# 75th International Executive Council meeting & 9th Asian Regional Conference

## WEF Nexus

# The Water-Energy-Food-Nexus:
## Applications & Impact on Societies, Environment and Ecosystem

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WEF Nexus Working Group
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ICID•CIID

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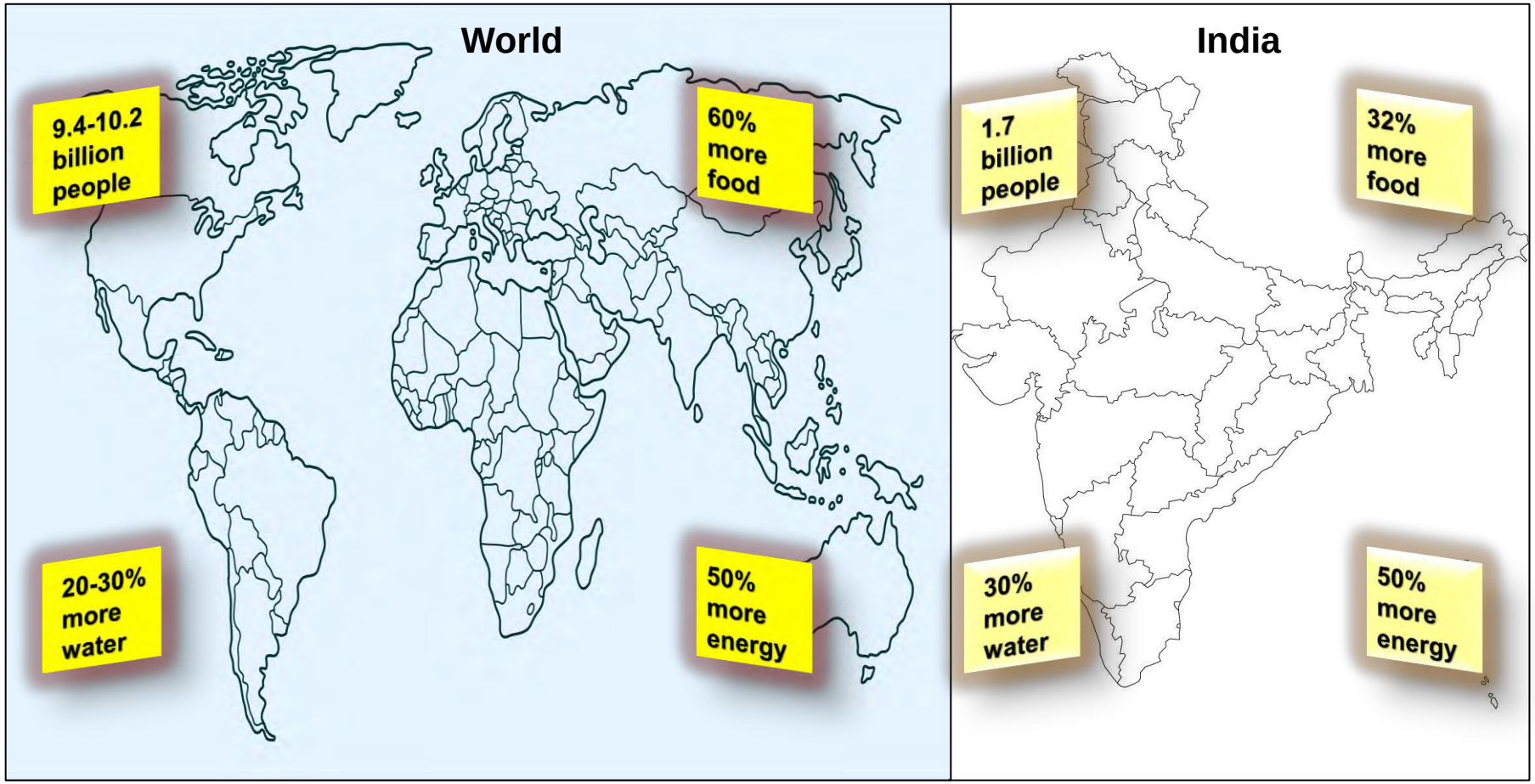
**Honorary Vice President of ICID and Vice Chairman of the ICID WG WEF-Nexus

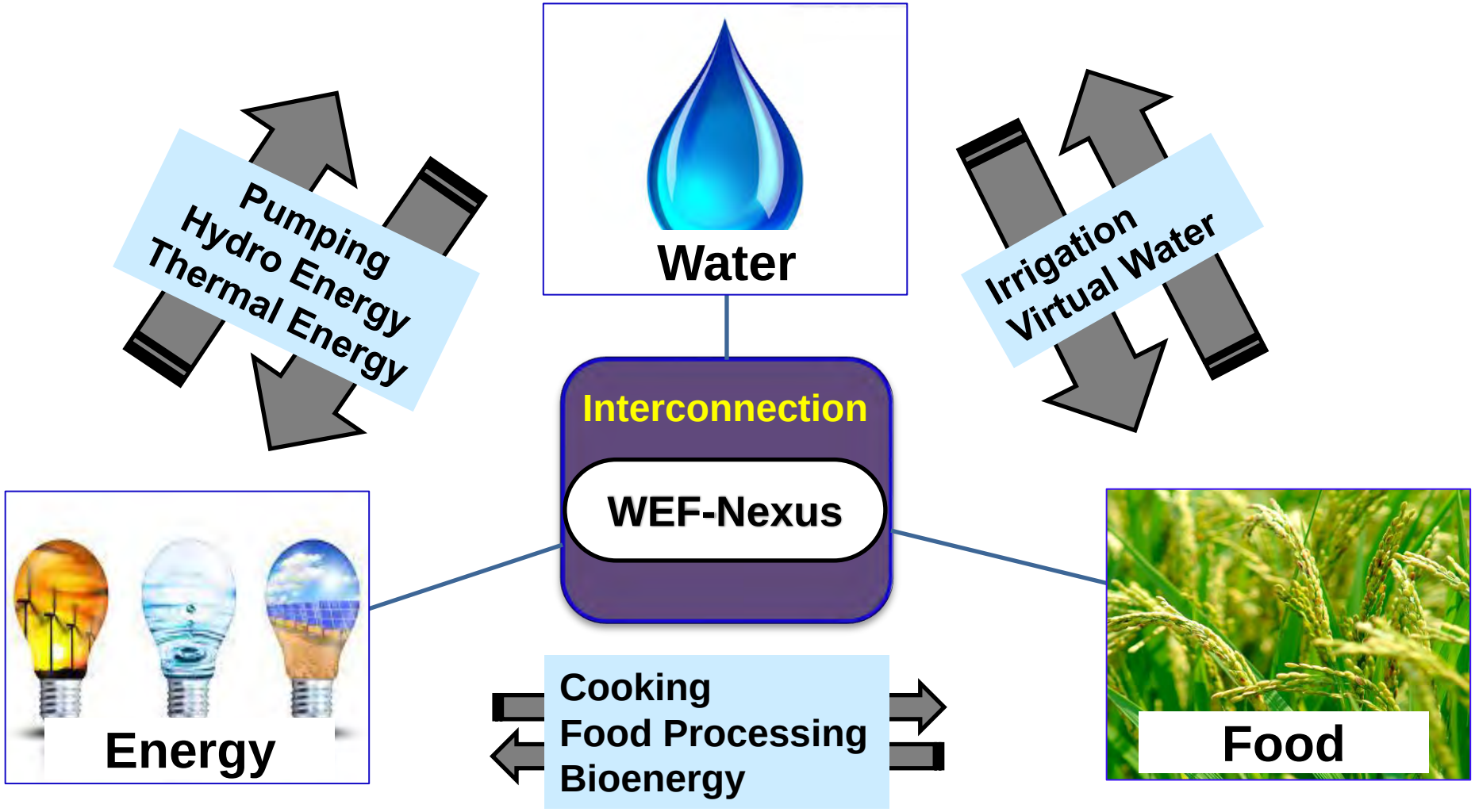
# 2050 Challenges




Need for a

**SYSTEMETIC WEF-NEXUS APPROACH**

# Water-Energy-Food Nexus



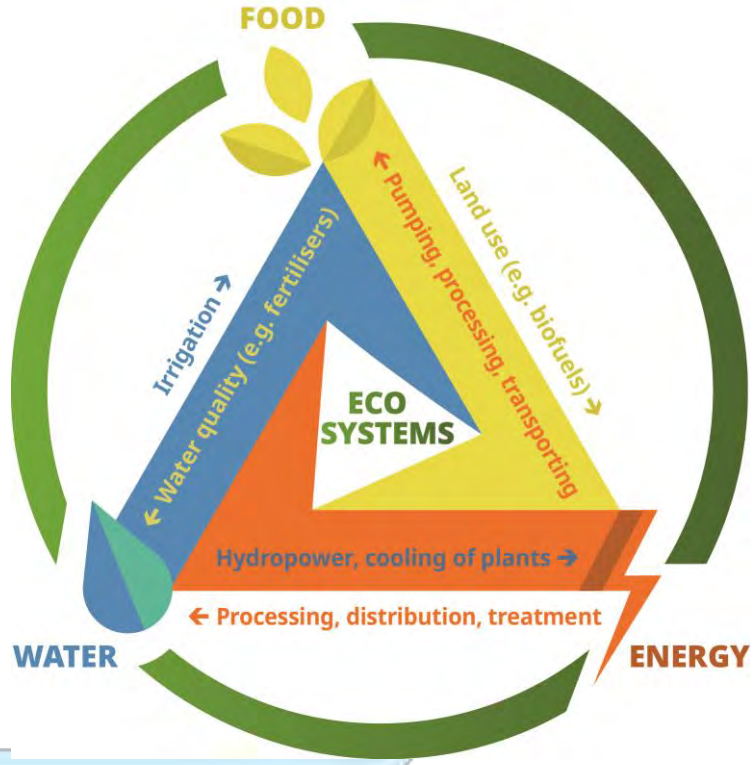
## Multi-dimensional interlinkages between water, energy, food and ecosystems

Water <-> Energy: Water plays a key role in energy production, e.g. in hydroelectric plants, for cooling thermal (fossil-fuel or nuclear) plants and in growing plants for biofuels. Conversely, energy is required to process and distribute water, to treat wastewater, to pump groundwater and to desalinate seawater.

Water <-> Food: Water is the keystone for the entire agro-food supply chain. Conversely, agricultural intensification impacts water quality.

Food <-> Energy: Energy is an essential input throughout the entire agro-food supply chain, from pumping water to processing, transporting and refrigerating food. Conflicts around land use for food production may arise in the case of biofuels or extended solar installations.

Healthy ecosystems are an essential requirement for the sustainability of all the above and are negatively affected if water, energy or food are used in an unsustainable way.



# WORKING GROUP ON WATER, FOOD AND ENERGY NEXUS (WG-WFE_N)

Objectives of the WG are

(a) to develop approaches by which we can advise on “how to produce more crop per drop per kilowatt energy and per unit area of land”,

(b) to promote the efficient use of water in crop production,

(c) to provide models and input to test crop-water-energy models,

(d) to develop techniques to balance water supply against water demand,

(e) to promote the multifunctional use of water especially in paddy (rice) cultivation,

(f) to investigate the adaptation of agriculture to climate change and to promote low input agriculture.

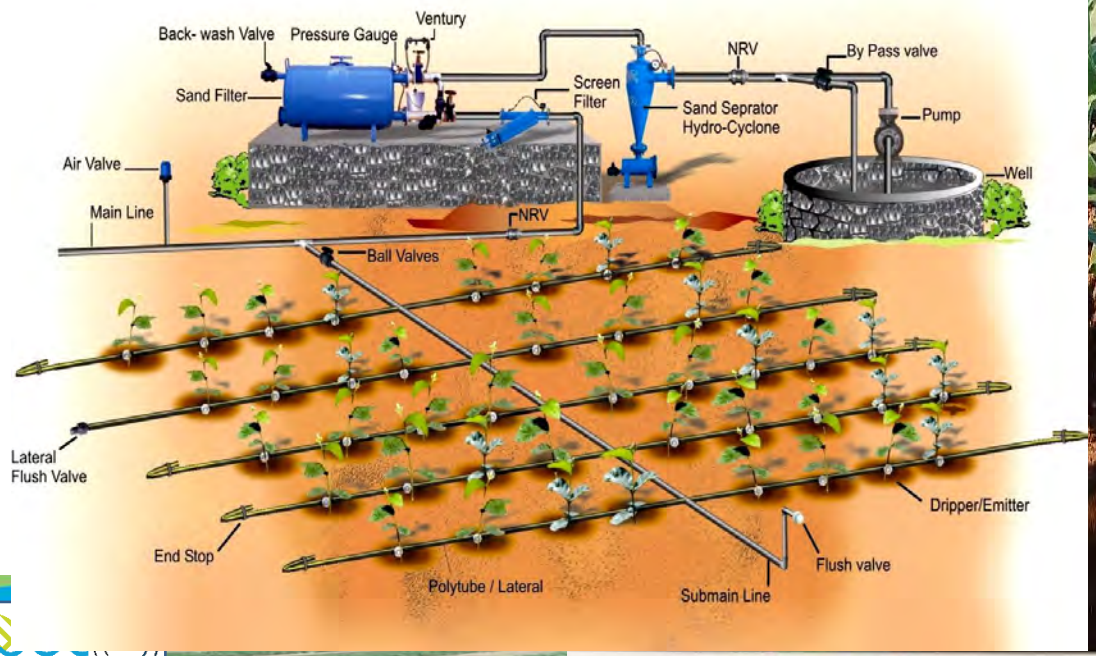
(g) to contribute to effective implementation of the ICID vision 2030.

# NEW FOCUS ON NEXUS

- The interdependence of the water, food and energy is well known since early civilization.
- The present challenge is how to produce more crop per drop per kwatt energy per unit area of land. This is the essence of the new focus on the nexus.

Efficient Land Water Energy Management

ICT
for
On-Farm Water Management


Back- wash Valve
Pressure Gauge
Ventury
Sand Filter
Screen Filter
NRV
By Pass valve
Sand Seprator Hydro-Cyclone
Pump
Air Valve
Well
Main Line
NRV
Ball Valves
Lateral Flush Valve
Dripper/Emitter
End Stop
Flush valve
Polytube / Lateral
Submain Line

# MICRO IRRIGATION PAYS: WEF NEXUS

## Experiences of APMIP

I. Total Area Covered : 1.0427 m ha
- a) Drip : 0.7617 m ha
- b) Sprinkler : 0.2810 m ha

II. MI system cost
- a) Total : Rs 41,708 Million
- b) Farmers contribution : Rs 10,427 Million

III. Annual cost (CRF 0.2055) based on
- a) Total cost : Rs 8,571 Million
- b) Farmers contribution : Rs 2,143 Million

IV. Additional yield

@Rs 15,000/ha minimum : Rs 15,640 Million

V. Payback period based (II/IV)
- a) Total cost : 2.7 years
- b) Farmers contribution : 0.7 year

VI. Every rupee on MI yields (IV/III)
- a) Total annual cost : Rs 1.8
- b) Farmers annual cost : Rs 7.3

Additional benefits

a. Water saving : 149 TMC

b. Energy saving: 417 million unit

c. Labor saving

d. Employment avenue

# WG WEF-N
# International Workshops


BALI, 2019


ADELAIDE, 2022

VIZAG, 2023

# Out come of 3 International Workshops

ICID Working Group on WEF Nexus conducted three international workshops in 2019 in Bali, Indonesia, in 2022 in Adelaide, Australia and in Vizag, India in 2023. In these workshops, the Working Group focused on the following issues as part of its mandate:

- Water-Energy-Food–nexus at field, regional and country scales.
- Quantification of the Water security Index, Energy Security Index, Food security Index and the overall WEF Index.
- The trade-offs between the WEF nexus elements
- The spatial distribution of WEF Index across the scales (local, region, state, and country)
- Socio-Economic analysis of the nexus application.
- Management practices that promote the Nexus.
- Institutional and Governance issues in implementing the Nexus.
- WEF Nexus application and benefit at trans-boundary scale
- Quantifying the climate change impact on the WEF Nexus
- WEF Nexus impact on the Societies, Environment, and the Ecosystem.

Webinar on

# ‘Application of Models in the WEF-Nexus’

held on line on 11th April 2024

| S.No | Topic | Presented by |
|---|---|---|
| 1 | Development and Application of Water Energy Food Nexus Model | Rajendra Singh, Professor IIT, Kharagpur, India  |
| 2 | The integrative analytical WEF Nexus model: Its Applications and Derivatives | Luxon Nhamo, Sylyster Mpandeli et al, WRC, South Africa  |
| 3 | Integrated Modelling for Addressing WEF-Nexus | Alok Sikka & Nexus Gains India Team, IWMI  |

- The Webinar was chaired by PH Prof Ragab
- More than 170 participants have attended
- The presentations and recording of webinar available on ICID website

# WEF Nexus Tools/Models

## 46 WEF Nexus Tools/Models (Taguta et al., 2022)

- Developed between 2009-2021
- 61% Unreachable to the intended users
- 70% Lack key capabilities like GIS integration and scale transferability
- Only 28% have been applied by multiple-users

**MuSIASEM** (Giampietro et al., 2009)

**WEAP-LEAP** (SEI, 2012)

**WEF Nexus tool 2.0** (Daher and Mohtar, 2015)

**Pardee RAND WEF Security Index** (Willis et al., 2016)

**Q-Nexus** (Karnib, 2017)

**SIM4NEXUS** (Susnik et al., 2018)

**WEF Nexus Index** (Simpson et al., 2020)

**NeFEW** (Sadegh et al., 2020)

**WEF Nexus Discovery Map** (Arenas et al., 2021)

**Only Country/National Scale**

**No GIS Interface**

**Water & Energy Centric**

# Model Framework

Model Development

Food security related data

Water security related data

Energy security related data

Water Module
Output: Water Subindex, Accessibility, Availability

Food Module
Output: Food Subindex, Accessibility, Availability

Energy Module
Output: Energy Subindex, Accessibility, Availability

WEF Nexus Model

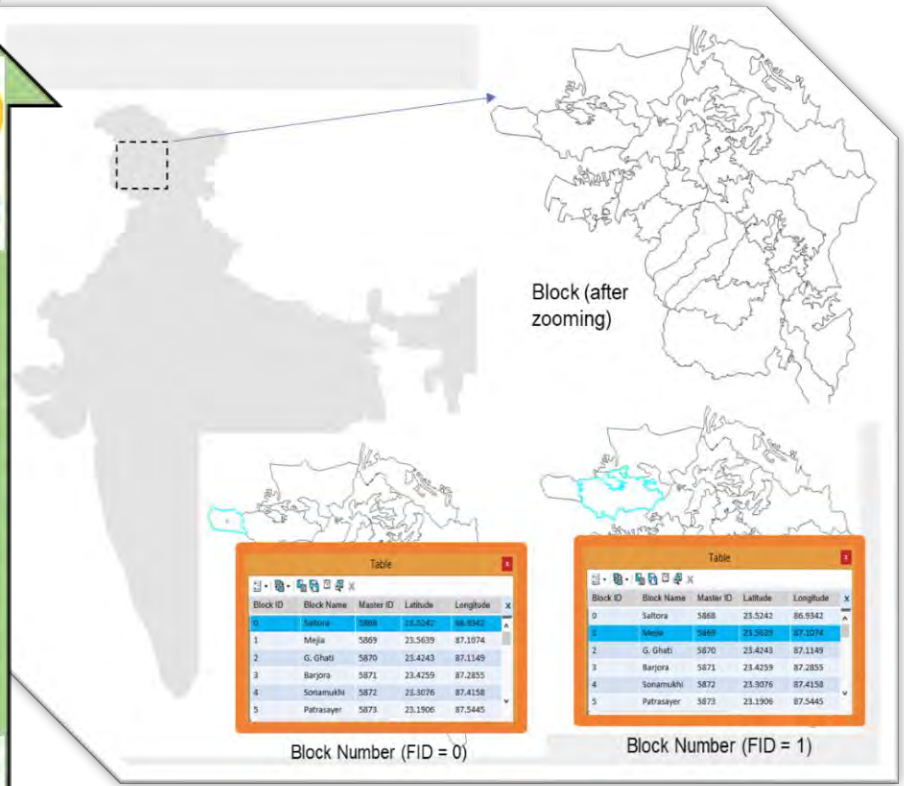
Water-Energy-Food nexus index

Validation of model outputs (Spearman's ρ)

Database Development

Python & MySQL

Model Development




Modified Pardee RAND WEF Nexus Index

RSGISLib (Python Module) for RS and GIS

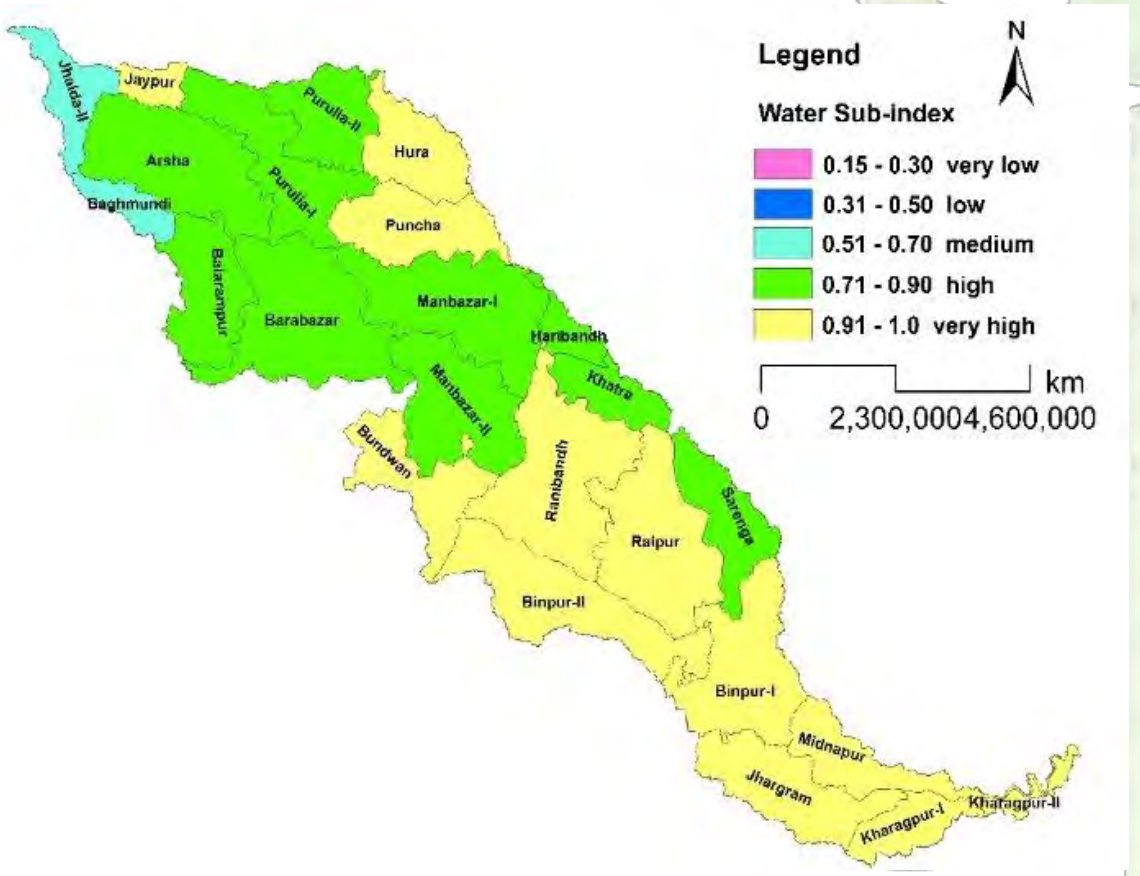
# GUI of Developed WEF Nexus model

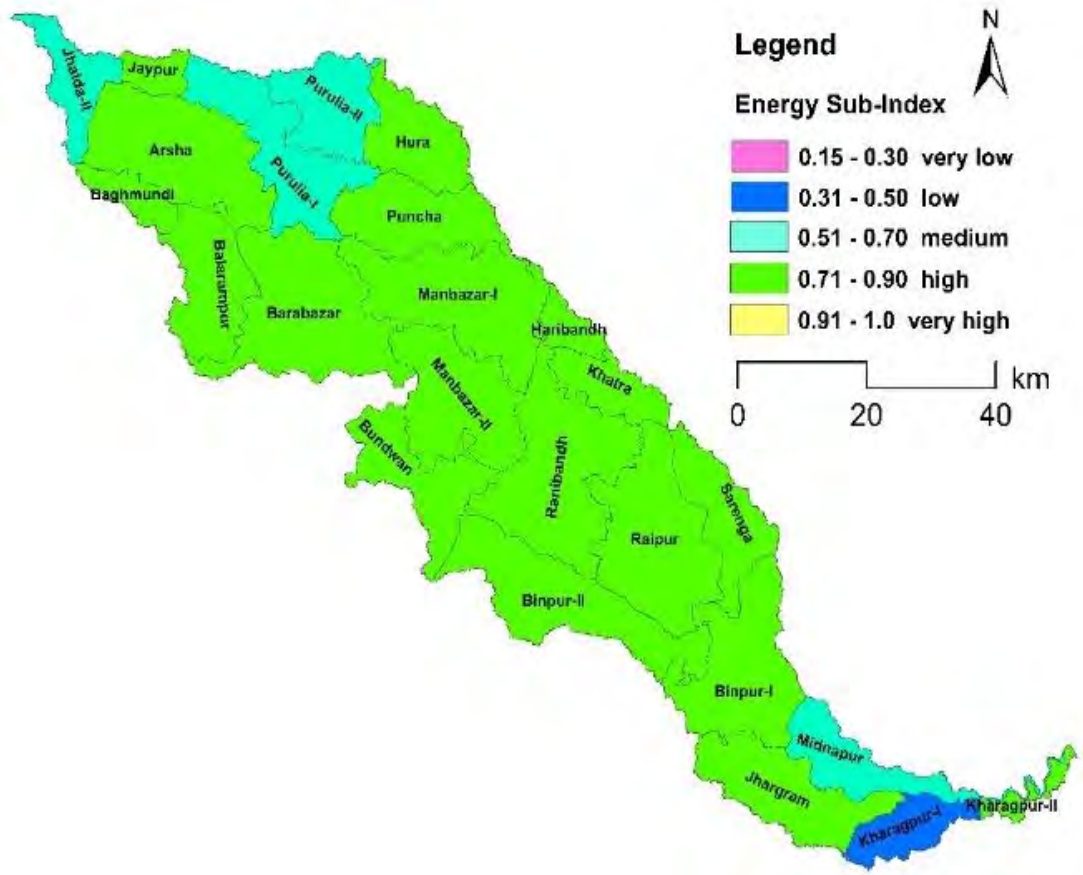

(a) Start Window

Results

# Model Testing at the Basin and Sub-National Scales

## Testing at the Basin Scale



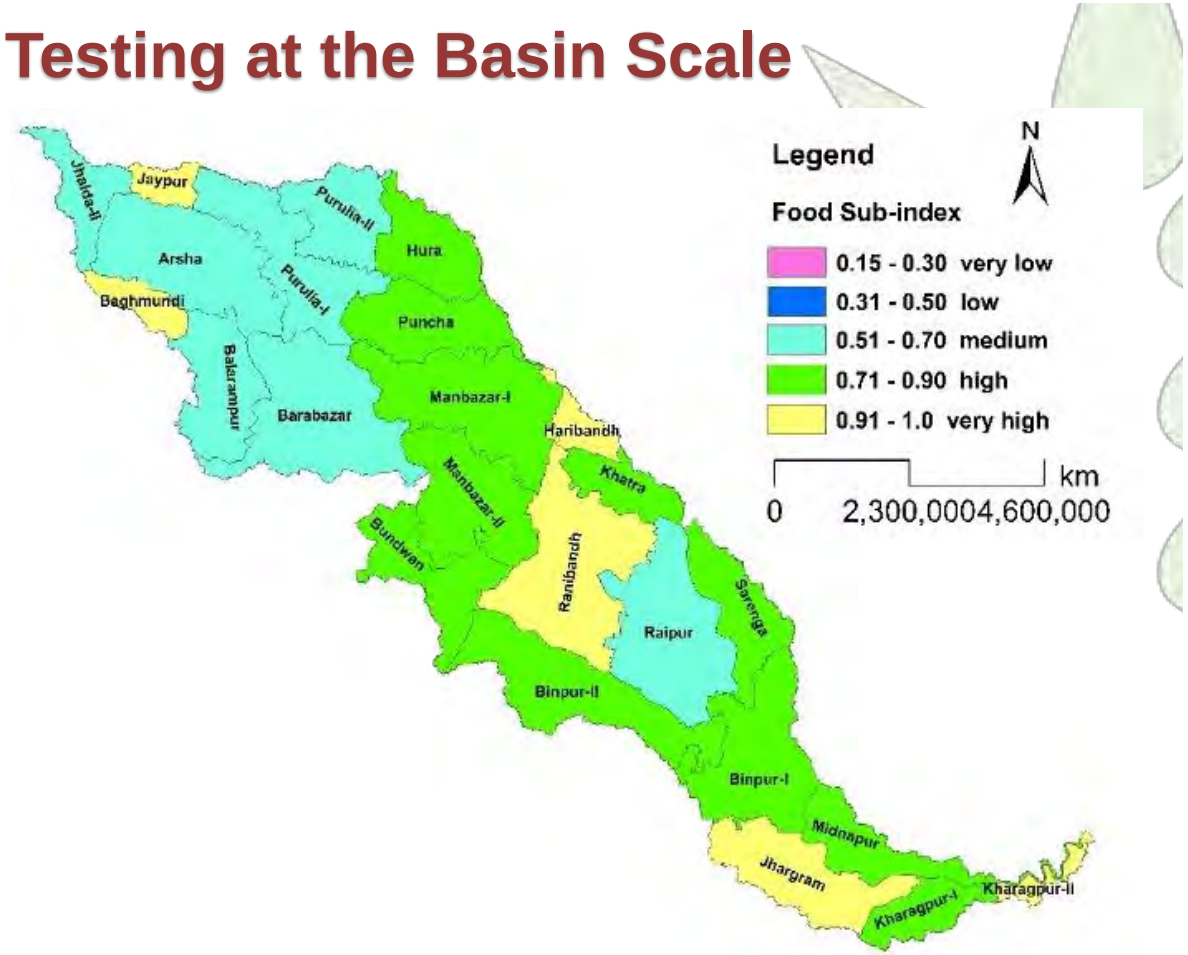

- Water Sub-index varies from medium to very high
- 92% blocks have a high to very high WSI

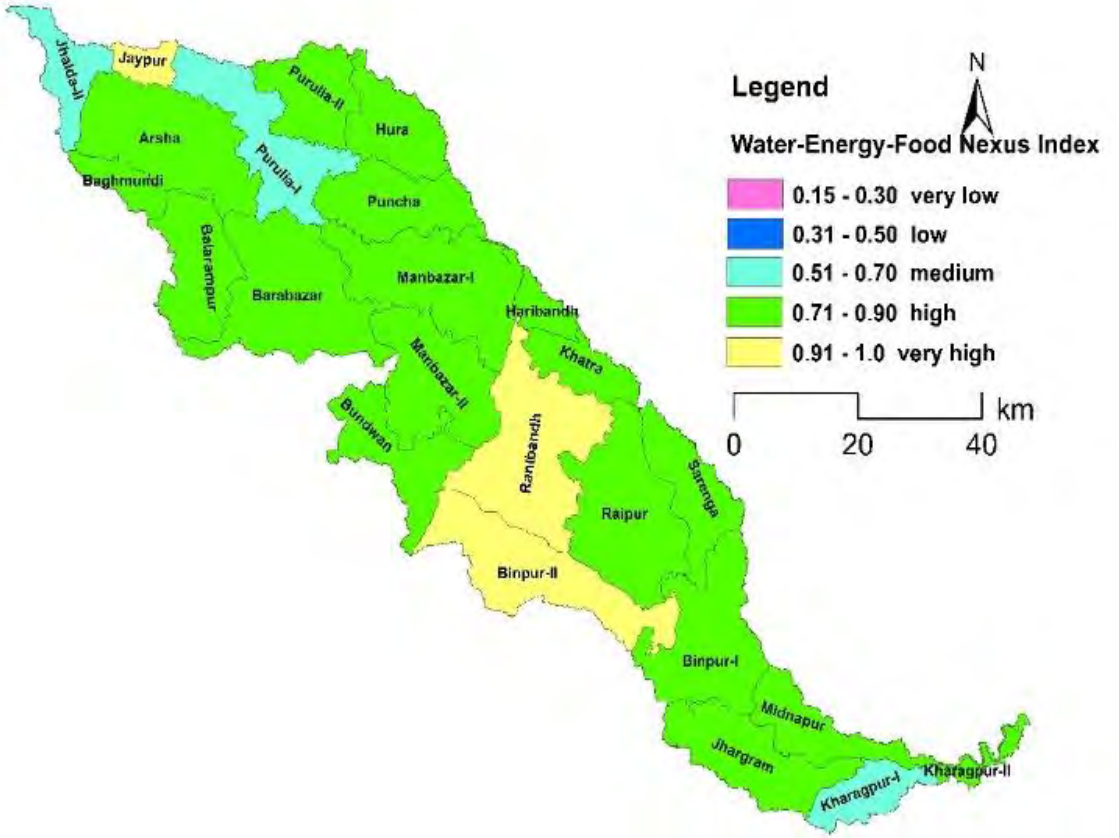
- Energy sub-index varies from low to high
- 79% blocks have a high ESI

Results

# Model Testing at the Basin and Sub-National Scales

## Testing at the Basin Scale



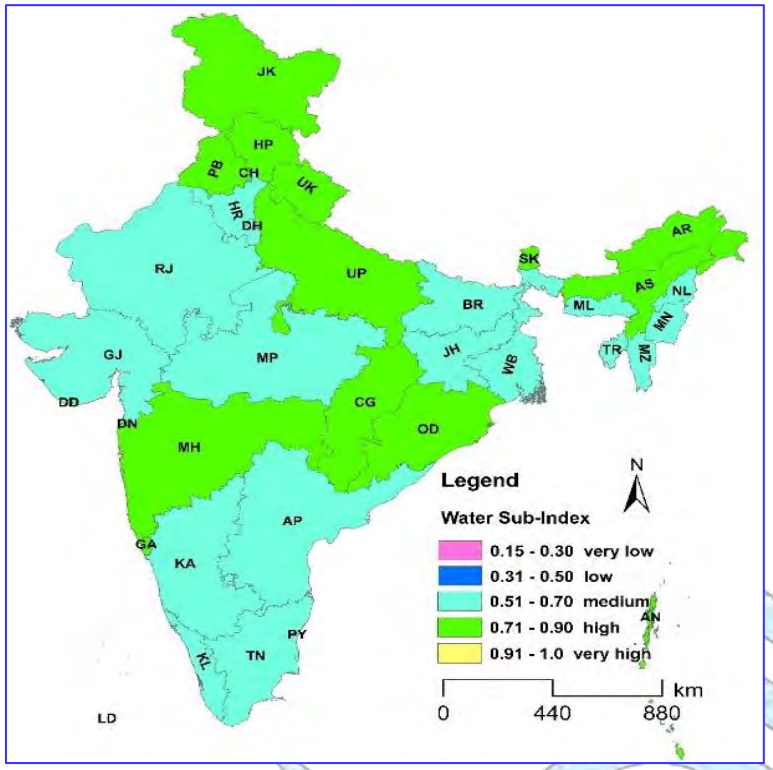

- Food Sub-index also varies from medium to very high
- 70% blocks have a high to very high FSI

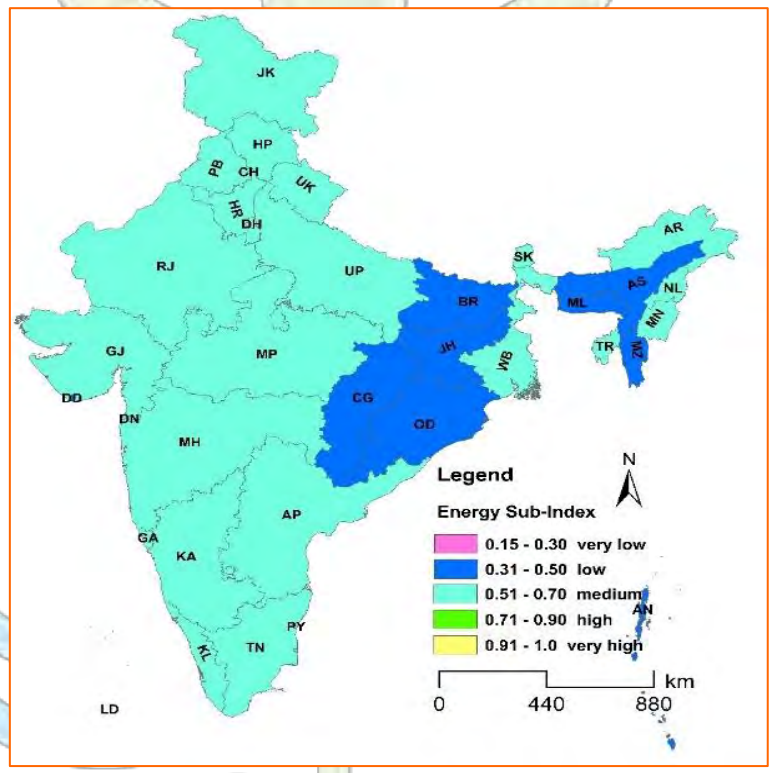
- 75% blocks have a high to very high WEFNI
- Since all blocks have water, energy and food sub-indices greater than 0.50, it shows that the blocks are on the path to achieving WEF security

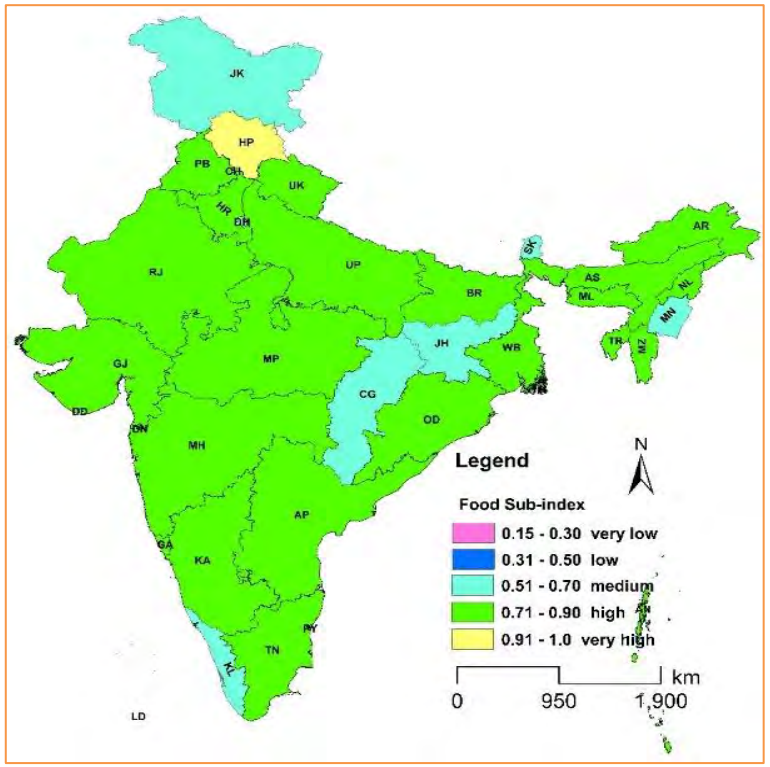
Results

# Model Testing at the Basin and Sub-National Scales

## Testing at Sub-National Scale




- Water Sub-index varies from medium to high
- 57% of States/UTs have medium WSI, and 40% have high WSI

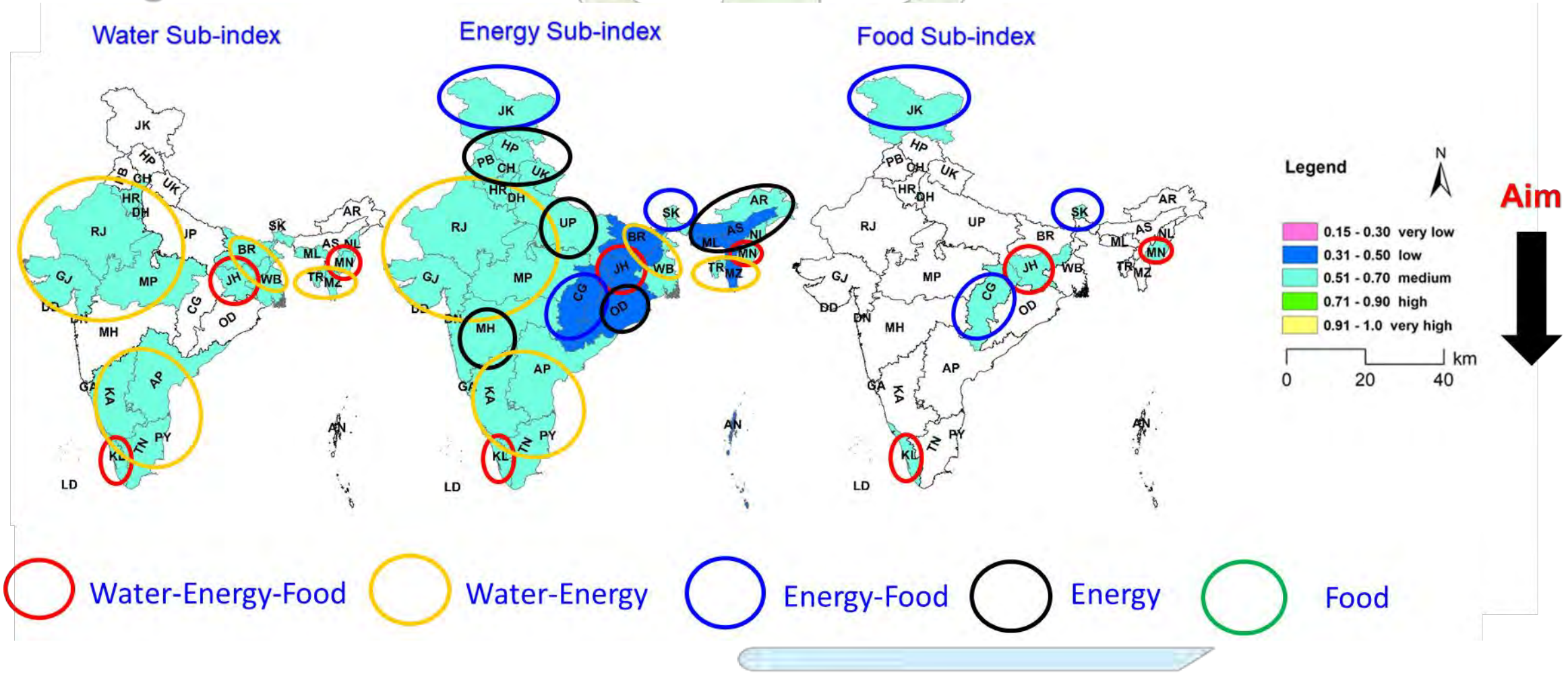
- Energy Sub-index ranges from low to medium
- 71% of States/UTs have medium ESI

- Food Sub-index varies from medium to very high
- 80% of States/UTs have a high FSI

Policy Intervention Needs

# Model Testing at the Basin and Sub-National Scales

## Testing at Sub-National Scale



# Benefits of WEF Nexus Implementation

a) at field level include,

- improvements in water productivity, better agronomic and engineering management, improved energy use efficiency,
- improved agriculture water management, e.g. rain water harvesting and soil water conservation technologies, improved crop varieties with high water use efficiency and
- improved agronomic practices, e.g. intercropping, micro-irrigation systems (drip and sub-surface irrigation) in place of macro-irrigation systems (overhead and sprinkler type irrigation) and practicing deficit irrigation to increase water productivity.
- These are important in achieving SDGs 2, 6, 12, 13 and 15.

b) At national level, the benefits of the nexus implementation include

- adopting more holistic approach in planning: e.g. if the national targets is to increase area under irrigation, then the plan should ensure matching available water and energy resources. In addition, the integrating plan will require investments in efficient irrigation schemes for enhanced economic development, resilient food systems and strengthening farmers' capability to adapt to climate variability and change and promote the cultivation of less water consuming crops suitable to local environments.

# WEF-Nexus in WWF10 Bali




World Water Forum10, 9-25 May 2024, Bali.
Organized WEF-Nexus Side Event as ICID Initiative.

# ICID Young Professional Trainings/Workshops

# Way Forward

- Sustainable water management under CC will require integrated approach to help increase yields while optimising water, land, and energy use efficiencies and environmental wellbeing.
- WEF nexus framework is important to understand and analyse trade-offs and synergies of interconnected WEF system
- It calls for transformative and systems approach.
- We need to think and act beyond the water to manage water judiciously

# Links for Contributions of WG WEF-N

Papers: International Workshop on Water-Energy-Food-Nexus: Implementation and Examples of Application, Adelaide, Australia, 2022 - https://icid-ciid.org/icid_data_web/Workshop_WFEN2022.pdf

Publication: Circular and Transformative Economy - Advances Towards Sustainable Socio-economic Transformation
Edited By: Luxon Nhamo, Sylvester Mpandeli, Stanley Liphadzi, Tafadzwanashe Mabhaudhi
https://www.taylorfrancis.com/books/oa-edit/10.1201/9781003327615/circular-transformative-economy-sylvester-mpandeli-stanley-liphadzi-tafadzwanashe-mabhaudhi-luxon-nhamo

World Water Policy Special Issue on Coping with Water Scarcity: New Advances in Africa and Beyond, Volume 9, Number 4, November 2023
Guest Editors: Ragab Ragab; Nadine Depre
https://onlinelibrary.wiley.com/toc/2639541x/2023/9/4

Report on Advances in Water Saving Methods
https://icid-ciid.org/icid_data_web/25CongWorkshop-ReportNewAdva

THANK YOU


thank you!