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IWMI International Water Management Institute

INTERNATIONAL COMMISSION ON IRRIGATION AND DRAINAGE (ICID)

Harmonizing Synergies Of Water-Energy-Food Nexus For Sustainable Water Management

Alok Sikka, D. Sena, Faiz Alam

IWMI – New Delhi

PLATINUM JUBILEE

Indo-Global Irrigation Summit 2025
24-25 June 2025, New Delhi, India

Water and Energy Intensive to South Asian Agriculture

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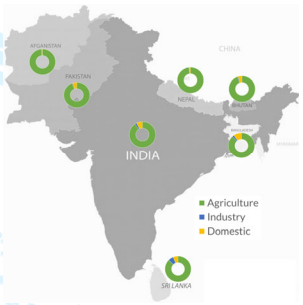
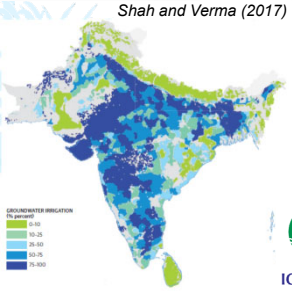
- SA supports **25% of the world's population** with just **4.6% of the world's water resources**
- **About 40% of cultivated land is irrigated**, with agriculture consuming over 90% of water-achieving food security
- About **60-80 % of irrigated area is serviced by groundwater** in India, Bangladesh 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)

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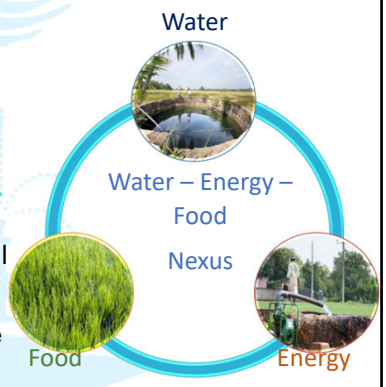
Managing water- with a WEF nexus lens

- Intrinsic interdependence and interconnection of water, energy and food makes SA Agriculture a fit case of the WEF nexus concept
- Sustainability concerns of water, energy, and input-intensive agri-food systems have increased the realization for dealing WEF Nexus
- This interconnectedness makes the nexus thinking more relevant for sustainably managing limited water and energy resources
- Unravelling the WEF nexus requires analysis of water–energy use and crop yield interactions in an integrated approach, to optimise the overall resource-use efficiency/productivity for **Nexus Gains**
- Metrics of productivity and footprints of water, food, and energy provide crucial information to harmonize the WEF nexus synergies
- Water is a **unifying thread** across this nexus triangle



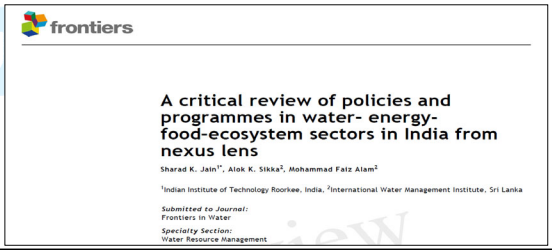
Incoherent Policies And Qualitative Trade-offs

- More than ≈ 40 programmes across WEFE sectors were studied to understand the efforts underway to attain the respective policy goals
- Significant overlaps among the programmes which could positively or negatively impact concerns among the sector(s).
- Need to quantify the trade-offs by using **integrated approach including modeling** with the WEFE nexus lens.

National Water Policy (2012)	Energy Policy (2017)	National Policy on Biofuels (2018)	National Agriculture Policy (2004)
National Forest Policy (1988)	Environment protection Act (2006)	National Agroforestry Policy (2014)	National Biological diversity policy (2012)

Policies developed in their domain area at different times

Policies of different sectors give inadequate consideration to impacts of decisions on related sectors


frontiers

A critical review of policies and programmes in water- energy-food-ecosystem sectors in India from nexus lens

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WEF Nexus framework for sustainable WM

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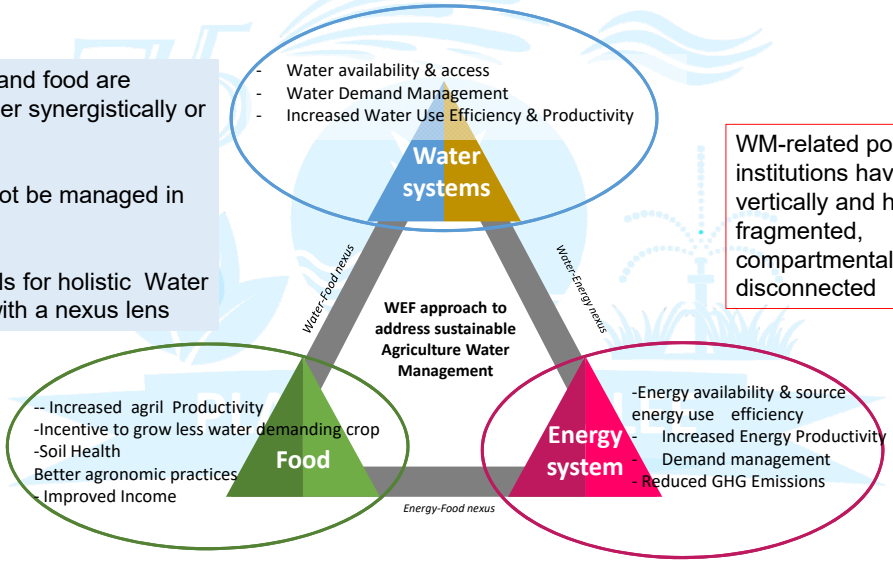
Water, energy and food are interlinked, either synergistically or adversely

So, water cannot be managed in isolation

Framework/tools for holistic Water Management with a nexus lens



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

Assessing WEF nexus in WaterManagement

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- 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


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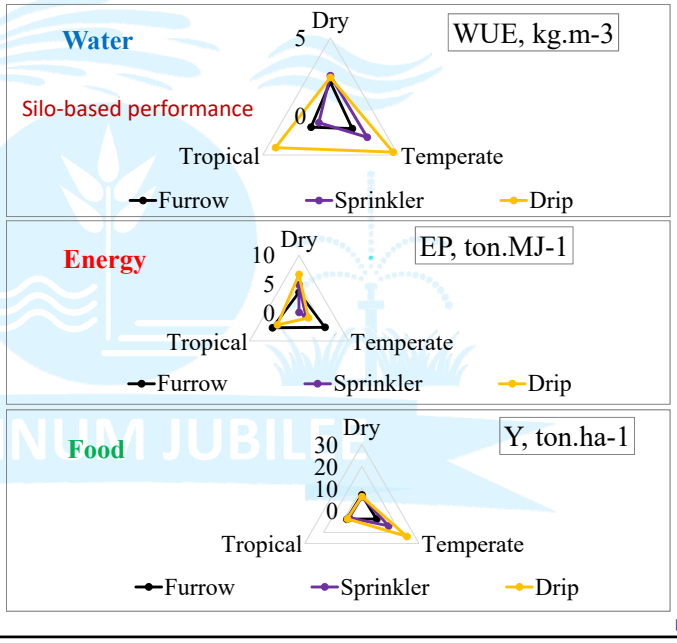
ENVIRONMENTAL RESEARCH LETTERS

TOPICAL REVIEW

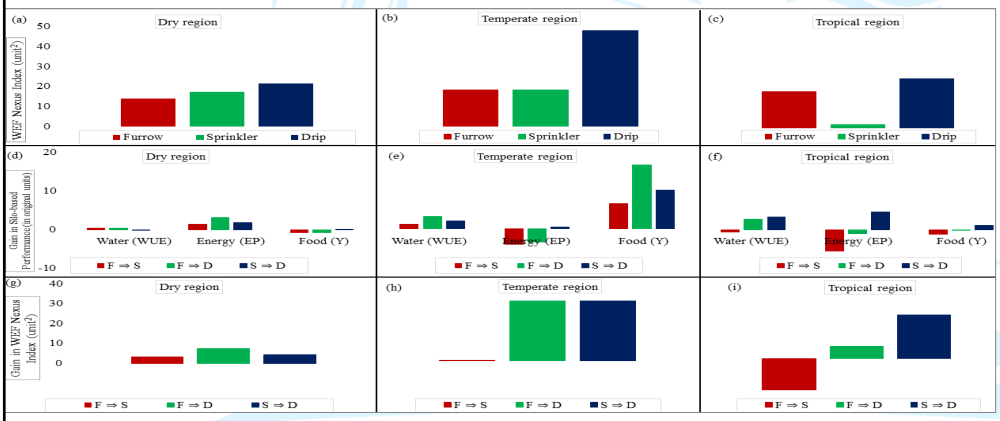
OPEN ACCESS

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

Cuthbert Taguta, Tinashe Lindel Dirwai, Aidan Senzanje, Alok Sikka and Tafadzwanashe Mabhaudhi



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



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

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

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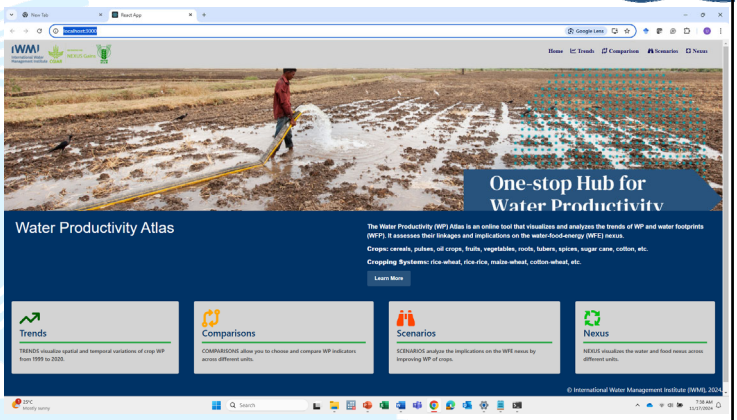
Water Productivity Atlas – Capabilities

- The WP Atlas is an online tool for assessing:
  - Water productivity (WP)
  - Water footprint (WFP)
- WP indicators include
  - Physical WP (kg/m^3)- consumptive water use (CWU)
  - Economic WP ($/m^3)- CWU
  - Nutritional WP (calorie, proteins, fat/m^3)
- WFP indicators include
  - Blue and green WFP (m^3/tonne) of more than 30 crops.
  - Green WFP: the effective rainfall (EFRF) at the root zone.
  - Blue WFP: the irrigation CWU -difference between the total CWU and the GRWFP.
- Spatial and temporal variation across different geographical scales
- Helps run scenarios for future planning and investment decisions, and examine NEXUS



- Water productivity of over 30 crops and predominant cropping systems for about 600 districts for last 20 years
- Crop data - Ministry of Agriculture, Govt of India.
- PET (district-level estimates from the monthly PET grids (https://crudata.uea.ac.uk/cru/data/hrg/, Harris et al. 2020.

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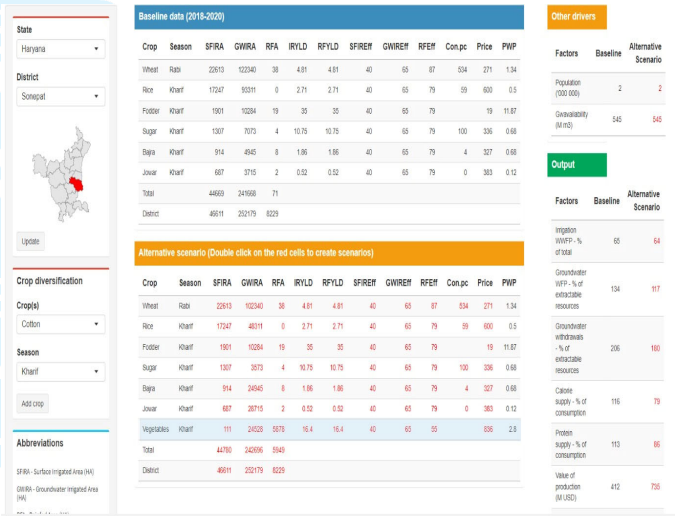
Crop Diversification & Water Use Scenarios

Crop-water use scenarios for addressing the WEF nexus, example: Sonepat district, Haryana

- Reduce groundwater irrigated area of
  - Rice by 45000 ha from 93311 ha to 48,000 ha;
  - Sugarcane by 3500ha, from 7073 to 3573 ha, an
  - Wheat area by 20000 ha, from 122340 to 102340 ha
- increase groundwater irrigated area of
  - Jowar-kharif by 25000 ha
  - Bajra-Kharif by 20000 ha, and
  - Vegetables-rabi by 23500 ha

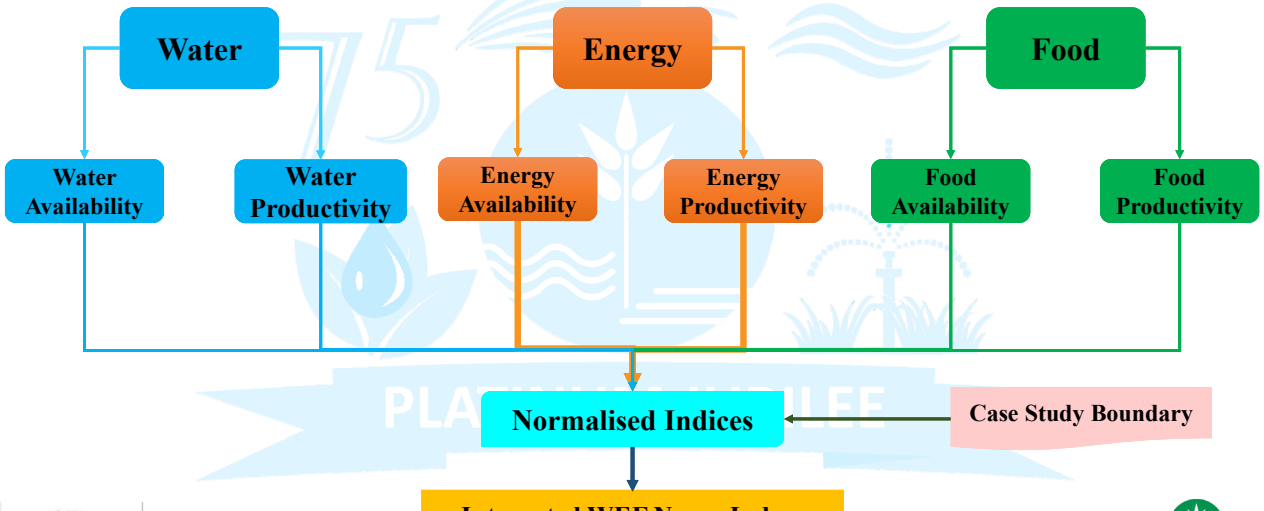
What you get

- Reduced GW footprint: 134 percent to 117 percent of the extractable groundwater resources
- Decrease in total energy consumption by 13% from 1223 Mwh to 1068 Mwh
- Increase EWP: 1.99 to 3.39 USD/ m^3, with substantial nutritional surpluses.



A useful approach to assess nexus and examine scenarios

WEF Nexus Composite Index



WEF Nexus DSS

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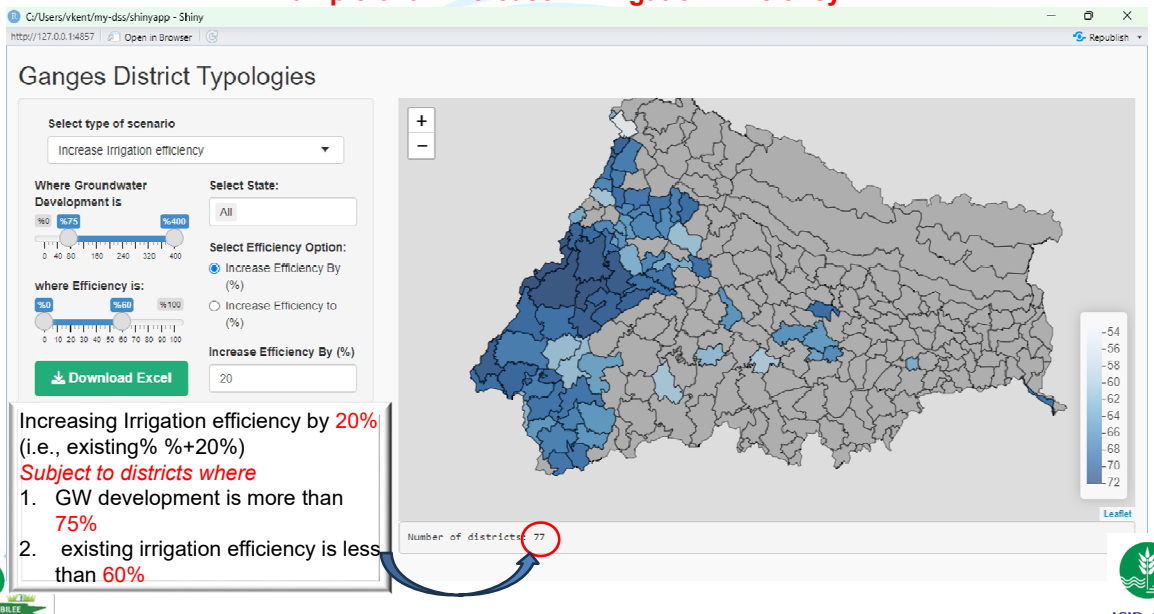
WEF Nexus DSS – scenario generator

Example of an Increase in Irrigation Efficiency



Increasing Irrigation efficiency by 20% (i.e., existing% %+20%)
Subject to districts where
1. GW development is more than 75%
2. existing irrigation efficiency is less than 60%

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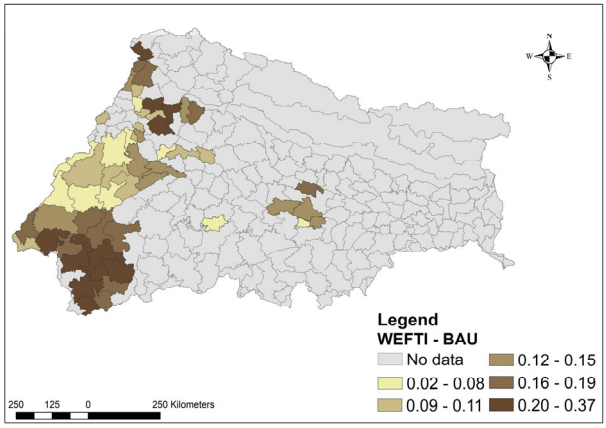
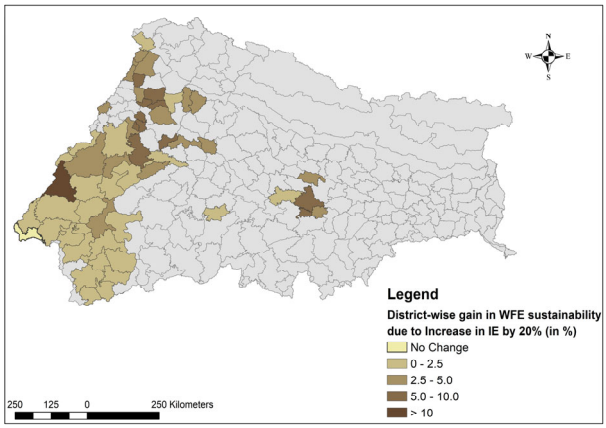
Comparison of WEFTI for BAU & IIE





WEFTI for BAU for regions with conditions
Where groundwater development is more than 75% and Irrigation efficiency is less than 60%

Percentage of gain in WEFTI due to increase in IE (20%)

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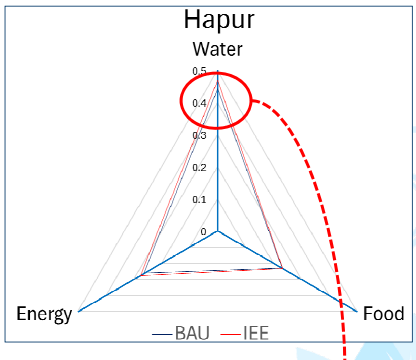
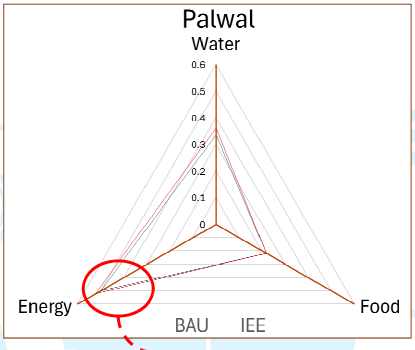
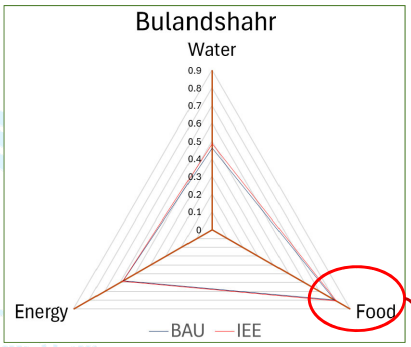
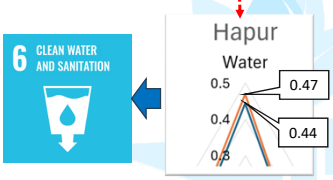
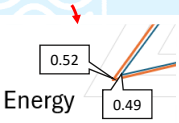








6.4.1 (Change in water-use efficiency over time),
6.4.2 (Level of water stress)



7.3.1 (Energy intensity reduction)
7.2.1 (Renewable energy share)

2.3.1 (Agricultural productivity)
2.4.1 (Proportion of agricultural area under productive and sustainable agriculture),

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Operationalizing WEFE-Way Forward

- **WEF nexus framework** helps understand and analyse **trade-offs and synergies of interconnected WEF system** to maximize **Nexus Gains**
- Our analysis shows that **110 districts** in the Ganga Basin are highly **skewed in terms of WEF nexus** and need to correct the imbalance- make them **nexus friendly**
- Irrigation **modernization** be examined with a **WEF lens** for Nexus Gains
- Lack of coherent policies/programs - **key barrier** to Nexus gains
- **A decision tool / framework** can help identify and highlight the linkages among the policies/programs needed to be addressed for synergistic gains among the programs/policies for sustainable water management.
- Need to **think and act beyond the water to manage water** in harmony with energy, agriculture and environment.

Thank You

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