Renewables for African Agriculture:
Integrating Modelling Excellence and Robust Business Models

MESSAGEIX-NEXUS (NEST) OVERVIEW

Adriano Vinca

International Institute for Applied Systems Analysis (IIASA)

www.re4afagri.africa

LEAP-RE

Long-Term Joint EU-AU Research and Innovation Partnership on Renewable Energy

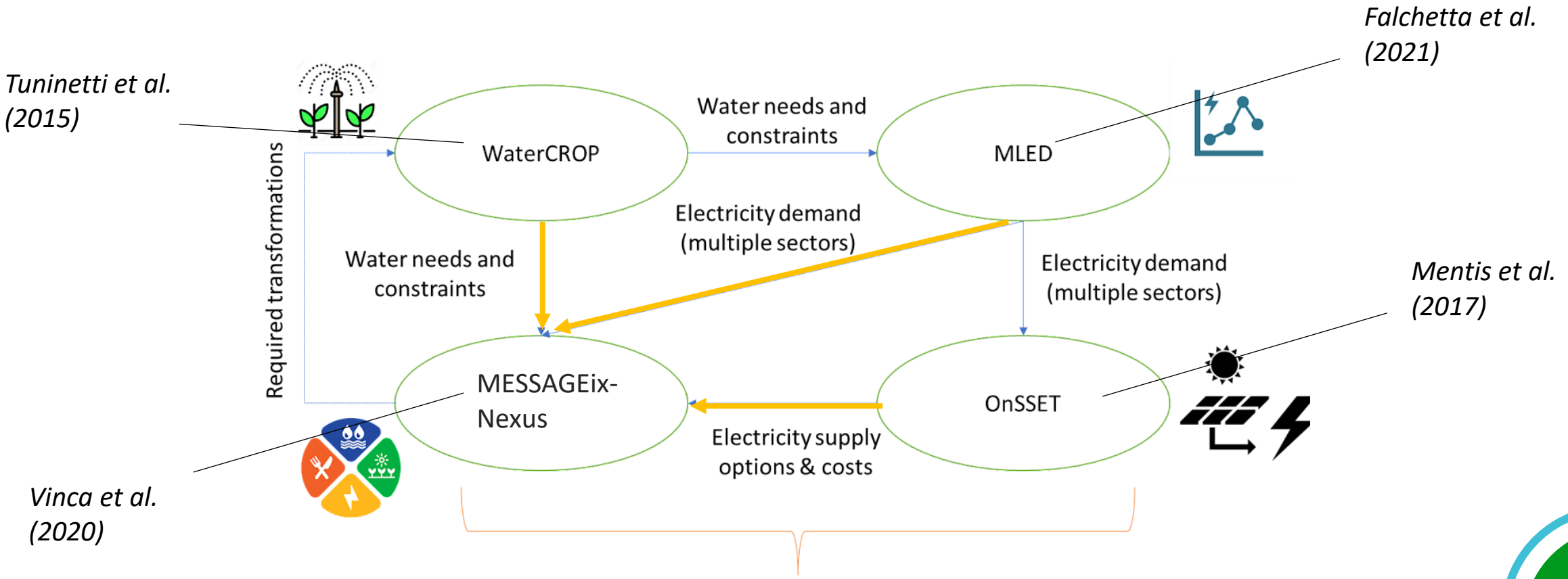
RE4AFAGRI

Renewable Energy for African Agriculture

The LEAP-RE project has received funding from the European Union's Horizon 2020 Research and Innovation Program under Grant Agreement 963530.

Data from the RE4AFAGRI platform

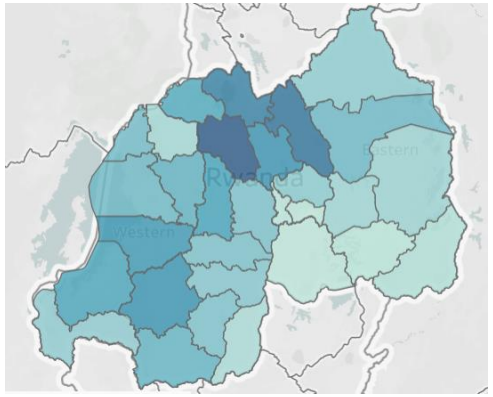
The RE4AFAGRI platform is a multi-model framework to analyse deficits, requirements, and optimal solutions for integrated land-water-agriculture-energy-development nexus interlinkages in developing countries. Four models representing land-water-crop-food-energy requirements and dynamics *(WaterCROP, M-LED, OnSSET and MESSAGE-Nexus)* are calibrated and soft-linked through the RE4AFAGRI platform.



10.1016/j.esr.2022.100922

From High Level policy to developers

High level Policies



Business planners

Developers, project implementation

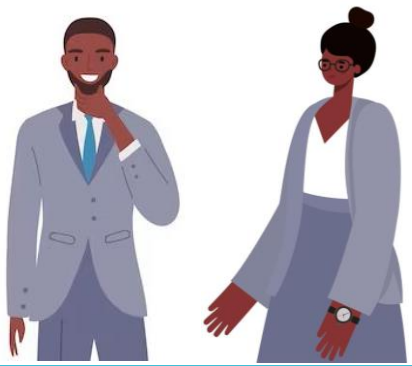
MESSAGEix-Nexus: Objectives

LEAP-RE

Explore capacity expansion in water infrastructure, agriculture and energy technologies under different narratives or scenarios

Access commodity flows and prices (e.g. surface and groundwater, electricity, crop products)

Investment portfolios under different narratives or scenarios



Understand the cross-sectoral implications of specific policies

Energy expert Agriculture expert

NEST or MESSAGEix-Nexus

NExus Solutions Tools (NEST)

Distributed Hydrology ISIMIP

Other spatial data

Model coupling

WaterCROP: water withdrawals

MLED: urban/rural energy demand

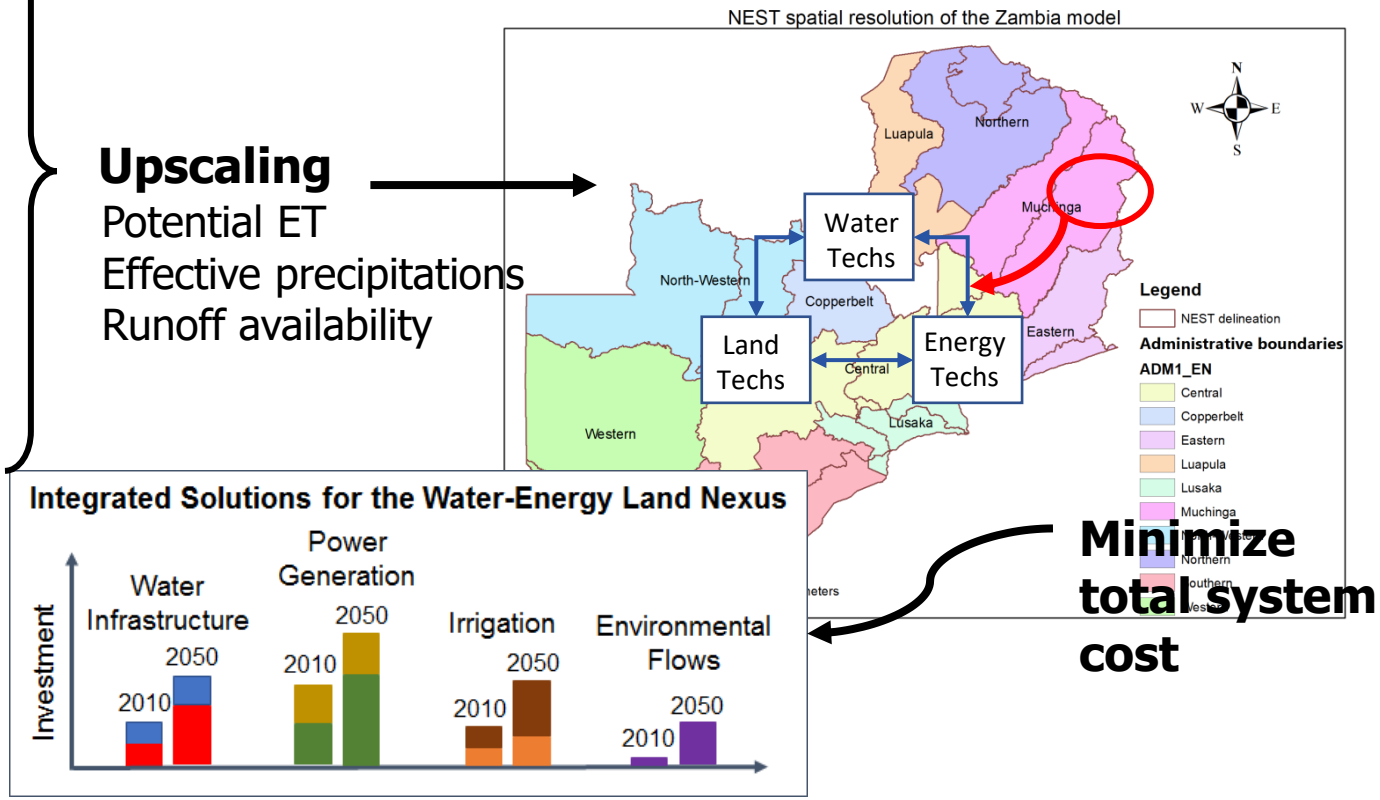
OnSSET: shared of energy access

Upscaling
Potential ET
Effective precipitations
Runoff availability

Infrastructure Planning

MESSAGEix

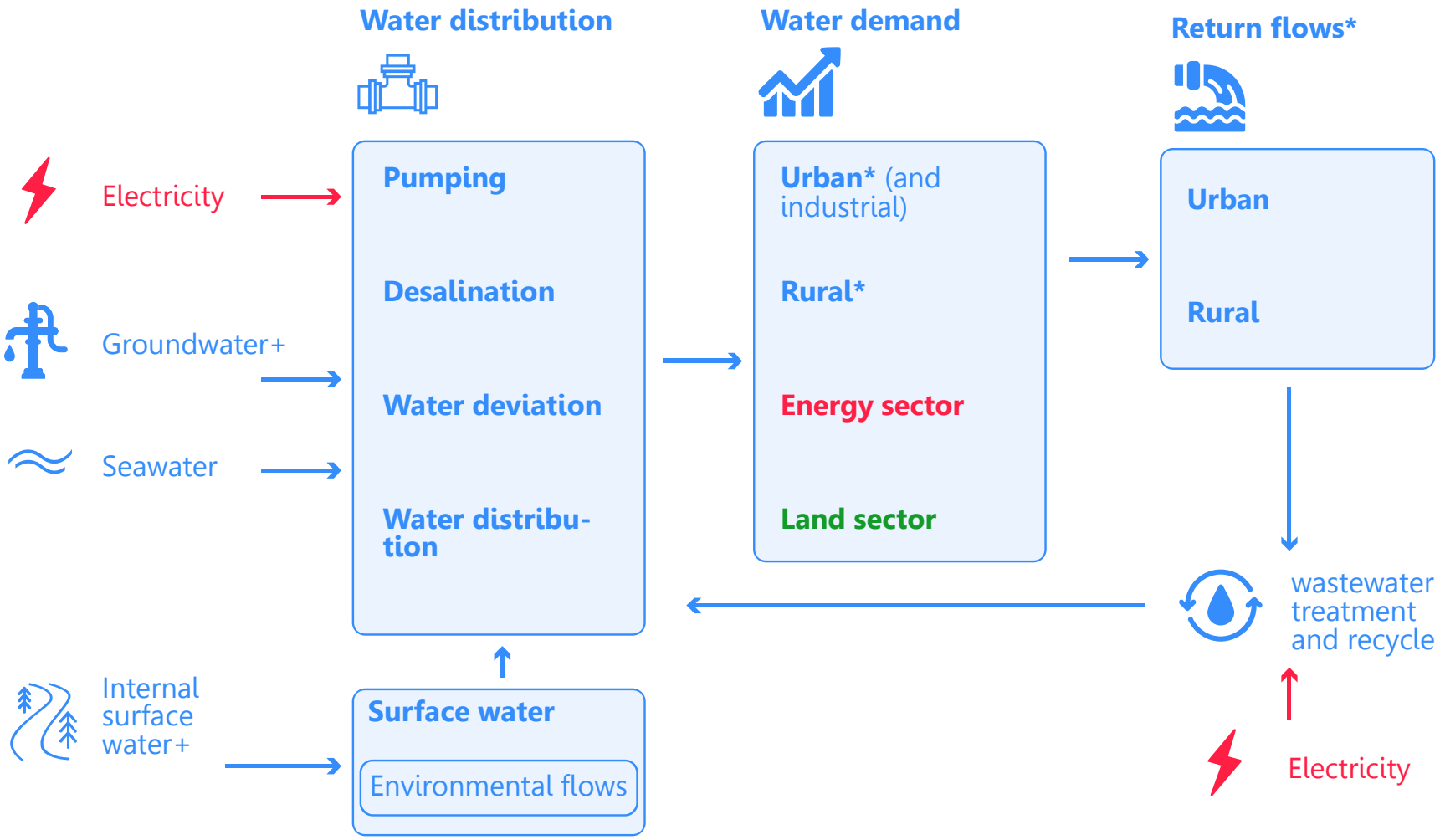
(Huppmann et al., 2018)



Minimize total system cost

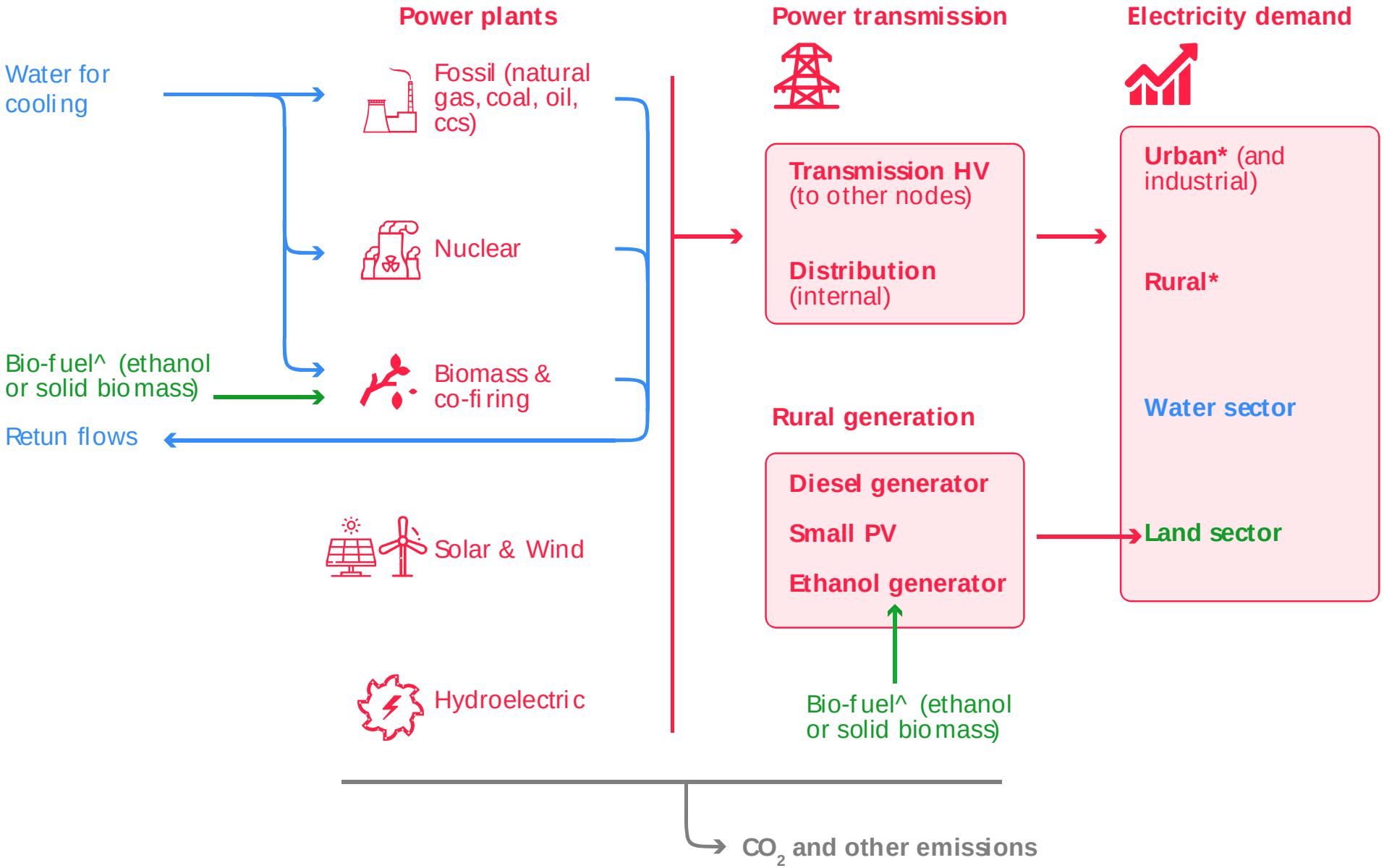
Vinca et al., 2020, GMD

Water system



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

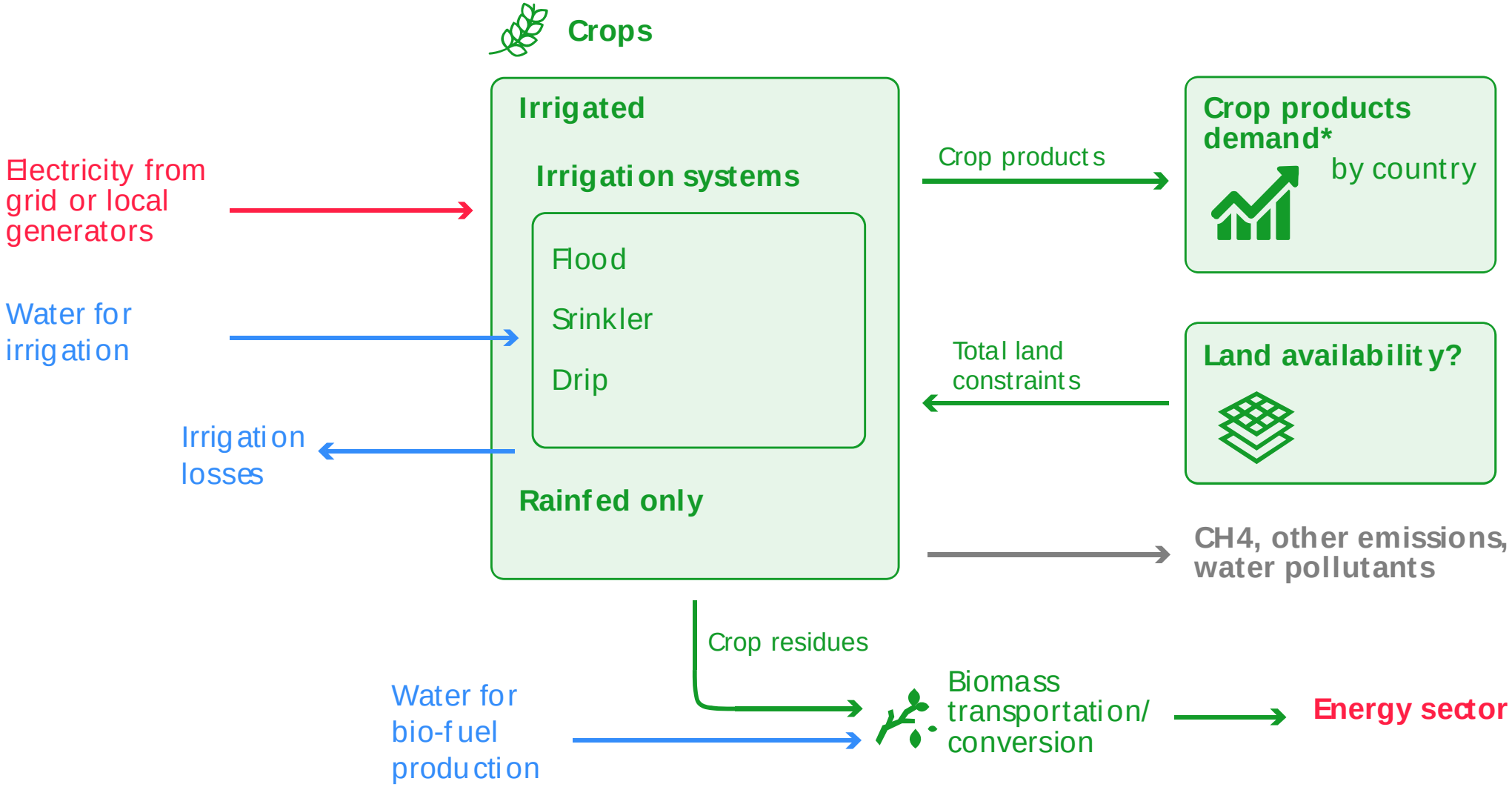
Energy System



* exogenous

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

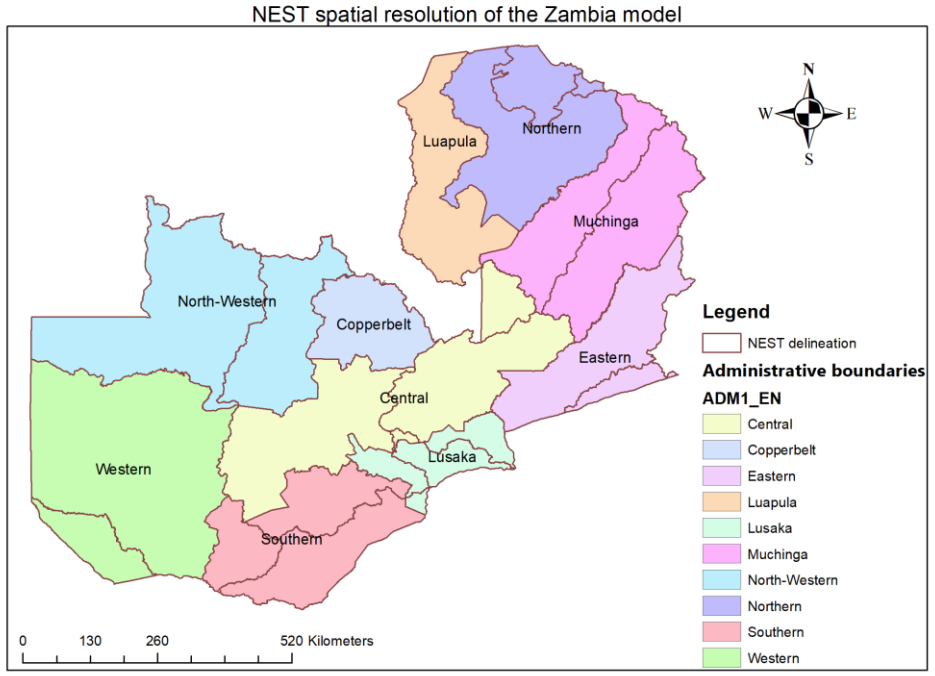
Land system



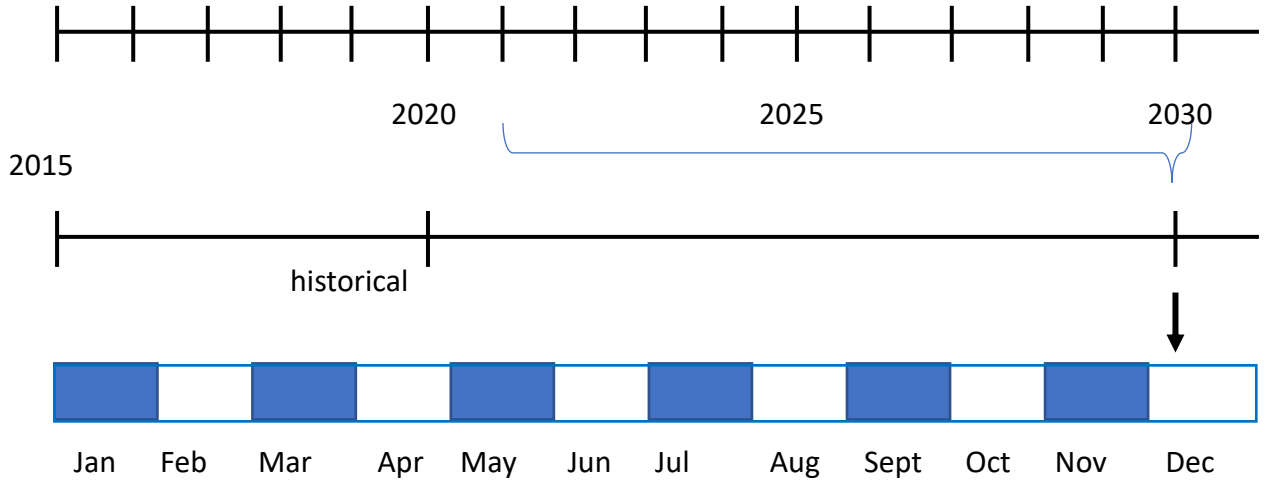
* exogenous.
? total available area for agriculture based on historical data

NEST spatial and temporal resolutions

Spatial:
user-defined BCUs
e.g. Intersecting hydroBASIN lvl 4
+ provinces

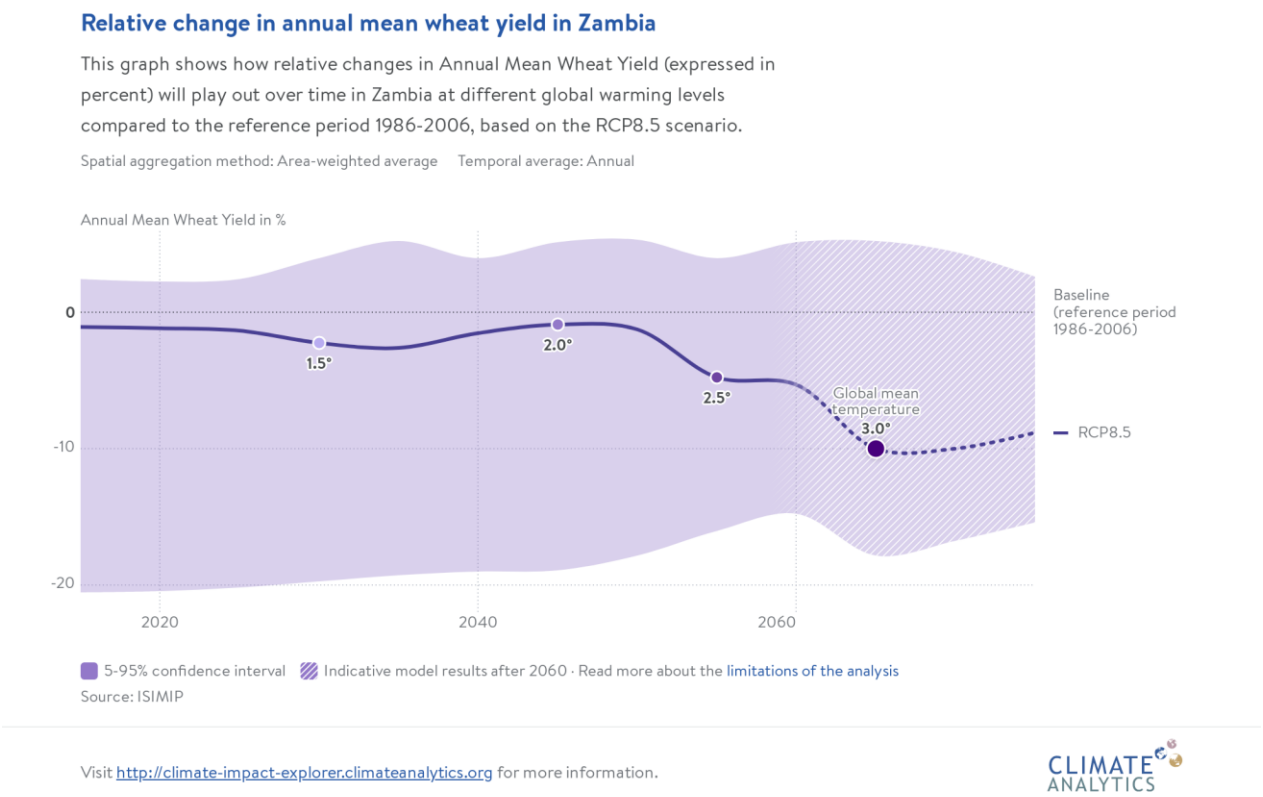


Temporal: flexible
multi-year time-steps + sub-annual dimension
E.g. 10y time-steps + 12 months sub-annual



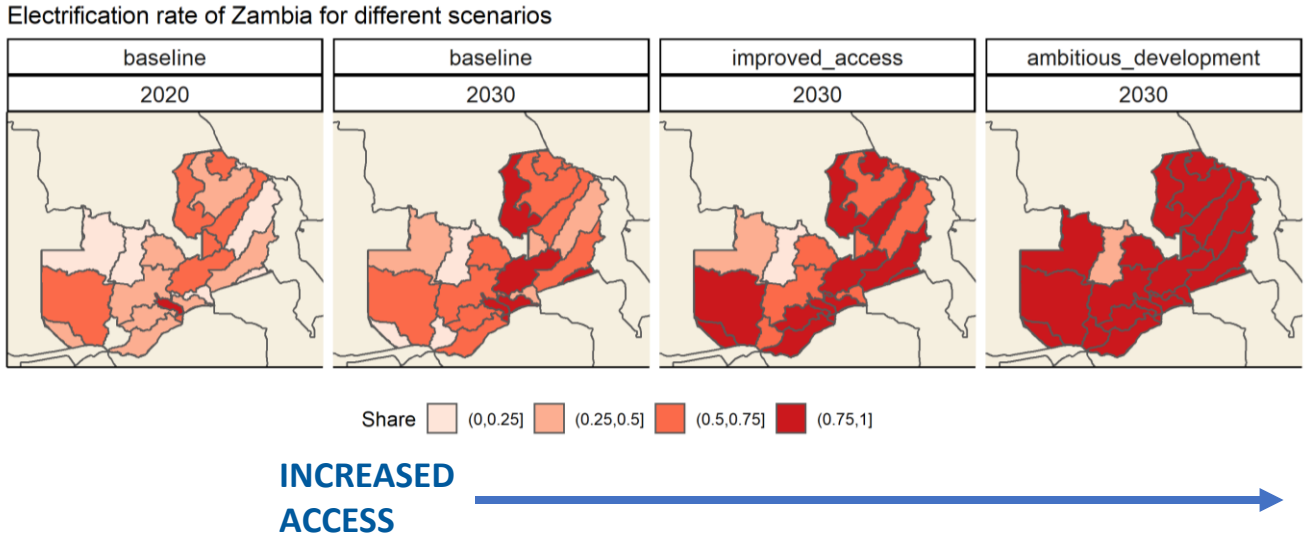
Possible policies

- Development pathways
- Climate impacts in Energy, hydrology and land
- Environmental policies (ecosystem preservation)
- Food export targets

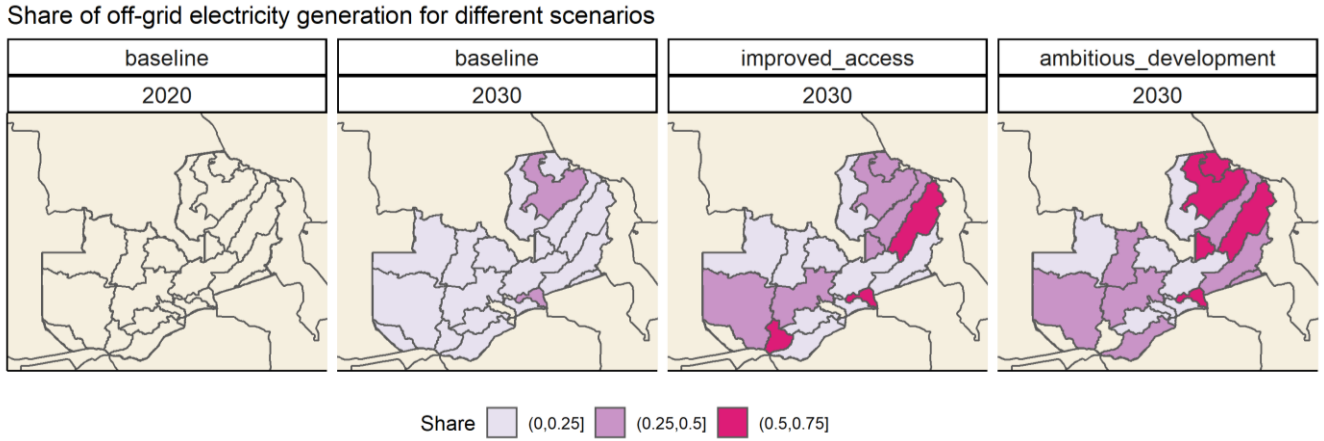


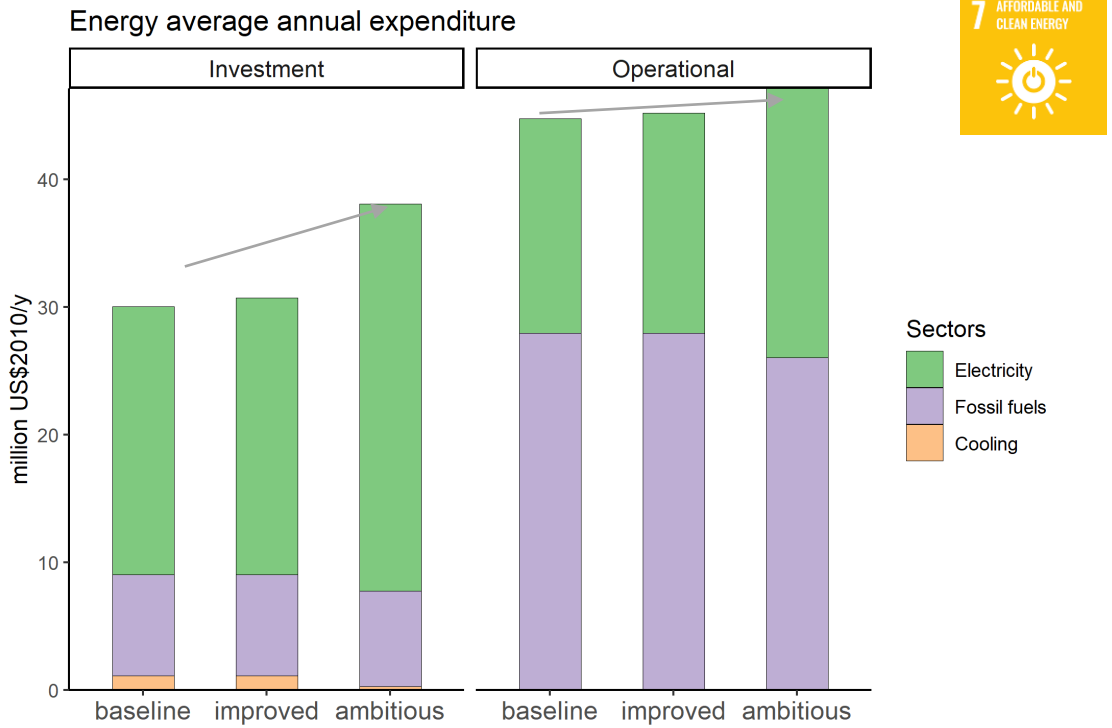
- **Power plants operation**
- **Cooling demand**
- **Hydropower**
- **Precipitations**
- **Water availability**
- **Crop yields**
- **Water requirements for crops**

Results – integrated water-energy needs



INCREASED ACCESS



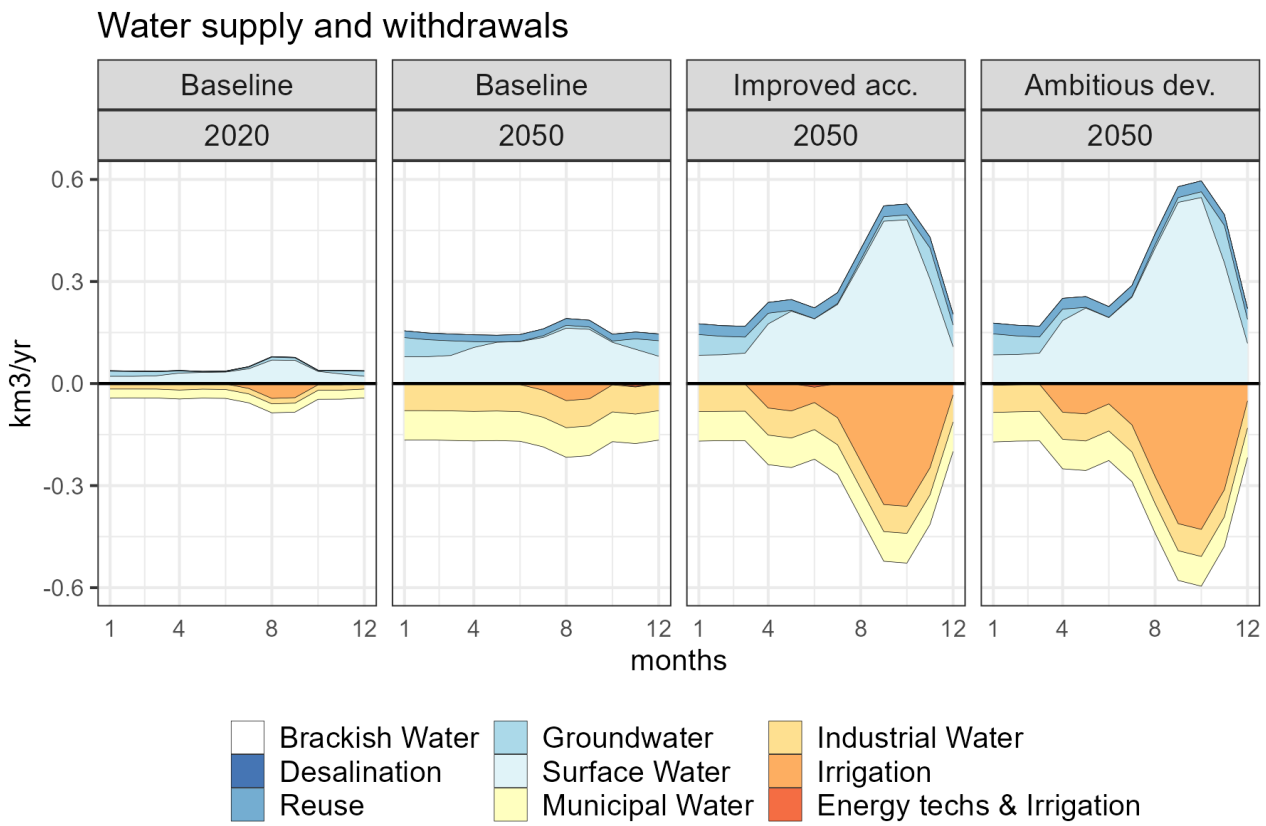


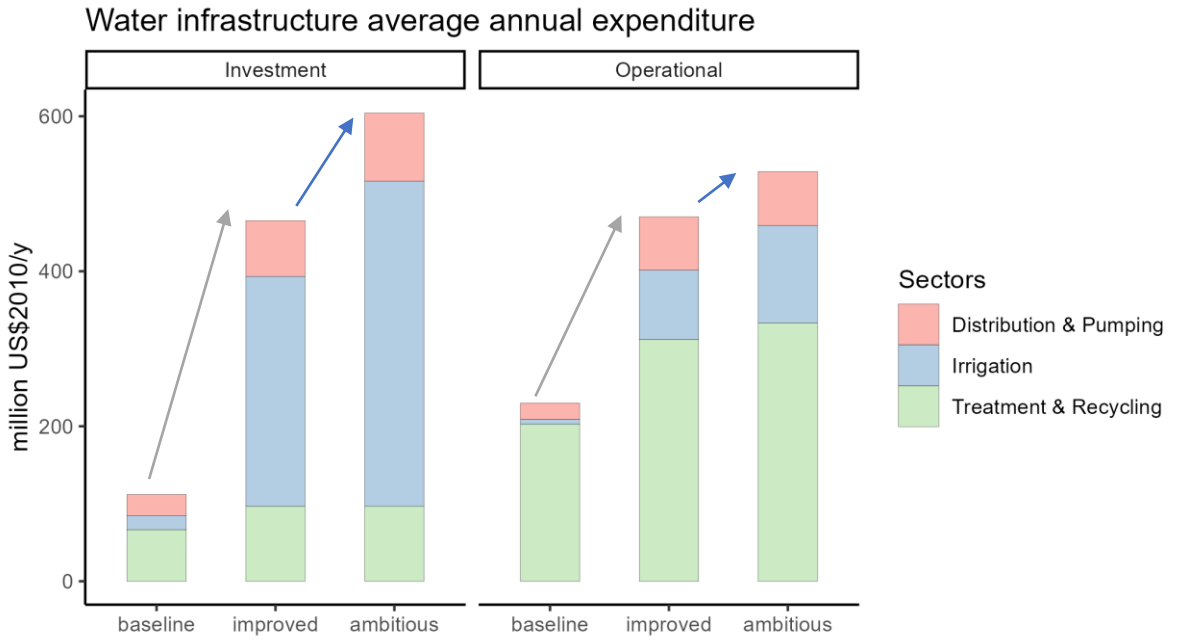
Increased requirements to achieve full electricity access in 2030:

+ 27% increase in annual investment

+ 5% increase in annual operational costs

Results – integrated water-energy needs





Water access gap closure by 2040 (improved):

annual investment +79%

operational costs: +70%

NEST output

Energy

- Energy use (Primary, Secondary, Final)
- Energy prices
- CO_2 emissions pathways
- Capacity requirements
- Energy supply portfolio
- A/C cooling gap
- Investment pathways
- Energy use of water commodities)
- Adjusted residential demands with increased access to electricity

Water

- Water withdrawals based on constraints
- Water supply outlook (combination of different sources)
- Capacity requirements of of water infrastructure technologies (wastewater, water distribution)
- Investment in the water infrastructure sector
- Drinking & irrigation water marginal prices
- Water footprint of energy sector

Land

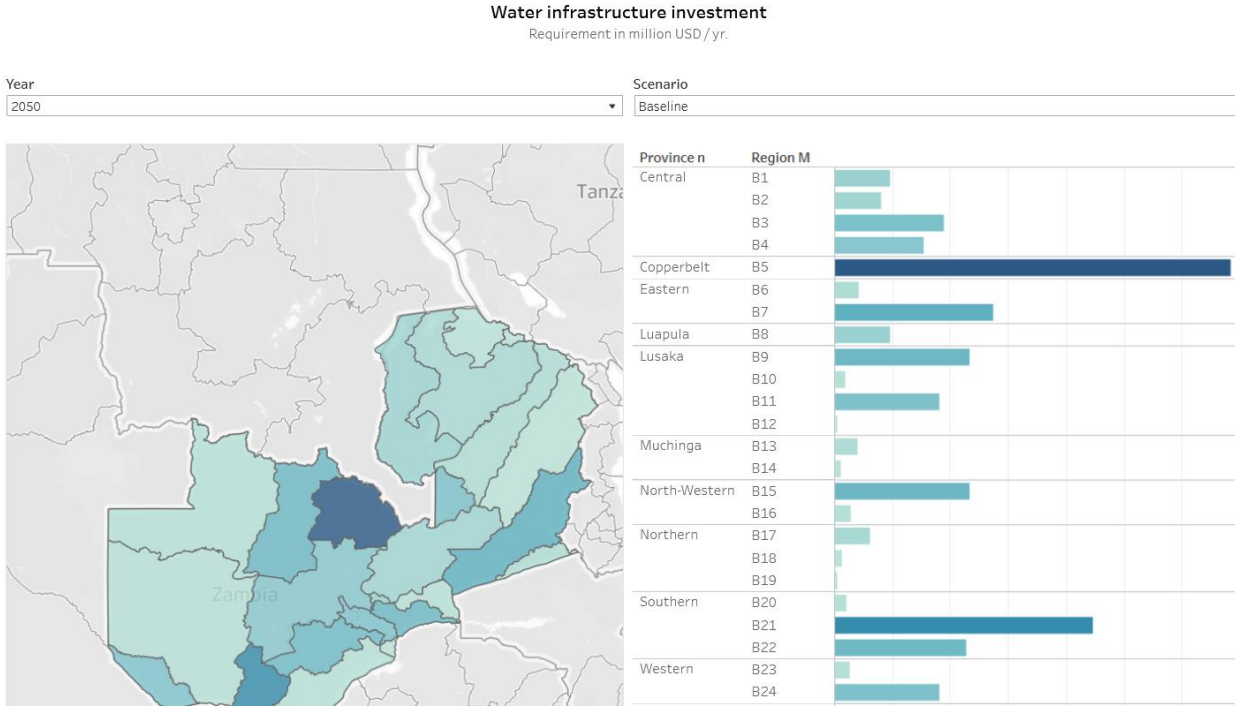
- Water Withdrawals for Irrigation
- Crop Yields
- Land Cover (different categories)
- Agriculture production & demand
- Fertilizer use & intensity
- Land use CO2 emissions

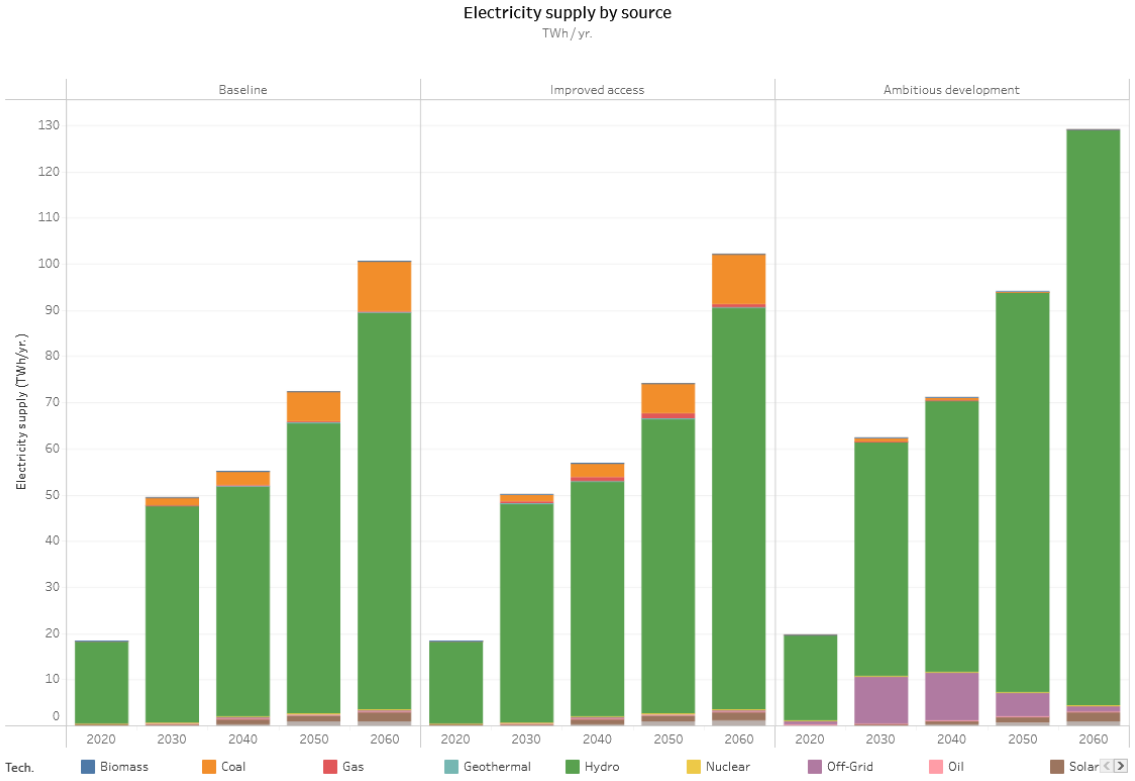
Socio-economics

- Population with access to drinking water, sanitation
- Urban & rural municipal demands
- Population with access to electricity, clean-cooking fuels
- Population with risk of hunger

Dashboard outputs

https://www.re4afagri.africa/dashboards-zambia/multi-sectoral-insights





NEST or MESSAGEix-Nexus

- NEST 2019 has it's own documentation (Vinca et al., 2019, open review GMD) open Github repository, interactive scenario explorer
- MESSAGEix is open-source tool, accessible and well documented online (limitation on solvers)
- Official maintained documentation

https://docs.messageix.org/projects/models/en/latest/

Geoscientific Model Development
An interactive open-access journal of the European Geosciences Union

The Nexus Solutions Tool (NEST): An open platform for optimizing multi-scale energy-water-land system transformations

Adriano Vinca[1,2], Simon Parkinson[1,2], Edward Byers[1], Peter Burek[1], Zarrar Khan[3], Volker Krey[1,4], Fabio A. Diuana[5,1], Yaoping Wang[1], Ansir Ilyas[6], Alexandre C. Köberle[7,5], Iain Staffell[8], Stefan Pfenninger[9], Abubakr Muhammad[6], Andrew Rowe[2], Roberto Schaeffer[5], Narasimha D. Rao[10,1], Yoshihide Wada[1,11], Ned Djilali[2], and Keywan Riahi[1,12]

Preprint | File available

MESSAGEix-GLOBIOM Nexus Module: Integrating water sector and climate impacts

March 2023
DOI: 10.5194/egusphere-2023-258

Lab: Sustainable Energy Systems Integration & Transitions (SESIT)

Muhammad Awais · Adriano Vinca · Edward A. Byers · Show all 15 authors · Volker Krey

MESSAGEix-Nexus

For inquiries contact:
vinca@iiasa.ac.at

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