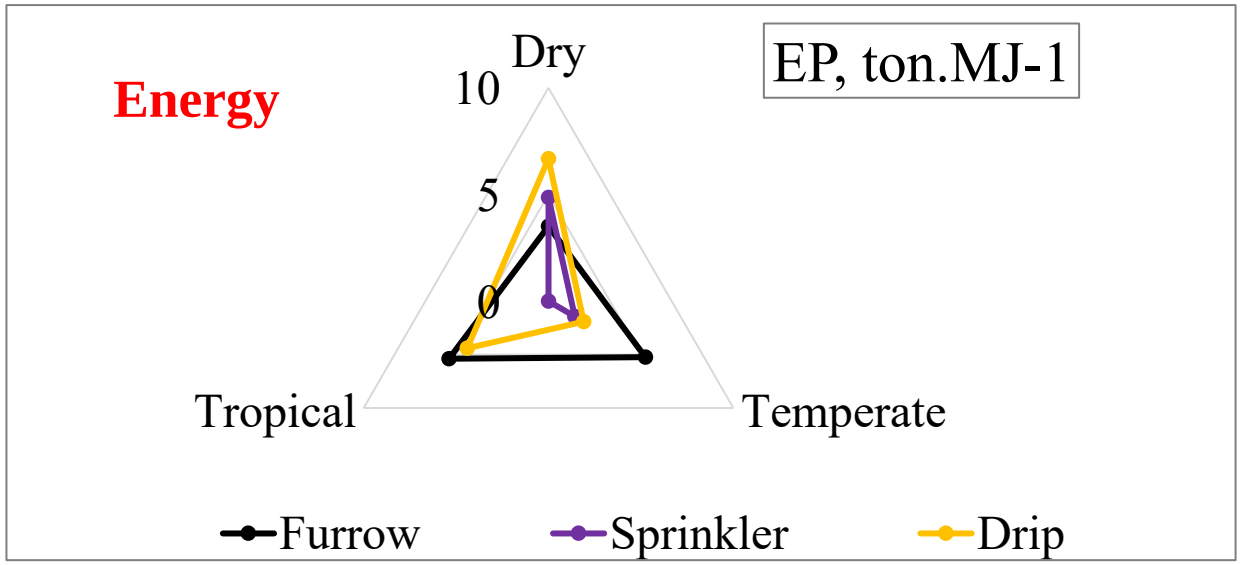
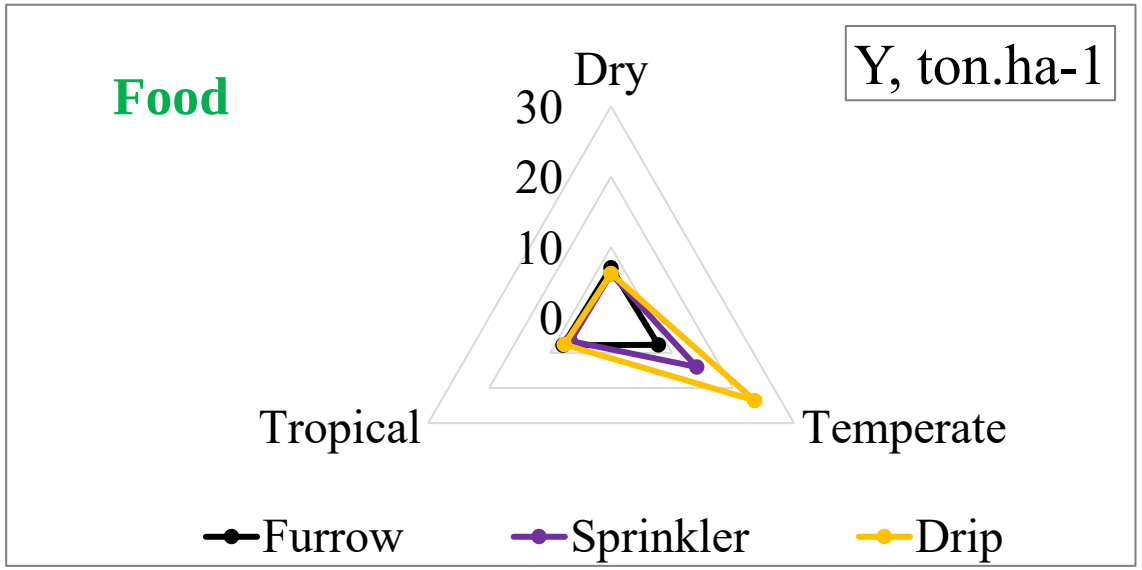
Sustainable irrigation technologies: a water-energy-food (WEF) nexus perspective towards achieving more crop per drop per joule per hectare

Cuthbert Taguta[1,2,*], Tinashe Lindel Dirwai[3,4], Aidan Senzanje[1,5], Alok Sikka[6] and Tafadzwanashe Mabhaudhi[2,7,*]

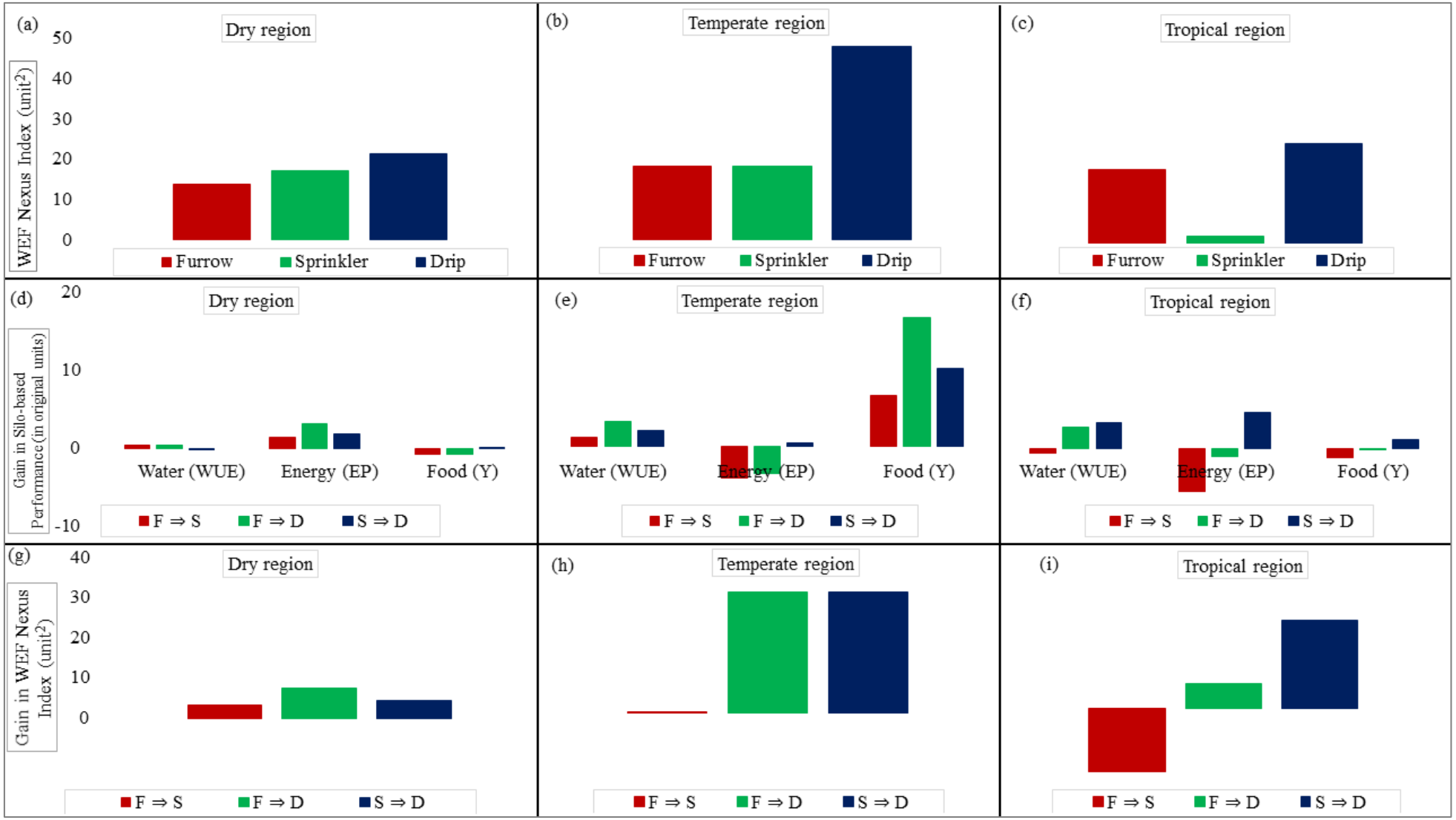
Silo-based performances visualised in sustainability polygons







Integrated WEF nexus-based approach to appraise performance of irrigation systems-an example

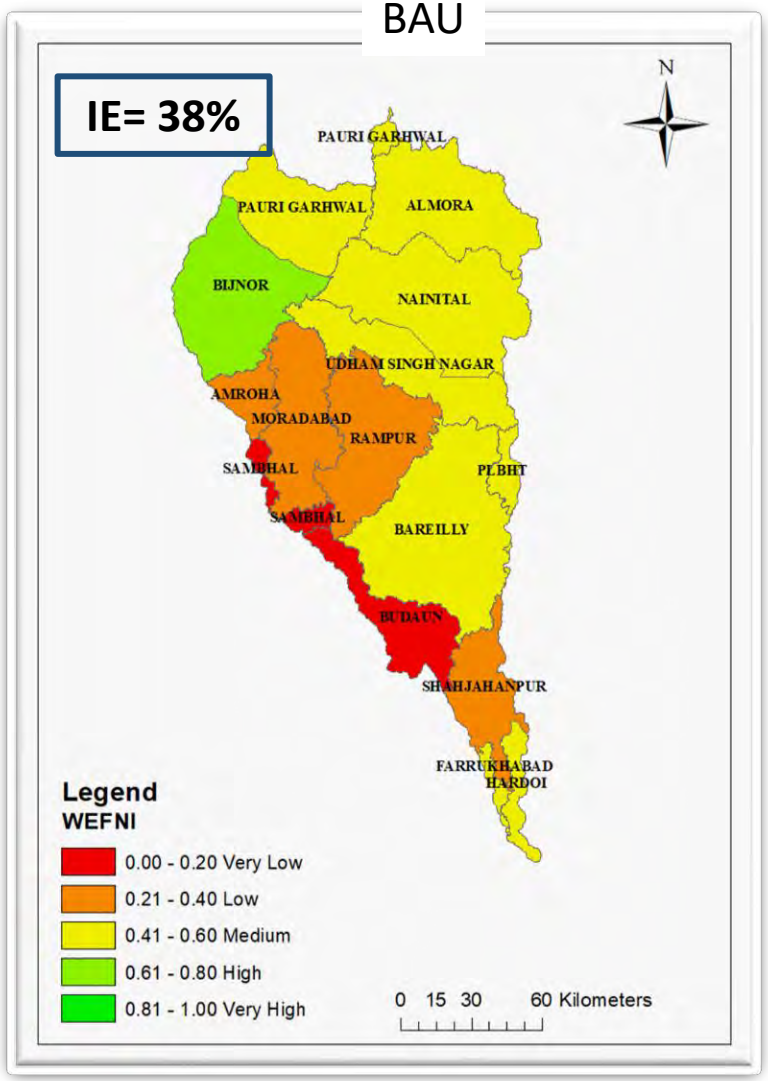


Integrated WEF nexus performance of irrigation systems in (a) dry, (b) temperate, and (c) tropical climates; impacts of irrigation modernisation on the water, energy, and food performance from a silo approach in (d) dry, (e) temperate, and (f) tropical climates; and impacts of irrigation modernisation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

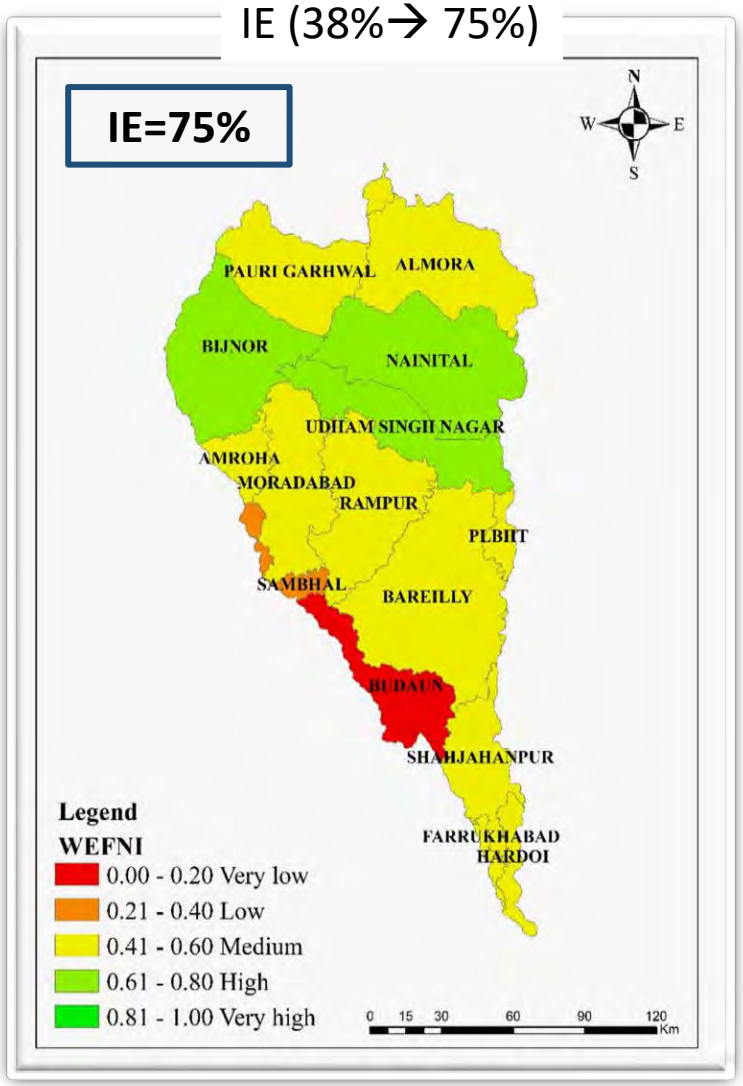
(Taguta et al., 2022, Environ. Res. Lett)

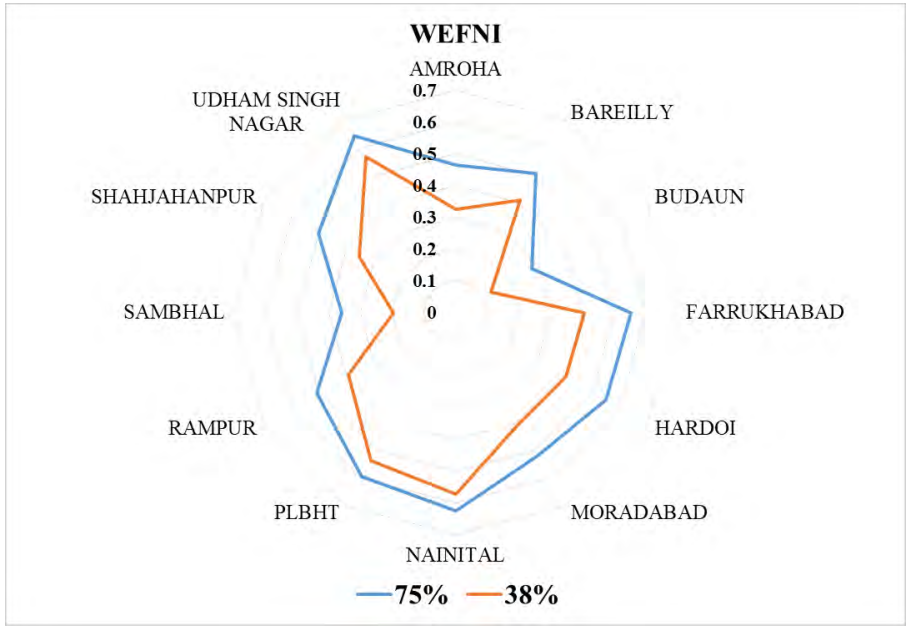
WEF Composite Index with IE increased from 38% to 75% (Adoption of MI System in all BAU poor performers)-an example

BAU



IE (38%→ 75%)

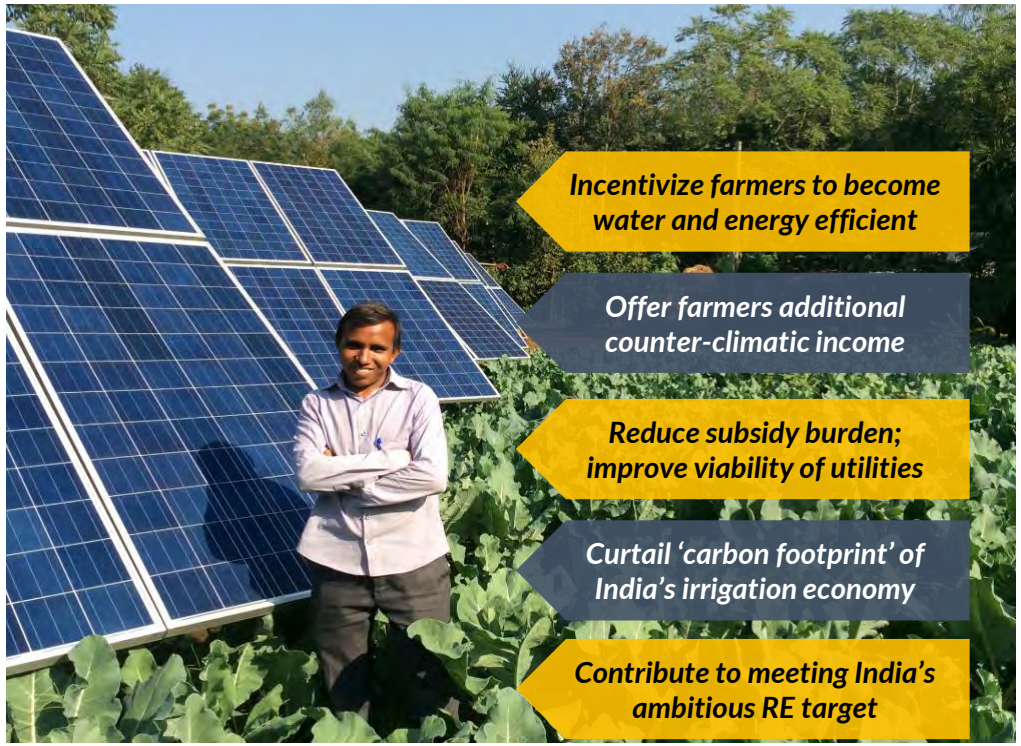




Compared to ALMORA, PAURI GARWAL, BIJNOR where BAU performance was kept as base

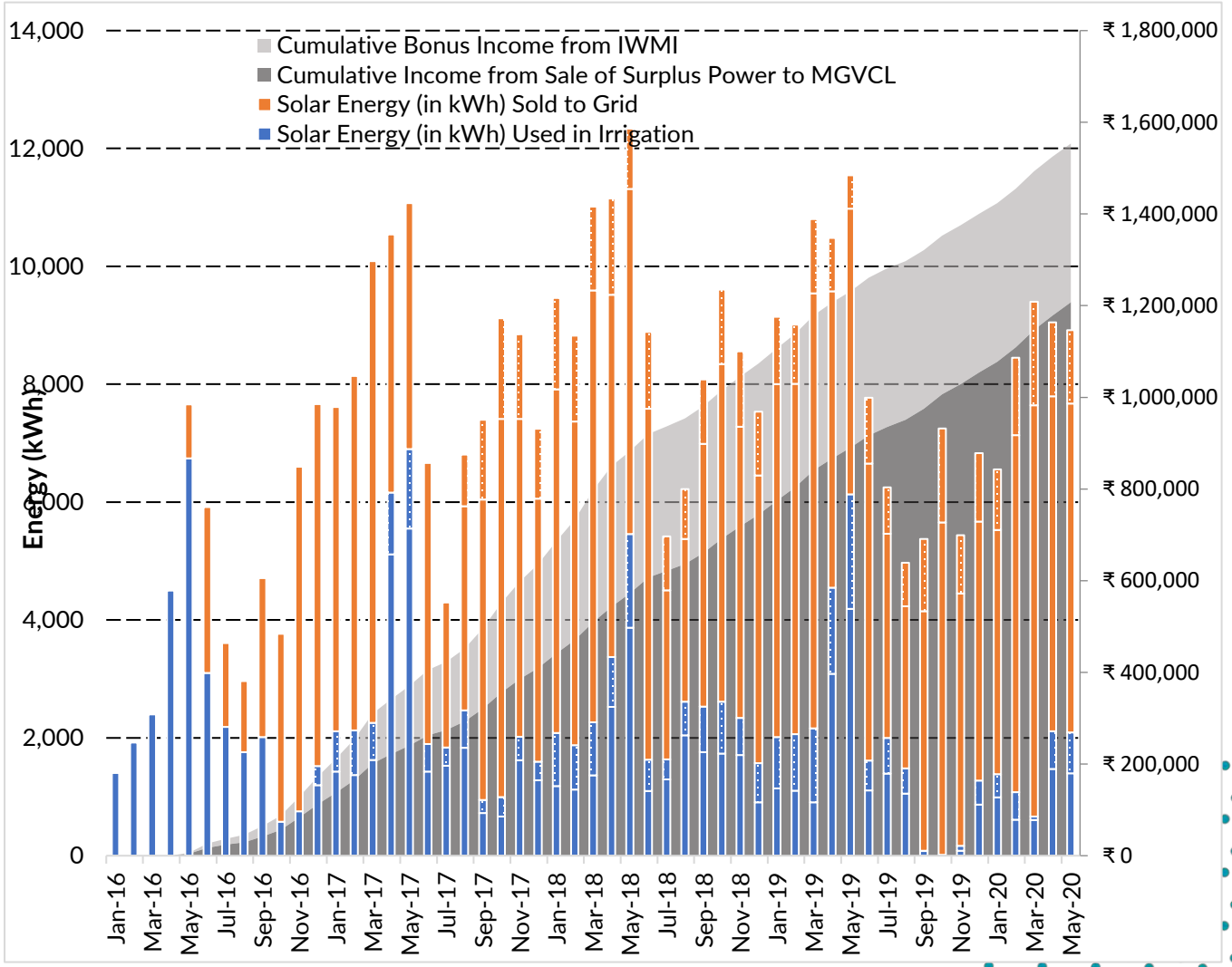
Water and Energy Smart Solar Irrigation-Nexus Gains

On-grid SIP: a GW-benign solar irrigation



SPaRC: Solar Power as Remunerative Crop

Incentivizing farmers to save GW via Feed in Tariff for evacuating energy to grid



Water and Energy Smart Solar Irrigation-Nexus Gains

Solar Irrigation Entrepreneurs in IGB: Off-grid

BEFORE: Oligopolistic Sellers' Market

- Irrigation cost: ₹2,500-3,000 per Ha
- Incomplete coverage, unmet demand
- Delayed Kharif; no third crop

AFTER: Competitive Buyers' Market

- Irrigation cost: ₹1,500-1,800 per Ha
- Each s-ISP sells to 80-100 buyers
- Improved cropping and irrigation intensity

Fee-for-service model for SIP with private sector as ISPs --- IDCOL in Bangladesh

- 20-30% reduction in irrigation tariff
- Time and labour saving for water buyers
- Targeted for boro growing regions – no change in GW application behaviour

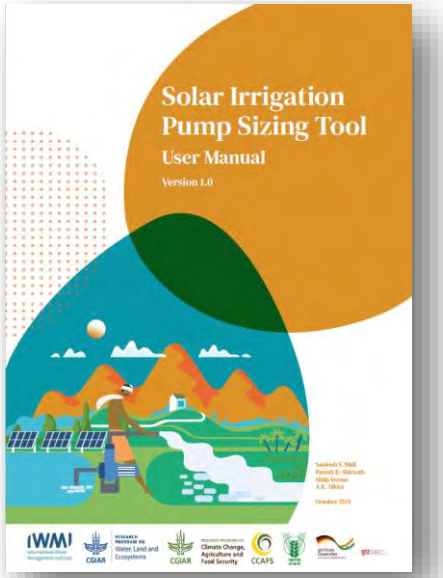
Eastern India – farmers as SISP

Bangladesh – Private companies/NGOs as SISP

SISP: Solar Irrigation Service Providers

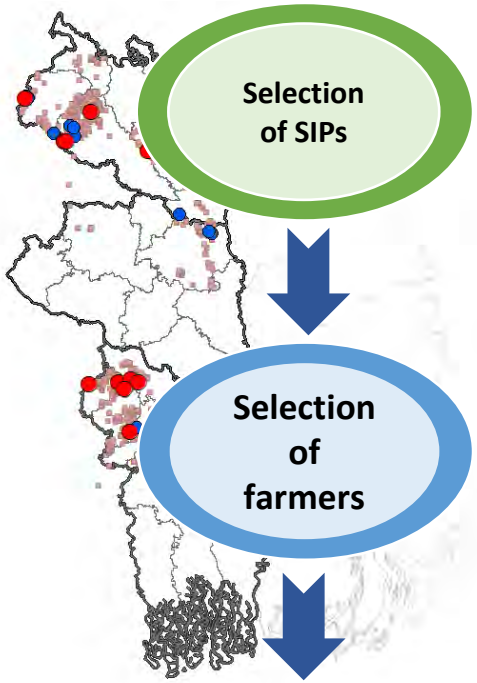
Increased access to water in GW rich eastern India and Bangladesh -improved CC adaptation

SPIS Sizing Tool – Excel Version



SIP Sizing Tool developed jointly by ICAR, IWMI and CCAFS for MNRE / PM-KUSUM, with support from GIZ and WLE

GW Sustainability under Solar Irrigation



Selection of SIPs

- 6 SIPs in North-West

Selection of farmers

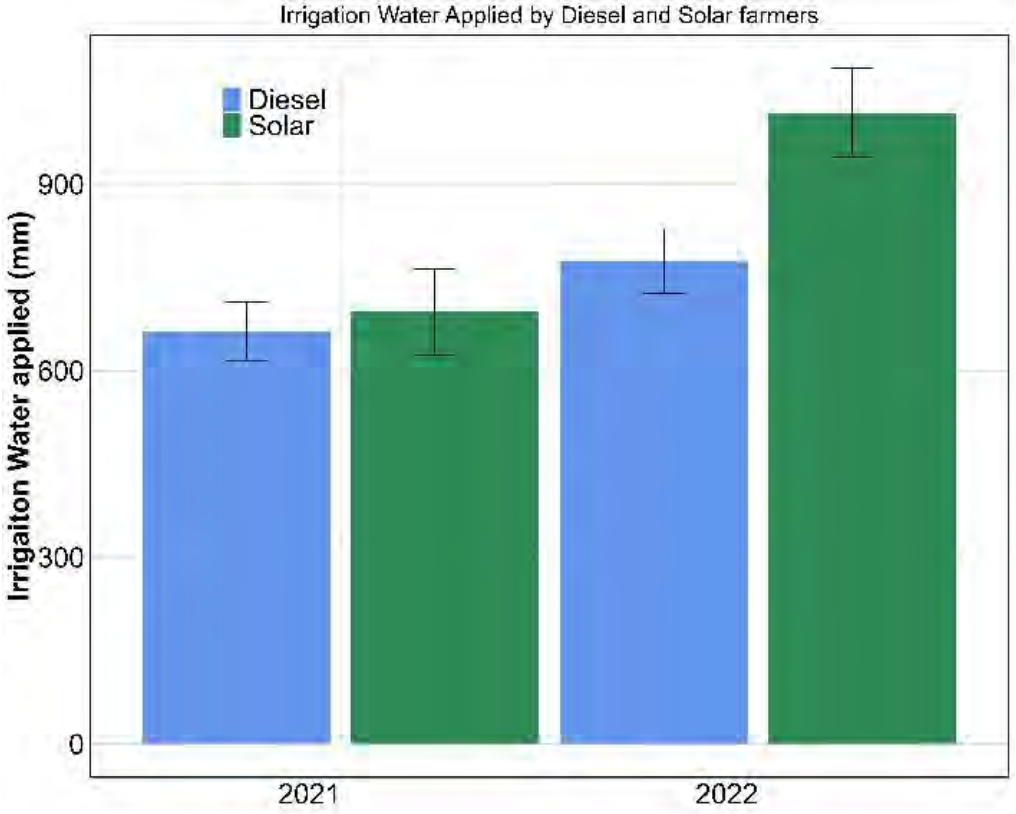
- Farmers in 3 outlets in each SIP
- Control diesel farmers nearby

Monitoring

- Water applied, irrigation hours
- Instrumentation
- Logbooks

Comparison & Assessment of sustainability (GW Modelling)

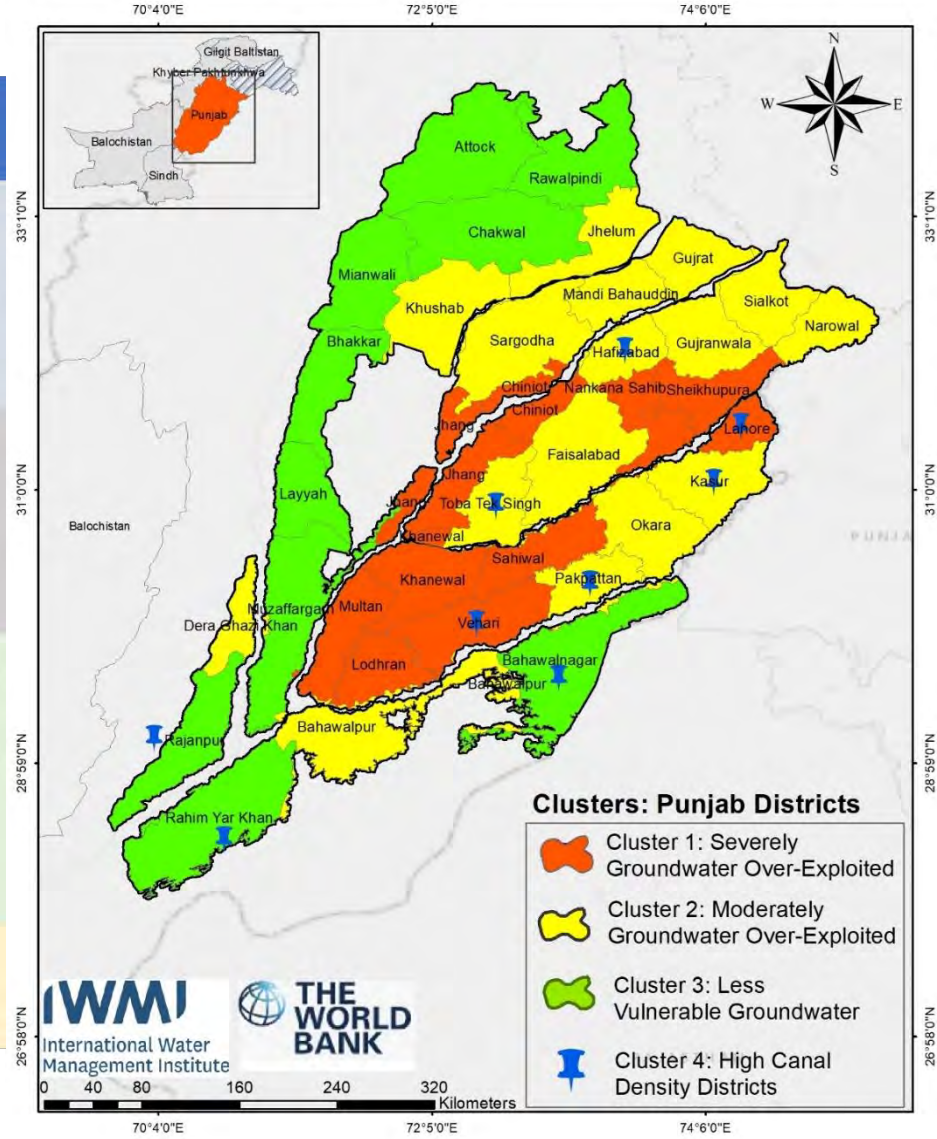
- SIP farmers vs diesel farmers



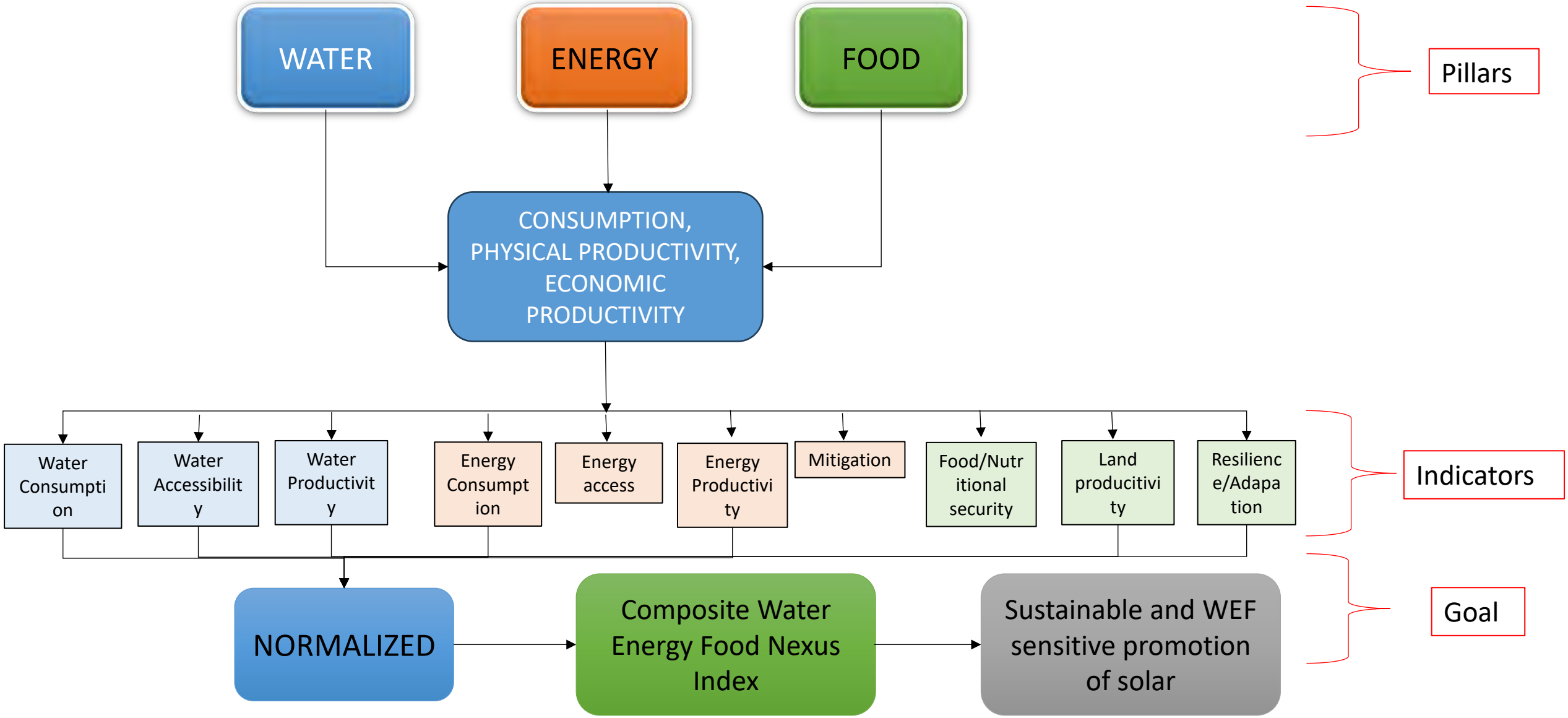
- Comparing SIP with diesel farmers in adjoining area
  - Similar biophysical (climate, soil) conditions
- Overall, for both seasons, average water applied for boro is similar (controlling for other factors) with no significant differences between SIP and diesel farmers
- In 22-23, SIP water use is 36 % higher and Diesel water is 30 % higher compared to 21-22
  - Due to much higher rainfall in 21-22 season

GW Vulnerability based SIPs with a WEF Lens- Pakistan

Cluster	Subcluster	Design Features		
		Technical	Financial	Institutional
Severely Groundwater Over-Exploited	Moderate-Low Poverty High Poverty	On-grid Net Metering High FiT Ratio: 4:5	Credit (6%) CapEx + Cr. + Int-Subv + Re-Mora	Individual SIPs or Feeder Tail-end Solar Plants
Moderately Groundwater Over-Exploited	Low Poverty Moderate-High Poverty	On-grid Net Metering Moderate FiT Ratio: 4:5	Credit CapEx + Cr. + Int-Subv + Re-Mora	Individual SIPs or Feeder Tail-end Solar Plants
Less Vulnerable Groundwater	Rainfed Districts Irrigated – Low Poverty Irrigated – Mod.-High Poverty	Off-grid Ratio: 1:1	Credit + Int-Subv Credit + Int-Subv CapEx + Cr. + Int-Subv + Re-Mora	Individual Off-grid SIP Individual Off-grid SIP Solar Enterprises
High Canal Density Districts	Canal-top Solar	On-grid Canal-Top	PPP-BO	Private Enterprises



WEF Nexus Composite Index for Solar interventions



Conclusions and Way Forward

- Sustainable agricultural water management will require integrated approach to increase productivity while optimising water and energy use efficiencies and environmental health
- It is important to understand and analyse trade-offs and synergies of various AWM interventions with a WEF nexus lens
- The WEF nexus approach has potential to holistically appraise performance of AWM as opposed to silo-based approach
- Consider relative importance and priorities of AWM interventions in local WEF nexus case studies
- Irrigation modernization to be complemented with sound basin-wide water management to realize WEF nexus benefits.
- Develop and test improved integrated data-driven nexus-based AWM analytic tools that guide implementation of AWM practices and technologies
- Policy coherence for aligning and streamlining incentives and signals of different policies to target groups for minimum conflicts, through coordination and integration between government agencies.

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Thank you…

Innovative water solutions for sustainable development

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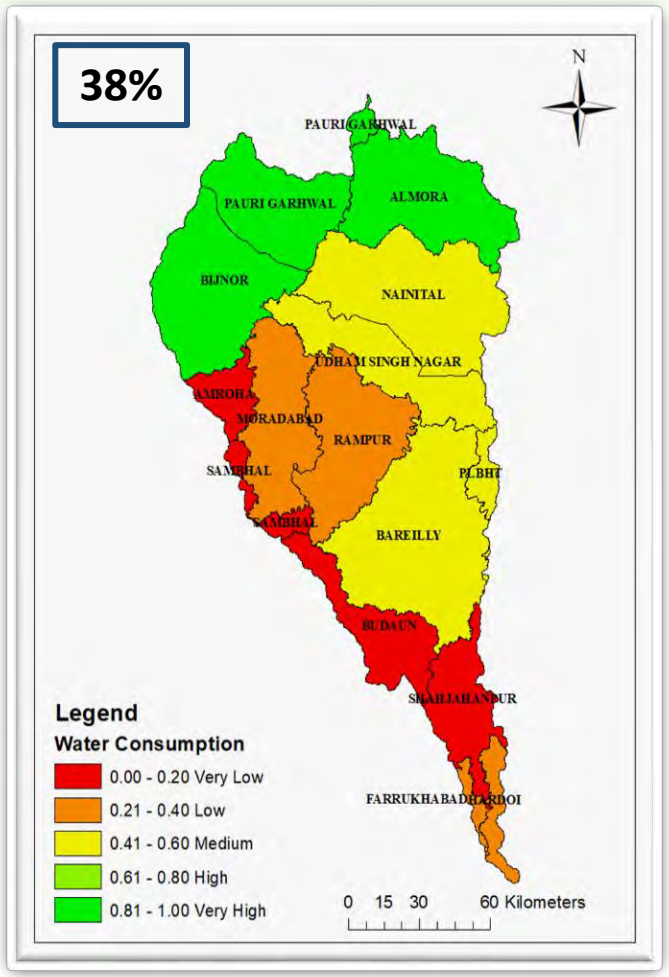
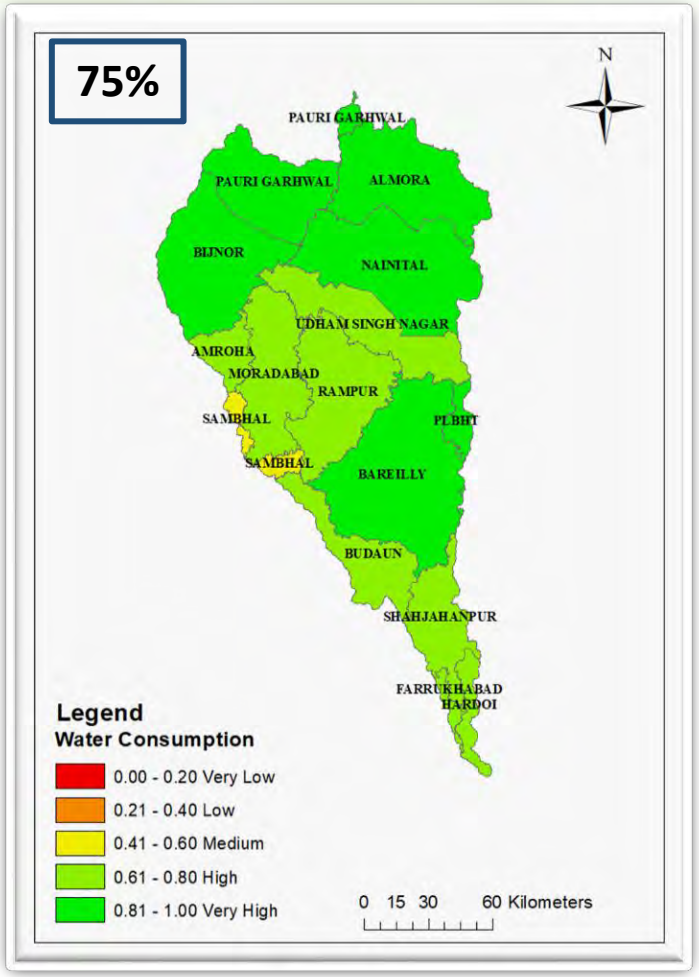
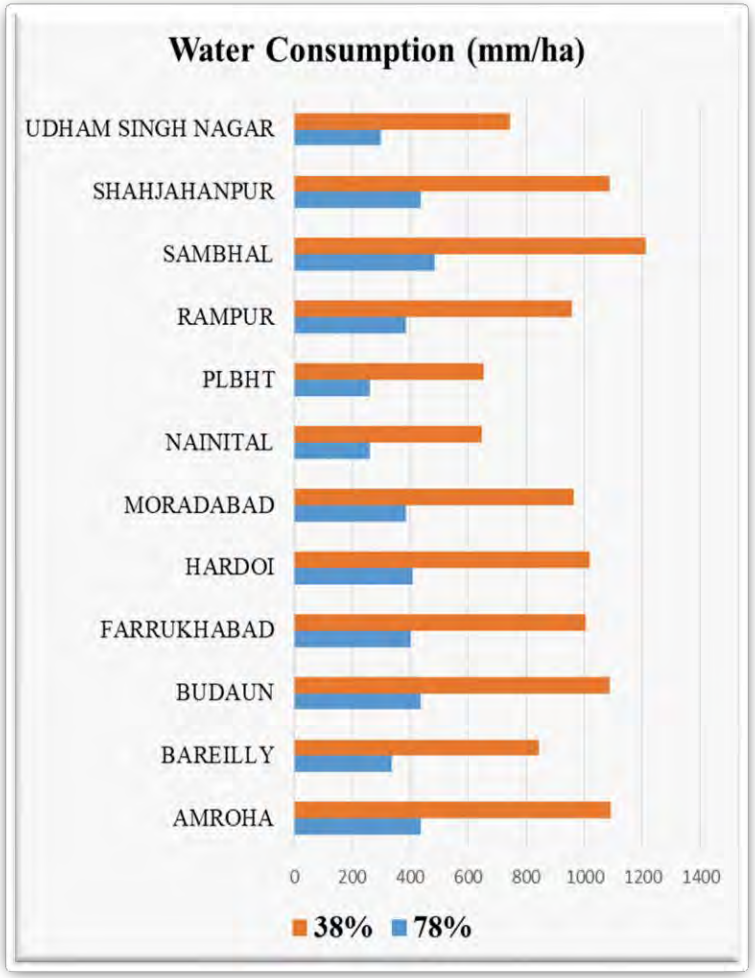
CGIAR

Reduction in water consumption due to MI system (IE 38% to 75%)







* ALMORA, PAURI GARWAL, BIJNOR