International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

science for global insight

Land-Energy-Water Nexus:
An overview of IIASA and new partnership with the Ministry of Environment, Forests, and Climate Change, Govt. of India

Simon Parkinson
International Institute for Applied Systems Analysis

International Institute for Applied Systems Analysis
IIASA

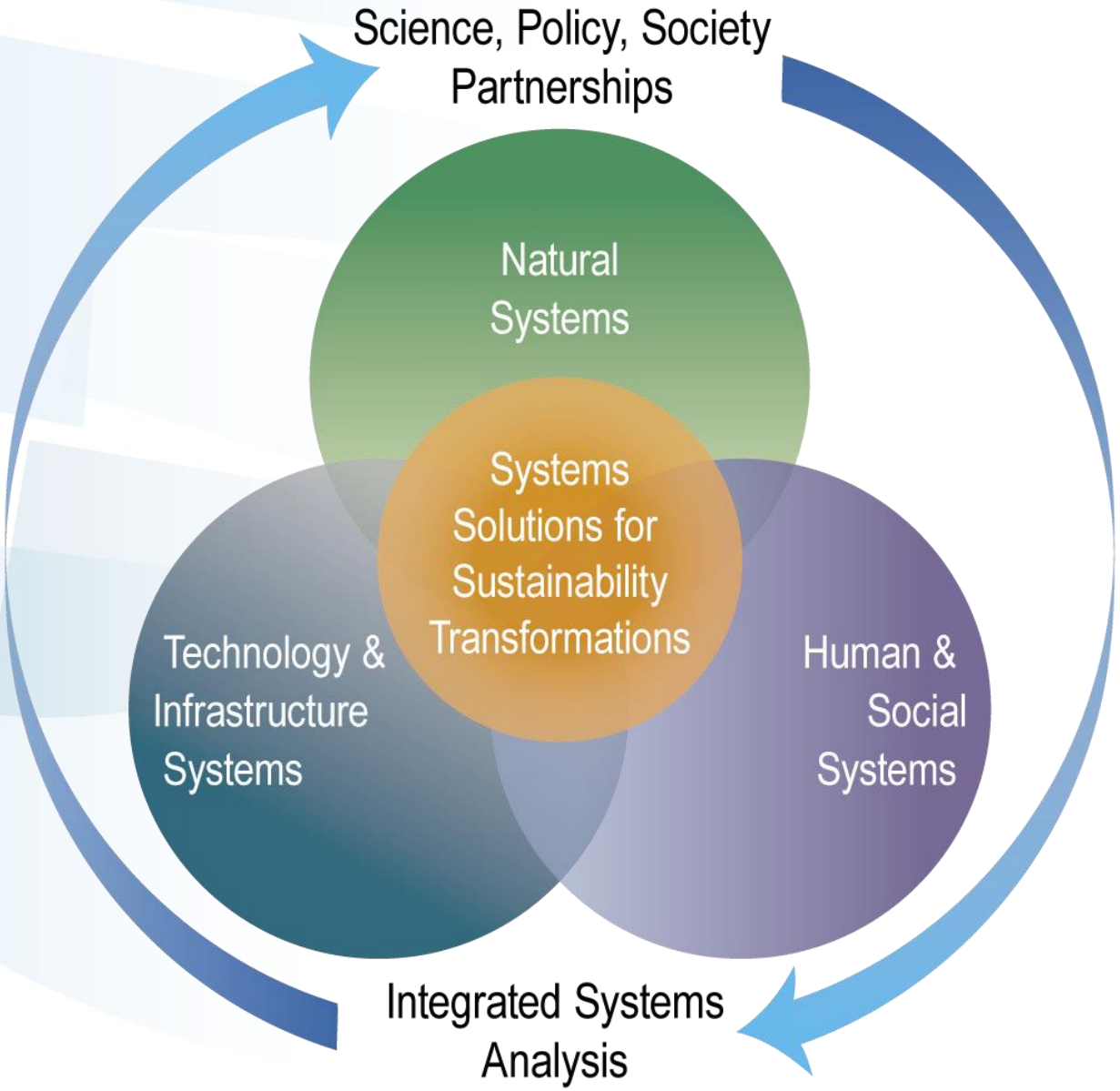
University of Victoria

UNCCD COP14 Side Event, Sept 12, 2019
Greater Noida, India

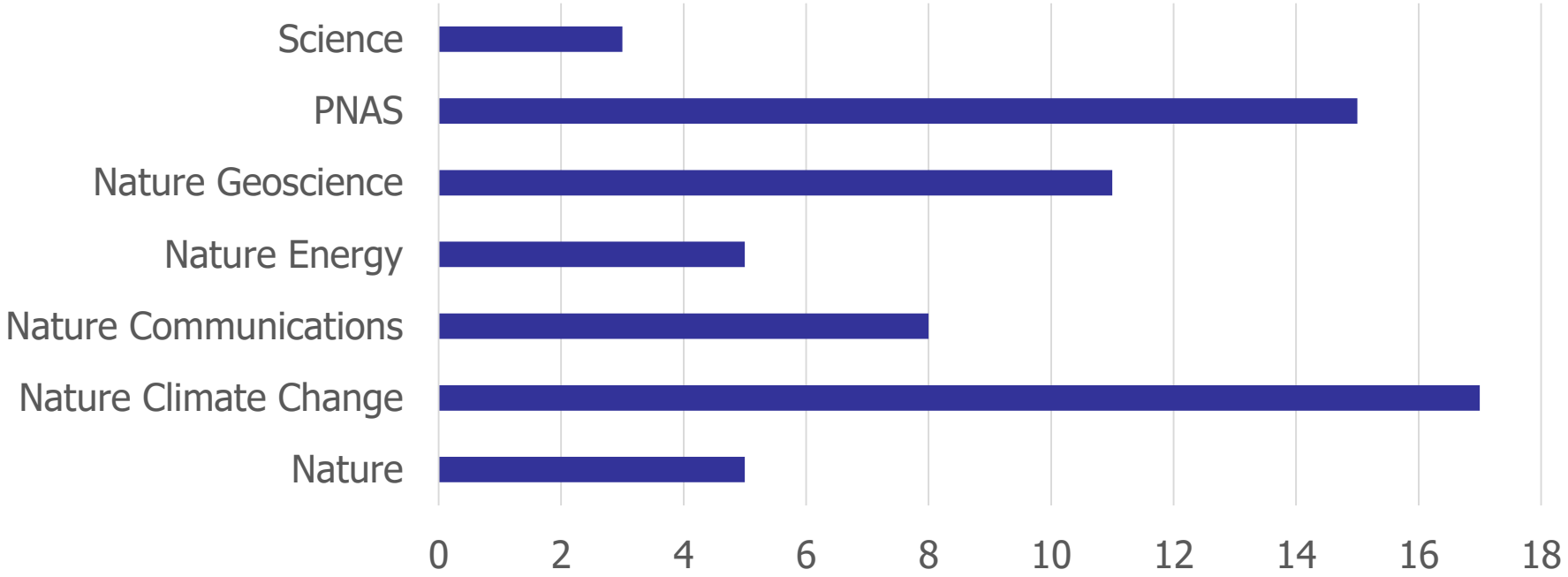
What is IIASA?

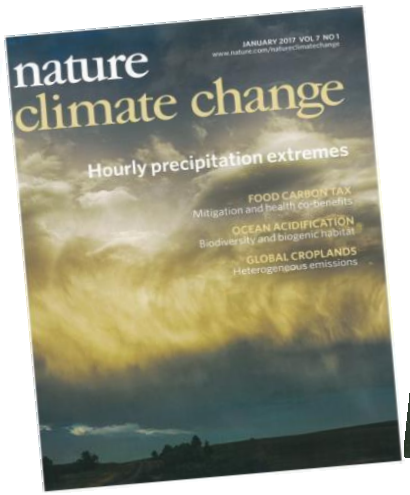
- Established in 1972 near Vienna, Austria, as a **bridge between East and West**, science diplomacy
- Today: International, independent, interdisciplinary research on **major global problems**
- Solution oriented**, integrated systems analysis** into the issues of sustainability and global transformation
- Dimensions: energy, land use, climate, air quality, technology, biodiversity, food, demography, natural hazards
- Currently **25 member countries**

Integrated Systems Analysis for Policy Advice



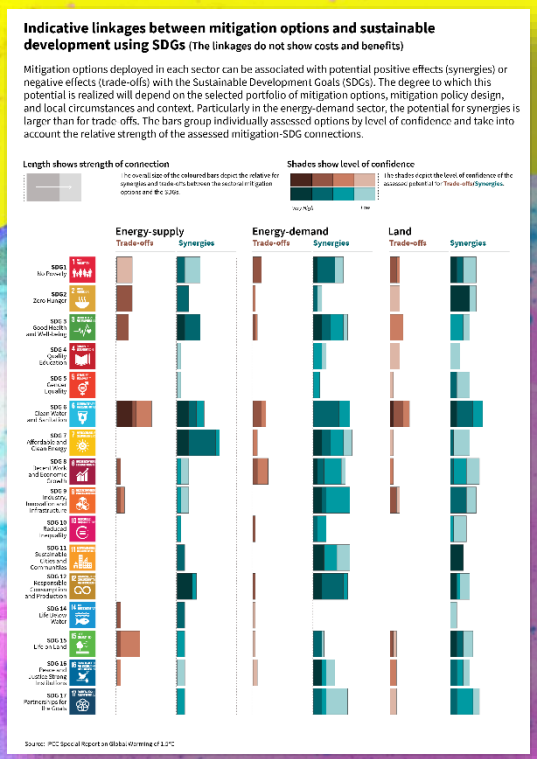
High-impact Publications 2017-18



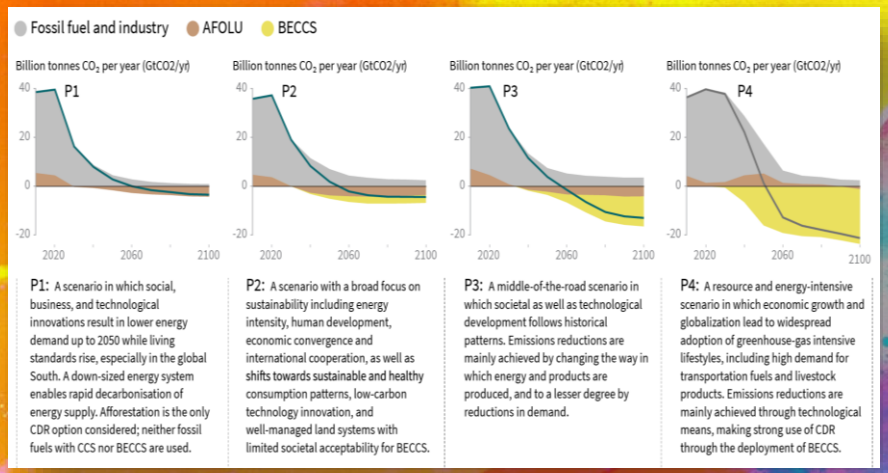


IIASA & IPCC Report on 1.5C

SDG implications coordinated by IIASA



Two out of four IPCC pathways from IIASA



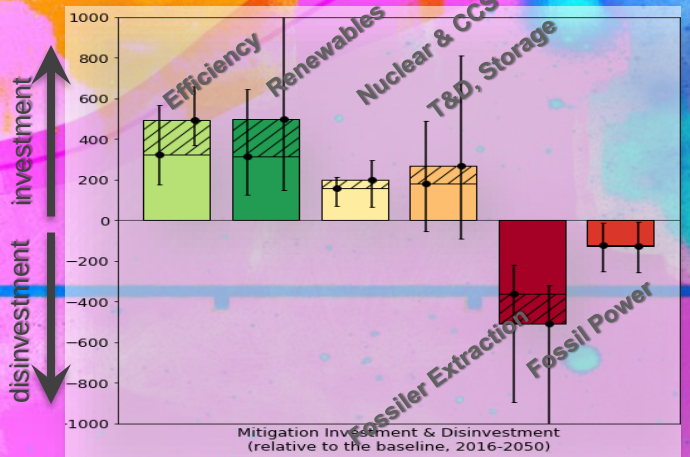
P1: A scenario in which social, business, and technological innovations result in lower energy demand up to 2050 while living standards rise, especially in the global South. A down-sized energy system enables rapid decarbonisation of energy supply. Afforestation is the only CDR option considered; neither fossil fuels with CCS nor BECCS are used.

P2: A scenario with a broad focus on sustainability including energy intensity, human development, economic convergence and international cooperation, as well as shifts towards sustainable and healthy consumption patterns, low-carbon technology innovation, and well-managed land systems with limited societal acceptability for BECCS.

P3: A middle-of-the-road scenario in which societal as well as technological development follows historical patterns. Emissions reductions are mainly achieved by changing the way in which energy and products are produced, and to a lesser degree by reductions in demand.

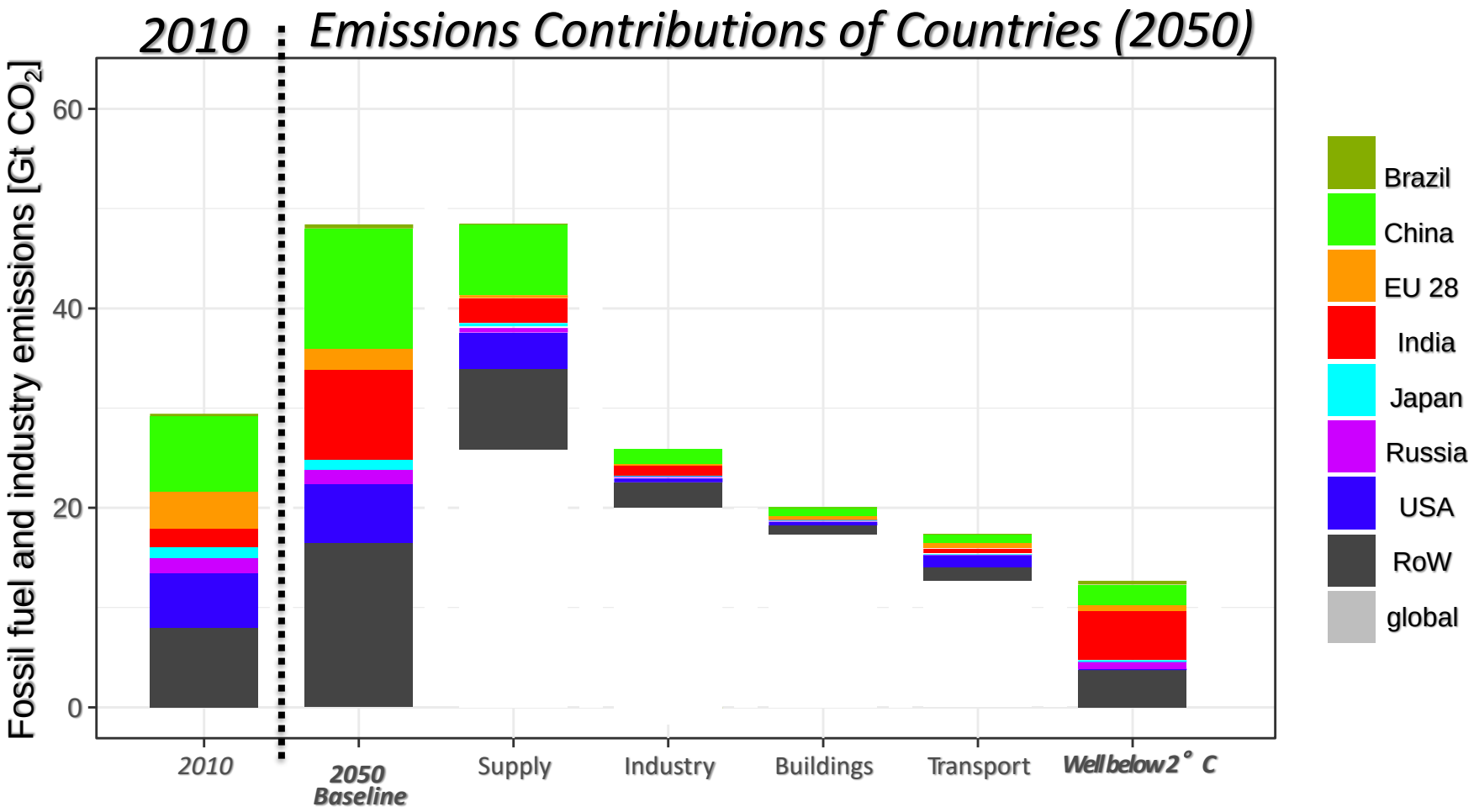
P4: A resource and energy-intensive scenario in which economic growth and globalization lead to widespread adoption of greenhouse-gas intensive lifestyles, including high demand for transportation fuels and livestock products. Emissions reductions are mainly achieved through technological means, making strong use of CDR through the deployment of BECCS.

Investments coordinated by IIASA



IIASA-IPCC MoU to host the data

Guide the Paris Process through Globally Coherent National Pathways



Source: CD-LINKS

National modelling: IIASA-NITI Aayog Energy model for India

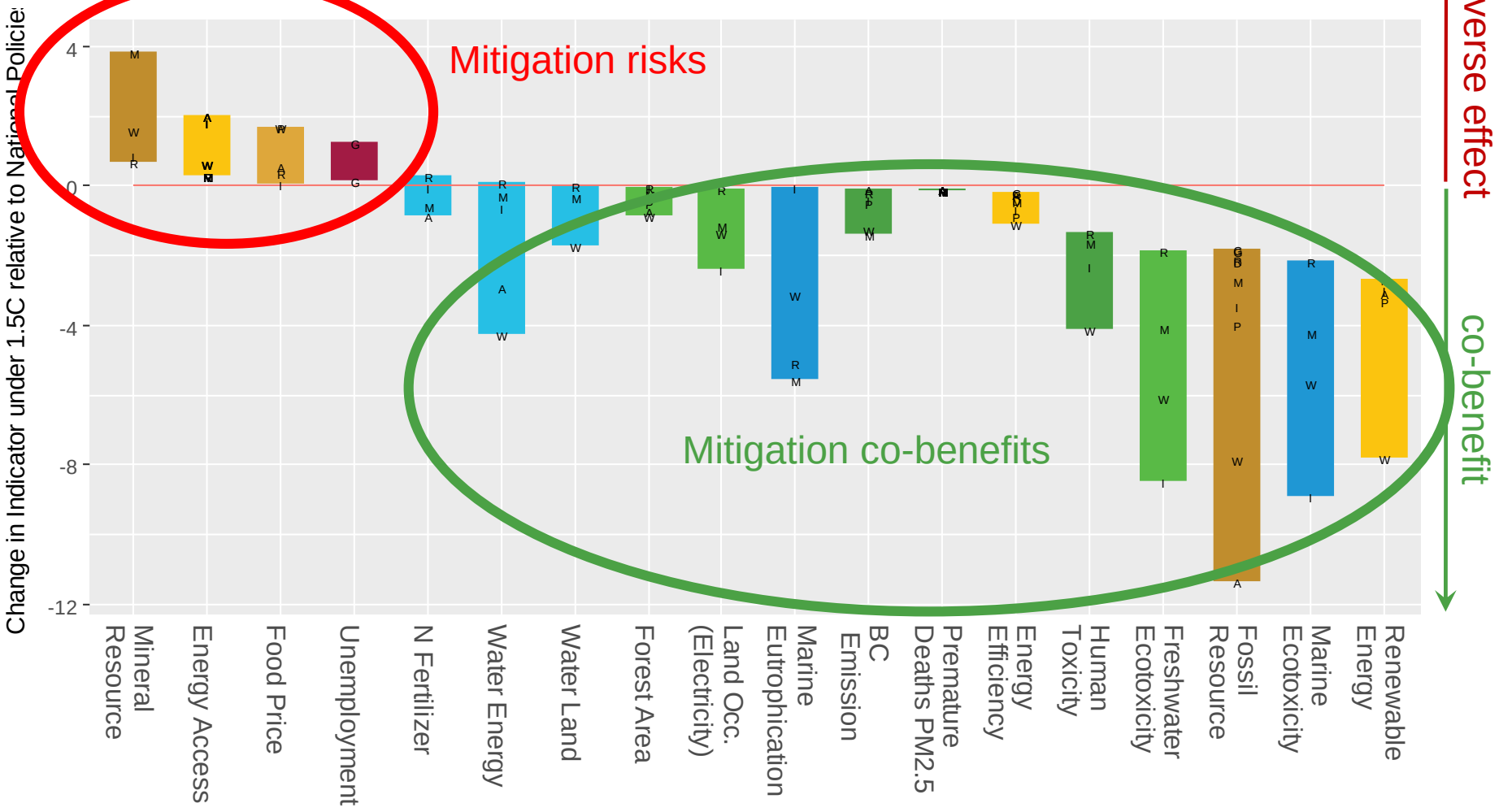
- IIASA-ENE's tools are applied widely for national energy planning
- Launch of the NITI Aayog Energy Model in March 2018
- Elaborate co-design and co-development phase
- Hands-on and on-line training
- Enabled through major investment by NITI into own capacity
- Similar co-development projects in Brazil (r), China (u.d.), Israel (p), South Africa (r), Egypt (p), and other countries..


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

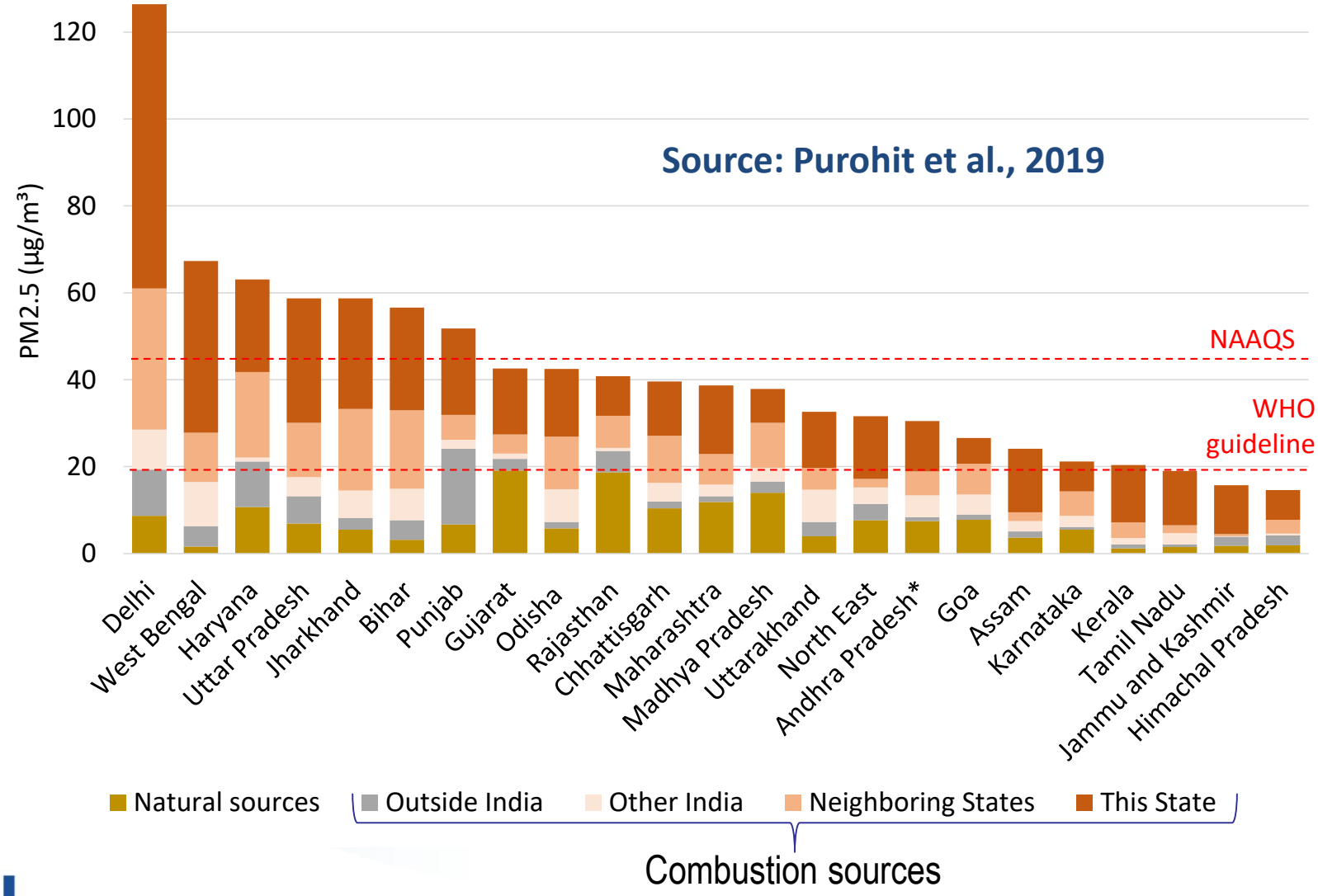
Impacts of Stringent Mitigation on SDGs

INDIA

Krey et al. (submitted) – under embargo, do not cite



Origin of PM2.5 population exposure by State/region in India, 2015

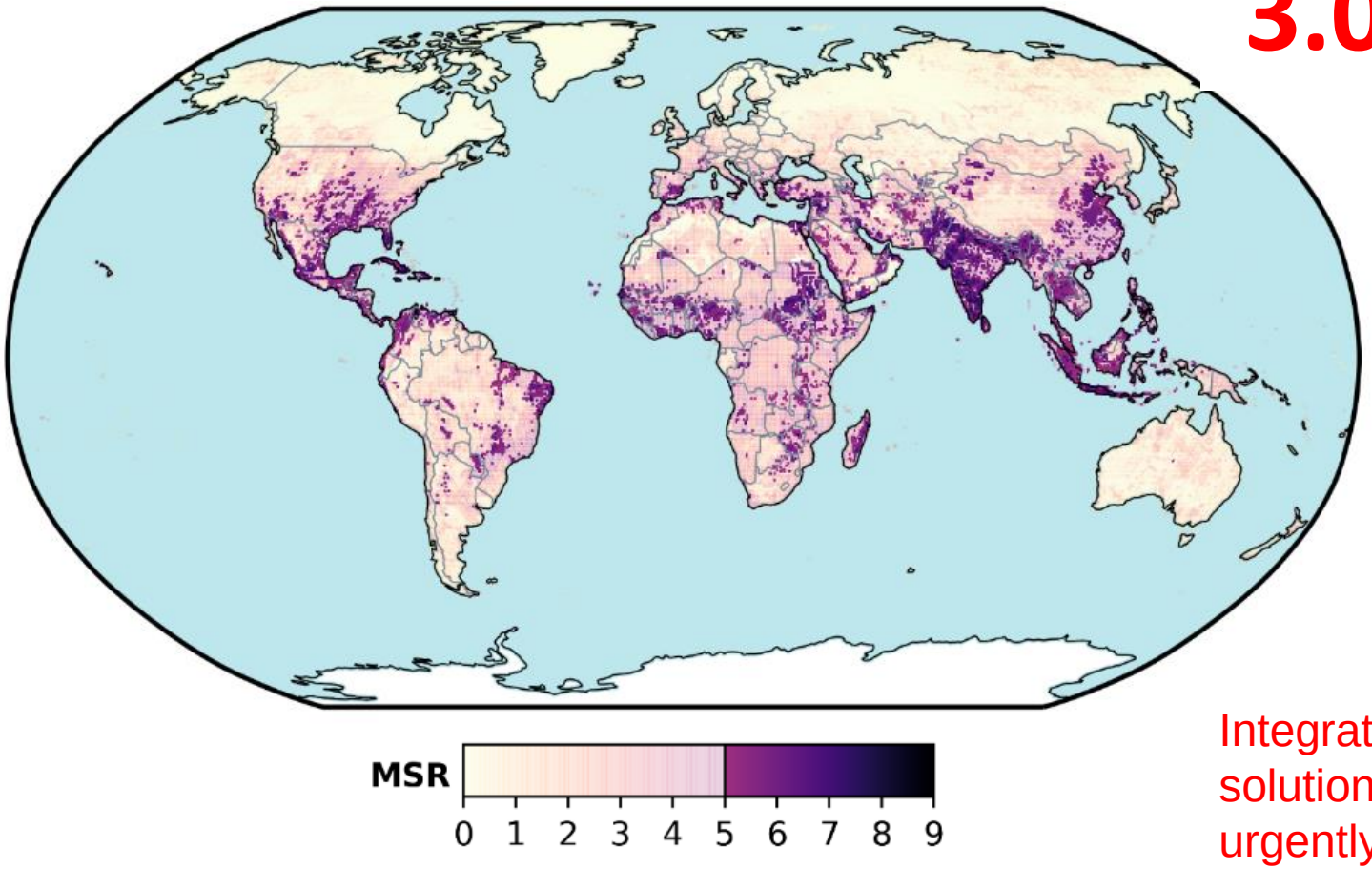


Land-Energy-Water Nexus

Sustainability challenges arising from cross-sector interactions

Hotspots under 1.5, 2 and 3 ˚C climate change

3.0 °C

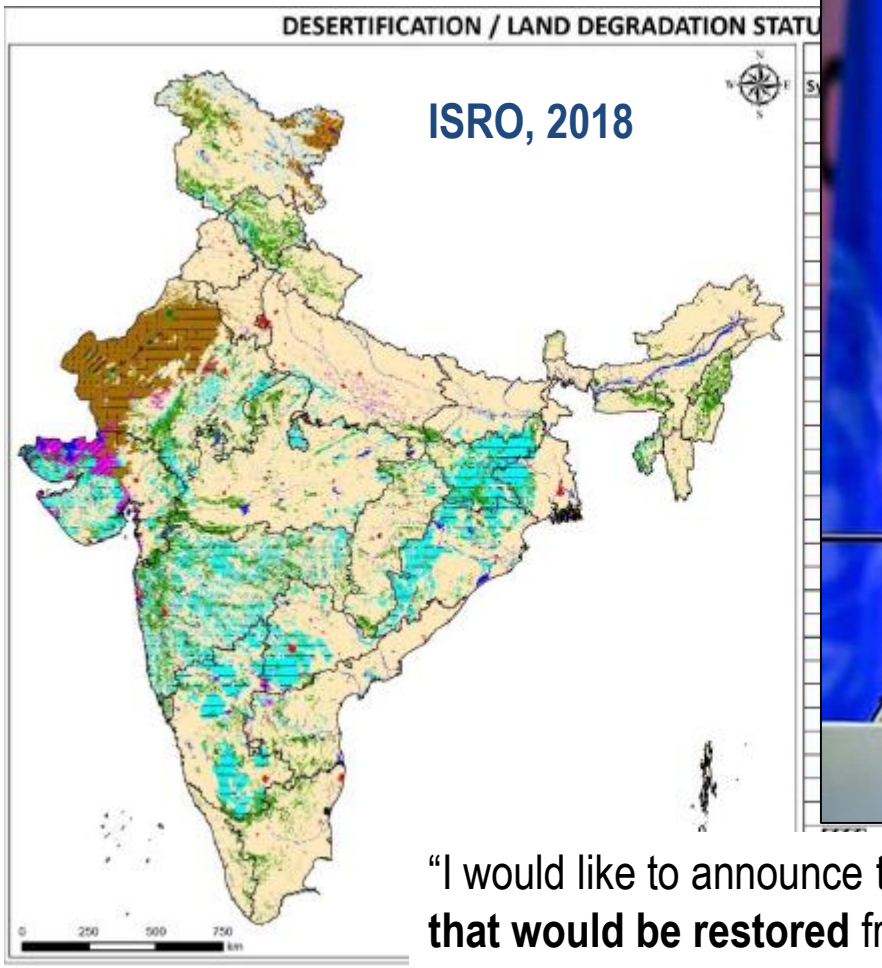


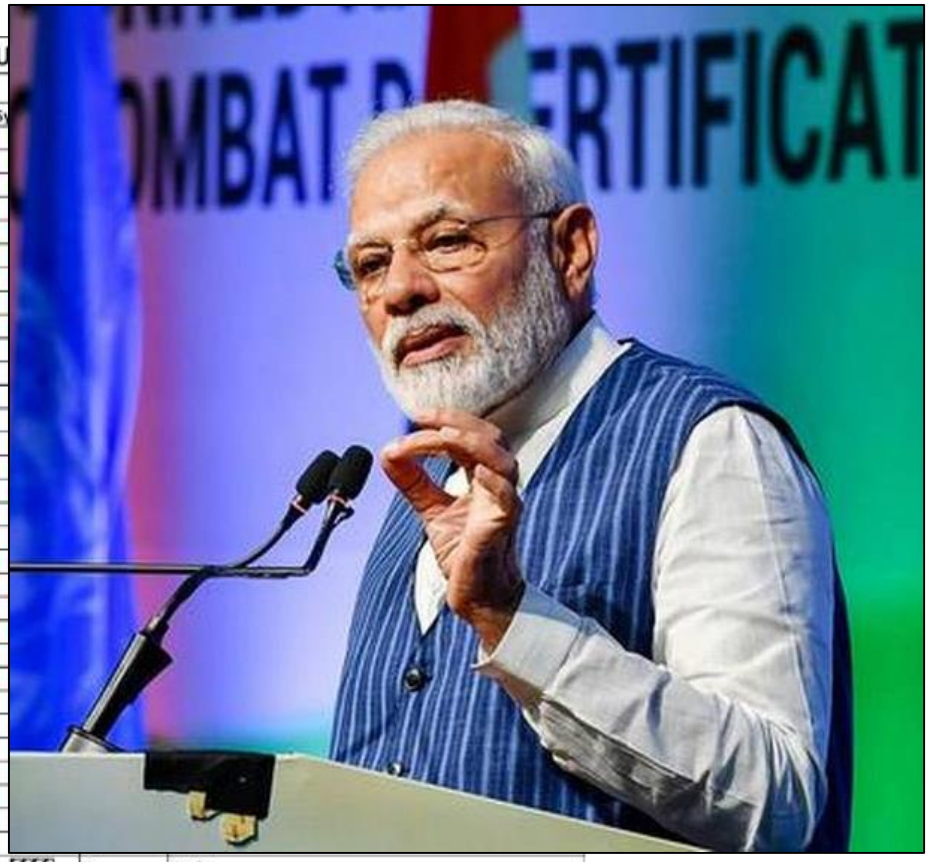
Multi-sector Risk Indicator

Integrated solutions urgently needed to avoid risks

Byers et al. (2018, ERL)

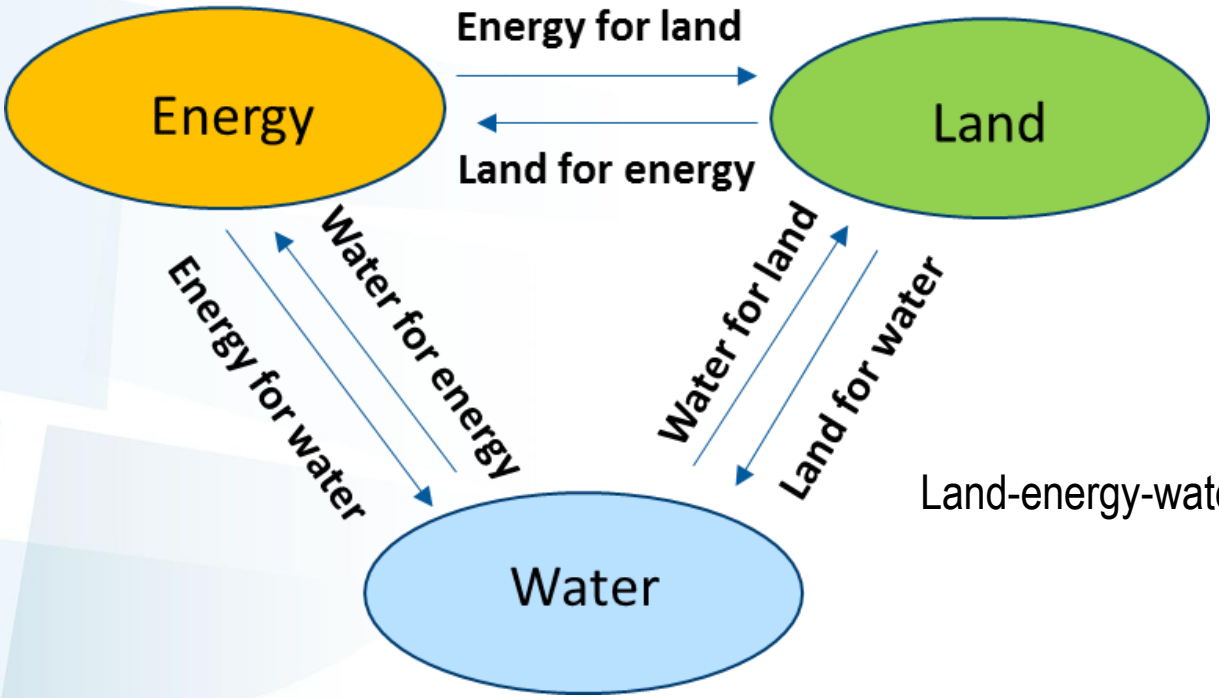
Land restoration policies in India





"I would like to announce that India would raise its ambition of the **total area that would be restored** from its land degradation status, from 21 million hectares **to 26 million hectares between now and 2030**."
[Sept. 9, 2019; UNCCD COP14]

Land policies are linked to energy and water



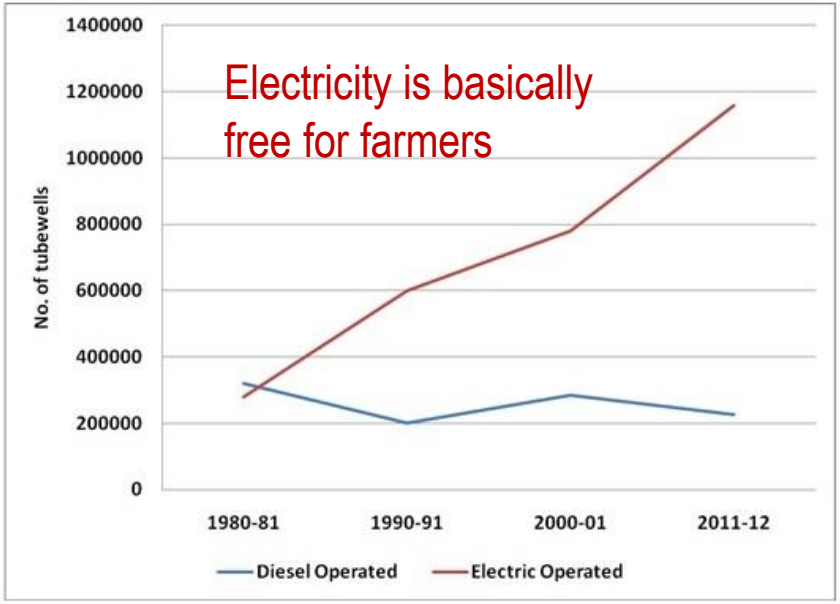
Land-energy-water nexus

How can we **design integrated policies** that **leverage interactions** to improve resource efficiency?

Use an integrated or **nexus approach**

Land-energy-water nexus in India

Growth in groundwater tubewells in Punjab

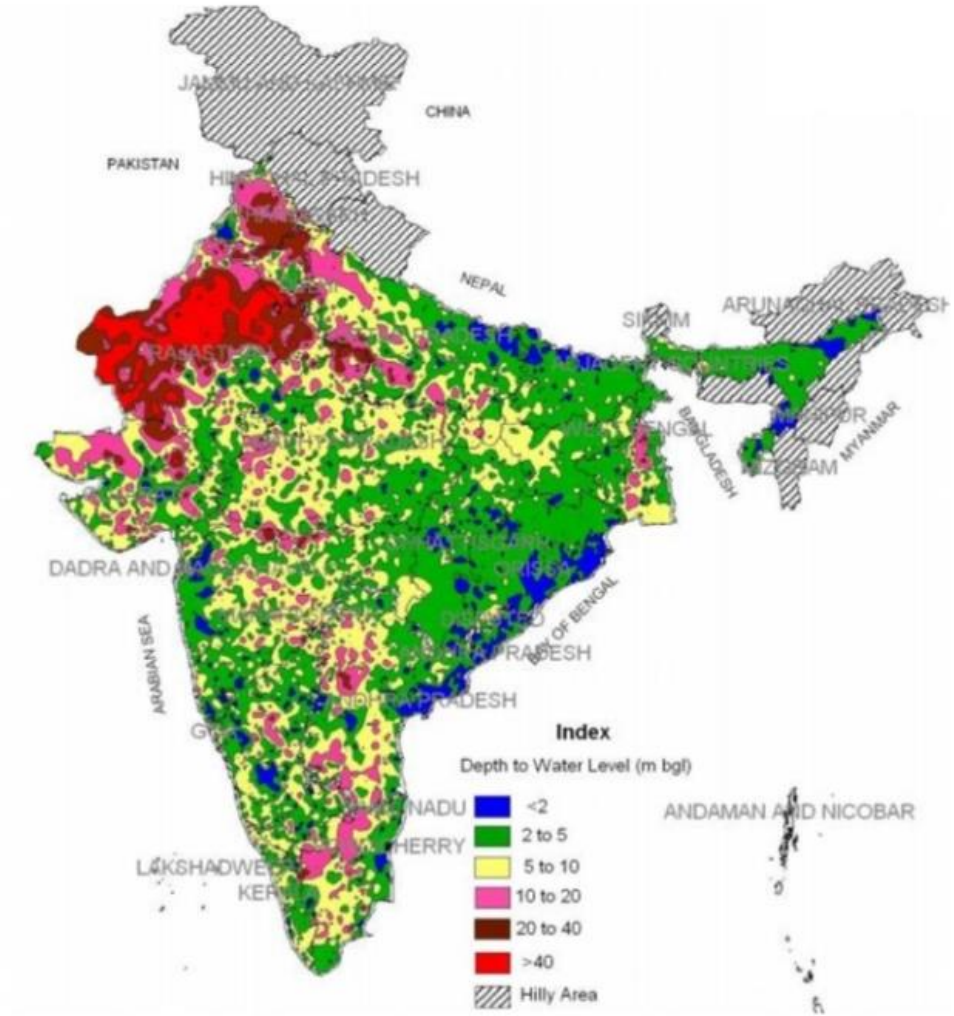


Statistical Abstract of Punjab, 2012

Potential solution

Shift water-intensive crops to regions with lower land productivity but higher water use efficiency and availability

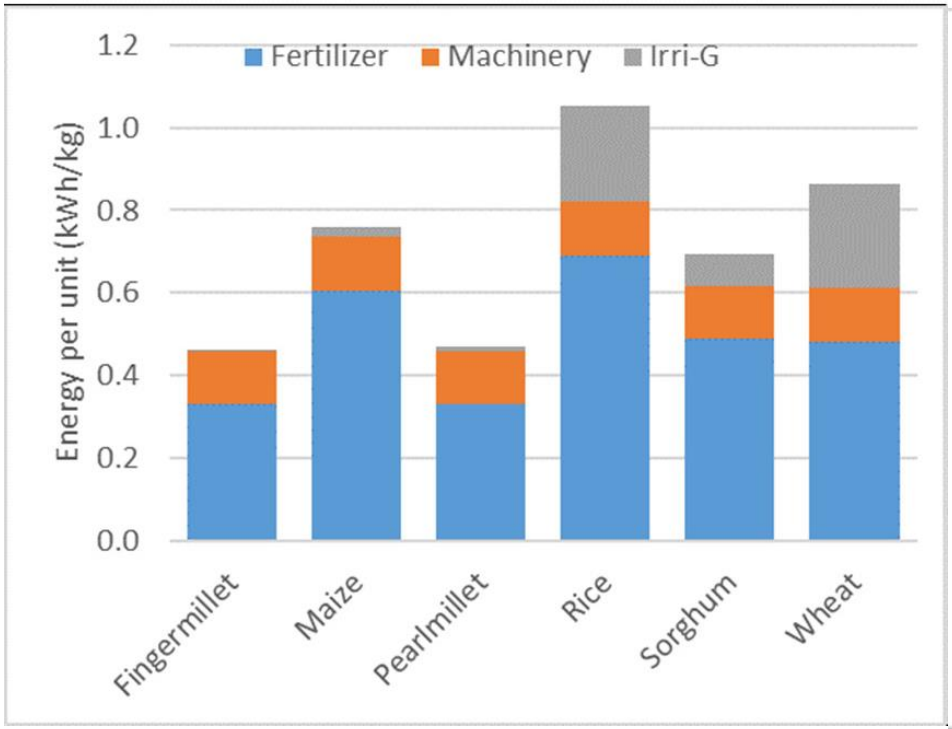
Depth to water level (pre-monsoon, 2014)

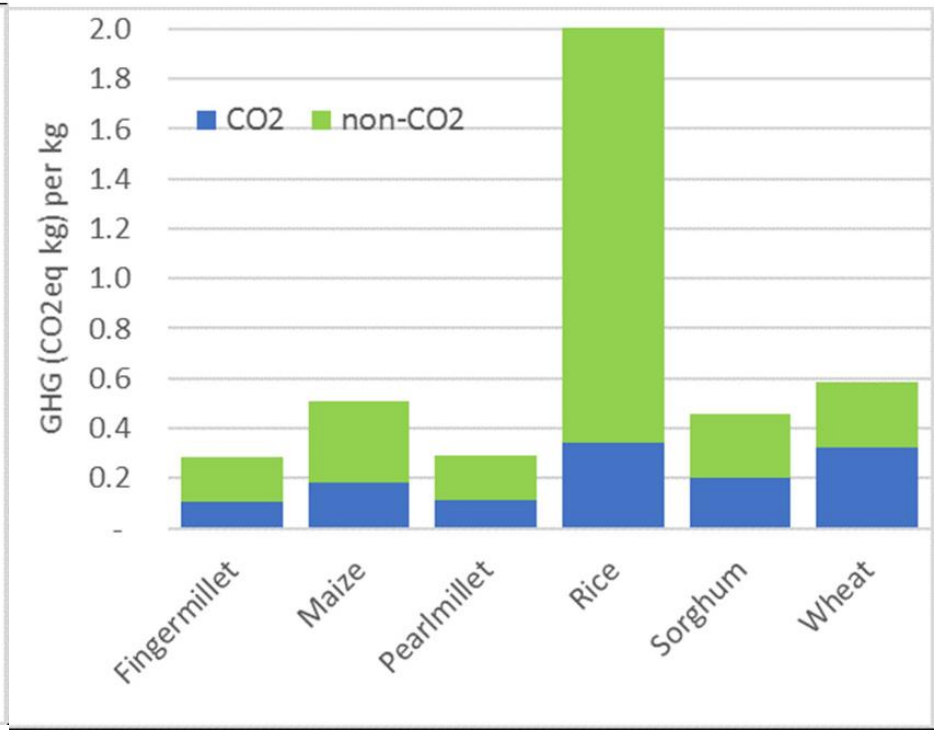


Central Groundwater Board (CGWB)

Land-energy-water nexus

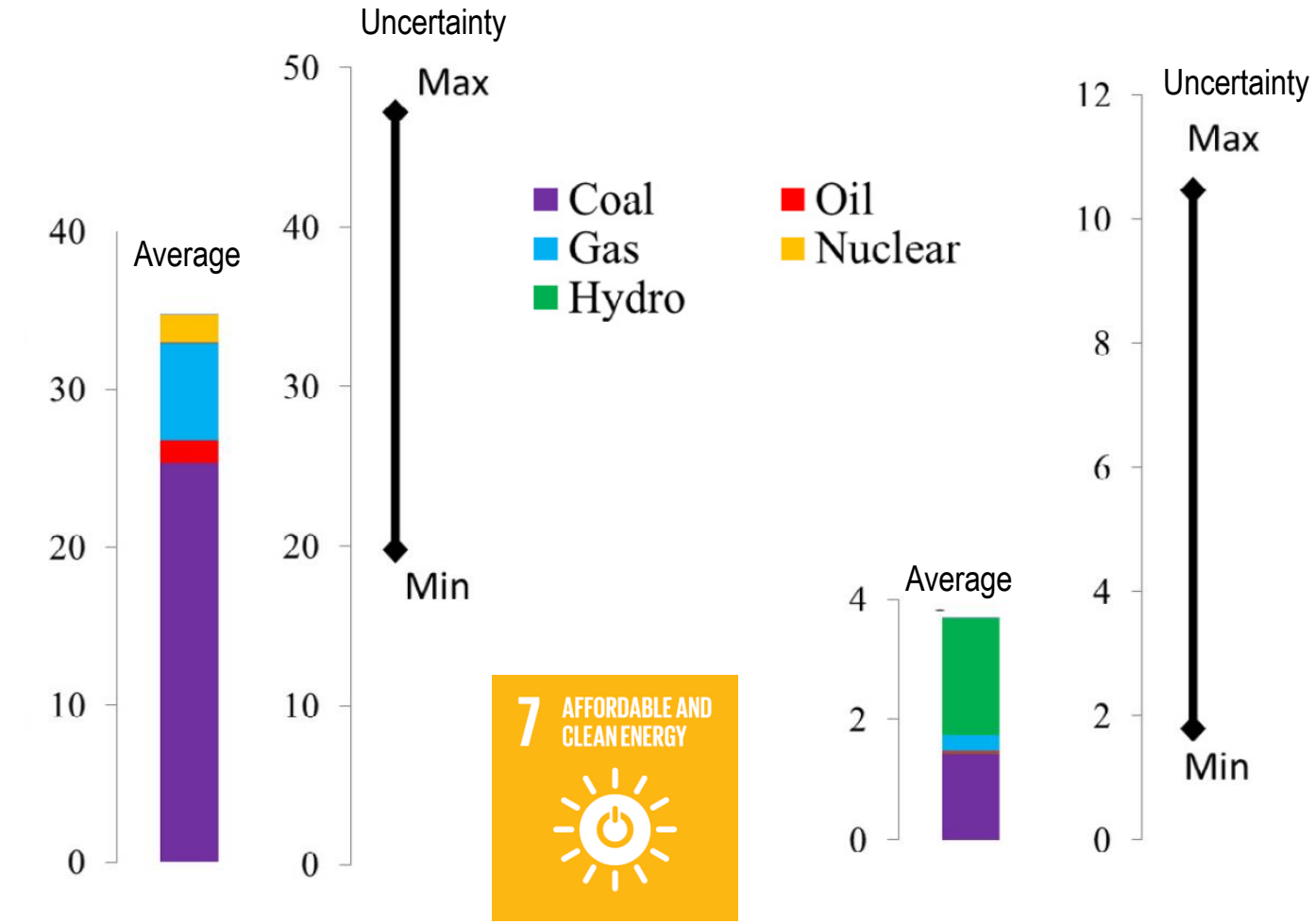
Pumping groundwater impacts CO2 emissions from crop production in India





Rao et al, 2018

Water for power in India

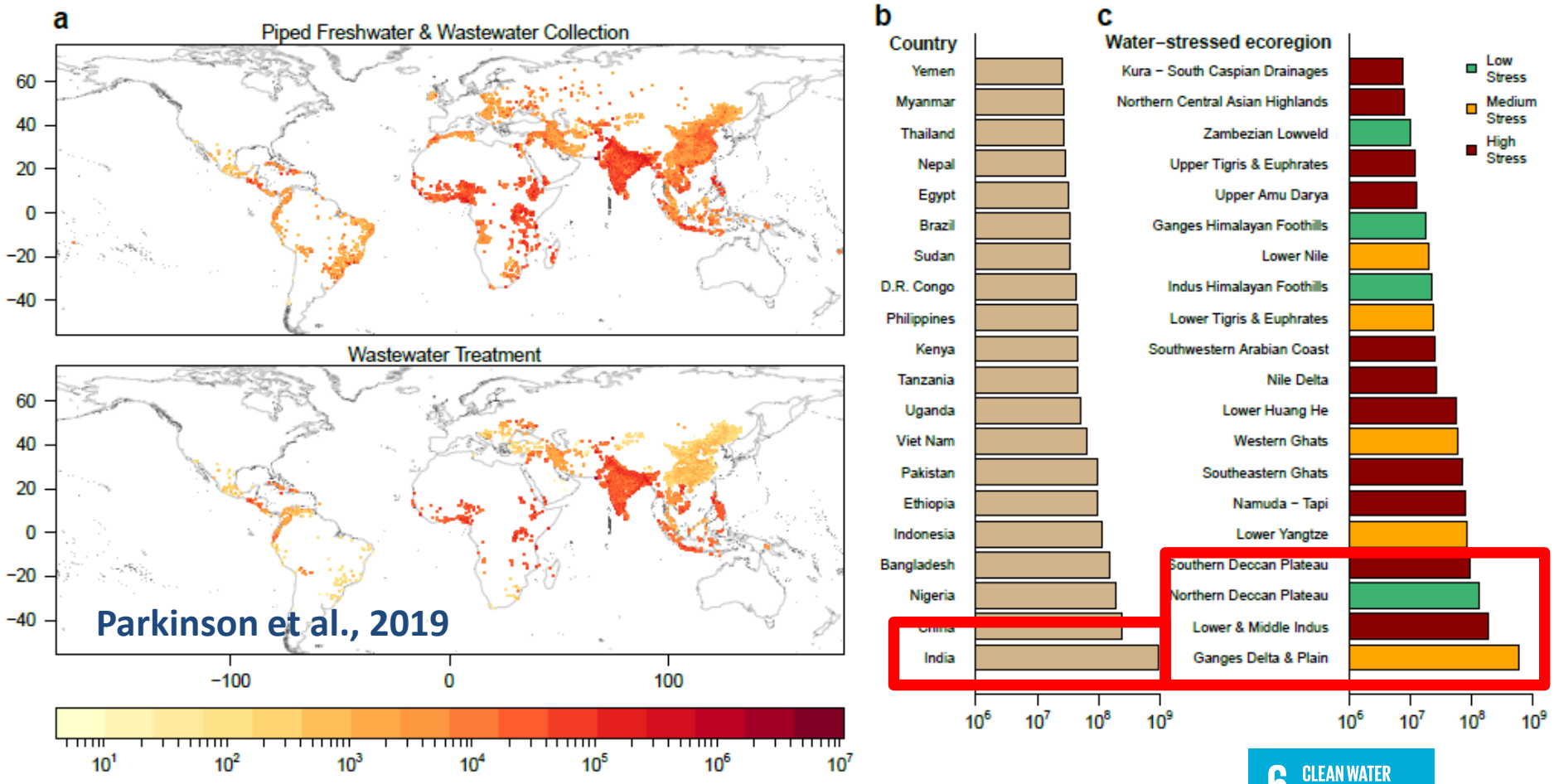


Water Withdrawal in 2010
[cubic kilometers]

Water Consumption in 2010
[cubic kilometers]

Srinavasan et al. (2017)

Energy needed to support clean water goals in India

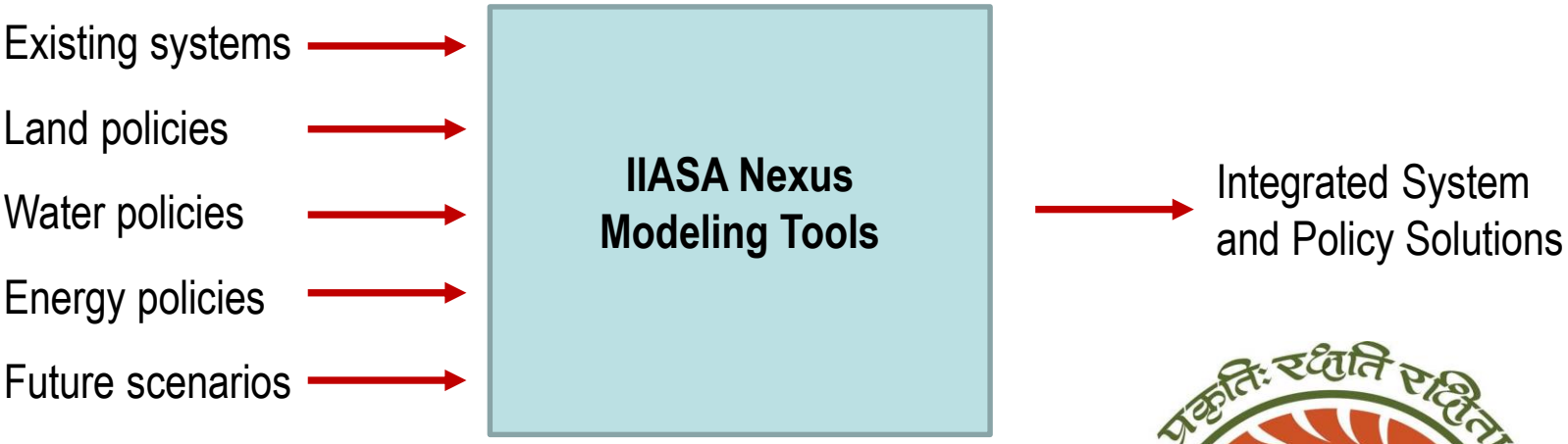


Additional number of people requiring piped water and wastewater collection by 2030 to achieve SDG6 (Clean Water & Sanitation)

6 CLEAN WATER AND SANITATION

NEW IIASA-MoEFCC partnership

Assessing interlinkages between land-use policies and the SDGs in India using a nexus approach



- **Build local capacity to develop and apply nexus models**

प्रकृतिः रक्षति रक्षिता
Nature Protects if She is Protected

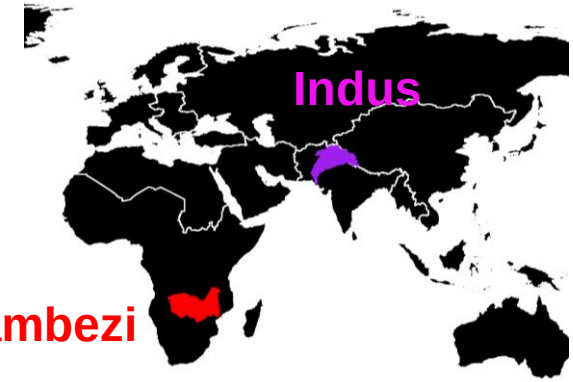
Outputs and timeline

- Inception report (Sept 2019)
- Modeling tool and database (Jan 2020)
- Policy analysis / final report (Aug 2020)
- Plans for 2nd phase (Aug 2020)

Previous IIASA work on nexus modeling

Integrated Solutions for the Water-Energy Land Nexus Project

- 3-year initiative funded by GEF and UNIDO
- Focus on SDGs, model development, stakeholder engagement and capacity building
- Case studies in the Indus and Zambezi basins

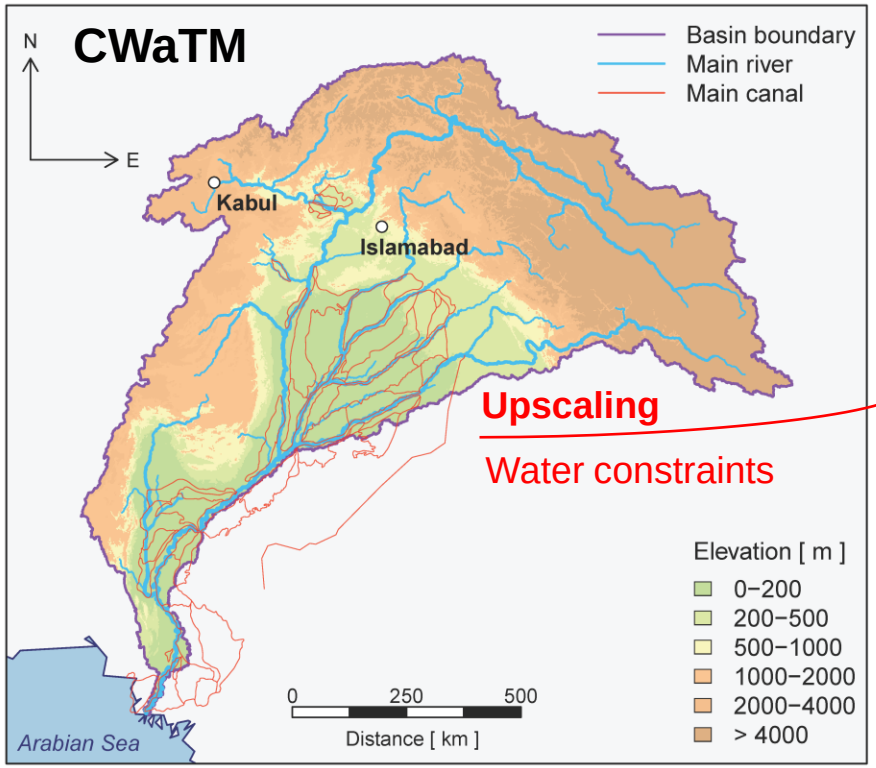


The **NE**xus **S**olutions **T**ool (**NEST**)
Multi-scale modeling for transforming systems

Objectives of the tool

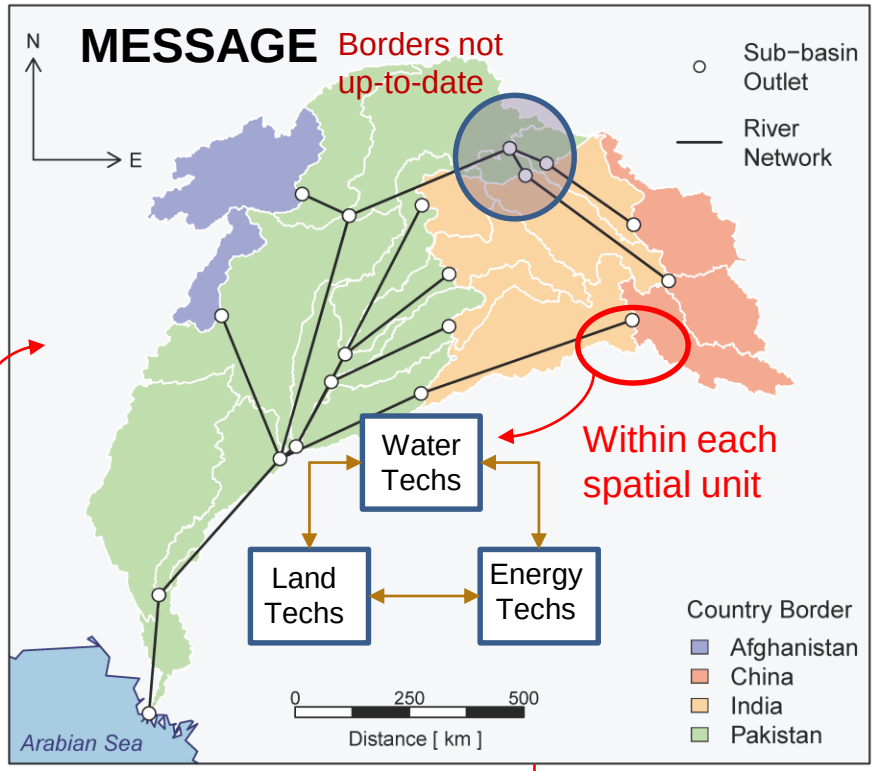
- Design long-term pathways (2020 to 2050) for land, energy and water systems
- Utilize a nexus approach to leverage interactions as solutions
- Provide results at a sub-national level and to incorporate policies occurring across different administrative levels

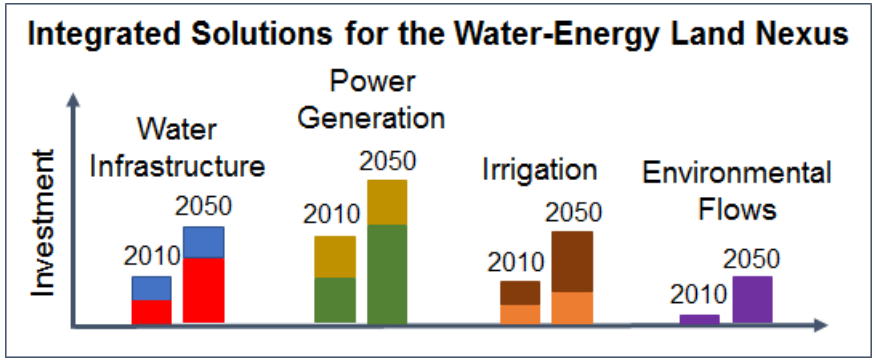
The **NE**xus **S**olutions **T**ool (**NEST**)
Multi-scale modeling for transforming systems



Upscaling

Water constraints

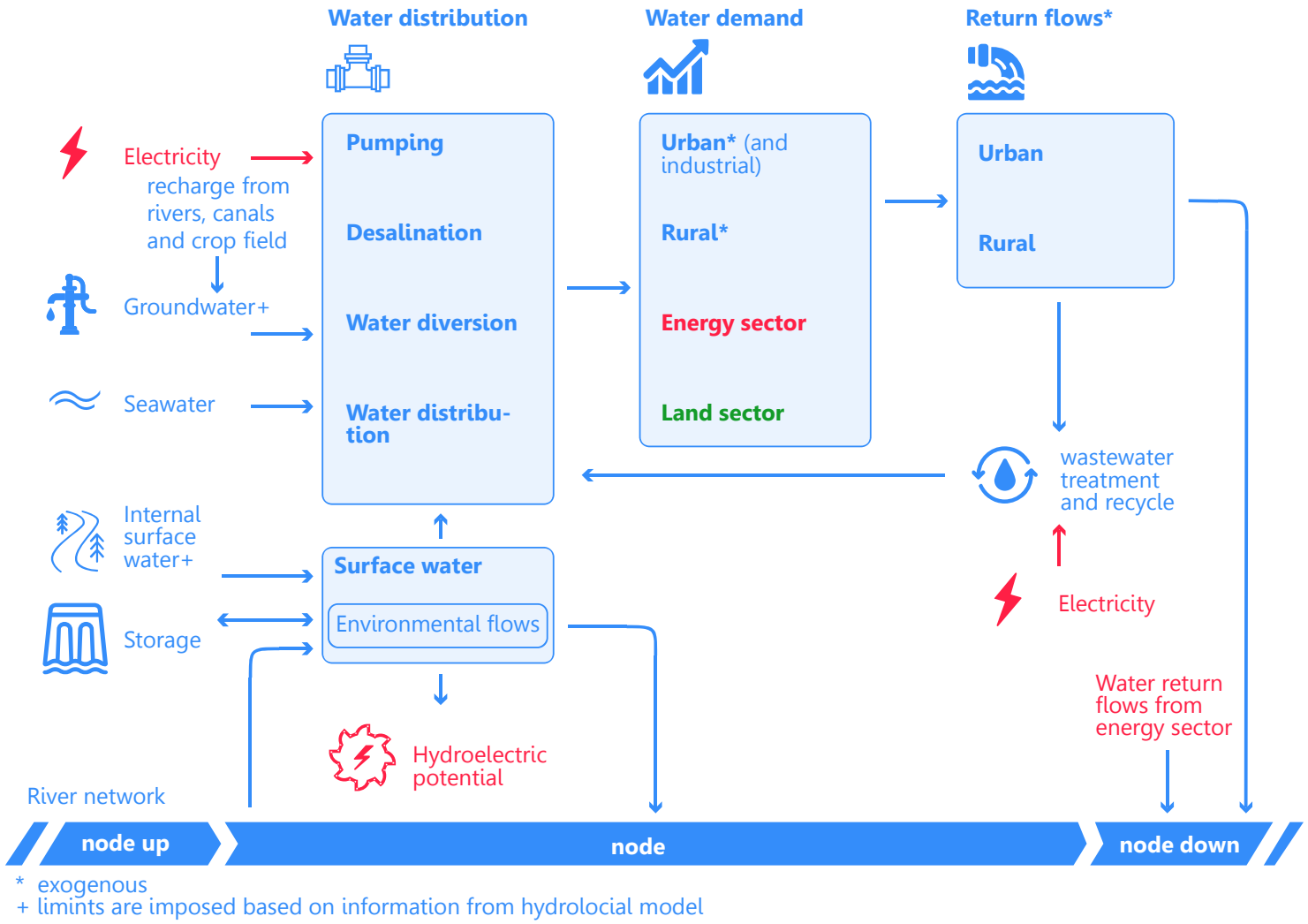




Vinca et al. (2019)

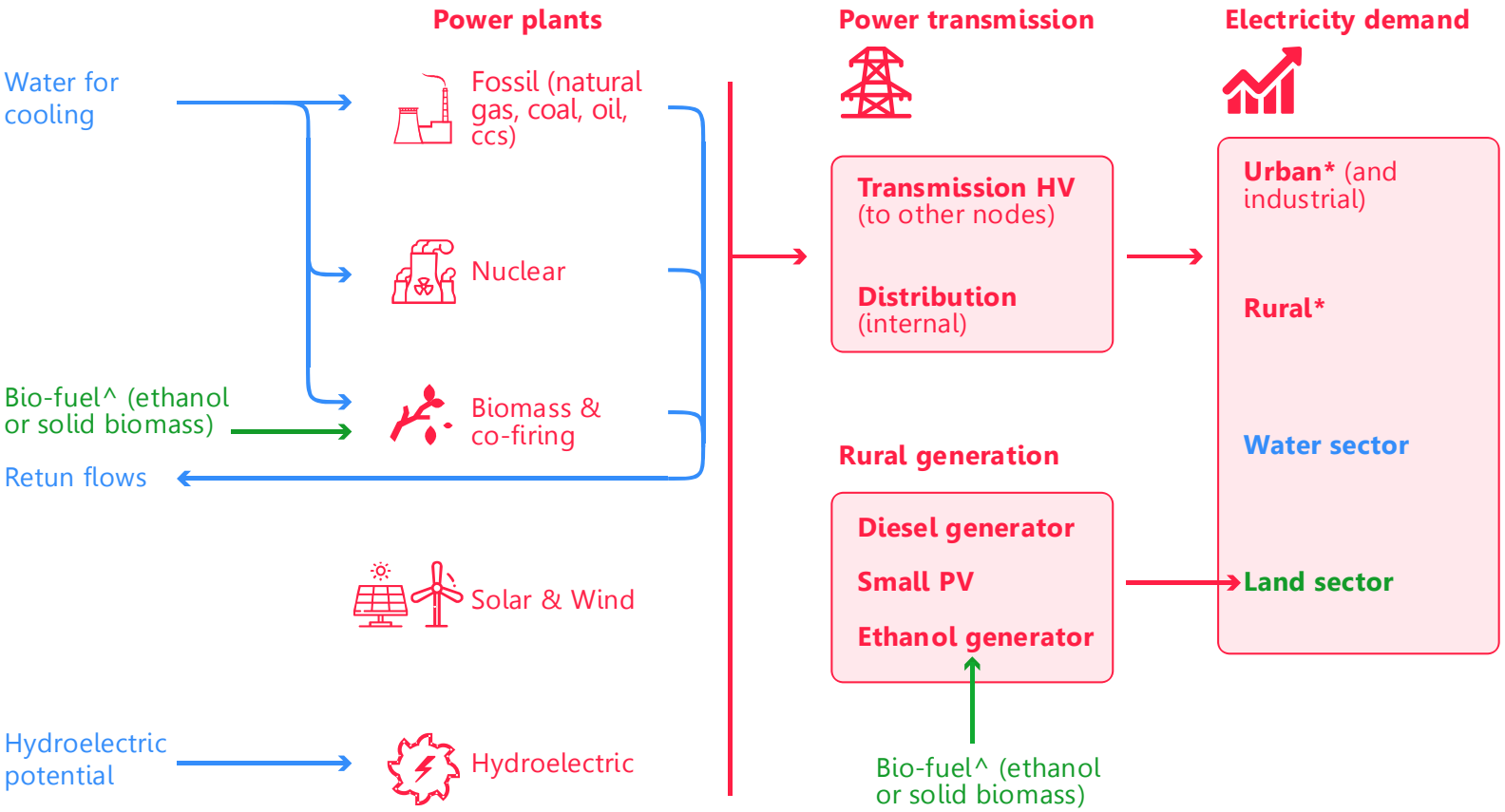
Multi-criteria optimization: Capacity and operation of technologies

Water supply-chain modeling



Vinca et al. (2019)

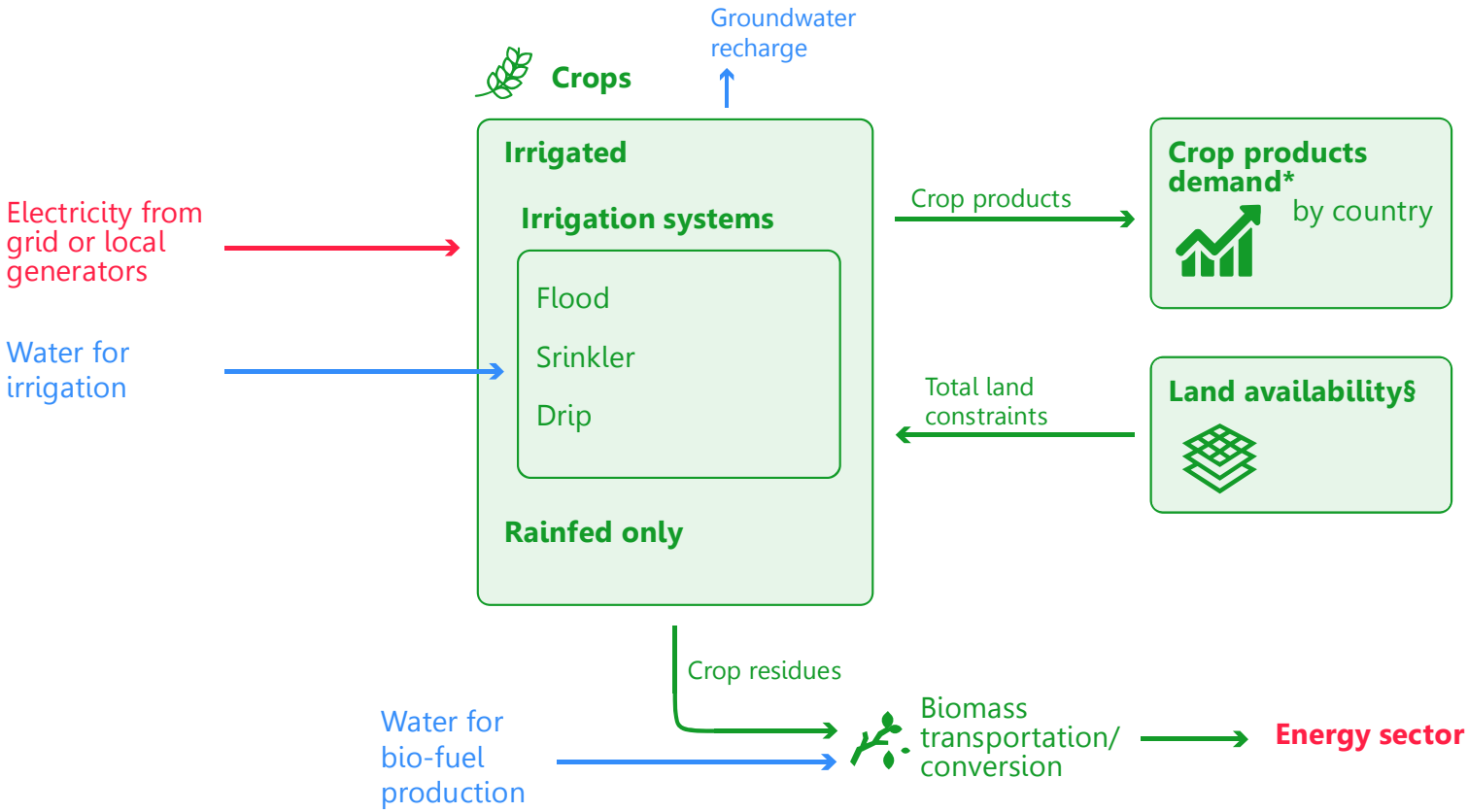
Energy supply-chain modeling



* exogenous
^ crop residues can be transported as solid biomass or converted in ethanol, technolgies not represented here

Vinca et al. (2019)

Crop supply-chain modeling



* exogenous.
§ total available area for agriculture based on historical data

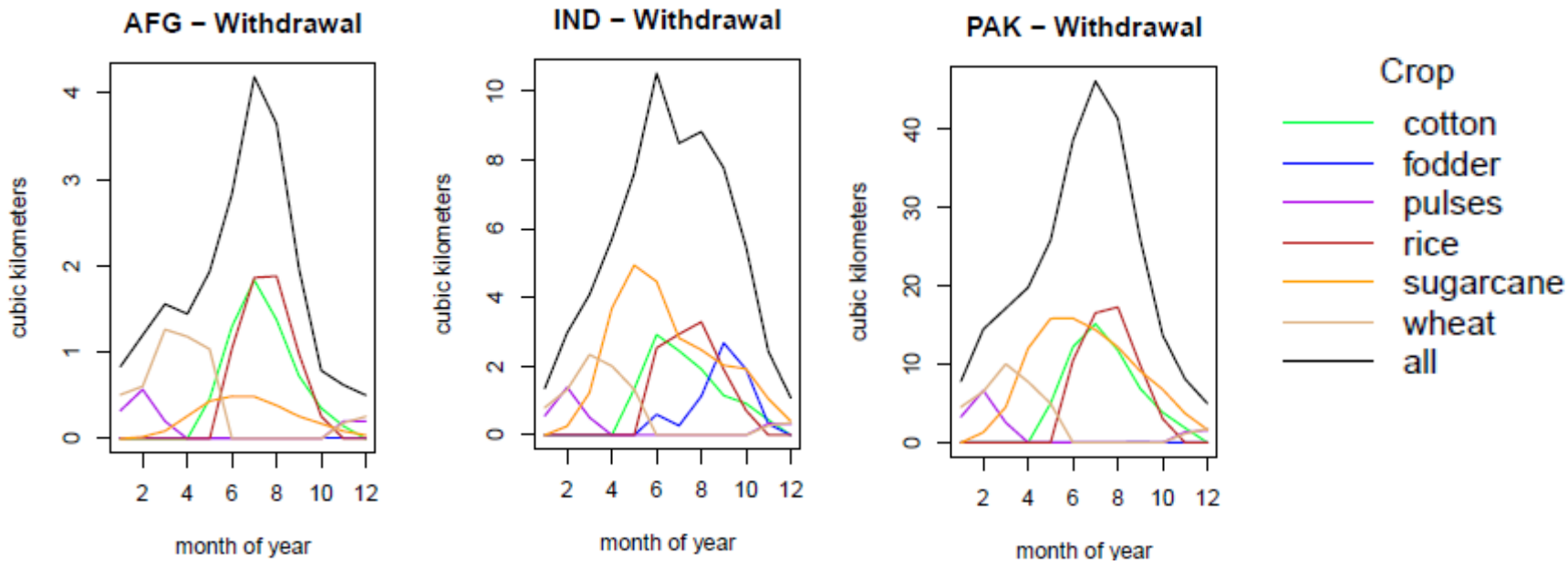
Vinca et al. (2019)

Input data

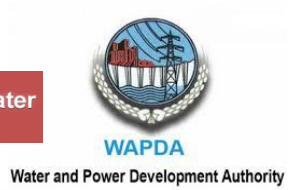
Mapping infrastructure, potentials and policies

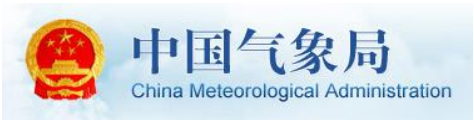
- ✓ Power generation (existing and planned)
- ✓ Transmission and road networks
- ✓ Groundwater pumping capacity
- ✓ Wind, PV and hydropower potentials
- ✓ Urbanization pathways
- ✓ Irrigation intensity
- ✓ Indus water treaty allocations
- ✓ Reservoirs (existing and planned)
- ✓ Urban water transfers (e.g., Karachi)
- ✓ Algorithms for model integration

Monthly irrigation withdrawals calibrated for 2015



Calibrating sub-national scenarios: Stakeholder Engagement





Ministry of Planning Development & Reform

Planning and Development Department

Government of Khyber Pakhtunkhwa
حکومت خیبر پختونخوا

Government of Pakistan
Ministry of Science and Technology

Xinjiang Institute of Ecology and Geography
Chinese Academy of Sciences

Indus Analysis

How to strike a balance between objectives?

… and at what cost?

SDGs

Transboundary Agreements & Water-Energy-Food Security

Scenario analysis

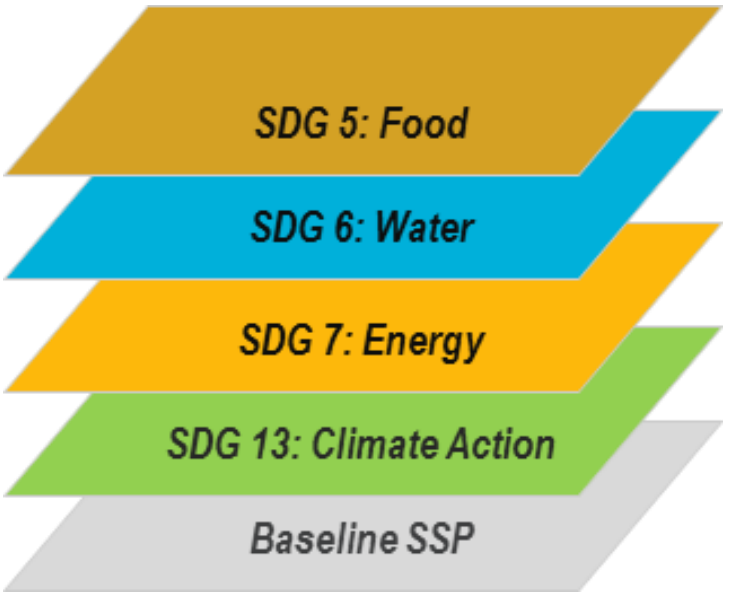
Baseline:

- Business as usual
- Indus Water Treaty
- Shared Socioeconomic pathways (population and economic growth assumptions)

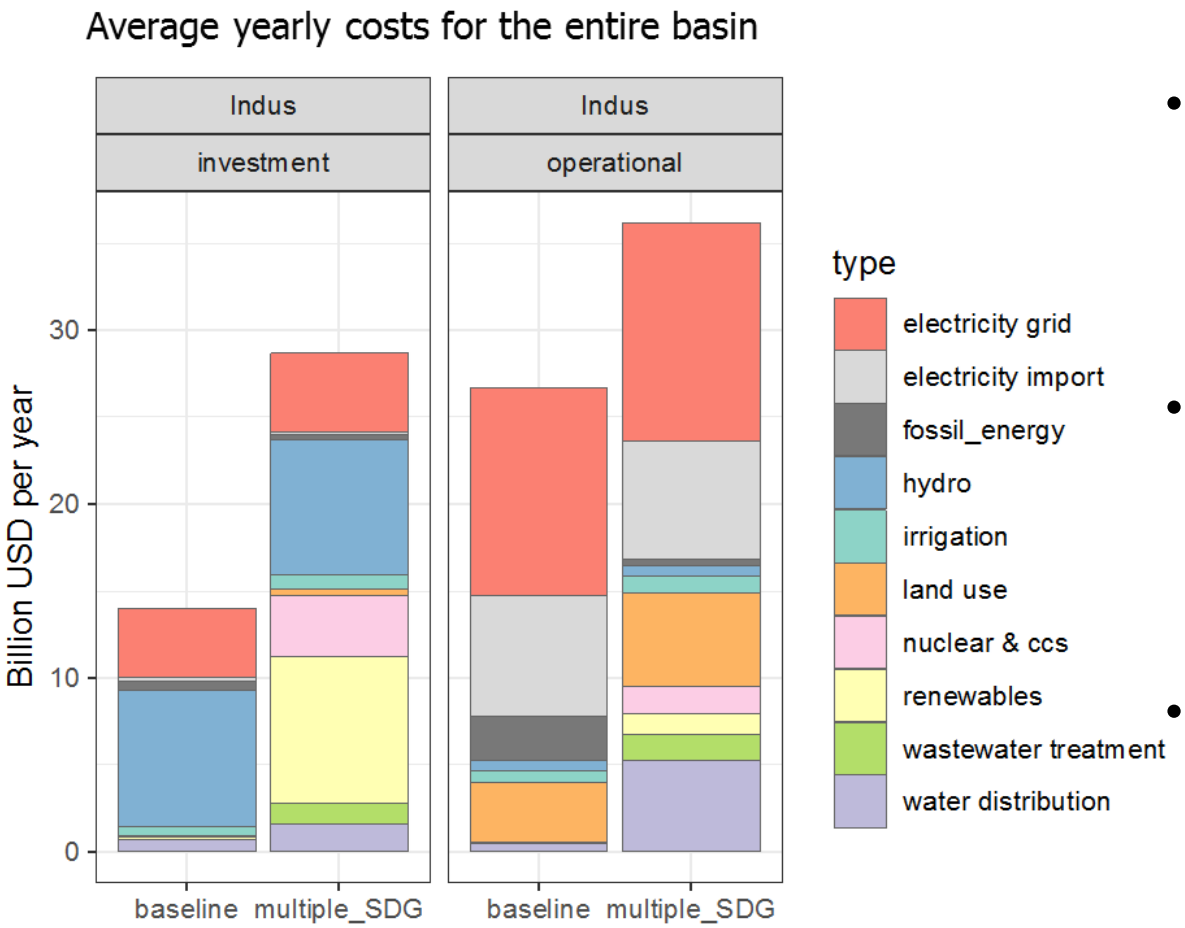
SDG:

- Infrastructure access and treatment rates
- Efficiency and emission targets
- Adaptation to impacts of climate change

SDG policies added on top of baseline setup



Integrated analysis of system costs under multiple SDG objectives



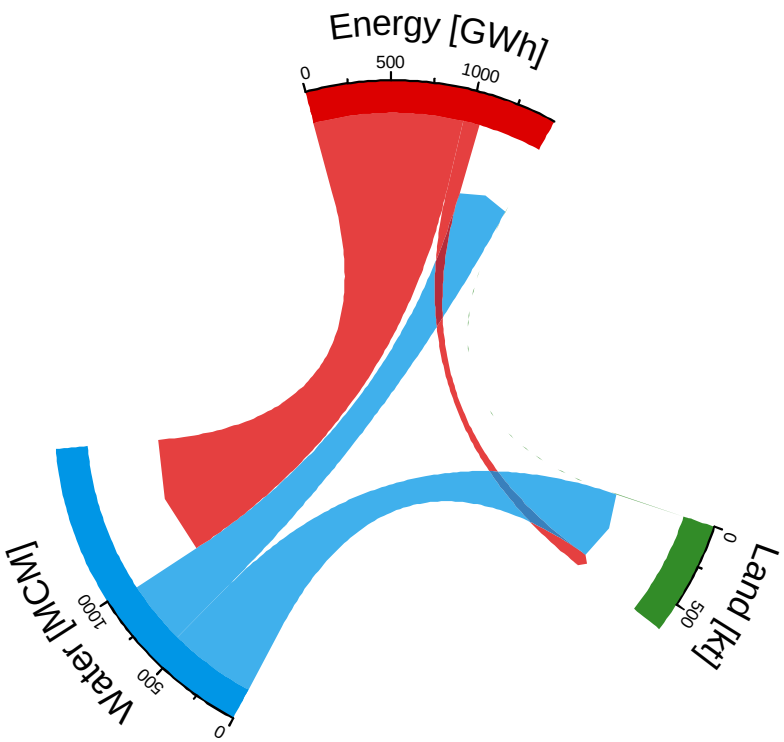
- Low carbon tech and wastewater distribution and treatment.
- Use of more efficient, but costly irrigation technologies.
- Higher land requirements from reduced irrigation

*Similar results can be generated for sub-basins and for each country's basin area

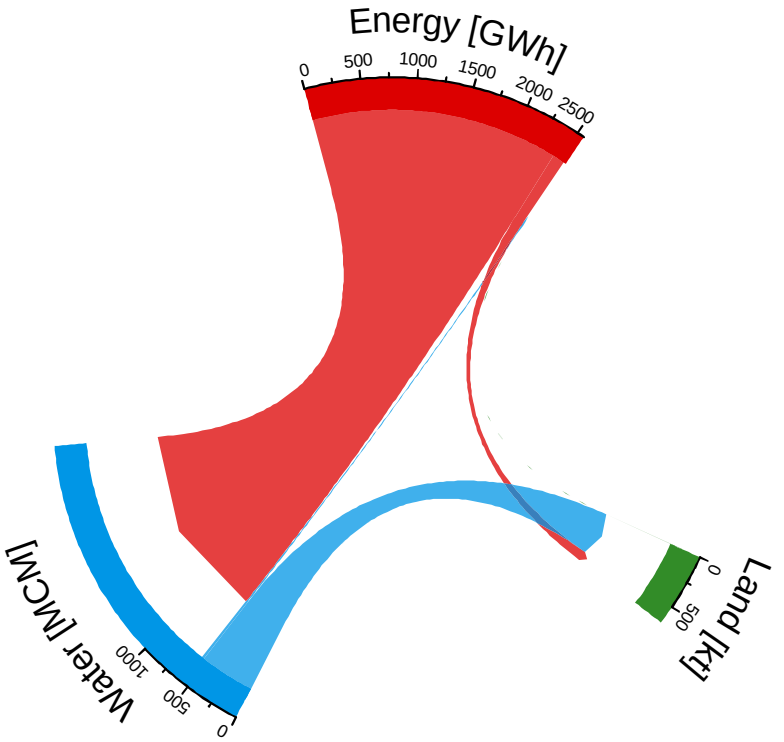
Preliminary results: do not cite or quote

Tracking basin-wide nexus interactions: 2030

baseline



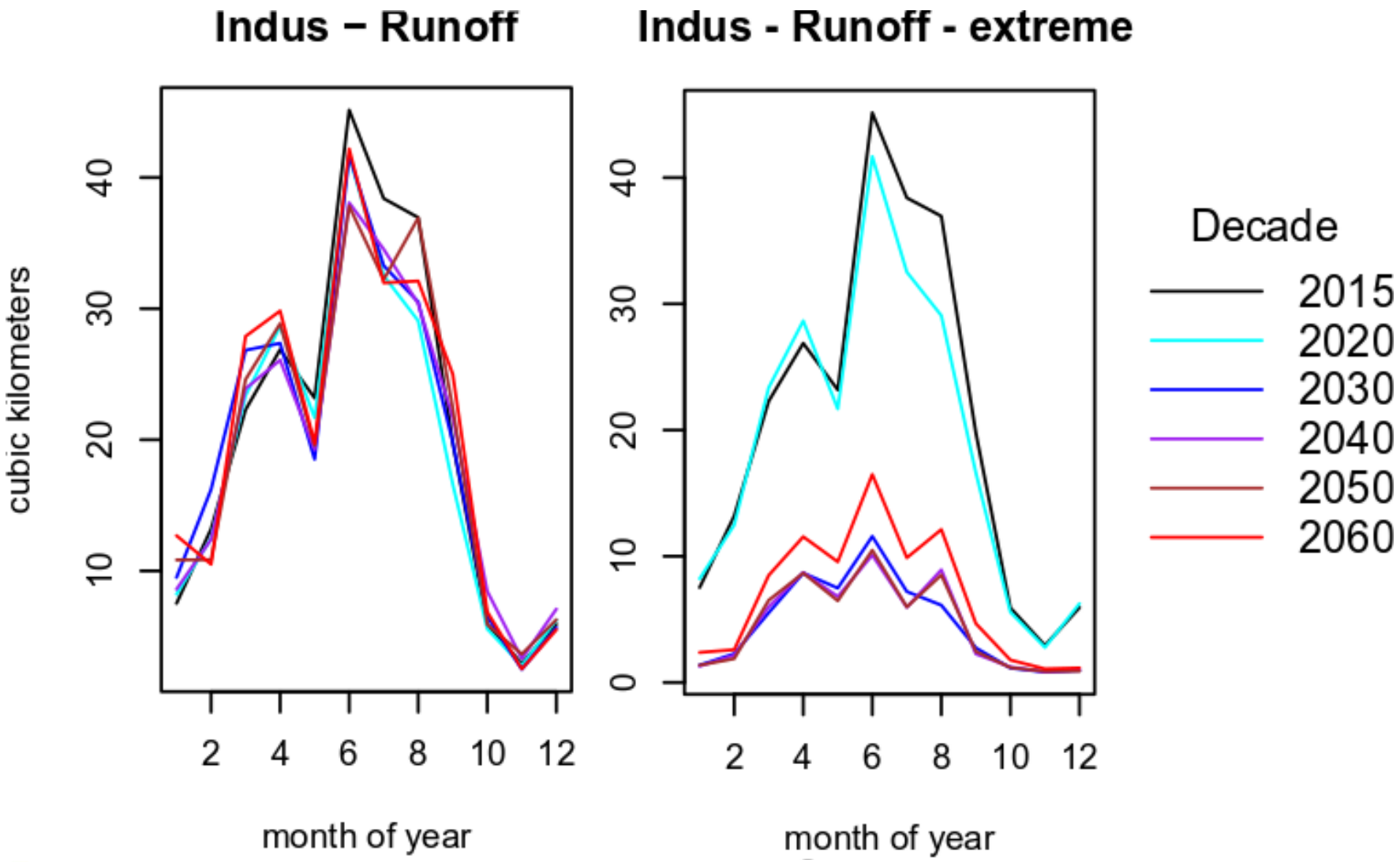
multiple SDG



Less power plant / irrigation water requirement.
More energy for water distribution / treatment

Preliminary results: do not cite or quote

Impact of water availability



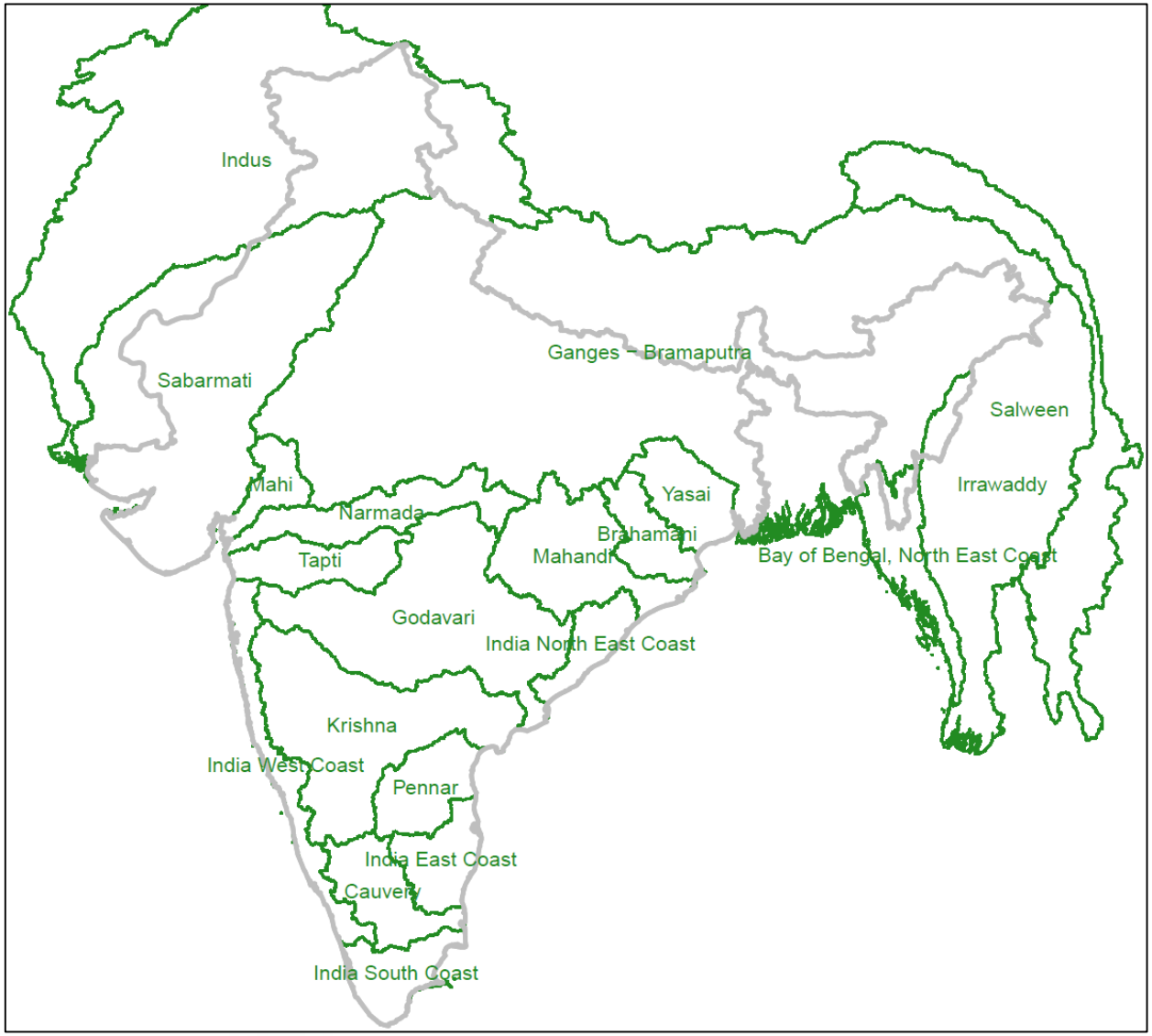
Preliminary results: do not cite or quote

Some key insights from the Indus analysis

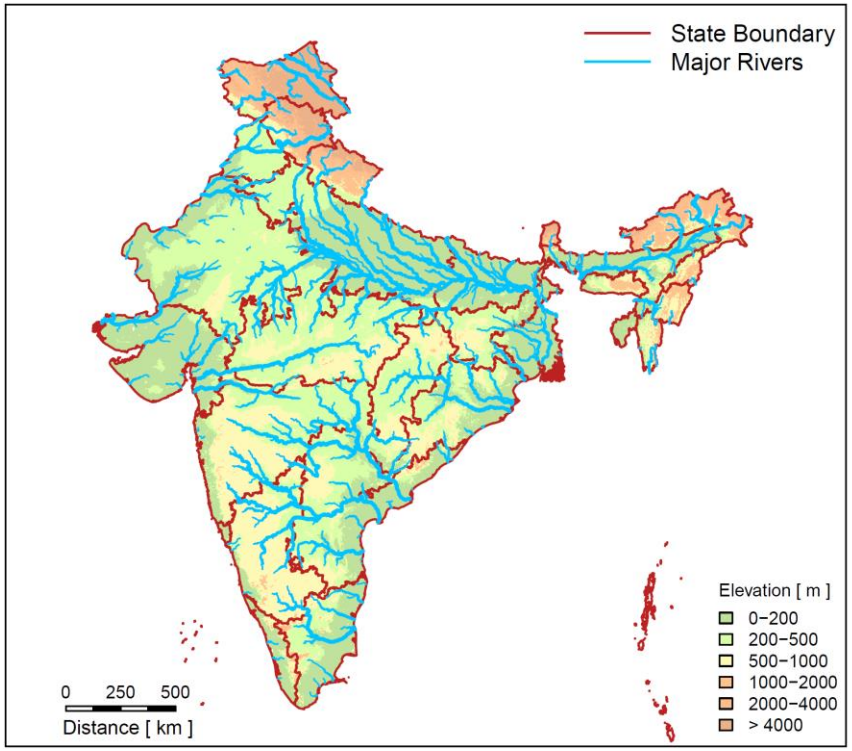
- Massive investments in water and energy systems needed to achieve SDGs
- Crop shifting can be an important solution but has implications on local livelihoods
- Cooperation across countries can reduce the costs to implement the SDGs
- Climate change impacts on water availability significantly increase costs

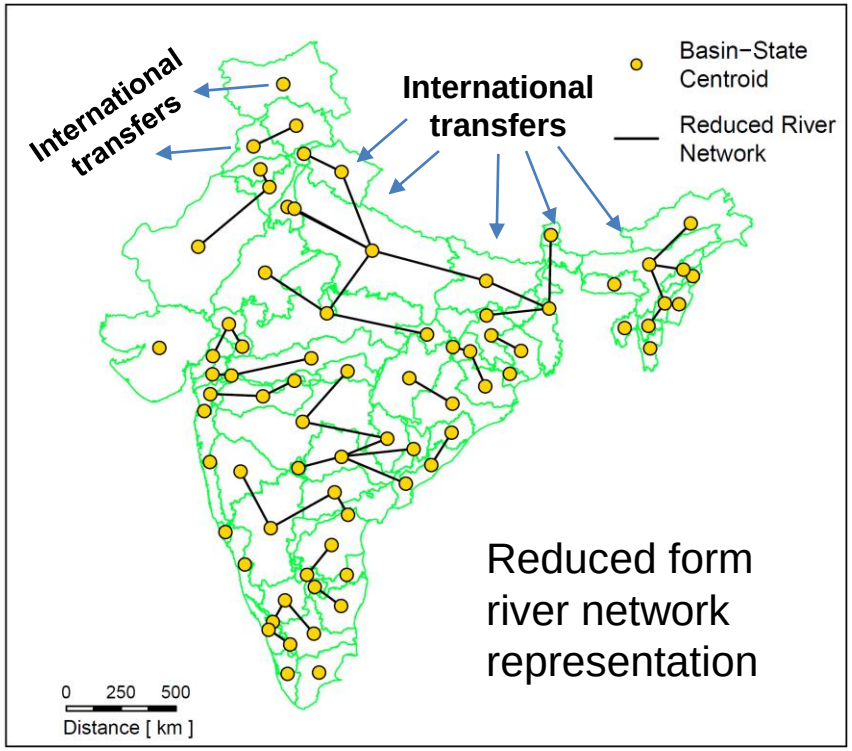
Application to India
Water allocation policies made at the state-level

But water is constrained at the river basin-level



Mapping river flow directions between states





Complex system with many inter-state and international water transfers

Assessment of data availability

- **National and state-level databases provide excellent coverage**
  - India Water Resource Information System
  - ISRO land degradation maps
  - Agriculture and irrigation maps
- **But need to link with stakeholders for representing policies and solutions**

Next steps

- **Stakeholder engagement**
  - Interactive meetings with ministries involved in land, water and energy planning
- **Model development**
  - Converging on spatial and temporal scales
  - Identifying the portfolio of technology solutions
  - Incorporating existing and future policies
- **Capacity building**
  - Training MoEFCC staff

Thank you! Questions?

Special thanks to:

Shri Anil Kumar Jain and Shri Jigmet Takpa, MoEFCC

and

Dr. Simi Thambi, MoEFCC

and

Dr. Anindya Bhattacharya, The Celestial Earth / IIASA

and

Dr. Keywan Riahi, IIASA

For further details, please contact me at:

parkinso@iiasa.ac.at