Finding integrated SDG pathways for the Indus River Basin

Simon Parkinson
Research Scientist
University of Victoria & Energy Program, IIASA

Co-authors: A. Vinca, E. Byers, P. Burek, V. Krey, N. Djilali, Y. Wada, K. Riahi
Scenarios Forum: Sub-national scenarios for integrated modeling and analyses
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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 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 disputes
- 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
- Employment impacts of transformations

Laghari and others (2012)
Research Question
How to strike a balance between objectives? … and at what cost?

SDGs

2. Zero Hunger
   - India

6. Clean Water and Sanitation
   - India

7. Affordable and Clean Energy
   - Pakistan

Transboundary Agreements

- Afghanistan
- Pakistan
Multi-scale modeling for transforming systems

**C WaTM**
- Basin boundary
- Main river
- Main canal

**MESSAGE**
- Sub-basin Outlet
- River Network
- Country Border
- Afghanistan
- China
- India
- Pakistan

**Up-scaling**
- Water constraints

**Down-scaling**
- Water and land-use

**Integrated Solutions for the Water-Energy Land Nexus**

*Vinca et al., (forthcoming)*
Constructing integrated SDG scenarios using the SSP-RCP framework

• **RCP narrative**
  – *Locks in*
    • climate impacts to demands and resources
    • mitigation level

• **SSP narrative**
  – *Locks in*
    • demand drivers (pop, urbanization, GDP)
    • Baseline infrastructure access levels
    • Budgetary constraints

• **SDG narrative**
  – *Locks in*: additional policies
Projecting infrastructure demand under clean water goals

Spatially-explicit municipal water withdrawal modeling for different socioeconomic scenarios

Access to piped water infrastructure under different scenarios

**Fraction of withdrawals from improved sources**

**Baseline**

**SDG6 Pathway**

- South Asia
- Sub-Saharan Africa
- Eastern Europe
- M. East & N. Africa
- Latin America
- Former Soviet
- Pacific Oceanic
- Western Europe
- Pacific Asia
- North America
- Central Asia (China)

**Target 6.1** Universal access to safe drinking water by 2030

Increased investment into water distribution and wastewater collection

Access to wastewater treatment under different scenarios

Baseline vs SDG6 Pathway

SSP2

Target 6.3
Half of all wastewater treated by 2030

Increased investment into wastewater treatment

Calibrating sub-national scenarios: Stakeholder Engagement
Tracking basin-wide investments

Preliminary Results
Do not cite or quote
Tracking electricity flows - Baseline

Preliminary Results
Do not cite or quote
Tracking electricity flows - SDG

Preliminary Results
Do not cite or quote
Conclusions

• **Nexus approach key to quantifying adaptation challenges associated w/ SSPs**
  – *Linking of earth system and economic models at high spatial resolution to quantify dynamic constraints on water, energy and land resources*
  – *Joint optimization of synergies and tradeoffs across the nexus*
  – *Challenge: models projecting future hydro-climatic conditions are highly uncertain*

• **Application to the Indus Basin**
  – *Investment costs to achieve multiple SDGs*
  – *New insights into adaptive measures across sectors*
Thank you!

Collaborators from around the world
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
Water

Electricity recharge from rivers, canals and crop field

Groundwater+

Seawater

Internal surface water+

Storage

Surface water

Environmental flows

Hydroelectric potential

Pumping

Desalination

Water deviation

Water distribution

Urban* (and industrial)

Rural*

Energy sector

Land sector

Urban

Rural

Node up

* exogenous

+ limits are imposed based on information from hydrological model
Energy

Power plants

- Fossil (natural gas, coal, oil, CCS)
- Nuclear
- Biomass & co-firing
- Solar & Wind
- Hydroelectric

Power transmission

- Transmission HV (to other nodes)
- Distribution (internal)

Electricity demand

- Urban* (and industrial)

Rural generation

- Diesel generator
- Small PV
- Ethanol generator

Water sector

- Rural*

Land sector

- Hydroelectric potential

- Bio-fuel^ (ethanol or solid biomass)

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

**Crops**

- **Irrigated**
  - Irrigation systems
    - Flood
    - Sprinkler
    - Drip

- **Rainfed only**

**Electricity from grid or local generators**

**Water for irrigation**

**Crop products demand** by country

**Total land constraints**

**Land availability**

**Crop residues**

**Water for bio-fuel production**

**Biomass transportation/ conversion**

**Energy sector**

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* exogenous.

§ total available area for agriculture based on historical data.