

# RE4AFAGRI

## RENEWABLES FOR AFRICAN AGRICULTURE: INTEGRATING MODELLING EXCELLENCE AND ROBUST BUSINESS MODELS

Project Coordinator: Manfred Hafner (HEAS)

Partners involved:

HEAS, IIASA, UCT, TFE, POLIMI, UNIZM, UNIRWA



# 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.

# Why RE4AFAGRI ?



LEAP-RE

## *Sub-Saharan African agricultural sector presents challenges*



- **More than half** of the sub-Saharan African (SSA) population depends directly or indirectly on **agriculture as their labour and income source**
- In sub-Saharan Africa (SSA) about **80% of the agricultural production comes from smallholder farmers**
- Most farmers practice **rainfed agriculture (covering >90% of cropland)**

**Rainfed agriculture => low agricultural Productivity**

**No electricity (lack of cold storage and crop processing) => raw crops sold to wholesale market**

**Poverty traps and inequality traps, as well as food insecurity**



LEAP-RE

# Scope of RE4AFAGRI

*But solutions exist and opportunities for development are huge!*

RE4AFAGRI



Sustainable irrigation and community-wide renewable electricity

Increased productivity & local crop processing

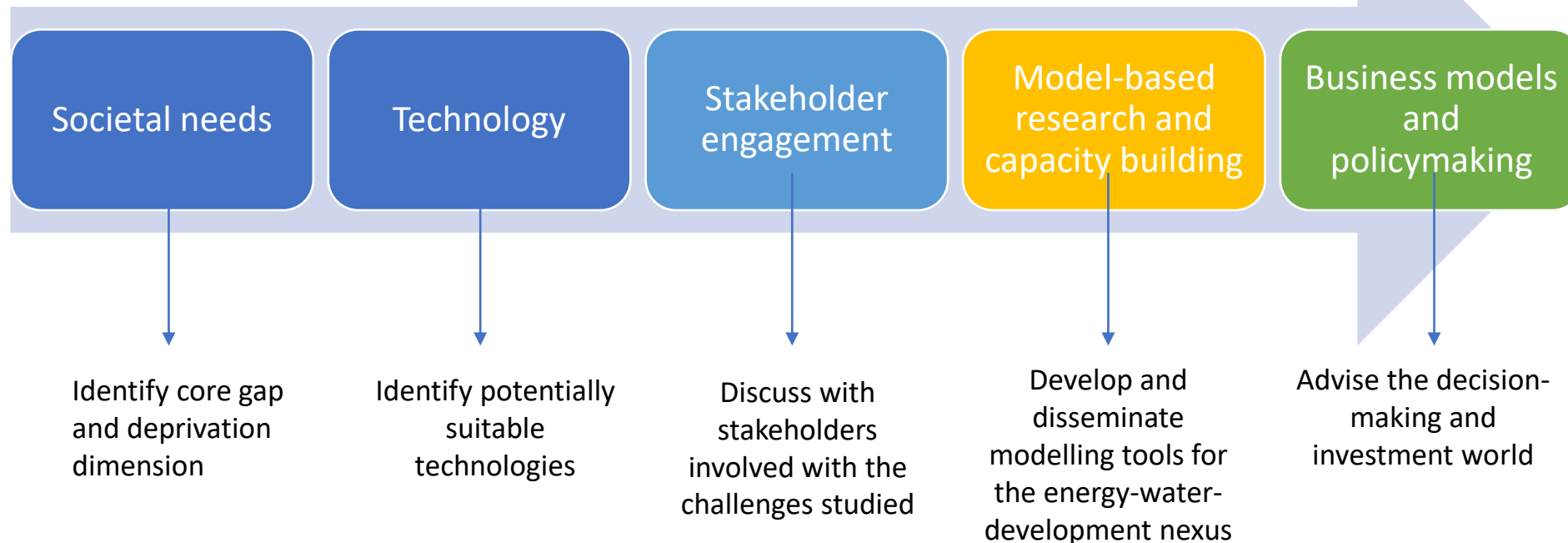
Agriculture as leverage for reduction of poverty and inequality



## *Aims of the project*

Demonstrating **technological, economic, and business model pathways** to:

- Sustainable cropland **irrigation** and community-wide renewable **electricity access**
- Increased agricultural **productivity, local crop processing and cold storage**
- Agriculture as **leverage** for reduction of **poverty and inequality**
- Agriculture as **leverage for energy access financing**



# RE4AFAGRI consortium



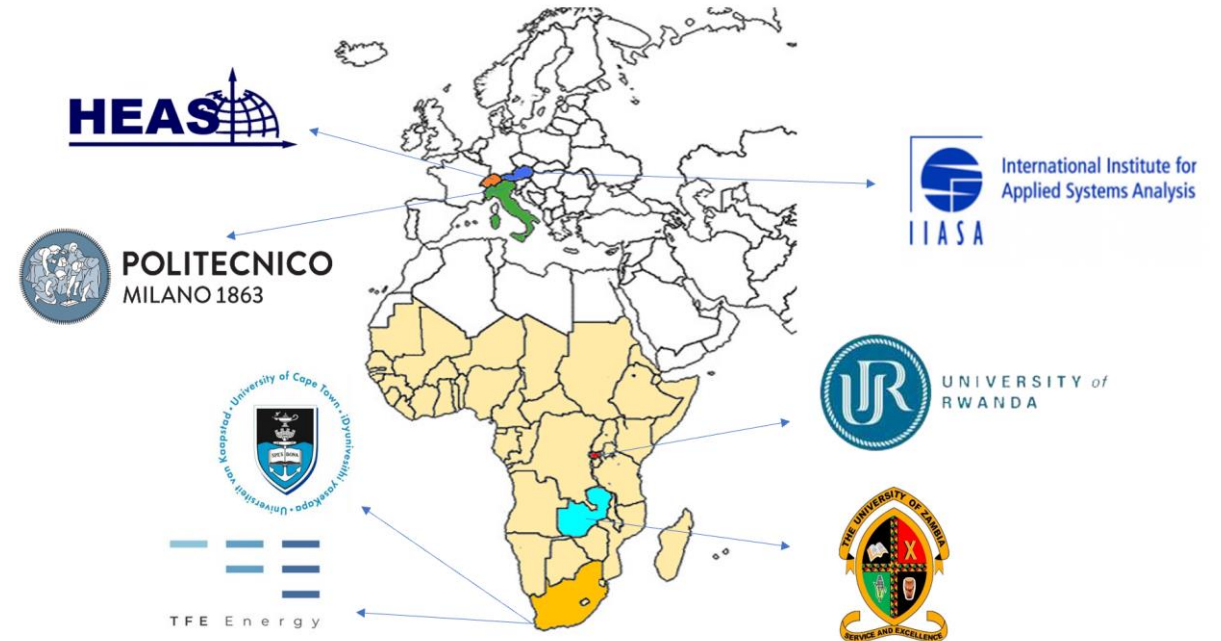
LEAP-RE

## Consortium

The RE4AFAGRI consortium combines:

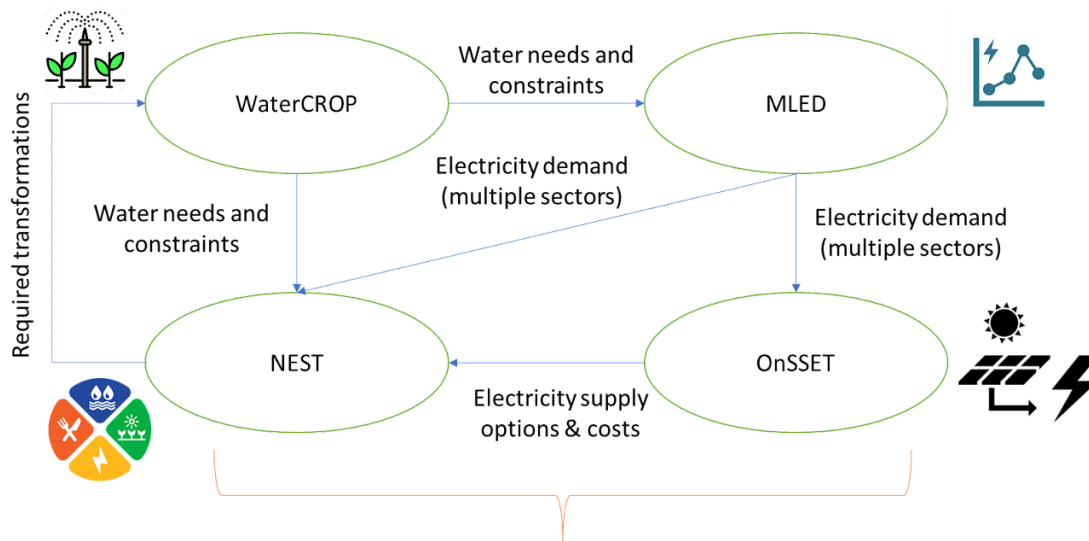
- **climate-water-energy-land-food-development nexus modelling** expertise (IIASA, UCT, POLIMI/TO)
- **business model and policy development** capacity (TFE-A, **HEAS\***)
- a deep knowledge of the **local realities** and the implied research avenues (**UNIZA, UNIRWA**).

\* **project coordinator**



The team includes **scientists, business experts, and policy researchers**.  
In addition, a **large number of external stakeholders and target users** from **African institutions and international organisations** were also involved through focus groups, workshops and capacity building activities.

## The RE4AFAGRI platform



Infrastructure and investment requirements estimated and impact analysis

## The techno-economic model

TFE Techno-Economic model for LEAP RE (2) .xlsx

File Edit View Insert Format Data Tools Help

Insert country name below: Nigeria

User to answer questions in blue:		Insert staple crop 1 below: Maize				Insert staple crop 2 below: Cassava			
General questions:	Unit	Irrigation	Drying	Shelling	Milling	Irrigation	Peeling	Grating	Milling
How many hours per day will the equipment be operational?	h/day	6	6	5	5	6	5	5	5
Across how many months per year will the equipment be used?	months/year	6	2	2	6	12	12	12	12
If the equipment will be connected to the grid, what is the tariff?	USD/kWh	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
If the equipment will be connected to a mini-grid, what is the tariff?	USD/kWh	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578
What is the current price per litre of diesel?	USD/L	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048
What is the distance from the farm to the market and back?	km	50	50	50	50	50	50	50	50
What is the fuel consumption of the vehicle that delivers crops to market?	l/km	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
How much do you expect to spend on maintenance per year?	USD/year	33	15	50	50	33	94	94	94
What is the monthly salary in USD that the equipment operator will earn?	USD/month								
Irrigation-specific questions (additional inputs on irrigation sheet):									
What is the upfront cost of the relevant solar water pump?	USD	\$2,361				\$2,361			
What is the power rating of the pump?	kW	0.36				0.36			
Agro-processing specific questions:									
What is the upfront cost of the relevant processing machine?	USD		\$1,566	\$2,420	\$3,000		\$3,250	\$2,000	\$285
What is the maximum possible throughput that the machine can deliver?	kg/hour		83	400	1,000		800	1,000	1,300
What is the power rating of the processing machine?	kW		0.20	2.20	30.00		1.10	4.75	11.00
Automatic answers, feeding into results sheets:									
Capacity utilization	%	12.50%	1.79%	1.49%	4.46%	25.00%	8.93%	8.93%	8.93%
Operating hours	h/year	1095	156	130	391	2190	782	782	782
Portion of salary (1 worker) attributed to operation of the equipment	USD/year	\$469.88	\$313.25	\$313.25	\$939.76	\$939.76	\$1,879.52	\$1,879.52	\$1,879.52
Realistic machinery throughput	kg/h		83	200	500		400	500	650
Annual energy consumption	kWh/year		394	31	287		788	860	8603
Power rating reverse calculation	kW		0.36	0.2	2.2		0.4	1.1	4.8

Insert country name below: Rwanda

Insert staple crop 1 below: Maize

Insert staple crop 2 below: Cassava

Main inputs Price margin inputs Payback period results IRR results Irrigation inputs&calcs\_NIG Irrigation inputs&calcs\_RWA Irrigation

### Contribution of the project to AU – EU R&D cooperation:

model development based on synergetic sharing technical + local knowledge between EU and AU member states research institutions

All tools are open access: free to use for the benefit of the Sub Saharan African community

# RE4AFAGRI country applications



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## The RE4AFAGRI dashboards



### Dashboards homepage



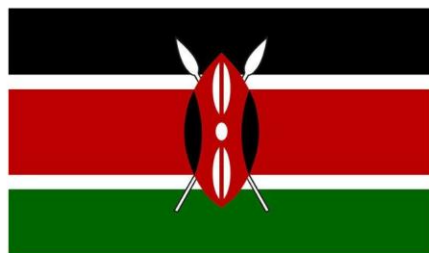
Zambia



Rwanda



Nigeria



Kenya



Zimbabwe



Other countries

- A powerful decision support tool with interactive dashboards

→ Support **policymaking** through sub-national gaps and needs assessment for tailored measures and investments

→ Support **private infrastructure developers** in site selection for maximising financial sustainability and development impact

- Enriched with **direct access to download the raw output data**

[www.re4afagri.africa](http://www.re4afagri.africa)

# The RE4AFAGRI dashboards



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## Dashboards - Zambia

[www.re4afagri.africa](http://www.re4afagri.africa)

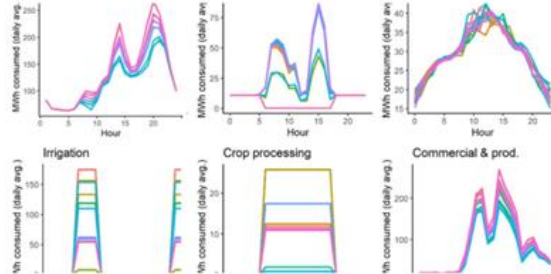


### Agriculture and water requirements

Assess the current rainfed irrigation situation and visualize our water requirement estimates to close the irrigation gap



### Crop processing



### Multi-sectoral electricity demand

Browse our estimates for the community electricity demand from the residential, healthcare, education, water pumping, crop processing and SMEs sectors



### Electricity access



### Irrigation water pumps

Navigate the technological and investment requirement estimates for installing and operating groundwater and surface water pumps, also with PV + battery



### NEXUS Solutions Tool



# Dissemination activities and results: publications, users involved, etc.



LEAP-RE

- Publication of **RE4AFAGRI platform source code, data, training materials, and dashboards**
- Publication of **techno-economic model and user guide** and report of insights
- Publication of **three scientific papers in high-impact journals (Energy Strategy Reviews, ERL (x2))**
- Presentation of the research at **high-level events and conferences** in Africa (LEAP-RE Stakeholder Forum) and in Europe (EGU23, IAMC 23)

[www.re4afagri.africa](http://www.re4afagri.africa)



A renewable energy-centred research agenda for planning and financing Nexus development objectives in rural sub-Saharan Africa

Giacomo Falchetta<sup>a,b,c</sup>, Adedoyin Adeleke<sup>c</sup>, Mohammed Awais<sup>a,d</sup>, Edward Byers<sup>a</sup>, Philippe Copinchi<sup>a,k</sup>, Sam Duby<sup>e</sup>, Alison Hughes<sup>f</sup>, Gregory Ireland<sup>g</sup>, Keywan Riahi<sup>a</sup>, Simon Rukera-Tabaro<sup>h</sup>, Francesco Semeria<sup>i</sup>, Diana Shendrikova<sup>c</sup>, Nicolò Stevanato<sup>c</sup>, André Troost<sup>e</sup>, Marta Tuninetti<sup>h</sup>, Adriano Vinca<sup>a</sup>, Ackim Zulu<sup>i</sup>, Manfred Hafner<sup>a,k,l</sup>

<sup>a</sup> International Institute for Applied Systems Analysis (IIASA), Schloßpl. 1, 2361, Laxenburg, Austria  
<sup>b</sup> Centro Euro-Mediterraneo sui Cambiamenti Climatici, Italy, Università Ca' Foscari Venezia, Italy and RFF-CMCC European Institute on Economics and the Environment, Fondamenta S. Giobbe, 873, 30121, Venice, Italy  
<sup>c</sup> Department of Energy, Politecnico di Milano, Via Lambruschini 4, 20156, Milan, Italy  
<sup>d</sup> Institute for Integrated Energy Systems, University of Victoria, Victoria, BC, Canada  
<sup>e</sup> TFE Africa, 152 Main Rd, Maitland, Cape Town, 7945, South Africa  
<sup>f</sup> University of Cape Town (UCT), Energy Systems Research Group, Department of Chemical Engineering, Cape Town, South Africa  
<sup>g</sup> College of Agriculture, Animal Sciences and Veterinary Medicine, University of Rwanda, PO Box 210, Musanze, Rwanda  
<sup>h</sup> Dipartimento di Ingegneria dell'Ambiente, del Territorio e delle Infrastrutture, Politecnico di Torino, Corso Duca degli Abruzzi, 24, 10129, Torino, Italy  
<sup>i</sup> School of Engineering, University of Zambia, Box 32279, Lusaka, Zambia  
<sup>j</sup> HEAS AG, Galmustrasse 60, 6315, Oberägeri, Switzerland  
<sup>k</sup> SciencesPo PSA, 28 Rue des Saints-Pères, 75007, Paris, France  
<sup>l</sup> John Hopkins University SAIS, Via Beniamino Andreatta, 3, 40126, Bologna, Italy



## Integrated modelling of renewable energy-centered sustainable development futures in rural Africa

Giacomo Falchetta<sup>1,2</sup>, Gregory Ireland<sup>3</sup>, Marta Tuninetti<sup>4</sup>, Adriano Vinca<sup>1</sup>  
 1. IIASA, 2. CMCC, 3. University of Cape Town, 4. Politecnico di Torino

**Context & objectives**

- Multi-dimensional and overlapping Nexus challenges in rural sub-Saharan Africa (>80% rainfed irrigation, <35% electricity access, >15% insufficient food intake, >40% below poverty line, >300 million people by 2050)
- Need for multi-level interventions (from national policies, to regional/river basin-scale planning, to local planning and investment)
- Study objectives: soft linking bottom-up water and energy demand and infrastructure assessment models into a multi-node, national Nexus-extended Integrated Assessment Model (MESSAGE-NEST, Vinca et al. 2019)

**Materials & methods**

- Harmonized SSP-RCP and policy target scenarios to 2050 across models (baseline, improved access, ambitious development) and consistent stakeholder-validated modeling assumptions
- Four models integrated in the "RE4AFAGRI modelling platform" are run in sequence and soft-linked, connecting bottom-up demand onto multi-node IAM for supply and investment assessment
- Integrated modeling platform applied to several SSA country-studies. In this poster Zambia country-study demonstrated
- Focus on multi-level assessment benefits

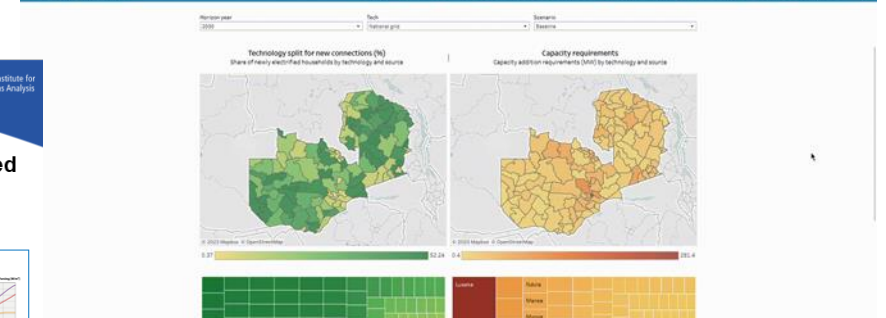
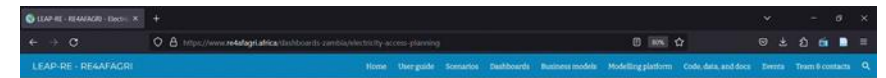
**Results**

WaterCrop, MLED, CUSSET, MESSAGE-NEST

bottom-up, a, bottom-up

**Implications**

- bottom-up, a



TFE Techno-Economic model for LEAP RE (2) .xlsx

		Irrigation				Drying				Shelling				Milling			
	Unit																
1	How many hours per day will the equipment be operational?	h/day	6	6	5	5	6	6	5	5	5	5	5	5	5	5	5
2	Across how many months per year will the equipment be used?	months/year	6	2	2	6	6	12	12	12	12	12	12	12	12	12	12
3	If the equipment will be connected to the grid, what is the tariff?	USD/kWh	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
4	If the equipment will be connected to a mini-grid, what is the tariff?	USD/kWh	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578	0.578
5	What is the current price per litre of diesel?	USD/L	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048
6	What is the distance from the farm to the market and back?	km	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
7	What is the fuel consumption of the vehicle that delivers crops to market?	l/km	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059	0.059
8	How much do you expect to spend on maintenance per year?	USD/year	33	15	50	50	33	94	94	94	94	94	94	94	94	94	94
9	What is the monthly salary in USD that the equipment operator will earn?	USD/month															
10	Irrigation-specific questions (additional inputs on irrigation sheet):																
11	What is the upfront cost of the relevant solar water pump?	USD	\$2,361											\$2,361			
12	What is the power rating of the pump?	kW	0.36											0.36			
13	Agro-processing specific questions:																
14	What is the upfront cost of the relevant processing machine?	USD	\$1,596	\$2,420	\$3,000					\$3,250	\$2,000	\$285					
15	What is the maximum possible throughput that the machine can deliver?	kg/hour	83	400	1,000					800	1,000	1,300					
16	What is the power rating of the processing machine?	kW	0.20	2.20	30.00					1.10	4.75	11.00					
17	Automatic answers, feeding into results sheets:																
18	Capacity utilization	%	12.50%	1.70%	1.49%	4.46%				25.00%	8.93%	8.93%	8.93%				
19	Operating hours	h/year	1095	150	391	2160				782	782	782					
20	Portion of salary (1 worker) attributed to operation of the equipment	USD/year	\$469.68	\$313.25	\$313.25	\$939.76				\$939.76	\$1,879.52	\$1,879.52	\$1,879.52				
21	Realistic machinery throughput	kg/h		83	200	500				400	500	650					
22	Annual energy consumption	kWh/year	394	31	287	11732				788	860	3715					
23	Power rating reverse calculation	kW	0.36	0.2	2.2	30.0				0.4	1.1	4.8					

## ENVIRONMENTAL RESEARCH LETTERS

### LETTER • OPEN ACCESS

### Solar irrigation in sub-Saharan Africa: economic feasibility and development potential

Giacomo Falchetta<sup>4,1,2</sup>, Francesco Semeria<sup>3</sup>, Marta Tuninetti<sup>3</sup>, Vittorio Giordano<sup>3</sup>, Shonali Pachauri<sup>1</sup> and Edward Byers<sup>1</sup>

Published 5 September 2023 • © 2023 The Author(s). Published by IOP Publishing Ltd

Environmental Research Letters, Volume 18, Number 9

Focus on Technology and Global Change

Citation Giacomo Falchetta et al 2023 Environ. Res. Lett. 18 094044

DOI 10.1088/1748-9326/acfe5



# Addis Ababa Capacity Building: modelling tools workshops (1 week)



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**RE4AFAGRI's Joint Workshops on tools for planning, scenarios and policy analysis of the water-energy-land nexus for equitable development in rural Africa**

*Organised with World Resources Institute Africa, 30 in-person participants from 15 African countries in Addis Ababa, **16-20 October 2023** (~125 registered for 2-day hybrid event)*

Co-organised and sponsored by



**LEAP-RE**

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



Joint workshops in numbers

**143**

applications

**30**

participants (in person)

**10**

expert trainers

**156**

online participants (days 1&2)

**1/3  
female**



# Kigali: LEAP-RE stakeholder forum



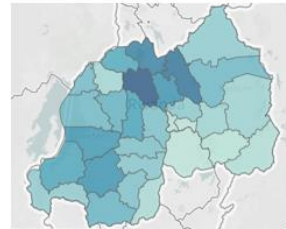
LEAP-RE

- ❖ Keynote presentation on RE4AFAGRI,
- ❖ RE4AFAGRI Workshop: Interactive decision making tools and business models for electrification of smallholder agriculture through renewable energy
- ❖ LEAP-RE Workshop: Transversal workshop for business models for decentralized renewable energy
- ❖ LEAP-RE RESchool: bottom-up electricity demand assessment

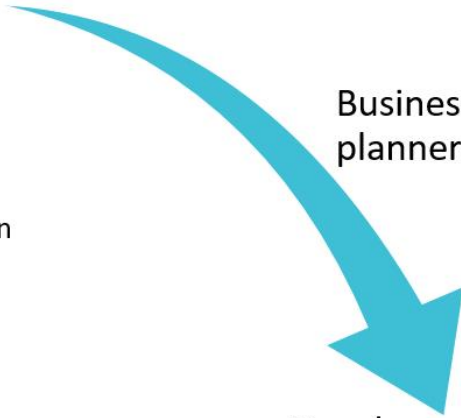
Interactive decision making tools and business models for electrification of smallholder agriculture through renewable energy



High level Policies



Business planners



Policy plans, regulation and incentives



Developers, project implementation



# Several Online RE4AFAGRI tutorials



LEAP-RE

## → youtube videos

- ❖ **For final users (RE developers, farmer associations, policy makers)** – tutorials on how to use the platform of models and business model simulations to help the SSA community to reap for themselves the benefit of the RE4AFAGRI work
- ❖ **For SSA model-developers**: in depth tutorials on the scientific models to allow SSA (and other) researchers to continue developing and adapting the modelling suite to SSA countries

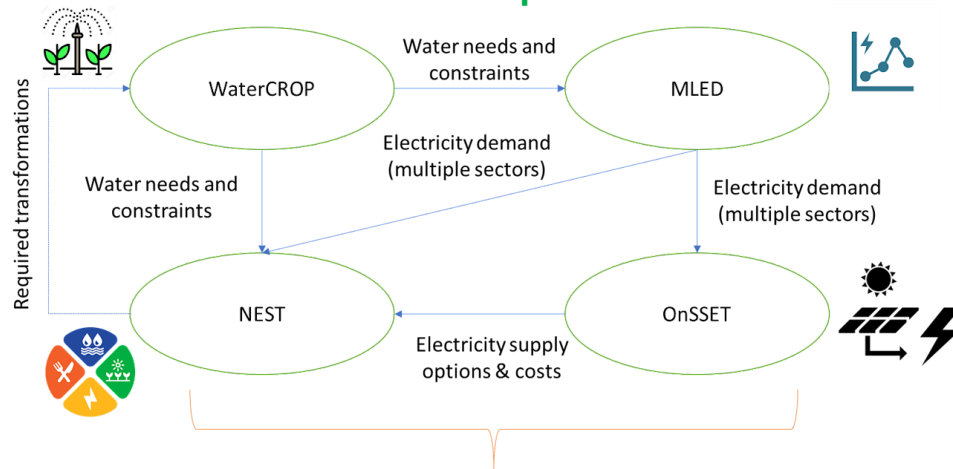
Short introductory Videos  
for all RE4AFAGRI tools

Detailed Tutorial Videos of  
all RE4AFAGRI tools for Users

In-depth Tutorial Videos of all  
RE4AFAGRI tools for modellers

# Introductory overview videos

## The RE4AFAGRI platform



Infrastructure and investment requirements estimated and impact analysis

## The techno-economic model

TFE Techno-Economic model for LEAP RE (2) .xlsx

Insert country name below:		Insert staple crop 1 below:				Insert staple crop 2 below:				
Nigeria		Maze				Cassava				
User to answer questions in blue:	Unit	Irrigation	Drying	Shelling	Milling	Irrigation	Peeling	Grating	Milling	
<b>General questions:</b>										
1	How many hours per day will the equipment be operational?	h/day	6	6	5	5	6	5	5	
2	Across how many months per year will the equipment be used?	months/year	6	2	2	6	12	12	12	
3	If the equipment will be connected to the grid, what is the tariff?	USD/kWh	0.086	0.086	0.086	0.086	0.086	0.086	0.086	
4	If the equipment will be connected to a mini-grid, what is the tariff?	USD/kWh	0.578	0.578	0.578	0.578	0.578	0.578	0.578	
5	What is the current price per litre of diesel?	USD/L	2.048	2.048	2.048	2.048	2.048	2.048	2.048	
6	What is the distance from the farm to the market and back?	km	50	50	50	50	50	50	50	
7	What is the fuel consumption of the vehicle that delivers crops to market?	l/km	0.059	0.059	0.059	0.059	0.059	0.059	0.059	
8	How much do you expect to spend on maintenance per year?	USD/year	33	15	50	50	33	94	94	
9	What is the monthly salary in USD that the equipment operator will earn?	USD/month								
10	<b>Irrigation-specific questions (additional inputs on Irrigation sheet):</b>									
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12	What is the power rating of the pump?	kW	0.36			0.36				
<b>Agro-processing specific questions:</b>										
13	What is the upfront cost of the relevant processing machine?	USD	\$1,566	\$2,420	\$3,000		\$3,250	\$2,000	\$285	
14	What is the maximum possible throughput that the machine can deliver?	kg/hour	83	400	1,000		800	1,000	1,300	
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<b>Automatic answers, feeding into results sheets:</b>										
16	Capacity utilization	%	12.50%	1.79%	1.49%	4.46%	25.00%	8.93%	8.93%	8.93%
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18	Portion of salary (1 worker) attributed to operation of the equipment	USD/year	\$469.68	\$313.25	\$313.25	\$939.76	\$639.76	\$1,879.52	\$1,879.52	\$1,879.52
19	Realistic machinery throughput	kg/h		83	200	500		400	500	650
20	Annual energy consumption	kWh/year	994	31	287	11732	798	880	3715	8939
21	Power rating reverse calculation	kW	0.36	0.2	2.2	30.0	0.4	1.1	4.8	11.0

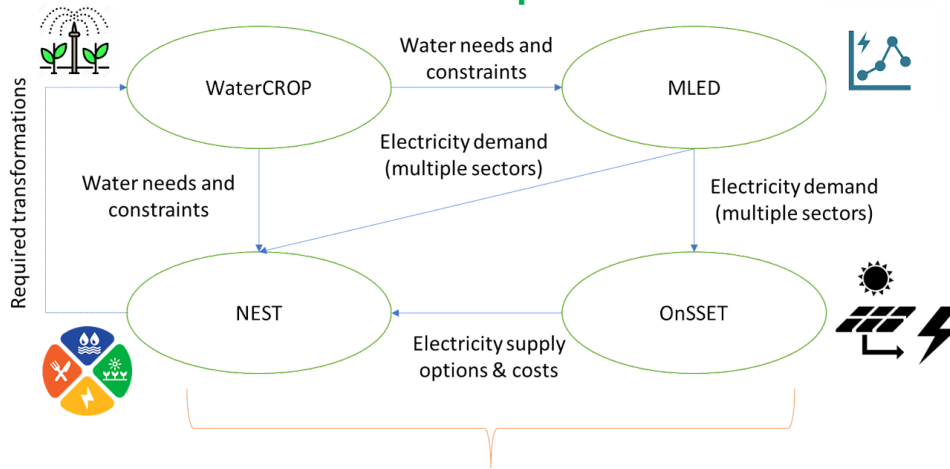
## Short introductory and overview Videos on purpose and use of the RE4AFAGRI tools

- 1) Intro/Overview of RE4AFAGRI project
- 2) Dashboard and its use
- 3) Modelling Platform (interaction of the 4 models)
- 4) WaterCrop model
- 5) M-LED model
- 6) NEST
- 7) Business models and techno-economic tool



# Tutorial videos for Users

## The RE4AFAGRI platform



Infrastructure and investment requirements estimated and impact analysis

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20	Power rating reverse calculation	kW	0.36	0.2	2.2	30.0	0.4	1.1	4.8

## Detailed Tutorials for Users of the platform (developers, farmer associations, policy makers)

1) Modelling platforms and dashboard training

2) Business models and techno-economic tool training



# Tutorial videos for Model-developers

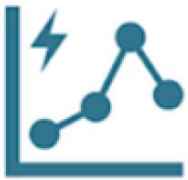


LEAP-RE



## WaterCROP

- Software installation procedure
- Model introduction, running and tailoring



## MLED

- Software installation procedure
- Model introduction, running and tailoring



## NEST

- Software installation procedure
- Model introduction, running and tailoring



## OnSSET

- Software installation procedure
- Model introduction, running and tailoring

## Suite of in-depth Tutorials for Model-Developers

- to further work on the RE4AFAGRI tools
- to expand the RE4AFAGRI models to other SSA countries
- to further tailor the RE4AFAGRI modelling suite to the evolving realities of SSA countries



**Watch the other training videos...**

**THANK YOU**

CONTACT US FOR MORE INFORMATION



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[www.leap-re.eu](http://www.leap-re.eu)



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