International Institute for Applied Systems Analysis
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University of Victoria

# Integrated Modeling of Climate, Land, Energy and Water Strategies (CLEWS) for the Indus Basin

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*Workshop on the National Expert SDG7 Tool for Energy Planning (NEXSTEP)*
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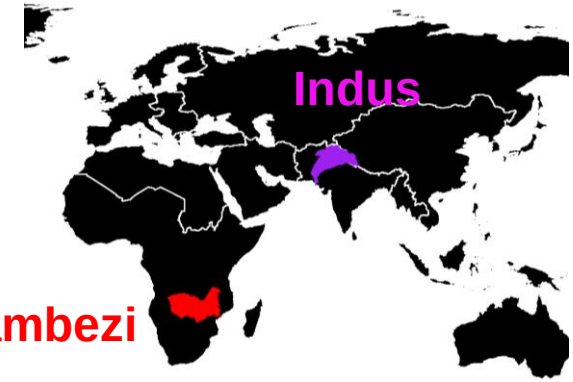
# Context:
# Integrated Solutions for the Water-Energy Land Nexus Project

- 3-year initiative funded by GEF and UNIDO (1-year remaining)

- Focus on SDGs, model development, stakeholder engagement and capacity building

- Case studies in the Indus and Zambezi basins



# Nexus challenges for the Indus basin

**Water, land and ecosystems**

- Transboundary policies
- Complex canal and irrigation system
- Very little flow reaches the sea
- Groundwater depletion
- Lack of wastewater treatment and storage

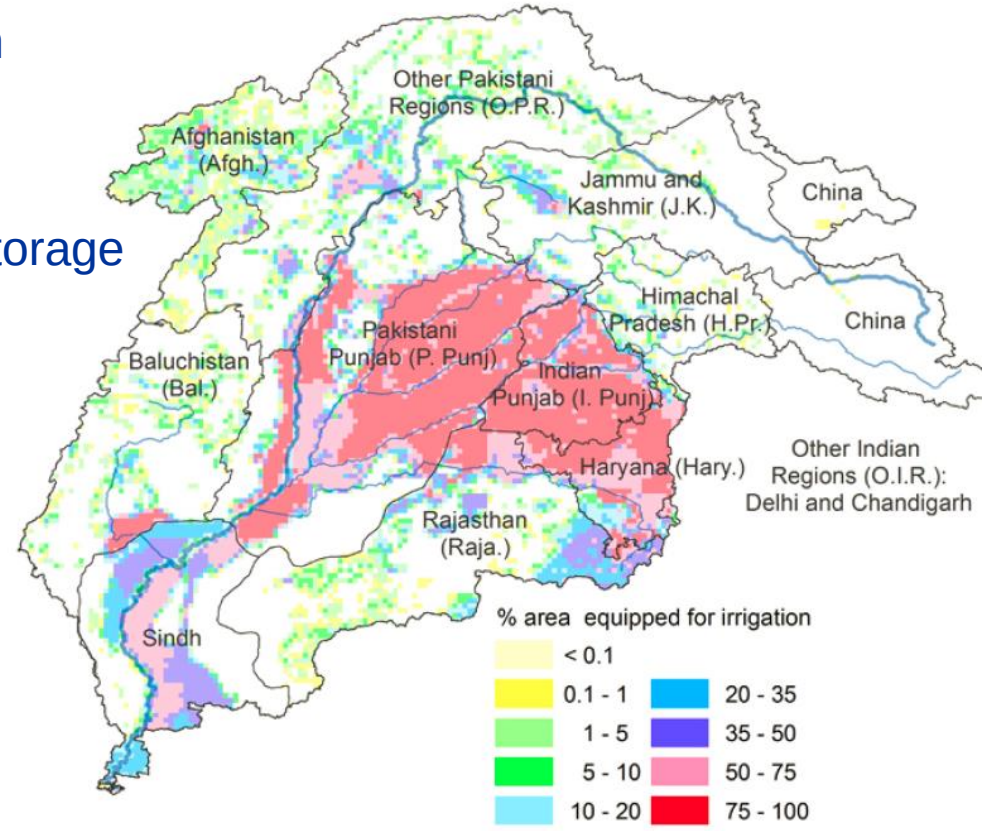
**Energy systems**

- Electricity can be unreliable
- Planned expansion of coal
- Hydropower generation

**Livelihoods**

- Air pollution
- Climate extremes
- Employment impacts of transformations

**Laghari and others (2012)**



# Research Question

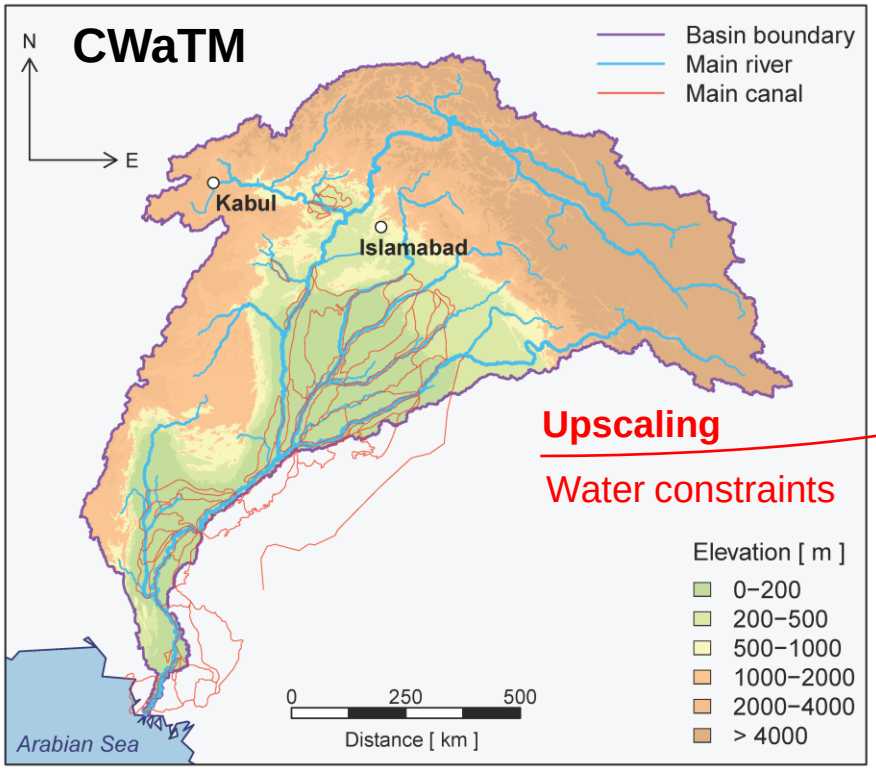
How to strike a balance between objectives?

… and at what cost?

## SDGs

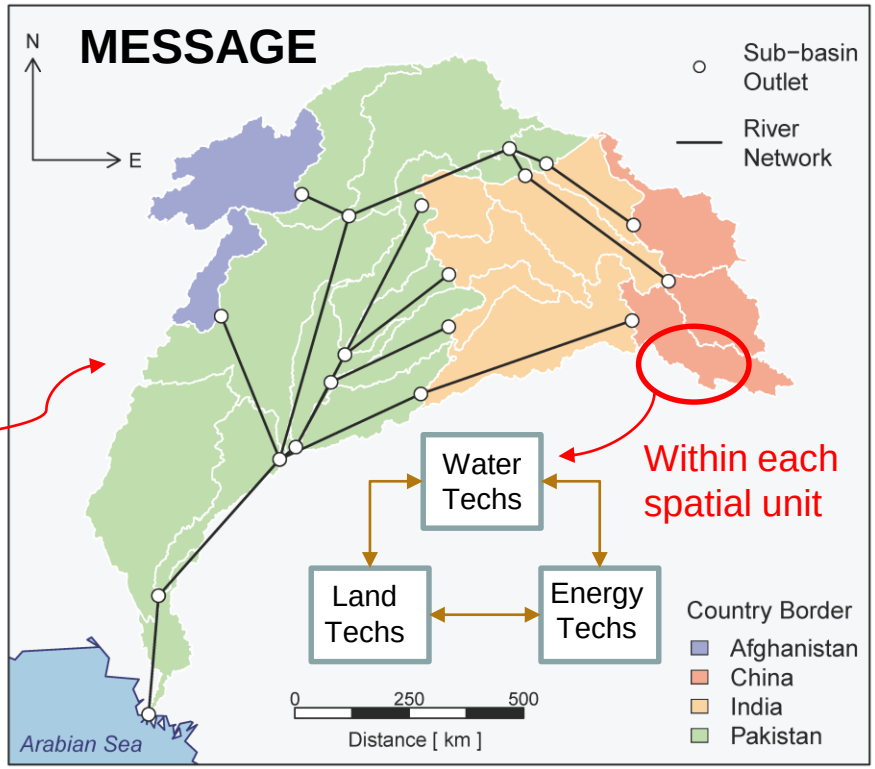

## Transboundary Agreements

# Multi-scale modeling for transforming systems

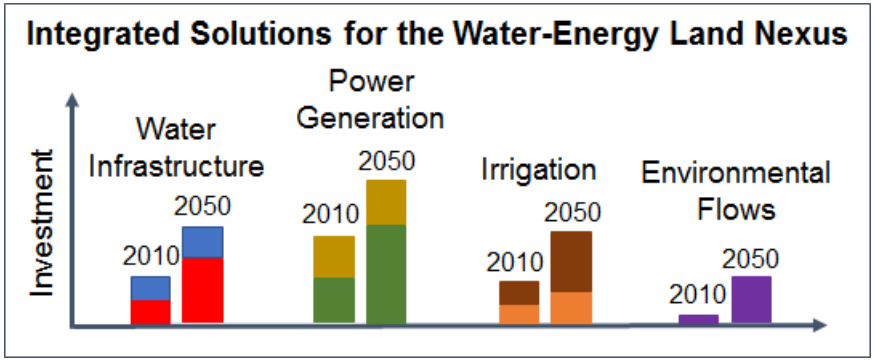



**Upscaling**

Water constraints



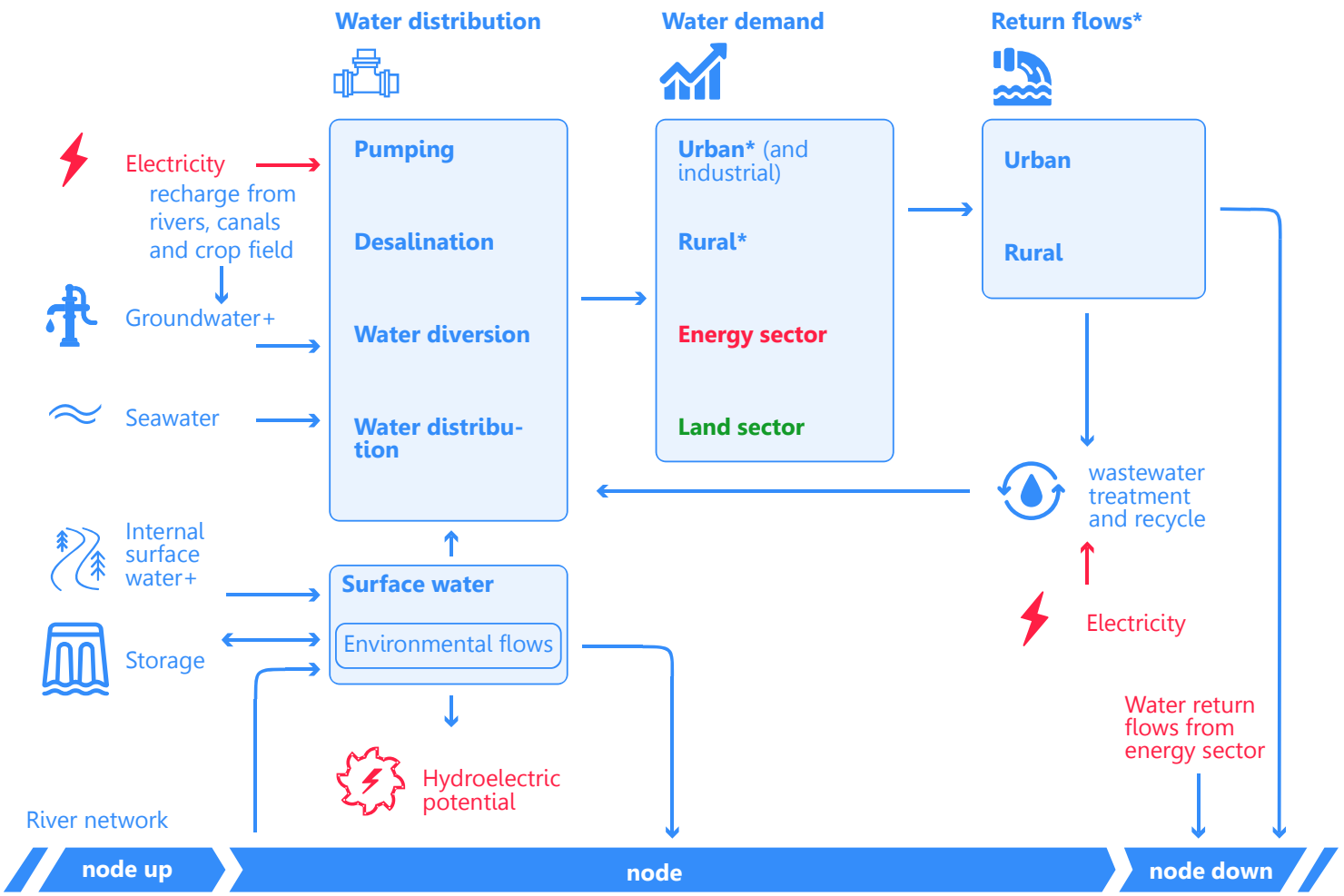

**Downscaling**
Water and land-use




**Multi-criteria optimization**:
Capacity and operation of technologies

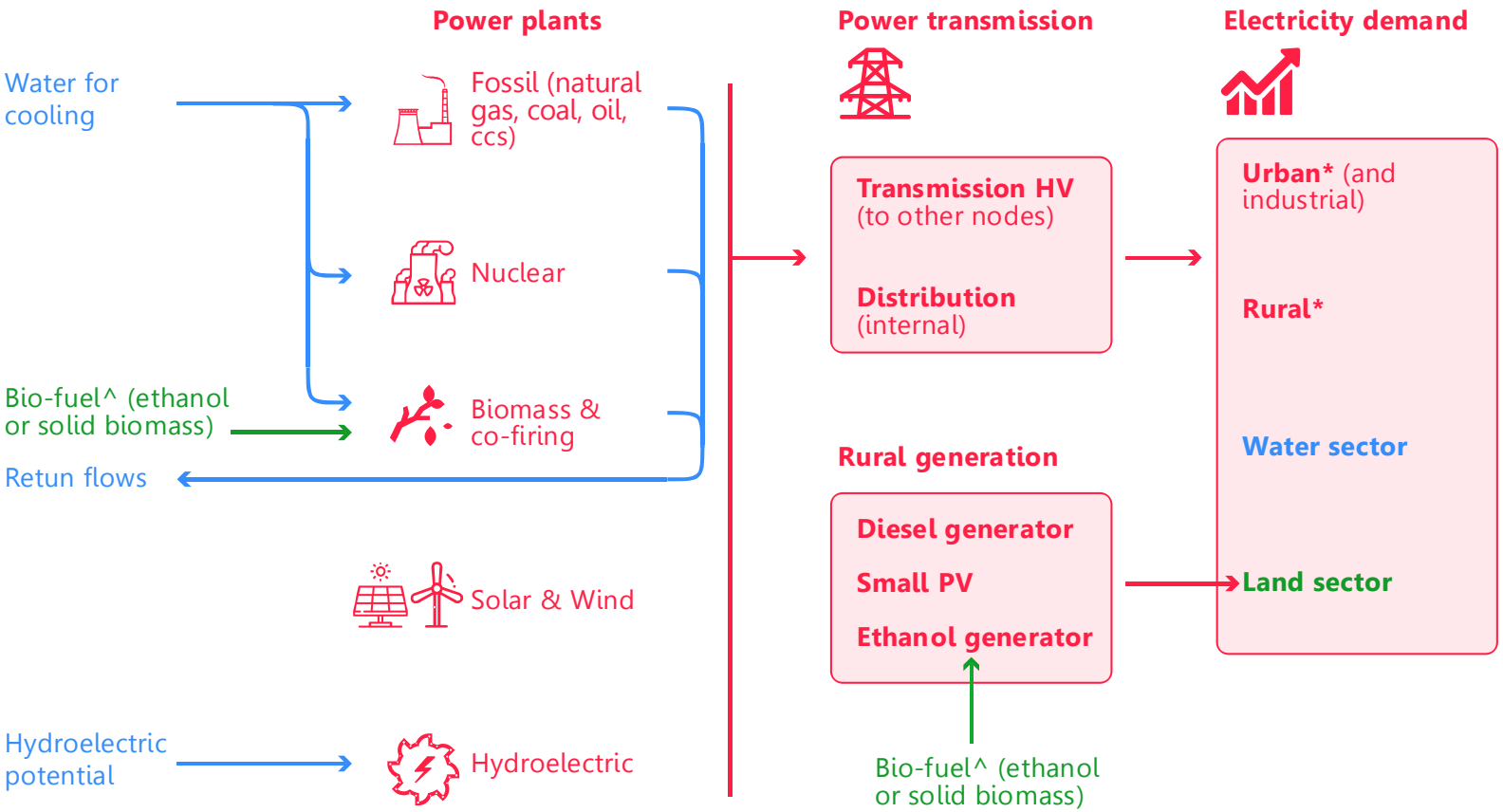
Adriano Vinca and others, (forthcoming)

# Modeling CLEWS: Water system



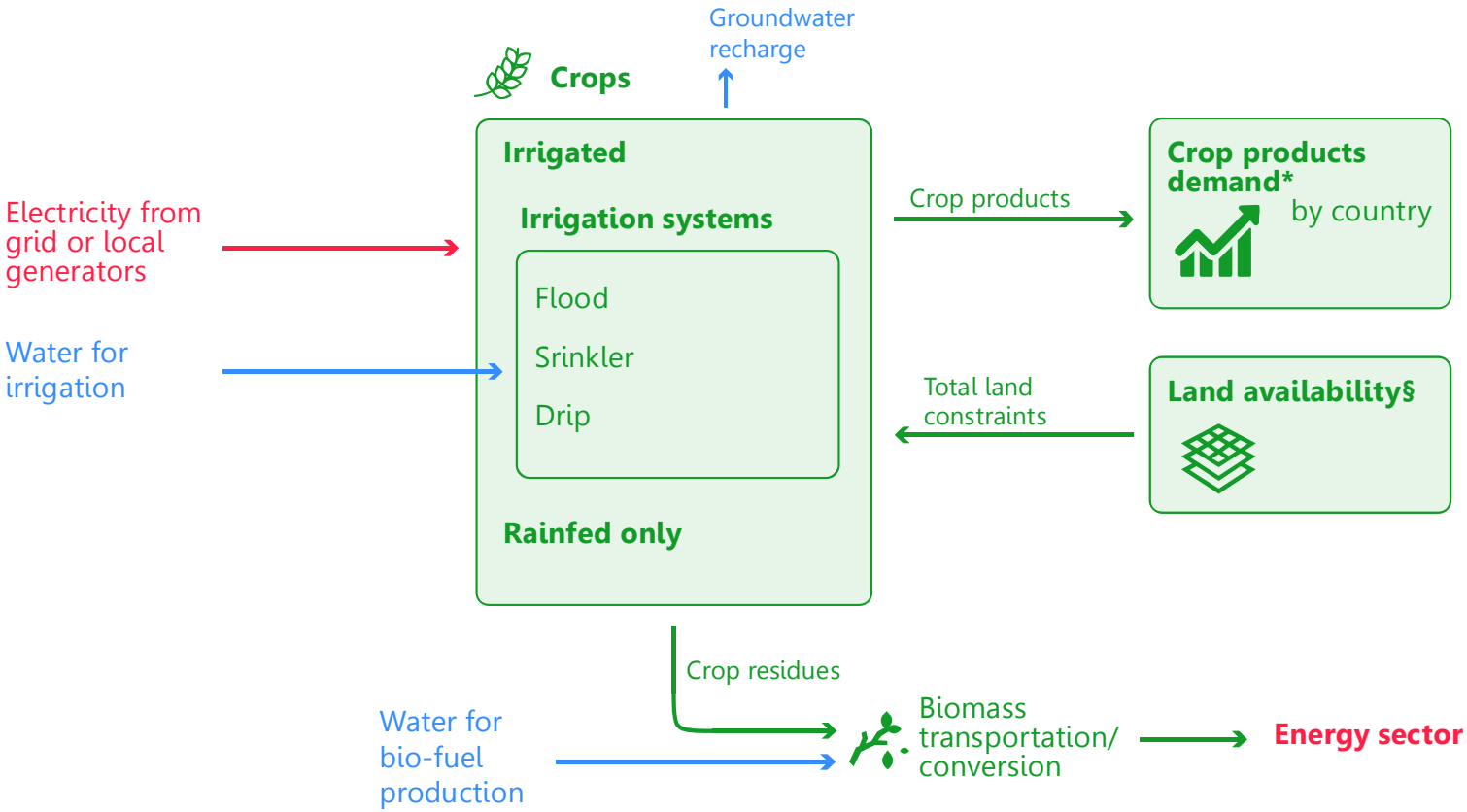

* exogenous
\+ limints are imposed based on information from hydrolocial model

# Modeling CLEWS: Energy system




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

# Modeling CLEWS: Land-use (cropping) system



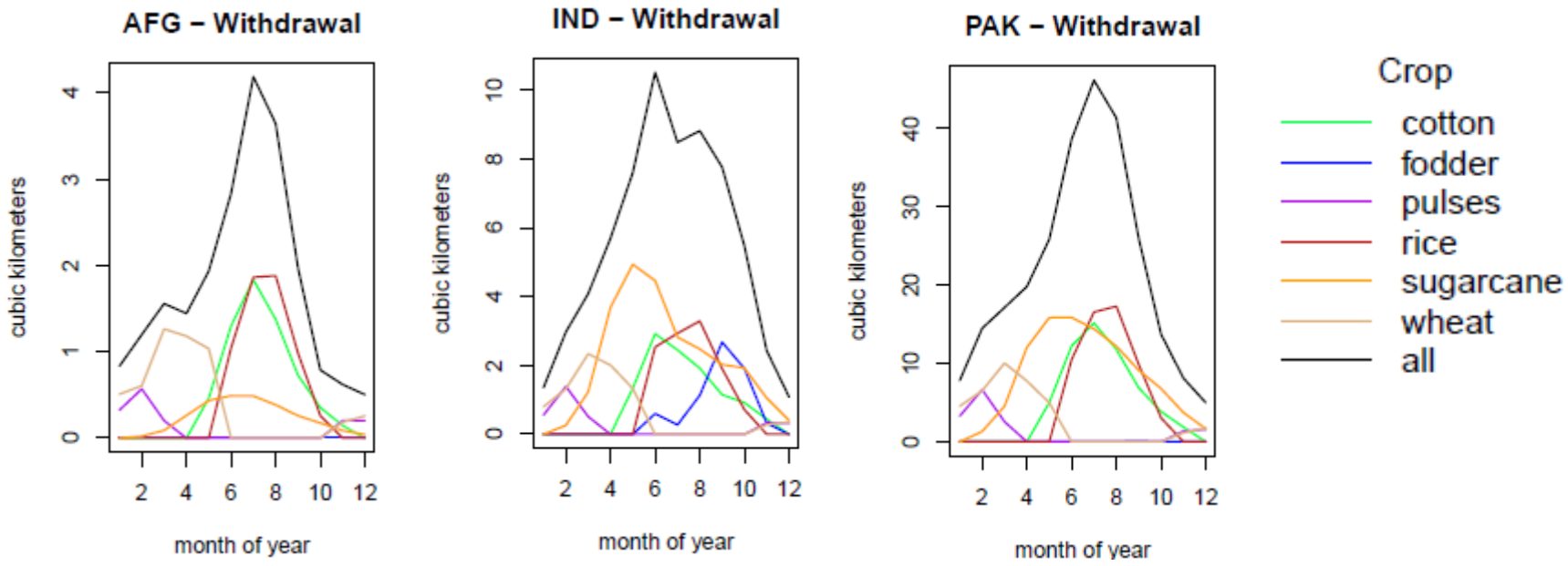

* exogenous.
§ total available area for agriculture based on historical data

# 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

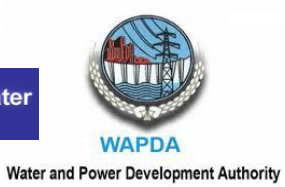
**Monthly irrigation withdrawals calibrated for 2015**

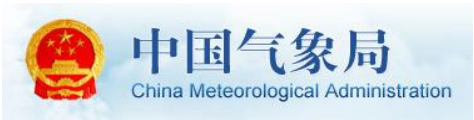


# Calibrating sub-national scenarios: Stakeholder Engagement































# Scenario analysis

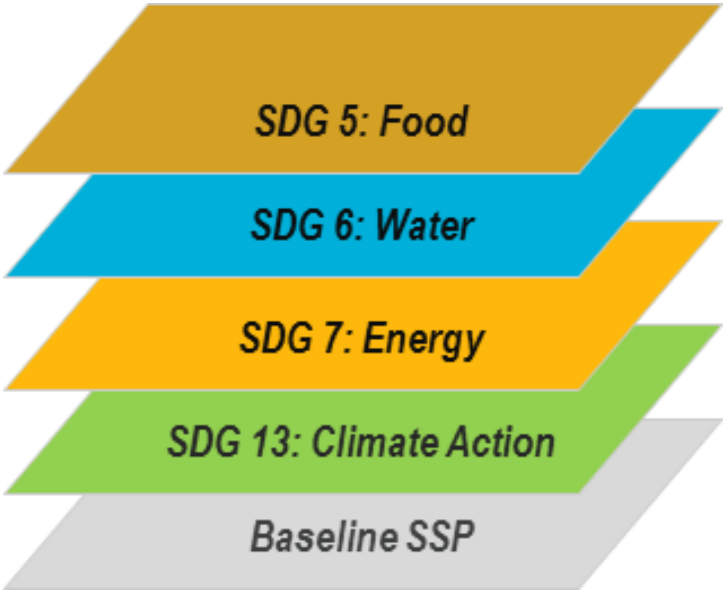
**Baseline:**

- 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

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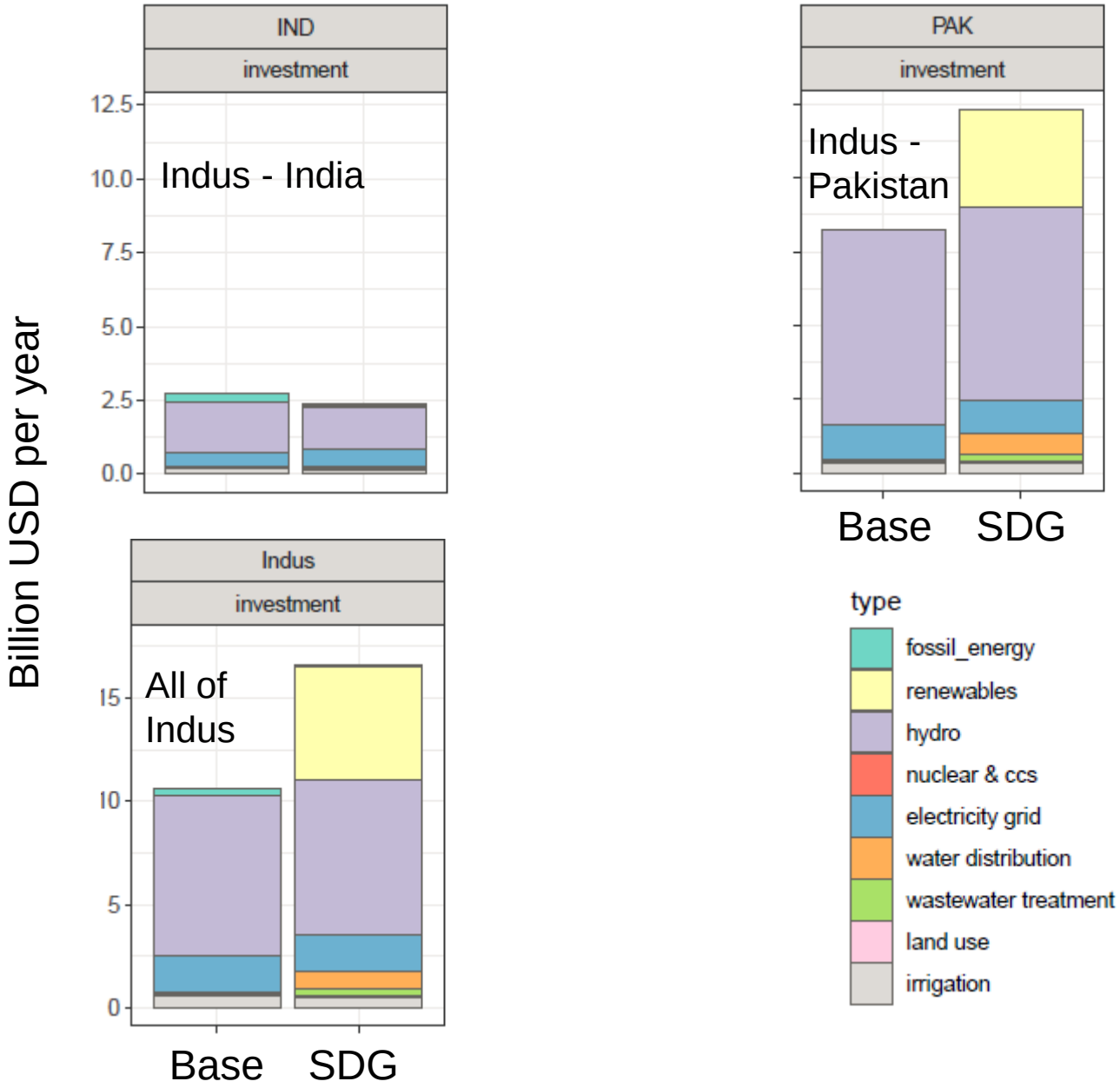
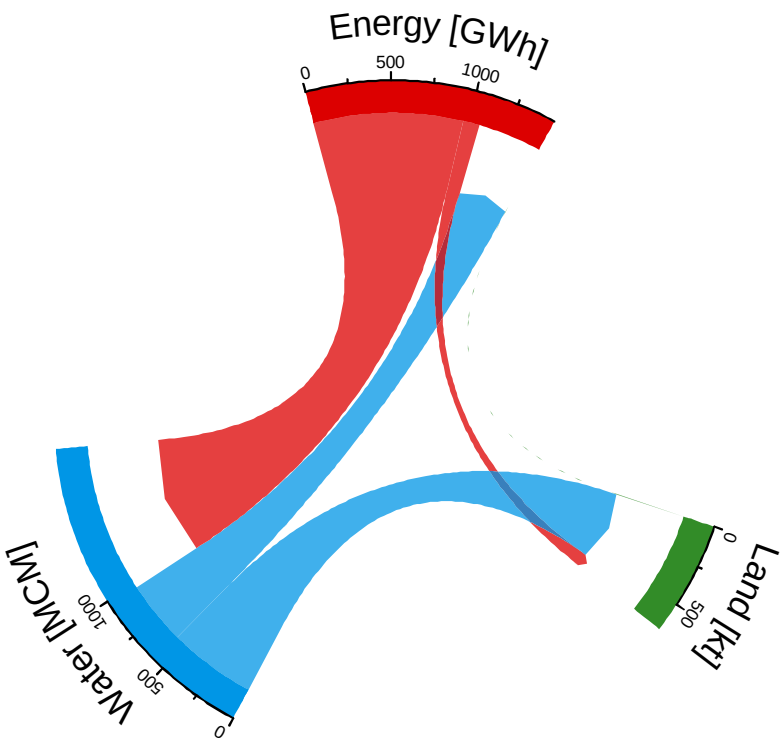
# Tracking basin-wide investments: Average 2015-2030



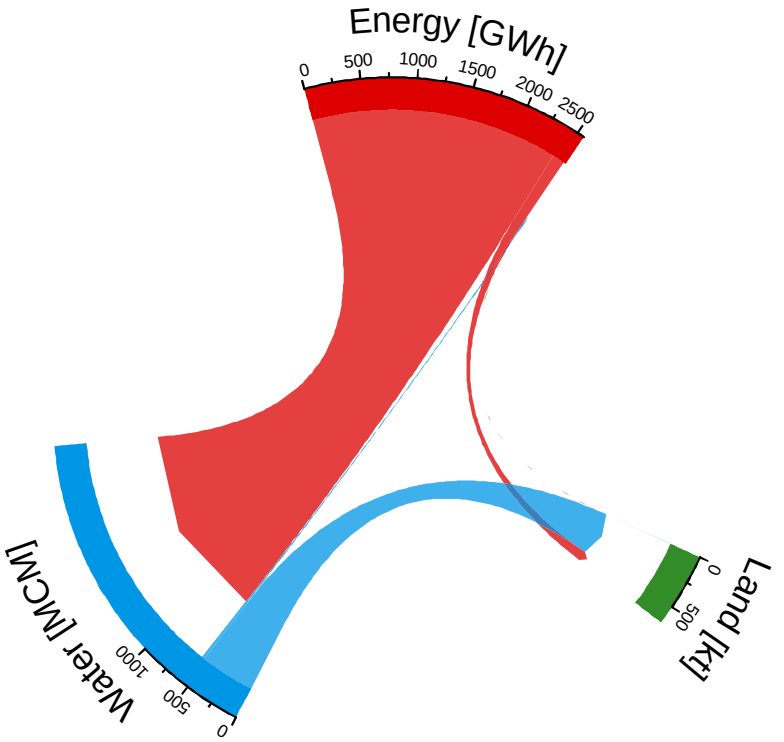

**Preliminary Results**
**Do not cite or quote**

# 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**

# Future work:
# Focus on SDG implementation in Asia

- **Pearl River Basin**
  - Highly urbanized basin in China (including Hong Kong)

- **Scaling up to the national-level in India**
  - Multiple linked basins covering the entire country
  - Collaboration w/ Ministry of Environment Forestry and Climate Change

# Conclusions

- **New integrated tool for SDG analysis**
  - Representing water-energy-land systems in a coherent framework to identify interactions across SDGs
  - Stakeholder engagement to ensure pathways align with local needs
  - Flexible for application in other regions / scales

# Thank you!

## Collaborators from around the world











## For more information on the modeling tools

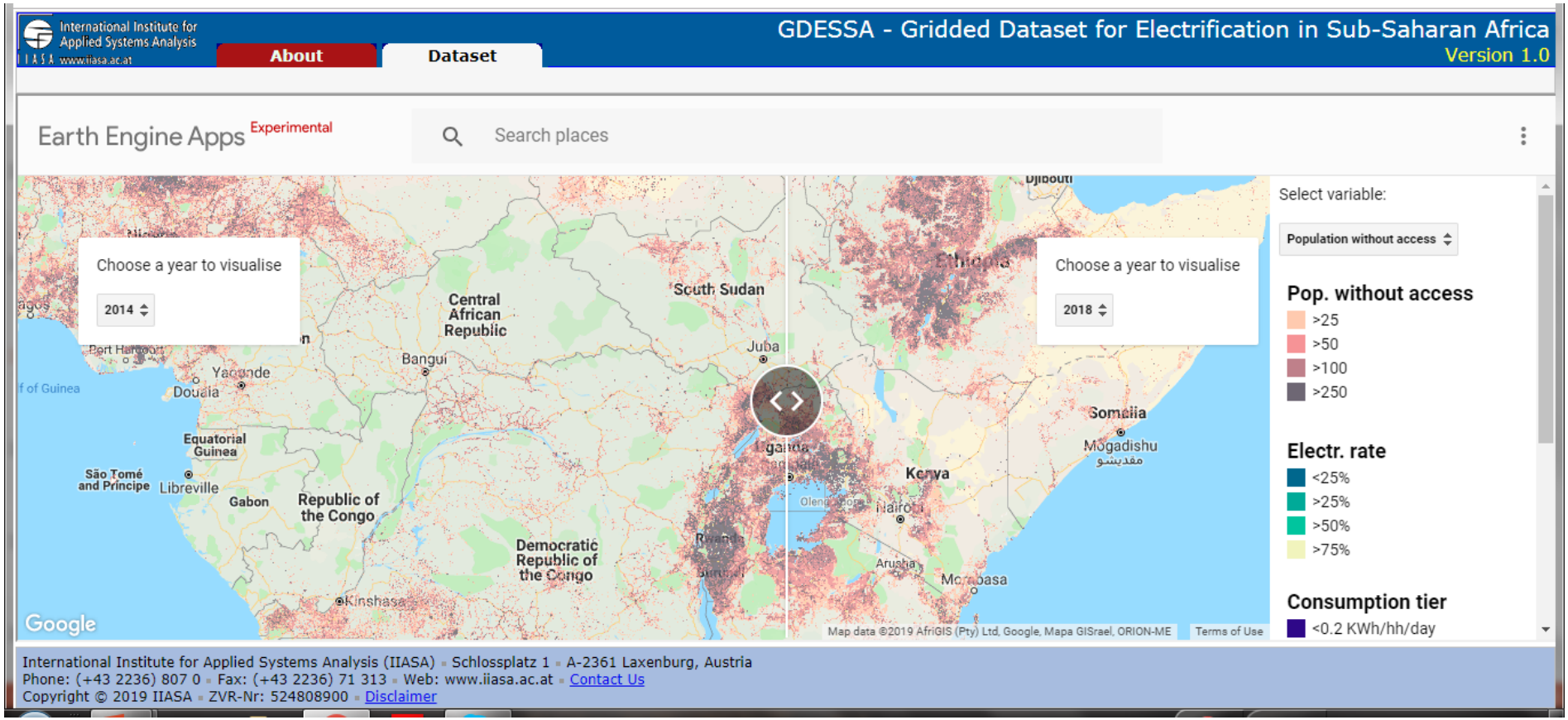
**MESSAGEix**
https://messageix.iiasa.ac.at/

**Community Water Model (CWatM)**
https://cwatm.iiasa.ac.at/

**GitHub**
https://github.com/iiasa

# EXTRA

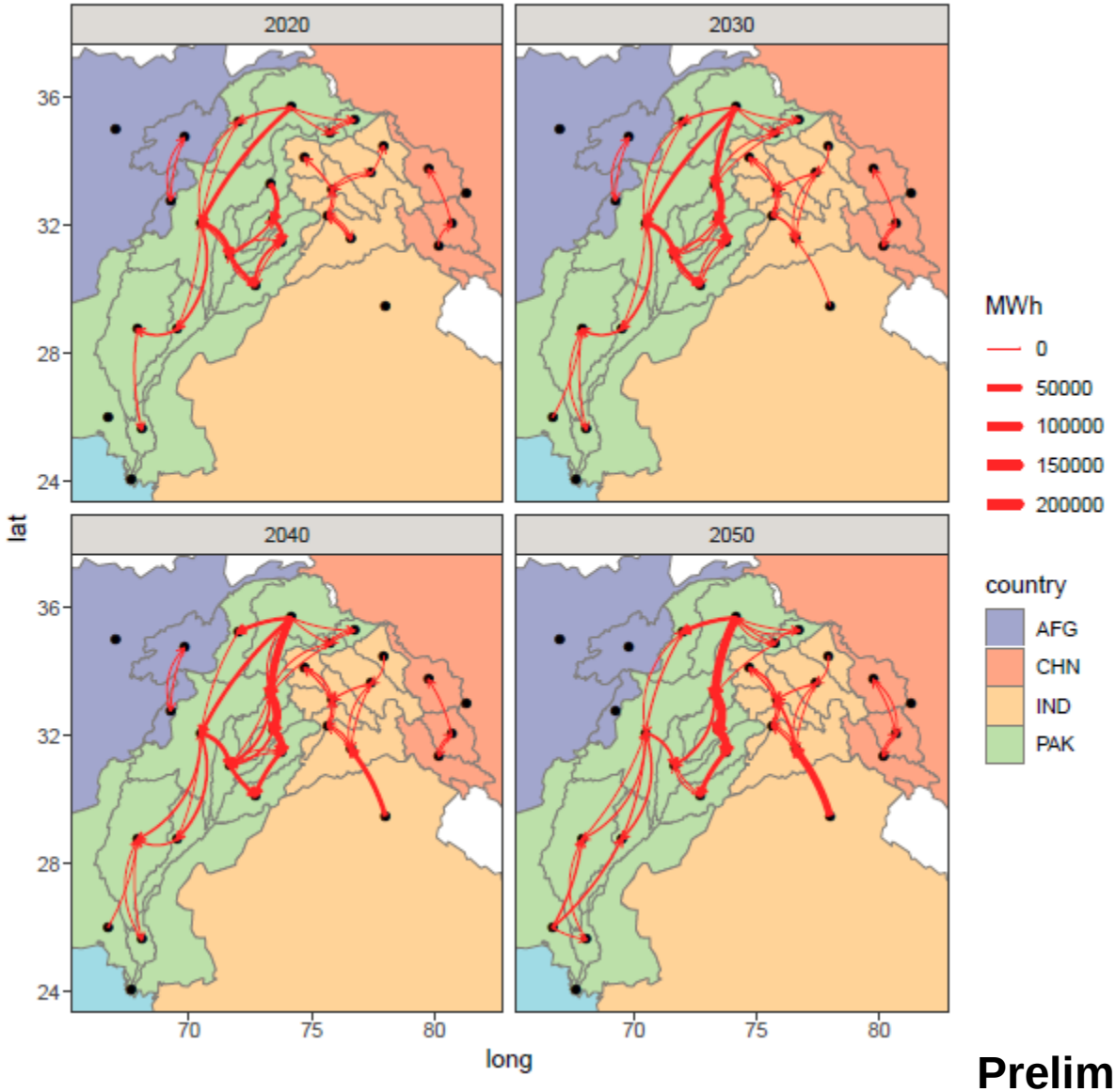
# Estimating dynamic electrification rates




https://data.ene.iiasa.ac.at/kolp/GDESSA/gdessaDataset.html

Giacomo Falchetta and others (forthcoming)

# Tracking electricity flows - Baseline




**Preliminary Results**
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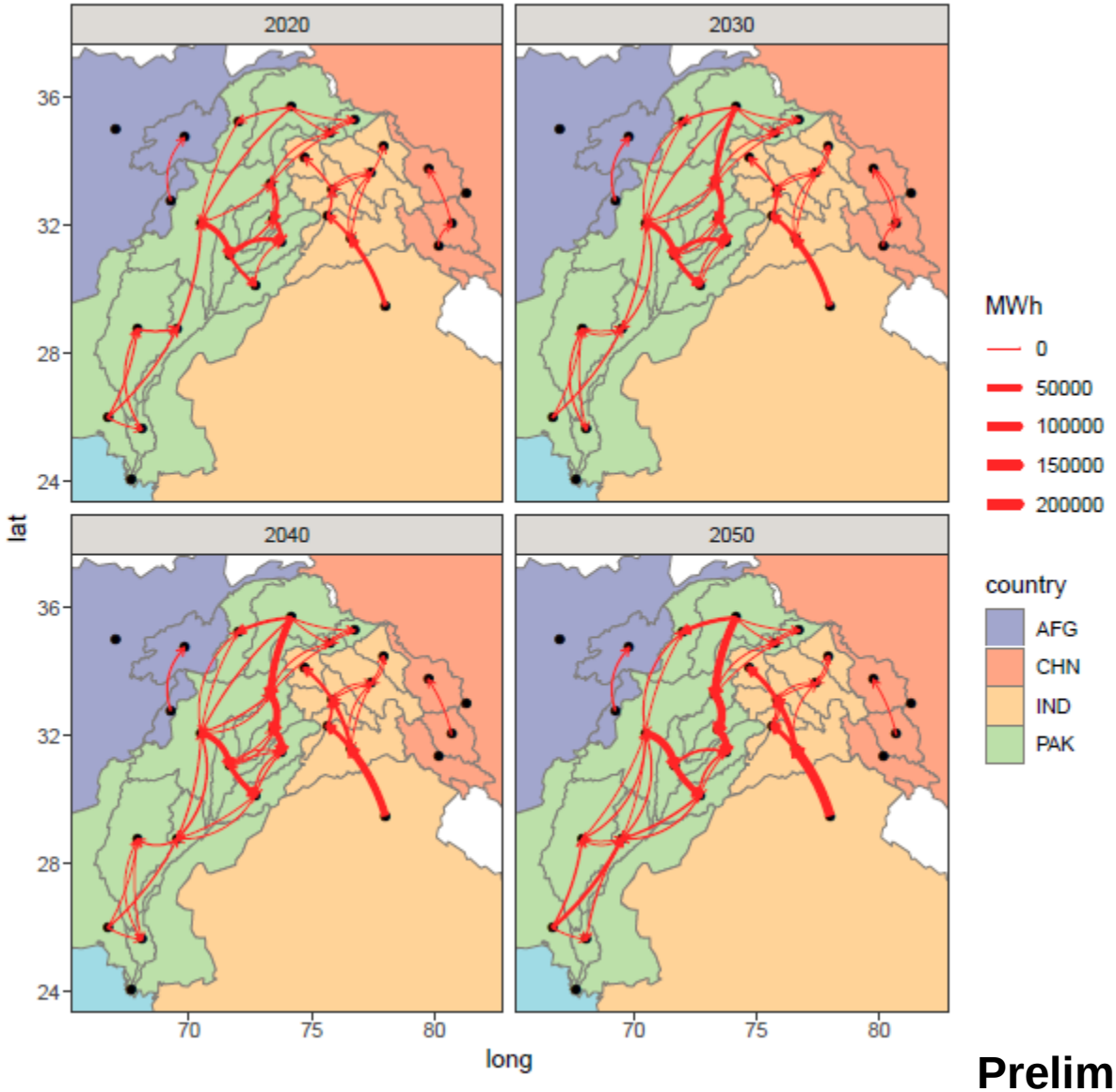
# Tracking electricity flows - SDG




**Preliminary Results**
**Do not cite or quote**

# Constructing integrated SDG scenarios using the SSP-RCP framework

- **RCP narrative (climate projections)**
  - *Locks in*
    - climate impacts to demands and resources
    - mitigation level
- **SSP narrative (societal projections)**
  - *Locks in*
    - demand drivers (pop, urbanization, GDP)
    - Baseline infrastructure access levels
    - Budgetary constraints
- **SDG narrative (policy levers)**
  - *Locks in:* additional policies