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LEAP-RE

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

Report about the outcome on scientific collaboration of 12

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Summary

Report about the outcome on scientific collaboration of RE4AFAGRI (LEAP-RE WP12) as deliverable of Task 12.7

Approval

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LEAP-RE

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

Report about the outcome on scientific collaboration as deliverable of Task 12.7

Deliverable D12.9

WP12 of LEAP-RE (RE4AFAGRI)

www.leap-re.eu

<https://www.leap-re.eu/re4afagri/>

Authors: Manfred Hafner (HEAS), Giacomo Falchetta (IIASA), Philippe Copinschi (HEAS), Edward Byers (IIASA), Adriano Vinca (IIASA), Gregory Ireland (UCT), Alison Hughes (UCT), Fabio Inzoli (PoliMi), Simon Rukera-Tabaro (UR), Francesco Semeria (PoliTo), Marta Tuninetti (PoliTo), Ackim Zulu (UNZA)

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Acronyms

IIASA: International Institute for Applied Systems Analysis

LEAP-RE: Long-Term Joint Research and Innovation Partnership on Renewable Energy between the European Union and the African Union

M-LED: Multisectoral Latent Electricity Demand assessment tool

MESSAGEix: Model of Energy Supply Systems And their General Environmental Impact

NEST: NExus Solutions Tool

OnSSET: Open Source Spatial Electrification Tool

POLITO: Politecnico di Torino

RE4AFAGRI: Renewable Energy for African Agriculture – Modelling Excellence and Robust Business Models

SSA: Sub-Saharan Africa

UCT: University of Cape Town

WaterCROP: Water Crop assessment model

1. Background

In sub-Saharan Africa 80% of agricultural production comes from smallholder farmers, who face constraints that reduce their productivity resulting in a large crop yield gap. Extensive rain-fed agriculture (90% of all croplands) under the unpredictable and erratic rainfall pattern is a leading cause of the low productivity and food insecurity in Africa, together with a low degree of mechanisation. This has been reinforcing a persistent poverty trap triggering cyclical famines and jeopardising local development opportunities.

To address these challenges, there is a need for agricultural transformation to ensure increased revenue opportunities and food security of the smallholder farmers of the continent. The input of electric energy provides a foundational building block upon which significant development becomes possible. Access to affordable energy enables pumping groundwater, rainwater harvesting and storage in underground or surface storage tanks, and power Virtual workshops for audiences in Rwanda, Nigeria, Zambia and ng crop processing and cold storage machineries that could significantly contribute to poverty elimination. This would have positive consequences for food security (SDG 2), ensuring healthy life (SDG 3), ensuring equitable and inclusive education (SDG 4), access to water (SDG 6), access to energy (SDG 7) and local socio-economic development (SDG 8), thus contributing to the reduction of rural-urban and gender inequalities (SDG 10).

The **LEAP-RE Pillar 2 WP12 (RE4AFAGRI)** project aims at informing and contributing to the transformation of the African smallholder farmers' agriculture and demonstrate planning and implementation approaches to the integrated water-energy-food-environment-economic development nexus management and business models for infrastructure implementation that are truly tailored to the local needs and socio-cultural and economic and financial context.

This deliverable summarises the key outcomes on scientific collaborations achieved throughout the duration of RE4AFAGRI, while also discussing its heritage in terms of replication, exploitation, and future prospects.

2. Main scientific achievements

Throughout its duration, RE4AFAGRI was committed in advancing the scientific understanding of the climate-water-renewable energy-agriculture-development Nexus and the creation of robust business models for private companies that can sustainably support private smallholder farmers of SSA in their effort to eradicate poverty and inequality.

Concerning the first scientific pillar, RE4AFAGRI researchers have achieved the integration of multi-scale modelling excellence to coherently represent the water-energy-land-climate-food dimensions and interactions. The modelling team has published the source code of a new, integrated, open-source modelling platform: the RE4AFAGRI platform: https://github.com/iiasa/RE4AFAGRI_platform/ (deliverable D12.3). The underlying principles behind the platform development are exposed in Falchetta et al. (2022), while the functioning of the platform is described in the Github repository's wiki (which also constitutes project deliverable D12.4) https://github.com/iiasa/RE4AFAGRI_platform/wiki.

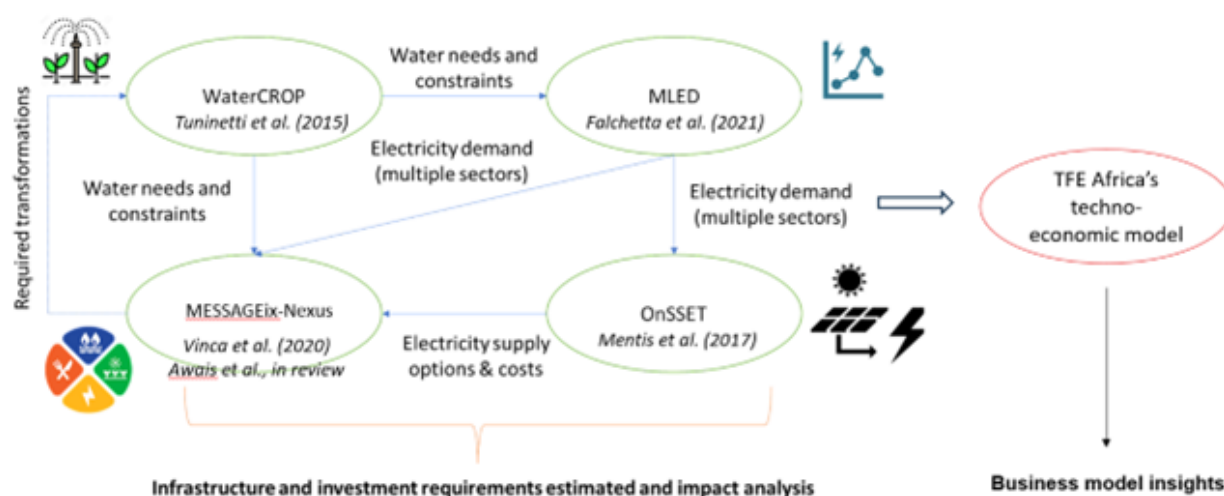


Figure 1: Workflow of the RE4AFAGRI integrated modelling platform and the model linkages

With regards to the scientific outputs, peer-reviewed papers have described the platform development and a set of results based on its applications. For instance, in a first perspective paper (Falchetta 2021), it is argued that the paradigm of rural electrification should be centred around an integrated approach aiming at increasing agricultural productivity and profitability, as these bear the necessary potential to enable local income generation and thus also provide an incentive for private energy investment, including in the residential sector. In the paper, a theoretical framework for the integrated approach is proposed (the same framework lies behind the RE4AFAGRI implementation) and the crucial synergetic role of data modelling and business and policy research to pursue this paradigm is discussed.

Then, the entire consortium published a position paper (Falchetta et al. 2022), in which the RE4AFAGRI team laid out a research agenda that promotes the integration of multi-scale modelling excellence along the climate-water-renewable energy-agriculture-development Nexus and the creation of robust business models for private companies that can sustainably support private smallholder farmers of SSA in their effort to eradicate poverty and inequality. In proposing the agenda, the authors team highlighted the importance of integrating energy access into the Nexus framework from both research and investment perspectives

As part of the project, the MESSAGEix-Nexus (NEST) module was further developed and applied for country applications, as demonstrated by the peer-reviewed technical paper Awais et al 2024 (<https://gmd.copernicus.org/articles/13/1095/2020/>) and published open source on the RE4AFAGRI modelling platform and on the "message-ix-models" IIASA's public Github repository.

Coming to results-based publication, an application of the RE4AFAGRI modelling platform on the specific case of the solar irrigation technology (Falchetta et al. 2023) demonstrated that over one third of unmet crop water requirements of 19 major crops in smallholder cropland of SSA could be supplied with standalone solar photovoltaic (PV) irrigation systems that can be paid back by farmers within 20 years. This accounts for 60 km³ yr⁻¹ of blue irrigation water requirements distributed over 55 million ha of currently rainfed harvested area (about 40% of the total). Crucially, we identify 10 million ha with a profit potential >\$100 ha⁻¹ yr⁻¹. To finance such distributed small-scale infrastructure deployment and operation, we estimate an average discounted investment requirement of \$3 billion

yr⁻¹, generating potential profits of over \$5 billion yr⁻¹ from increased yields to the smallholder farmers, as well as significant food security and energy access co-benefits. We demonstrate the critical importance of business models and investment incentives, crop prices, and PV & battery costs in shaping the economic feasibility and profitability of solar irrigation. Yet, we find that without strong land and water resources management infrastructure and governance, a widespread deployment of solar pumps may drive an unsustainable exploitation of water sources and reduce environmental flows. Our analysis supports public and private stakeholders seeking to target investments along the water–energy–food–economy–sustainable development nexus.

Another paper, currently under review, is demonstrating the implementation of the RE4AFAGRI modelling platform and the related business models analysis in the country study of Zambia. The preliminary research derives an understanding of how water and energy requirements affect each other and jointly shape infrastructure and investment pathways. Specifically, we find that scenarios with increased ambition in expanding irrigation and agricultural productivity result in improved diffusion and economic feasibility of mini-grid infrastructure to provide universal energy access. Moreover, by linking technical models with business model analysis, we demonstrate the framework conditions and micro and macro determinants to ensure feasibility of investment and uptake of small-scale Nexus infrastructure, crucial for rural development. Altogether, our research demonstrates how integrated modelling with an explicit focus on Nexus interlinkages can represent the enabling role and business conditions for renewable energy to become a leverage of rural sustainable development

In addition to scientific research, RE4AFAGRI researchers have analysed and developed tools to understand the business-policy-technology interactions that lay behind the feasibility of granular technology and their mass adoption among rural communities. TFE's Techno-Economic model (open-source and documented, available on www.re4afagri.africa) allows users to assess the relevance and interaction of farmer-level to policy-level decisions in shaping the economic feasibility and profitability of different options and level of integration of energy inputs into the smallholder farmer value chain.

3. Main dissemination and engagement achievements

With regards to the second scientific pillar, in the early stages of RE4AFAGRI's implementation – as part of Task 12.1 - RE4AFAGRI researchers have engaged with a broad array of engagement and mutual learning activities with stakeholders. The focus group discussions focused on Nigeria, Rwanda, Zambia and Zimbabwe, where a series of discussion groups with national stakeholders (representing farmers associations, renewable energy developers, irrigation experts and policy makers) were organised in 2021-2022. These discussions involved more than 30 stakeholders from the four countries in order for African realities at the core of the project to be properly identified and integrated in the modelling and business development activities. Ahead of focus group online meetings, each stakeholder was requested to fill a questionnaire covering issues on land, irrigation and energy access from both a technical and a business and policy angle. Areas covered in the questionnaire for Focus Group Discussion include crop production (covering types, irrigation, yield and revenue); processing (Needs, scale, capacity and limitations); irrigation (type, capacity, pump types, willingness to pay, joint procurement, management and limitations) and the benefits of modelling to the stakeholders towards improving energy access to increase irrigation and farming operations of smallholder farmers.

After the initial focus groups have been conducted, during the modelling and business model development activities (in 2022-2023), the dissemination and engagement activities of RE4AFAGRI focused on the following actions:

- Design and implementation of the RE4AFAGRI website, hosting the RE4AFAGRI dashboards as well as updates on a running basis on the open-access materials (data, code, guides) produced during the project and the forthcoming dissemination and capacity building events.
- Participation to the 1st LEAP-RE stakeholder forum in Autumn 2022 in Pretoria, South Africa, where the status of research of RE4AFAGRI was presented to the LEAP-RE General Assembly and the broader network of stakeholders
- Several researchers from the LEAP-RE project
- Participation to the 2nd LEAP-RE stakeholder forum in Autumn 2023 in Kigali, Rwanda, where RE4AFAGRI presented in the plenary session on science-policy interfaces related to LEAP-RE consortium activities, as well as in side events on business models experience sharing and mutual learning.

In addition, outputs from RE4AFAGRI were showcased in a published article on the renowned power sector platform, ESI Africa. The article briefly introduces the reader to what RE4AFAGRI is, acknowledges LEAP-RE and the European Commission, provides high level information of different RE4AFAGRI workflows and points the reader to the official RE4AFAGRI website where the different outputs can be accessed. The article can be accessed [here](#). The same content was published on the [website of the Alliance for Rural Electrification](#), an industry body representing energy access and distributed renewable energy in the Global South.



Figure 1: Screenshot of the article published on ESI Africa

4. Main capacity building achievements

In addition to advancing scientific research and disseminating the key findings, RE4AFAGRI has actively sought (also through a dedicated Task, 12.5) to organise and participate in broader capacity building activities finalised at increasing the pool of users and developers of the tools and knowledge developed in RE4AFAGRI. The ultimate aim is empowering African scientists, practitioners, and stakeholders with the knowledge and tools necessary to shape policies and strategies that promote balanced and inclusive growth. The starting point for capacity building activities is the open-source nature of all the tools, data, and documentation behind RE4AFAGRI research.

First and foremost, in the context of Task 12.5, an in-person workshop on the water-energy-land nexus organized by LEAP-RE RE4AFAGRI was organized between October 16th and October 20th 2023 in Addis Ababa, Ethiopia. Jointly organized by IIASA and the World Resources Institute (a key external stakeholder involved with RE4AFAGRI), the workshop brought together in Addis Ababa more than 30 researchers and practitioners from 14 African countries (selected among 143 applicants), and additionally 9 expert trainers, to arrange a week-long joint workshop focusing on tools for planning, scenarios, and policy analysis of the water-energy-land nexus. The workshops were organized into two parts: the first one, taking place on Monday and Tuesday, introduced in-person and online participants (the first two days were arranged in hybrid in-person and virtual format and made openly accessible via Zoom to anyone registering online) to ongoing data and model-based work for water-energy-land-food nexus assessment, with a specific focus on both public decision-making and private system developers and investors. This included a keynote talk by the World Resources Institute on Monday, 16 October, demonstrations of Global Forest Watch, Aqueduct and the Energy Access Explorer, and a demonstration of the RE4AFAGRI modelling platform's dashboards. In addition to in-person participants, the first two were followed by 156 online participants. The event was opened by H.E. Dr. Sultan Woli, State Minister of the Ethiopian Ministry of Water and Energy. A networking event including local experts from Addis Ababa concluded the first day's activities for in-person participants. While the Addis Ababa event, entitled Hybrid Joint Workshops on Tools for Planning, Scenarios and Policy Analysis of the Water-Energy-Land Nexus for Equitable Development in Rural Africa was focused on the technical models of RE4AFAGRI, as a consortium we decided to also present aspects of the business model work done by TFE at the event. Participants included mostly academic modelers specialised in energy access modelling, which is why we deemed it appropriate to present details of the wider context in which energy access models are embedded, i.e. the macro-operating environment and the ground realities of financial viability. Towards this end, André Troost presented a brief overview of the abovementioned techno-economic model and discussed different manifestations of business models for smallholder electrification. Days 3-5 were dedicated to hands-on training on a range of quantitative modelling tools related to the water-energy-land-food nexus. Training in days 3-5 was split into two tracks focused on energy and nexus issues, with participants choosing their track of preference and receiving more in-depth tuition on open-access models in those themes. Overall, the joint workshops held in Addis Ababa have been a key objective since the RE4AFAGRI project's inception to ensure that the best research methodologies and insights using open-source models and data are disseminated among local researchers and practitioners working across sub-Saharan Africa.



Figure 2: group picture of trainers and trainees (see news item below for a full gallery of the workshops)

A IIASA news item and photo gallery of the event is found at <https://iiasa.ac.at/news/oct-2023/successful-joint-workshop-supports-equitable-development-in-rural-africa>

Key to the successful delivery of the workshop was leveraging partnerships who could contribute to the organization of the activities. The expense of travelling to the workshop was beyond the vast majority of participants but it was important to ensure that finance should not be a barrier to participation. Partnership with WRI meant that local costs for the venue hire and local logistics were managed smoothly by in-country staff, including visa applications. One of the IIASA member organizations is the Science Granting Councils Initiative, a collection of 18 science councils across sub-Saharan Africa, who were contacted and invited to sponsor participation. Ultimately, almost half the participants received travel support from the councils of Ethiopia, Zambia, Kenya and South Africa. Partnership with the World Bank Energy Sector Management Assistance Program also resulted in the funding for hotel and airport transfers for 15 participants. IIASA further contributed 8.000 EUR for travel costs and the networking reception.

To leverage on the success of the workshop, in the first quarter of 2024 further **online training and dissemination activities** were developed to expand the pool of users and developers of the RE4AFAGRI modelling platform and extend the project impact onto an even larger community and number of countries.

A collection of videos have been recorded, professionally edited, and publicly made available on IIASA's YouTube channel and the RE4AFAGRI project website. The videos introduce and go into detail about the RE4AFAGRI research activities, with a focus on building capacity on the methods and tools developed within the project. The videos complement the growing resource of documentation on the models and links to their source codes, and are supplemented with powerpoint slidedecks also.

In addition, they will be extensively disseminated through social media engagement, e.g. Twitter and LinkedIn, and will be sent to the living community of almost 200 people that was created following the hybrid Addis Ababa workshops.

- **Short intros** (for dissemination purposes ~5 minutes each)
- **RE4AFAGRI Platform training** (~1 hour each)
- **RE4AFAGRI Platform training** (~1 hour each)

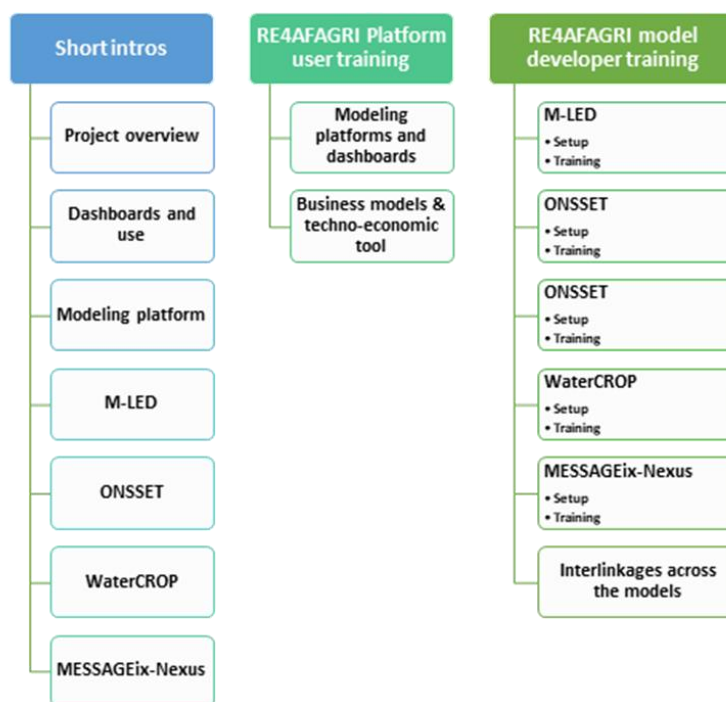


Figure 3. Overview of the videos developed on the RE4AFAGRI training materials.

In addition to the flagship events and online training activities, RE4AFAGRI contributed to the REnewable Energy Schools organised during the 1st and 2nd LEAP-RE stakeholder forums in Pretoria and Kigali in 2022 and 2023, respectively. Activities involved teaching the use of Geospatial data and methods for improving energy access mapping and electricity demand assessment for planning and policy purposes.

In parallel to research-related capacity building activities, three virtual events were held in July-August and September 2023, one for each case study country (Nigeria, Rwanda and a combination of Zimbabwe and Zambia) to present the techno-economic model developed in task 12.4 as well as findings from the business model report. Participants gained insights into modeling results for each of the countries and an overview of how the model's methodology works. We presented popular business models used by practitioners around the continent to electrify smallholder farmers and the status of regulations, infrastructure and financing that affect mini-grids and off-grid solar in each country. Each event was concluded by opening the floor and inviting participants to share insights from their contexts on the factors that influence their business model operations. The feedback often reconciled with our research: That access to finance remains an issue, that regulatory frameworks are often too slow-moving and that interest rates remain prohibitive. Occasionally additional comments were made that we did not consider in our research, e.g. the need for smallholder farmers to have access to water storage facilities to fully benefit from irrigation, and hence the need to integrate these costs into budgeting. During each session the audience was made aware of the in-person event to be held at the Second LEAP-RE Stakeholder Forum in Kigali and all participants were invited. All participants in these virtual events also gained early access to the techno-economic model to assess

the financial viability of electrifying smallholder agriculture. In total 55 participants attended the webinars: 25 attended the Nigeria event; 18 attended the Rwanda event; 12 attended the Zimbabwe and Zambia event.

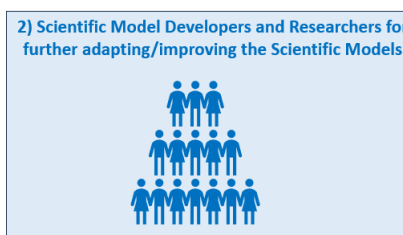
In addition, at the Second LEAP-RE Stakeholder Forum, we set out to present all RE4AFAGRI outputs in an interactive format. The session started with setting the agenda, followed by a presentation of the golden thread running through all of the RE4AFAGRI outputs. First was the NEST model, presented by Adriano Vinca, used to assist policymakers with data-driven decision-making pertaining to infrastructure development. Next was Giacomo Falchetta, who presented the RE4AFAGRI dashboards, which assist energy providers with identifying high-potential areas for electrification of agriculture. Finally, André Troost presented the rationale behind the techno-economic model and conducted a live demo, designed to help energy companies on the ground to identify agricultural activities that are financially feasible to electrify. During the demo, audience members were asked to participate by answering questions such as how many hours per day a solar water pump operates in their home countries. This information was fed into the model in order to demonstrate that it is customisable and user-friendly. Our aim was to ensure that the session contains two-way communication and that the audience co-creates the outcomes with us. Towards this end, we sketched a fictional manager of a mini-grid company and asked the audience to do the same, using Lego objects to further visualise the scenario in which this mini-grid developer operates. We demonstrated how our RE4AFAGRI models and tools benefit the mini-grid developer using the Lego objects. The final aim was to facilitate a new emerging conversation amongst participants of how electrification interventions aimed at smallholder agriculture can be improved. Towards this end we asked the question of what else is missing from the discussion. Participants added more Lego objects to their sketched scenarios to express their thoughts on what else could be needed, for example a person with a bag of money, referring to investment.



Figure 4: picture from the RE4AFAGRI capacity building event at the LEAP-RE Stakeholder Forum in Kigali

In 2024, RE4AFAGRI will in addition carry out several additional online capacity building programmes, both concerning the dashboards and business model tool for the community of business and policy users, as well as concerning the scientific models for model developers and researchers wishing to further adapting and improving the scientific models:

- The RE4AFAGRI online Capacity Building activities 2024 address two distinct Target Groups:



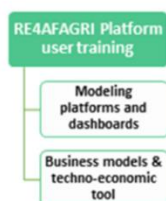
RE4AFAGRI Online Capacity Building activities address these two target groups separately with specific CB programmes for each group

1.1 Launch -> for Policy and Business users



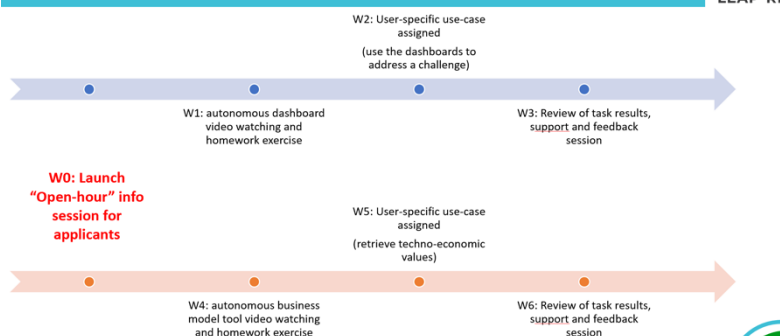
- May 2024
- The official launch session of the RE4AFAGRI Online Capacity Building programme, serves as an information session:
 - Purpose of the course
 - Structure
 - Timing
 - Outcomes
 - Requirements for the Certificates (one for each module)
 - Have watched all short videos and passed the quiz assessment
 - Have watched the module long video and passed the quiz assessment
 - Have successfully implemented the module task

1.2 Structure -> for Policy and Business users

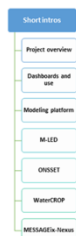


- Two Modules of 3-weeks each:
 - one on the Dashboard,
 - one on the business model techno-economic tool
- **first week:** participants are expected to watch and understand the videos, including filling a short quiz to check their understanding of the videos
- **second week:** the participants are expected to implement a little task (e.g. implementing use cases and producing an analysis thanks to the dashboards and/or collecting and implementing relevant data from their country into the business model, etc.)
- **third week:** a one 2h (max) session with the relevant RE4AFAGRI expert for each model to answer questions on difficulties encountered related to the module and task

1.3 Timeline-> for Policy and Business users



2.1 Launch -> Scientific Model Developers/Researchers



- May 2024
- The official launch session of the RE4AFAGRI Online Capacity Building programme, serves as an information session:
 - Purpose of the course
 - Structure
 - Timing
 - Outcomes
 - Requirements for the Certificates (one for each module)
 - Have watched all short videos and passed the quiz assessment
 - Have watched the dashboard long video and passed the quiz assessment
 - Have watched the model long videos and passed the quiz assessment
 - Have successfully implemented the first task for a "Certificate"
 - Have successfully implemented also the second task for the "Certificate with honours"

2.2 Structure -> Scientific Model Developers/Researchers



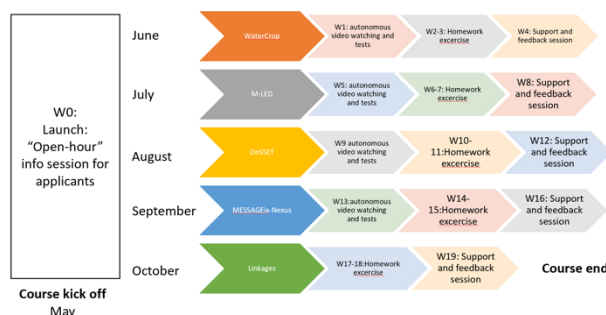
Four Modules of 4 weeks each, plus an interlinkage model (3 weeks):

- a participant can choose to follow just one model, or several, the last module can only be followed by someone having followed at least two previous modules

Structure of each Module:

- **first week:** participants are expected to watch and understand the video, including filling a short quiz to check their understanding of the videos
- **Second & third week:** the participants are expected to implement a little task (e.g. Collecting and implementing relevant data from their country into the model, etc.)
 - ❖ Each participant will be assigned two tasks/exercises for each module: a simple Task related to one of the countries where the models already work, and a slightly more sophisticated one for a country which is not yet covered by the model.
 - ❖ If a participant only does the first task/exercise (s)he will get a certificate, if a participant completes both exercises (s)he gets a certificate with honours.
- **fourth week:** a one 2h (max) session with the relevant RE4AFAGRI expert for each model to answer questions on difficulties encountered related to the module and task

2.3 Timeline for Scientific Model Developers/Researchers



Certificates

- Certificates will be delivered to participants for each module they have successfully completed



Fac simile



Figure 5: Online capacity building activities plan (to be held in 2024)

Overall, the RE4AFAGRI capacity building activities have the crucial benefit of building a community and network of experts across sub-Saharan Africa who will be able to further develop their existing skills and technical capacity within their organizations and countries in coming years. The success of the CB activities lay not only in their informative content, but also in their ability to trigger action through the creation of cross-disciplinary networks, enabling professionals from diverse backgrounds and countries to collaborate and pool their expertise, thereby amplifying the potential for impactful change.

5. RE4AFAGRI in numbers

RE4AFAGRI achievements can (partially) be summarised with the following achievements:

- Peer reviewed papers published: **4**
 - Falchetta, G. (2021). Energy access investment, agricultural profitability, and rural development: time for an integrated approach. In *Environmental Research: Infrastructure and Sustainability* (Vol. 1, Issue 3, p. 033002). IOP Publishing. <https://doi.org/10.1088/2634-4505/ac3017>
 - Falchetta, G., Adeleke, A., Awais, M., Byers, E., Copinschi, P., Duby, S., Hughes, A., Ireland, G., Riahi, K., Rukera-Tabaro, S., Semeria, F., Shendrikova, D., Stevanato, N., Troost, A., Tuninetti, M., Vinca, A., Zulu, A., & Hafner, M. (2022). A renewable energy-centred research agenda for planning and financing Nexus development objectives in rural sub-Saharan Africa. In *Energy Strategy Reviews* (Vol. 43, p. 100922). Elsevier BV. <https://doi.org/10.1016/j.esr.2022.100922>
 - Falchetta, G., Semeria, F., Tuninetti, M., Giordano, V., Pachauri, S., & Byers, E. (2023). Solar irrigation in sub-Saharan Africa: economic feasibility and development potential. In *Environmental Research Letters* (Vol. 18, Issue 9, p. 094044). IOP Publishing. <https://doi.org/10.1088/1748-9326/acefe5>
 - Awais, M., Vinca, A., Byers, E., Frank, S., Fricko, O., Boere, E., Burek, P., Poblete Cazenave, M., Kishimoto, P. N., Mastrucci, A., Satoh, Y., Palazzo, A., McPherson, M., Riahi, K., & Krey, V. (2024). MESSAGEix-GLOBIOM nexus module: integrating water

sector and climate impacts. In *Geoscientific Model Development* (Vol. 17, Issue 6, pp. 2447–2469). Copernicus GmbH. <https://doi.org/10.5194/gmd-17-2447-2024>

- Peer reviewed papers in preparation / submitted: **3**
 - Giacomo Falchetta, Adriano Vinca, André Troost, Marta Tuninetti, Gregory Ireland, Edward Byers, Manfred Hafner, and Ackim Zulu. From the models to the business models: achieving renewable energy-centered sustainable development futures for rural Africa.” Submitted to Environmental Development journal for peer review.
 - Francesco Semeria, Adriano Vinca, Giacomo Falchetta et al. Food loss & waste of staple crop products: mapping environmental impacts within the Nexus paradigm. To be submitted in 2024
 - Francesco Semeria, Adriano Vinca, Giacomo Falchetta et al. Reducing food loss & waste to improve sustainability in transformation pathways for the agri-food system – Modelling impacts across the Water-Energy-Food Nexus. To be submitted in 2024
- Project website online and .africa domain registered:
 - <https://www.re4afagri.africa/>
- Modelling platform source code online
 - https://github.com/iiasa/RE4AFAGRI_platform/
- Modelling platform replication data online
 - <https://zenodo.org/records/8365630#.ZFnjK3ZBxhk>
- Modelling platform user guide online
 - https://github.com/iiasa/RE4AFAGRI_platform/wiki
- Business model techno-economic model and its documentation published online:
 - <https://www.re4afagri.africa/business-models>
- Capacity building videos: **15**
 - Videos in the status of post-processing (as of March 2024), to be published in the IIASA (RE4AFAGRI task leader for capacity building activities) Youtube channel under a custom playlist and be disseminated as a LEAP-RE capacity building material. The material will also be posted on LEAP-RE and RE4AFAGRI websites.
- Scientific dissemination events organised/participation: **7**
 - 1st LEAP-RE Stakeholder Forum, 2022: RE4AFAGRI project presentation to the LEAP-RE general assembly (problems to be tackled, proposed methodology, expected results..)
 - EGU Annual Meeting 2022: Solar irrigation analysis presented
 - Scenarios Forum 2022: Solar irrigation analysis presented
 - EGU Annual Meeting 2023: RE4AFAGRI modelling platform development

- 2nd LEAP-RE stakeholder Forum, 2023: Keynote plenary presentation on RE4AFAGRI project results
- IAMC Conference 2023: RE4AFAGRI modelling platform implementation in Zambia – **best online poster award**
- EGU Annual meeting 2024: RE4AFAGRI modelling platform implementation in Zambia
- Consultation/dissemination events organisation: **9**
 - 6 initial focus groups to share knowledge and co-create the project research activities in 2021-2022 (Nigeria, Rwanda, Zambia, Zimbabwe)
 - 3 business models follow-up focus groups (Summer 2023; Nigeria, Rwanda and a combination of Zimbabwe and Zambia)
- Capacity building events organised/participation: **3**
 - 1st LEAP-RE Stakeholder Forum – renewable energy school
 - 2nd LEAP-RE stakeholder Forum – renewable energy school; business models interactive session
 - RE4AFAGRI, IIASA and World Resources Institute (WRI) joint Workshops, Addis Ababa
- External funding acquisition for CB activities
 - **44,000 €** (funders: World Bank, IIASA, WRI, Science Granting Councils Initiative)
- PhD/MSc. students involved/funded by RE4AFAGRI: **3+**
 - Francesco Semeria (POLITO)
 - Mathias Kustner (TFE)
 - Muhammad Awais (IIASA)
 - Participants to the Addis Ababa event included PhD students from several different African countries and affiliations

6. Replication, exploitation, and future prospects

While RE4AFAGRI officially comes to an end in M42 of LEAP-RE (March 2024), its living heritage is here to stay, and has at its core the RE4AFAGRI website (www.re4afagri.africa). Here, all the scientific, business and policy-related, and dissemination and capacity-building materials, are findable and accessible. The website hosts, for instance, the RE4AFAGRI dashboards, which allow exploring the results of the RE4AFAGRI modelling platform and will be actively developed and expanded as active efforts are taking place by RE4AFAGRI model users. This content is underpinned by the online training videos which form part of the longer lasting, open digital legacy of the project.

Future work, both as part of the RE4AFAGRI and LEAP-RE living heritage, and in future projects, further scientific advancements will contribute to even further exploring the key topics and interactions studied in RE4AFAGRI.

First of all, given the strong focus on agricultural production and food security, it would be important to assess the relation with clean cooking, another crucial development priority in sub-Saharan Africa. Ever more electrical cooking technologies are emerging as competitive and clean solutions, thanks to strong innovation (as also showcased in other LEAP-RE Pillars 1-2 projects) and decreasing costs. It

would be pivotal to assess the synergies between irrigation, crop processing and cold storage, and food cooking technologies, and how such synergies between these energy services can be leveraged to decrease costs, increase feasibility and maximise development impact.

In addition, more explicit focus on the impacts of climate change on different dimensions of agriculture (such as changing cropping patterns or crop types, as well as nutrition-related issues) should be assessed and Nexus interventions should be analysed.



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