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EGU General Assembly 2023

Soft-linking climate-land-water-energy assessment and planning models for sustainable development in rural Africa: preliminary results from the LEAP-RE RE4AFAGRI project

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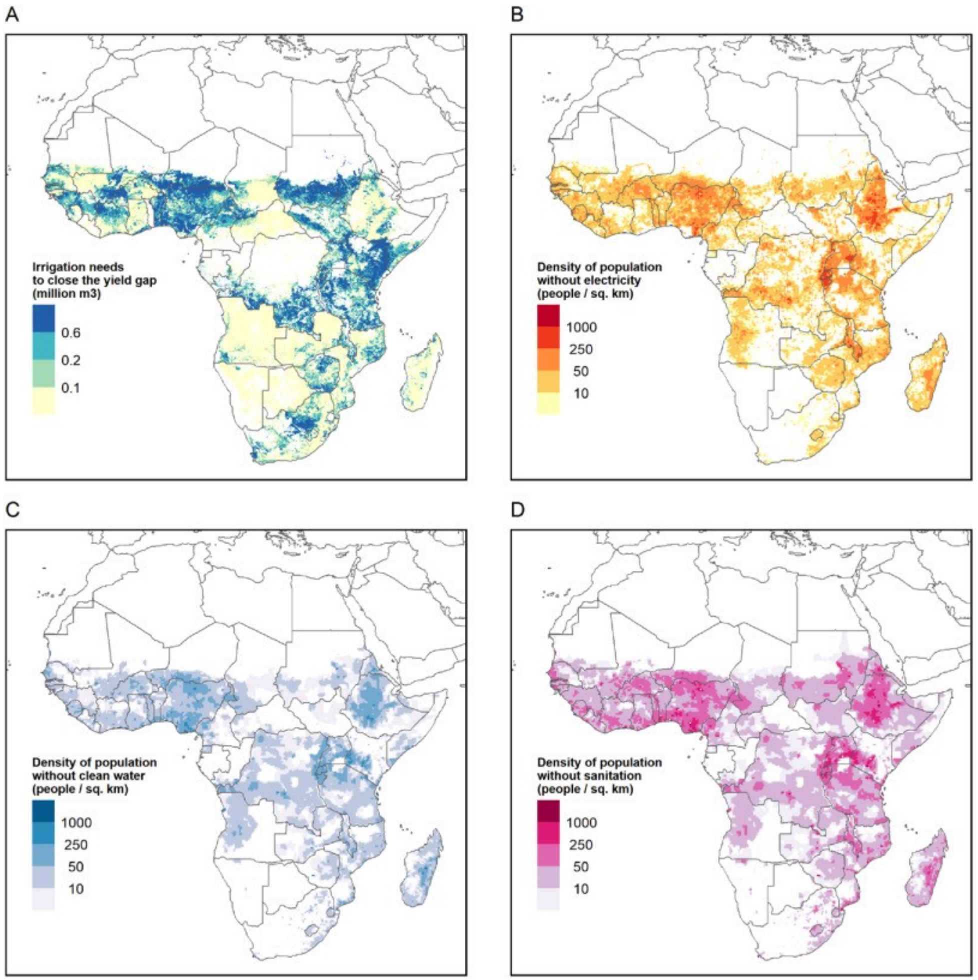
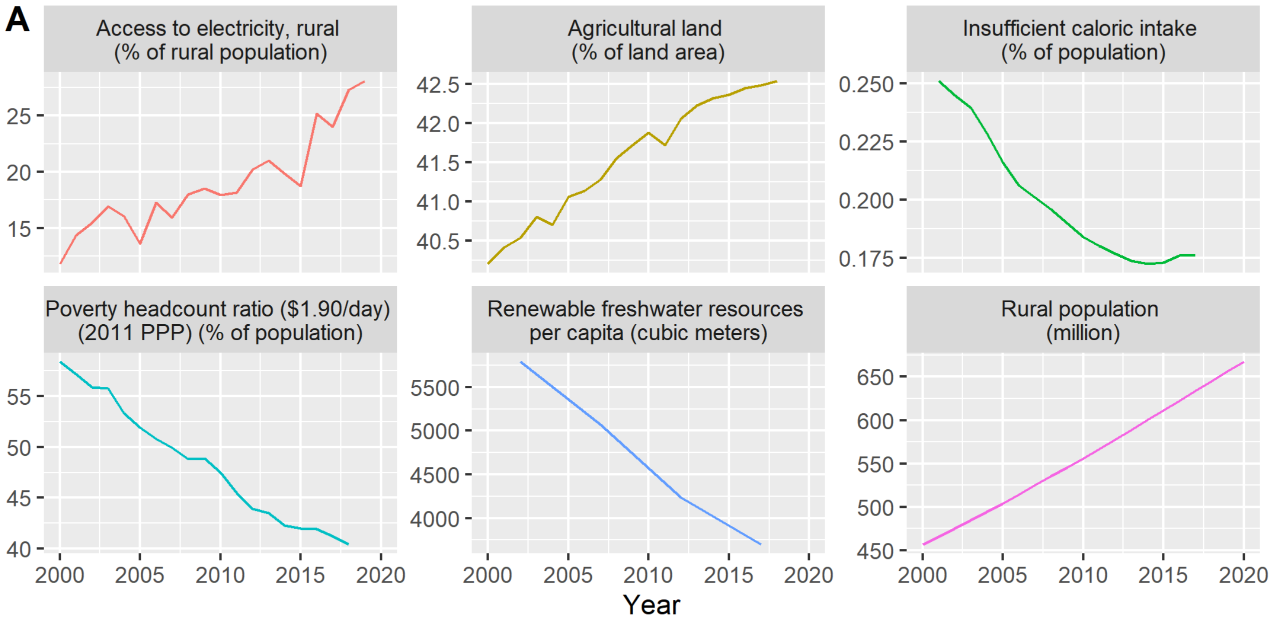
LEAP-RE

Background: rural SSA – WEFE Nexus challenges



10.1016/j.esr.2022.100922



Under baseline trends, most development gaps still **open** (or even larger) by 2030, together with a rapidly growing population (900+ million people by 2050, UN 2019 prospects)

- **Rainfed** agriculture and **scarce electricity access**
- Low **productivity** and **raw crops** to wholesale
- **Poverty** and **inequality** traps

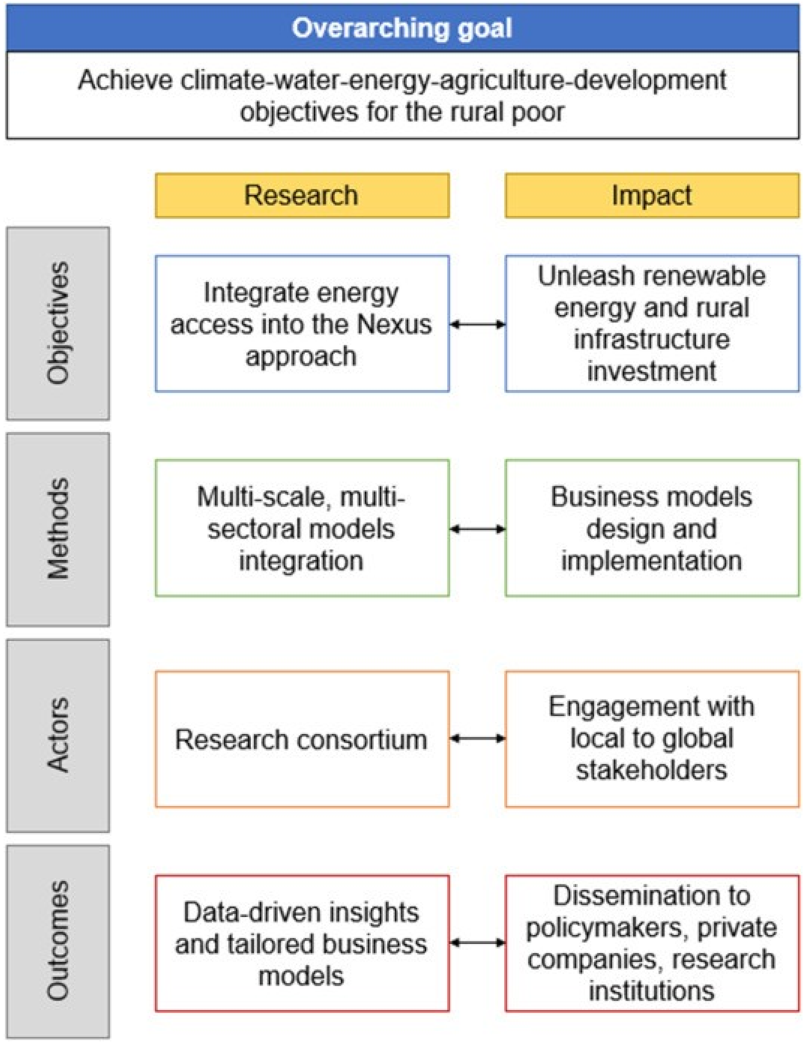
Figures: Falchetta (2021)
Data: World Bank, FAO

Study objectives

- Multi-sectoral **assessment and planning of technologies and policies** to promote integrated climate-water-renewable energy-agriculture sustainable development in rural areas
  - To inform **policymakers**
  - To support the creation of **robust business models** for private companies

- **Multi-scale focus**: local access to electricity and irrigation water; local system configuration and investment costs; up to macro consequences for financing energy and water supply technologies.

- Pilot implementation in **Zambia**, open modelling framework to **scale and replicate in other countries / basins**



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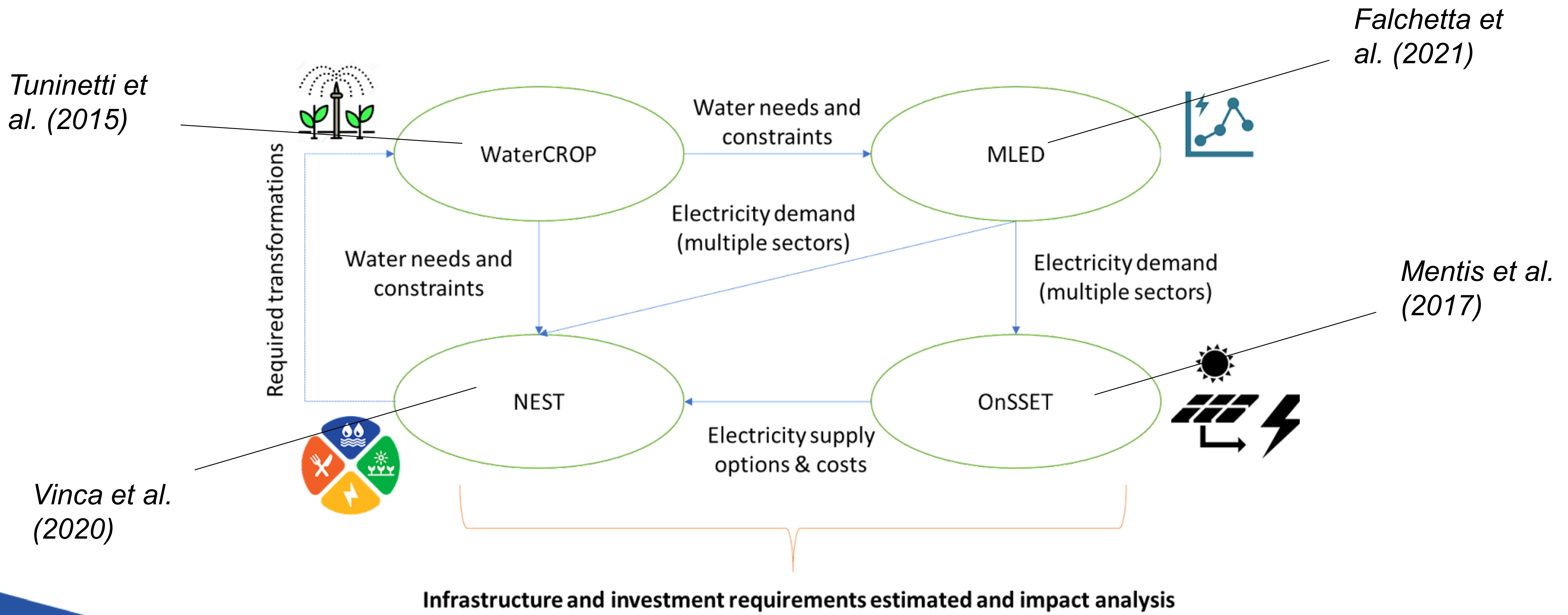
The RE4AFAGRI modelling platform

Four models representing land-water-crop-food-energy requirements and dynamics *(WaterCROP, M-LED, OnSSET and MESSAGE-NEST)* are calibrated and soft-linked through **the RE4AFAGRI platform.**



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Scenarios and data

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ISIMIP Inter-Sectoral Impact Model Intercomparison Project

MAPSPAM

iea International Energy Agency

GRID3 GEO-REFERENCED INFRASTRUCTURE AND DEMOGRAPHIC DATA FOR DEVELOPMENT

Scenarios table

Story/question	RCP	National goals	SSP
"Baseline"	RCP 7.0	Current policies Agriculture: historical trend of production	SSP2
Improved access	RCP 7.0	Electricity access: halving the gap in 2030 water access & sanitation: halving the gap in 2030; Food security: increasing water supply to meet domestic food crops production demand in 2030 (given current diet, no extensification, fertilization, trade)	SSP2
Ambitious development, sustainable targets	RCP7.0 (SSP1, RCP2.6 on land)	Energy universal access, universal water access & sanitation; nutrition security: improve yields to meet future food crop production demand to meet the EAT Lancet diet in 2030; Renewable electricity share = 100% + climate constraints	SSP2

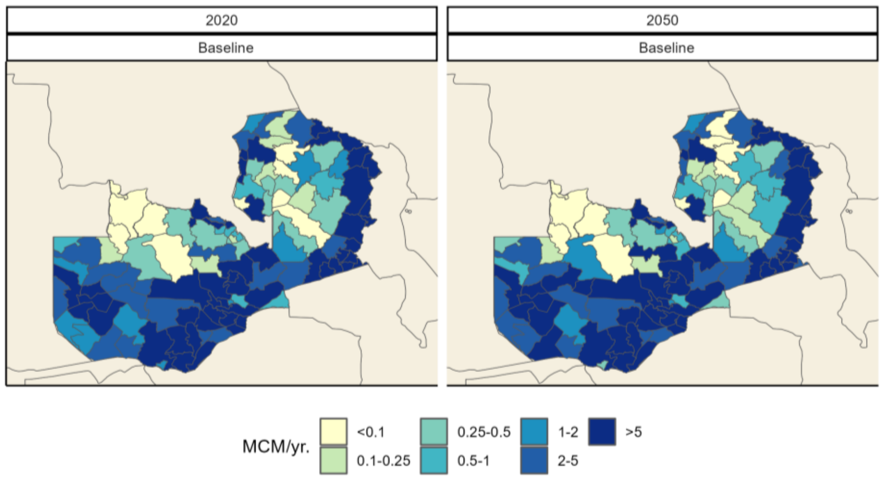
Main input datasets

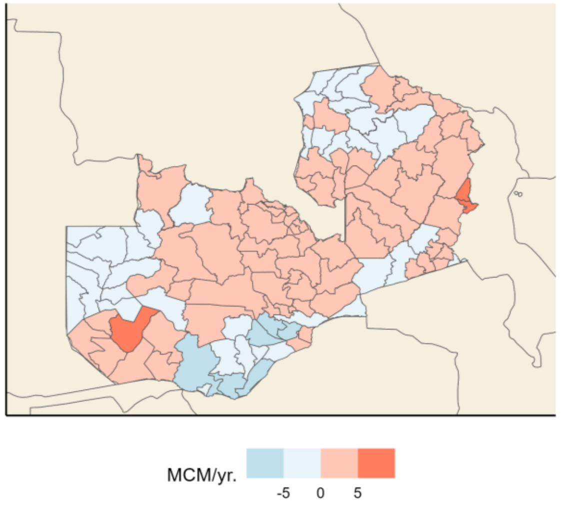
- ISIMIP3b climate data
- RCP-SSP: socio-economic development and climate projections
- MAPSpam 2017 SSA cropland extent
- IEA energy balances
- GRID3 population settelement extents
- OSM power grid geometry
- Global Solar & Wind Atlases (RES potential)
- MESSAGEiX database
- Additional data (see LEAP-RE deliverable 12.5)

1 NO POVERTY · 2 ZERO HUNGER · 5 GENDER EQUALITY · 6 CLEAN WATER AND SANITATION · 7 AFFORDABLE AND CLEAN ENERGY · 8 DECENT WORK AND ECONOMIC GROWTH · 10 REDUCED INEQUALITIES · 13 CLIMATE ACTION

Results – irrigation gap and needs

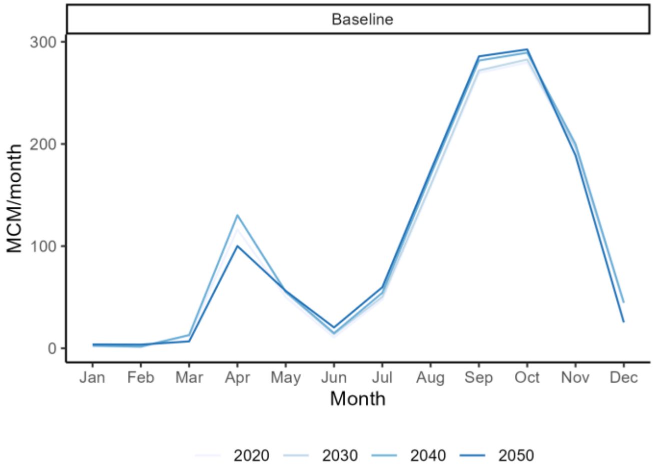
Total irrigation needs

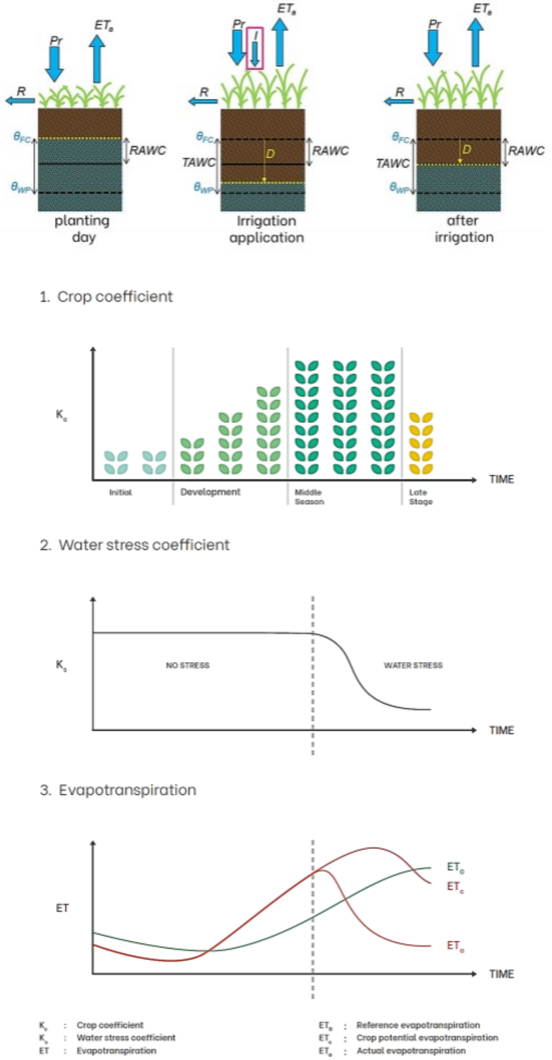




- In Zambia, **irrigation needs** grow as a result of **climate change** (2020-2050 in baseline scenario), as well as [not shown yet here] due to **increase of irrigated land** (improved access scenario) and to **close the irrigation gap** (ambitious development scenario).
- Total water demand grows from 1,180 MCM/yr. in 2020 to 1,250 MCM/yr. in 2050
- Considerable within-country variability observed in sub-national river basin/administrative unit intersections, and **shift in seasonality (intensification of peak demand).**

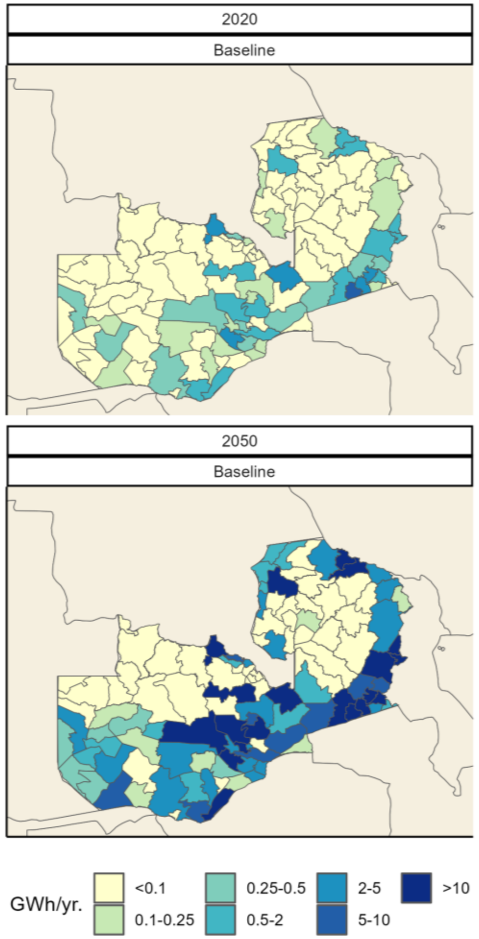
Total irrigation needs



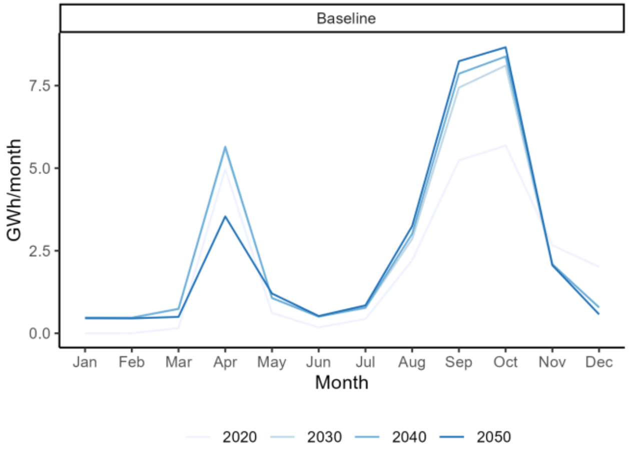


WaterCROP evapotranspiration model

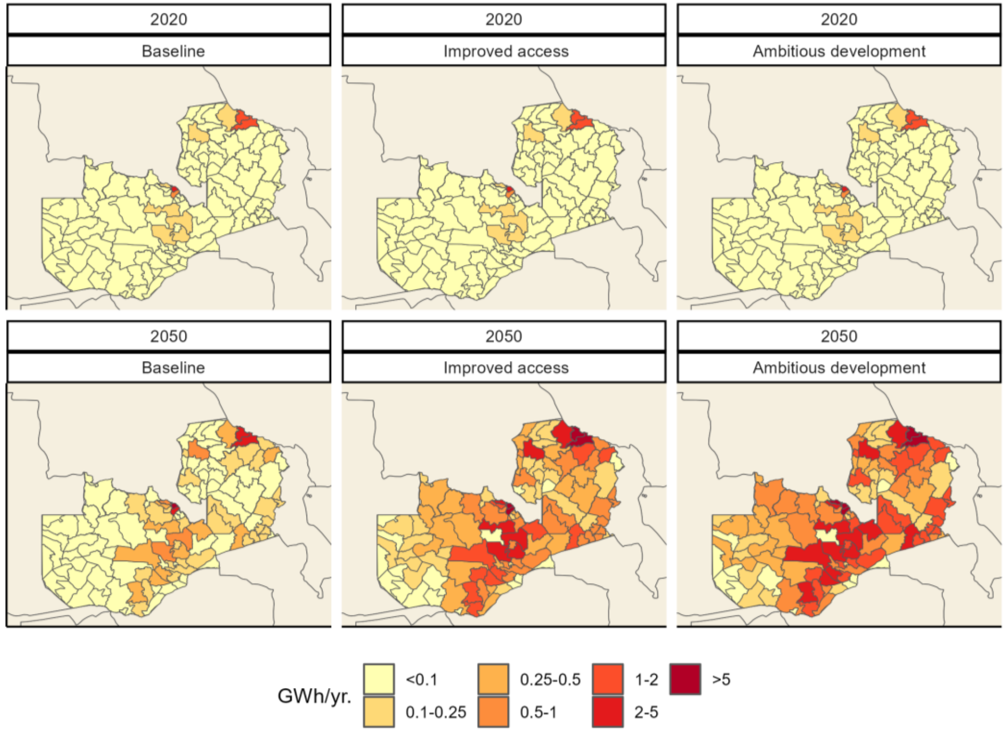
Results – water pumping and crop processing energy



- Energy demand for water pumping is determined both **by irrigation needs** and by the **local accessibility to groundwater/surface water resources.**
- Currently, **low demand** as vast majority of cropland is **rainfed…**
- With <u>irrigation expansion</u> and climate change → **growing demand**

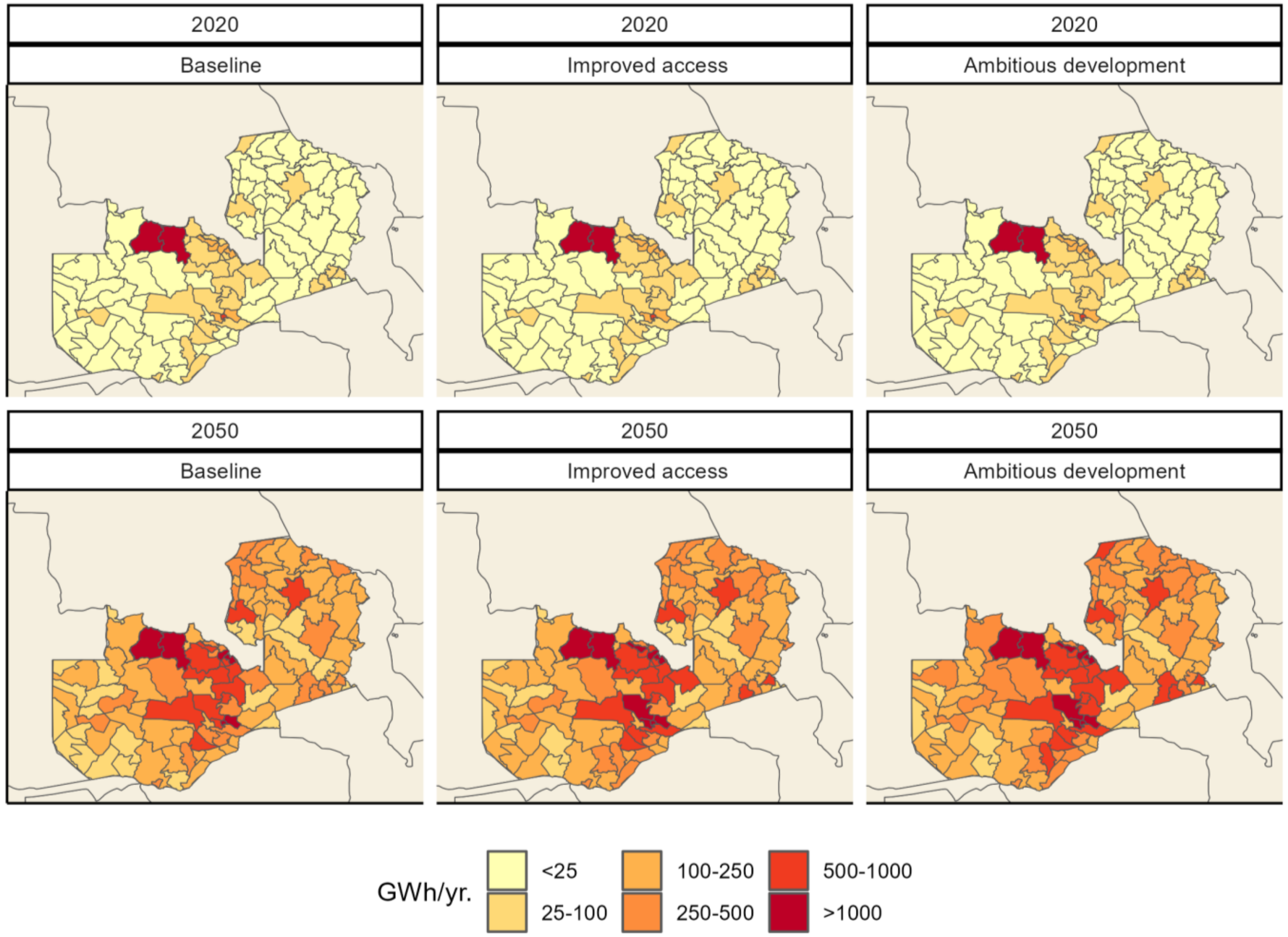


Seasonality of irrigation plays an important role in determining **monthly variability** in pumping energy demand.



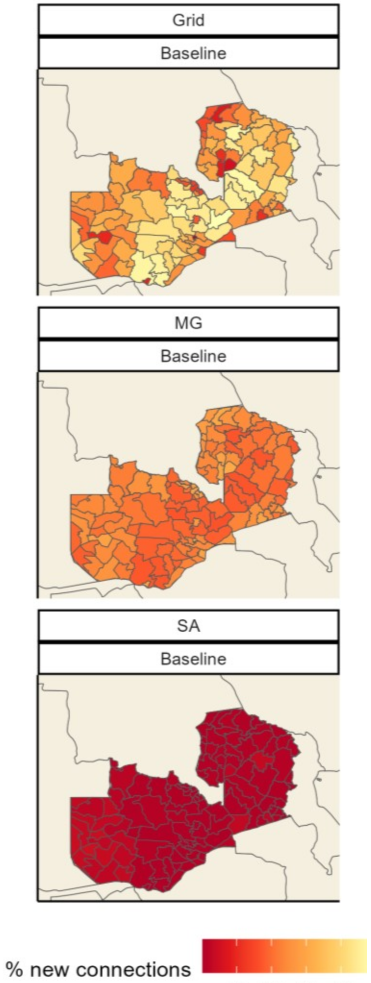
- Crop processing energy demand is a function of crop yield and processed throughput
- Considerable energy demand growth driven by policies promoting **energy access** and **local crop processing** in the three scenarios
- Impact of crop yield change induced by climate change embedded.

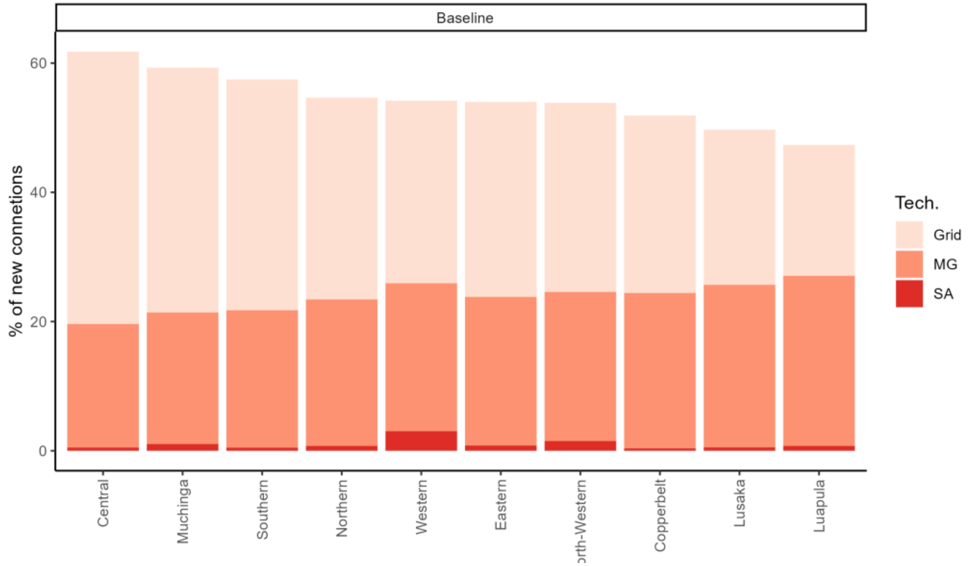
Results – electricity demand (total)

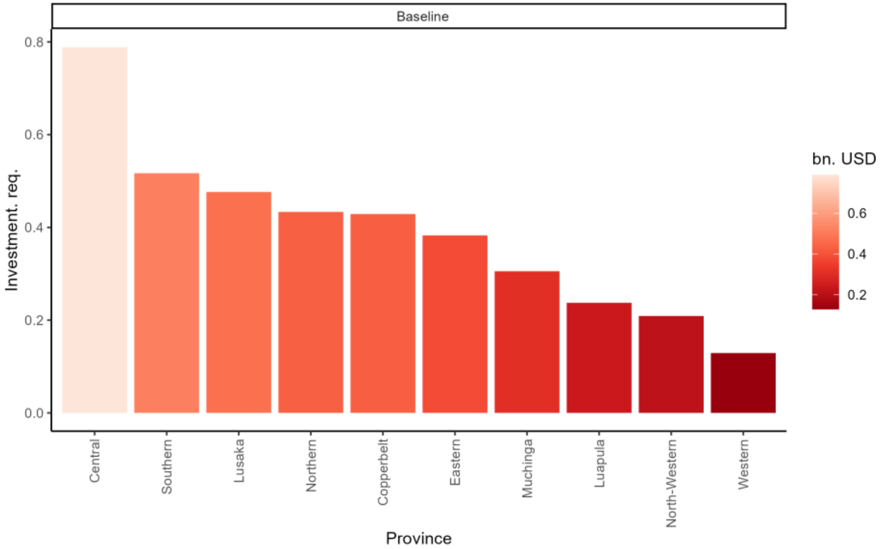


- Electricity demand is currently concentrated in the capital city **Lusaka** and in the mining districts in the **North-Western part of Zambia**
- Electricity demand will grow strongly and become less unequally distributed by 2050
- **Residential, commercial, and industrial demand** will represent the bulk of the growth in electricity demand-
- Still, **agricultural demand** plays an important role in rural areas and in determining electrification needs and solutions (next slides).

Results – energy access, 2030







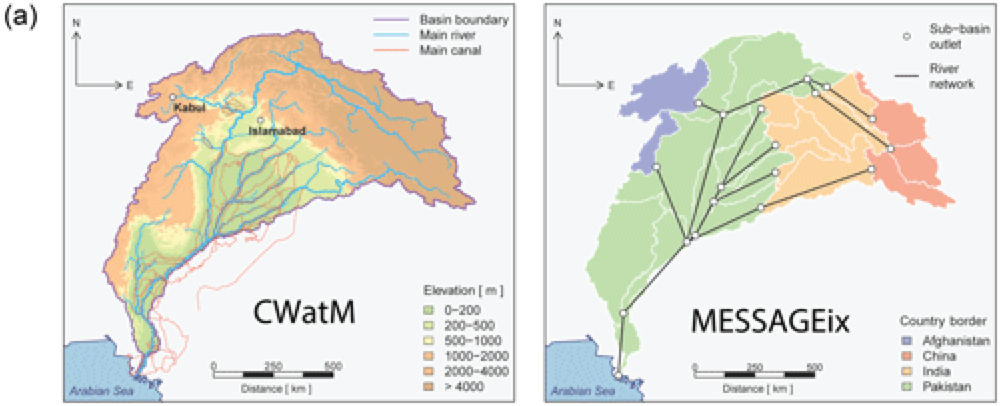
- The bulk of new connections **require central grid extension**, but a substantial number **(>1/3)** will come from **mini-grids.**

- **Standalone solutions** are mostly insufficient to provide energy for non-residential energy needs (e.g. crop processing) and thus only penetrate in few non-productive locations.

- **Investment requirements and capacity additions** mirror energy access gaps and cost-optimal set-ups
- Largest additions are found in **highly populated and productive-activity dense Lusaka and Central region**
- Overall, about **1.2 GW** are required to achieve **SDG 7.1** of universal electricity access **by 2030**
- This translates **in 3.9 bn. USD** in capacity, transmission, and distribution infrastructure investment requirements.

Final objective: integrated assessment and development goals

- Implementation of **bottom-up estimates** of local water needs, electricity demand, and optimal electricity access technologies presented here into **a WEF Nexus multi-node integrated assessment model**
- To estimate **investment portfolios under different scenarios and policies**
- For instance, **cost of water supply** and **synergies and trade-offs between development objectives**
- **National and sub-national basin-level** results to inform **stakeholders at multiple levels**



Basin boundary, river routing and elevation maps from HydroBASINS (Lehner, 2013)

Vinca et al. (2020)

EGU General Assembly 2023

Session HS5.5
Thu, 27 Apr, 09:05–09:15

Vinca et al., *The benefits of rural electrification to improve water access and irrigation in Sub-Saharan Africa, a water-energy-land assessment framework applied to Zambia*.

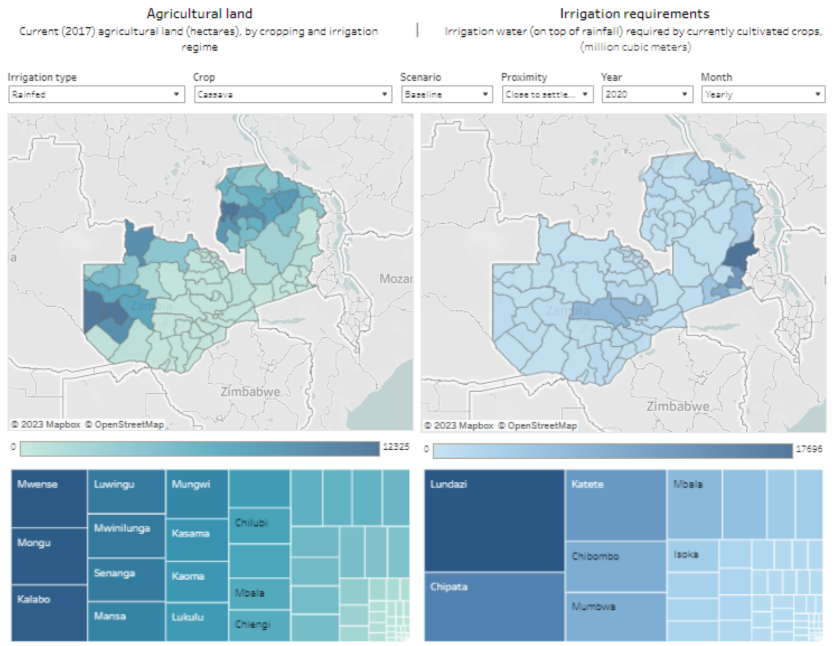
Code, data, and dashboards

Data:
The RE4AFAGRI Zenodo channel hosts both the data products generated as outputs of the modelling platform (visualised in the Dasbhoards) and the original input data to operate the modelling platform and replicate the analysis.

Code:
The RE4AFAGRI Github repository hosts the source code of the modelling platform, which, in combination with the data bundles, allows to run the analysis from scratch with customised assumptions and data, or adapt it to other geographies.

Documentation:
The RE4AFAGRI Wiki page hosts the official documentation of the modelling platform, to be used during the RE4AFAGRI capacity building activities, as well as by autonomous users willing to operate their own version of the platform.

Interactive results visualisation dashboards for stakeholders



[Enter the dashboards]

Forthcoming trainings and events

RE4AGRI – WRI Workshops - 2023

Addis Ababa, 16-20th October 2023

- **High-level course** on tools, assessment and policy analysis of the water-energy-land nexus in SSA
- **Technical course** on WEL-nexus modelling tools
- WRI offices, UNDP complex
- Approx 30 participants, **free to attend**

Info and application: https://iiasa.ac.at/events/oct-2023/re4afagri-iiasa-and-world-resources-institute-wri-joint-workshops

LEAP-RE RE4AFAGRI

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WORLD RESOURCES INSTITUTE

NRF National Research Foundation

LEAP-RE Stakeholder Forum

LEAP-RE

Kigali, 11-14th October 2023

A workshop to support African policy makers and private developers on topics relating to the water-energy-land nexus and rural development - focusing on making data-informed decisions with support of the RE4AFAGRI dashboards and business models.

Thank you!

LEAP-RE

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

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