SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	2021
Project Title:	Land Management for Climate Mitigation and Adaptation (LAMACLIMA)
Computer Project Account:	spnlcoum……
Principal Investigator(s):	Dim Coumou ……
Affiliation:	VU Amsterdam
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…… ……
Start date of the project:	1-09-2019
Expected end date:	1-09-2022

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)			23000000.00 SBU	20308301.99 SBU
Data storage capacity	(Gbytes)				

Summary of project objectives (10 lines max)

VU Amsterdam is partner in the new JPI-Climate/AXIS funded project LAMACLIMA (https://climateanalytics.org/projects/lamaclima/) that aims at advancing the scientific and public understanding of the coupled climate effects of land cover and land management (LCLM) options. The project aims at elaborating sustainable land-based adaptation and mitigation measures.

Planned Simulations

The interactions between LCLM and climate is quantified by conducting a set of sensitivity experiments using EC-Earth3-Veg. The output of these simulations will be analysed for (i) local climate impacts of changes in LCLM through biogeophysical effects such as changes in albedo or evapotranspiration, (ii) remote biogeophysical impacts through atmospheric teleconnections and (iii) biogeochemical impacts on the carbon cycle.

We generate simulations with the coupled-model EC-Earth3-Veg over the period 2014-2174 (160 years including 10 years of spin-up). We use the latest frozen version EC-Earth 3.2 at T255 resolution. Initially a set of 1 control and 4 scenario runs were planned. In a nutshell, these are the following (for the details of each run you can see the actual LAMACLIMA special request form):

1) Control Run: Successfully finalized.
2) 100% Natural Vegetation simulation. Successfully finalized.
3) 100% Crop simulation without Irrigation. Currently running.
4) 100% Crop simulation with Irrigation. Currently running.
5) 100% Natural Vegetation simulation including wood harvesting. Planned for Q3/Q4 2021.

Summary of problems encountered (10 lines max)

Simulation 4 (listed above) had to be conducted twice. Although before starting this simulation the model and output were thoroughly tested by running short versions and checking the outcomes, after the long simulation of this scenario was completed, we found that the output had some imperfections in the set up that compromised the scientific quality of the run. Therefore, it had to be improved and was re-done (currently running) with the unfortunate cost of extra resources.

Summary of plans for the continuation of the project (10 lines max)

Next to the completion of the runs described above, we plan three New Scenario Logic simulations as part of LAMACLIMA project. The new land-use scenarios are developed together with stakeholders and the LCLM changes will be driven accordingly by MAgPIE model. The objectives on which the new scenarios are being built are the following:

1) Limitation of global temperature increase to 1.5C, without compromising the global food security.

2) Zero hunger level achieved without any depletion of water resources.

3) Minimizing the local climate risks of the biogeophysical effects of LCLM changes.

The three new LCLM-driven scenario runs in EC-Earth-Veg will be fully coupled (ocean-atmosphere-LPJ-GUESS) transient simulations of the 21st century, running for 85 years each (2014 - 2100).

List of publications/reports from the project with complete references

Planned for next year

Summary of results

If submitted **during the first project year**, please summarise the results achieved during the period from the project start to June of the current year. A few paragraphs might be sufficient. If submitted **during the second project year**, this summary should be more detailed and cover the period from the project start. The length, at most 8 pages, should reflect the complexity of the project. Alternatively, it could be replaced by a short summary plus an existing scientific report on the project attached to this document. If submitted **during the third project year**, please summarise the results achieved during the period from July of the previous year to June of the current year. A few paragraphs might be sufficient.

……
……PLEASE SEE THE ATTACHED PROGRESS REPORT ……
……
……
……
……
……

LAnd MAnagement for CLImate Mitigation and Adaptation (LAMACLIMA)

Mid-term Report

1. Identification of the project

Project full title: LAnd MAnagement for CLImate Mitigation and Adaptation

Project acronym: LAMACLIMA

Project coordinator (name, title and affiliation): Dr Carl-Friedrich Schleussner, Climate Analytics gGmbH

Project partners:

Climate Analytics gGmbH (CA)
Vrije Universiteit Brussel (VUB)
Potsdam-Institut für Klimafolgenforschung e.V. (PIK)
Vrije Universiteit Amsterdam (VU)
Ludwig Maximilians Universität München (LMU)
Eidgenössische Technische Hochschule Zürich (ETH)
Center for International Climate Research (CICERO)

Starting date: 01.09.2019

End date: 31.08.2022

Project duration (months): 36

Reporting period: 01.09.2019-31.02.2021

Project website address: https://climateanalytics.org/projects/lamaclima/

2. Objectives of the Project *(max. 20 lines)*

The objective of the LAMACLIMA project (LAnd MAnagement for CLImate Mitigation and Adaptation) is to advance the scientific and public understanding of coupled effects between land-use and climate and to elaborate sustainable land-based adaptation and mitigation measures. Hereto we rely on a collaboration between physical climate scientists, economists, stakeholder

engagement experts and statisticians. The undertaken research activities first aim to uncover the climate effects of changes in Land Cover and Land Management (LCLM) as well as on other biophysical variables such as water availability or heat stress with Earth System Models. The integration of these results into land-use allocation and economic models will then allow the assessment of resulting sectoral impact such as on labour productivity and food security. Moreover, a statistical emulator for these LCLM impacts on biophysical and economic variables will be developed in order to allow quick exploration of the local climate and economic consequences of any LCLM pathway. This has the twofold objective of facilitating engagement of land-use stakeholders and support decision making, as well ensuring a more flexible and computationally efficient representation of LCLM impacts in economic models and Integrated Assessment Models. Furthermore, a scenario co-development effort gathering stakeholders and modellers will lead to the design of new LCLM scenarios that complement the existing Shared Socio-economic Pathways (SSPs). Additional model experiments will be conducted to unravel the potential of these LCLM scenarios to achieve the goals of the Paris Agreement as well as the Sustainable Development Goals (SDGs) 2 (Zero Hunger), 6 (Clean Water and Sanitation), 8 (Decent Work and Economic Growth), 13 (Climate Action), and 15 (Life on Land). These objectives haven't been modified since the proposal stage.

3. Short description of activities and intermediate results *(1 page)*

Activities and results:

WP 1 Interactions between LCLM and climate [VUB (lead), ETH, LMU, VU, Month 1-24]

- Implementation of LCLM scenarios [VUB, LMU and VU for CESM, MPIESM and EC-EARTH]
- Harmonisation of these scenarios across the 3 ESMs [combined efforts VUB, LMU, VU and CA]
- Finalisation of the sensitivity experiments [all for VUB, LMU, VU only control simulation]
- Implementation of a general data access point at DKRZ for all ESM model output for all project partners with more than 400 TB storage [LMU]
- Preparation of a general script applicable for all 3 ESMs to separate local and non-local signals for all variables [LMU]
- Preparation of ESM output for use in WP2 and 3 [VUB and LMU in collaboration with PIK, CA and CICERO]
- Presentation of preliminary results at international conferences [EGU2020: LMU, VUB and VU, iEMSs 2020: VUB and EGU2021: VUB, LMU] and smaller conferences
- Analysis of ESM output with a focus on bio geophysical [VUB] and biogeochemical [LMU] effects of LCLM on climate.
- Preparation of 2 scientific manuscripts [VUB and LMU] describing simulations and analysis.

***WP 2* Multi-sectoral costing of LCLM as adaptation measures [CICERO (lead), PIK, Month 1-28]**

- Implementation of the biogeophysical effects of afforestation in MAgPIE, which can now be endogenously considered by the model. A paper assessing the resulting effect is currently in preparation. [PIK]
- Development of a concept to split production cost in MAgPIE into labour and capital costs. This split provides the basis to assess the impact of climate change on labour productivity and their relief potential by LCLM adaptation options based on WP1 and WP3 data. [PIK, CICERO]

- In addition to afforestation and irrigation, implementation of a forestry sector in MAgPIE to represent the third LCLM option "wood harvest". [PIK]
- Modification of the core version of the GRACE model to incorporate irrigated and rainfed growing methods and depict land heterogeneity and conversion costs of land allocation. These model modifications aim to better represent adaptation options and transaction costs in the agriculture sector in the GRACE model. [CICERO]
- Revision of the GRACE model to better depict structural change in economies. This model feature is especially important for scenario analyses, which require long-term model runs (i.e., SSP-RCP based scenarios). [CICERO]
- Using the climate and crop model simulations available through CMIP5/ISIMIP2b, conduction of a global economic impact assessment of future climate change and heat stress impacts on crop yields and worker productivity. A manuscript summarizing main results was submitted to the *Economics of Disasters and Climate Change* journal. [CICERO, CA, VUB]

WP 3 Co-development of the emulator and the alternative SSPs [CA (lead), ETH, M1-36]

- Collaboration between CA and ETH to extend the Modular Earth System Model Emulator with spatially Resolved output (MESMER), already developed by ETH and which is able to statistically emulate global fields of local annual mean temperature simulated by Earth System Models in response to a given greenhouse gas emission trajectory. The first extension developed under LAMACLIMA involves the development of a module to downscale the local temperature projections at the monthly scale. A scientific manuscript is currently under preparation. [CA, ETH]
- Ongoing development of additional extensions of MESMER, to be able to statistically emulate the local changes in wet-bulb globe temperature and resulting changes in labour productivity in response to a given greenhouse gas emission trajectory, as well as the local changes in temperature in response to changes in afforestation/reforestation, irrigation, and wood harvest. [CA, ETH]
- Stakeholder outreach conducted from December 2019 onwards to increase stakeholder literacy on the LCLM-climate nexus, synergies and trade-offs of the deployment of LCLM measures for SDGs, and to identify key land-use stakeholders who could participate in the scenario co-development exercise. [CA]
- Extensive stakeholder searches and mapping were realised to create a base of 400 interested stakeholders and a key stakeholder group of 22, with a range of expertise relevant to the topic of land-use. [CA]
- Organisation of three public webinars (May-June 2020) which generated awareness for the project and helped build the stakeholder base. About 250 attendees from research organisations, consultancies, NGOs and governmental institutions. Recordings are available on the project website. [CA]
- Newsletter started in July 2020 (so far 2 editions available on the project website) [CA]
- Organisation of three 1.5-hour key stakeholder webinars in February and March 2021, preparing the key stakeholder group towards the 2-day scenario co-development workshop (April 2021). A virtual whiteboard was set up for internal use among the group using the MIRO software (results can be seen here - please note this is work in progress and should not be shared publicly). The webinars included preliminary results from sensitivity experiments

performed in WP1 or first results from WP2 to inform stakeholders of possible climate and economic effects of LCLM deployment. [CA, VUB, LMU, PIK, CICERO]

WP 4 Integrated analysis of the cross-sectoral interactions between LCLM, SDGs, climate mitigation and adaptation [LMU (lead), CA, CICERO, PIK, VU, VUB]

- Finalization of the alternative SSP-based scenarios building on the results from the stakeholder engagement workshop conducted in WP3 (in progress). Decisions of the stakeholder need to be translated into the IAM MAgPIE in order to be able to produce spatially and temporally distributed land-use maps applying the specific LCLM options
- Coordination of the exchange of land-use data between MAgPIE and the ESMs to prepare the integrated model framework required for the WP4 simulations (in progress)

4. Comparison of the project progress with the original work plan *(max. 1 page)*

WP Nr.	Work Package Title	Readiness level %	Original date		actual		results / comments on deviation
			Start	end	start	end	
1	Interactions between LCLM and climate	70	M1	M24	M1	M30	All WP1 simulations will be finalised before the end of M24. Yet for the analysis of the simulation output, we foresee 6 additional months. This delay can be ascribed to several unforeseen challenges in implementing the LCLM options in the ESMs, COVID-related issues, and the postprocessing required to harmonise the simulation output across ESMs.
2	Multi-sectoral costing of LCLM as adaptation measures	50	M1	M28	M1		Deviating from the initial schedule, data of WP1 was not provided to WP2 as planned. The delay was produced by hindrances in model simulation within WP1 and the decision of all project partners to provide data from WP1 through the emulator of WP3 to WP2. This change aims to provide MAgPIE with data on the respective labour productivity impact of LCLM options under consideration. The data from WP3 is expected in spring 2021 and its implementation in MAgPIE in summer 2021.
3	Co-development of the emulator and the alternative SSPs	40	M1	M36	M1		COVID required changes to stakeholder engagement activities and workshops, requiring the use of new interactive and online tools. Yet they remain largely on schedule; slight delays may occur in case longer interactions are required with specific stakeholder groups in order to account for their feedback on the

							scenario co-development exercise. The development of the emulator has however been delayed by technical difficulties, the repercussions of the delay in WP1 simulations, as well as the opening of several development workstreams in parallel.
4	Integrated analysis of the cross-sectoral interactions between LCLM, SDGs, climate mitigation and adaptation	5	M18	M36	M18		The work just started as planned. No results and no deviation envisaged for now.

5. New results *(max. 20 lines)*

- In 2020, Dr. Edouard Davin (LAMACLIMA partner) published a study in the framework of another project (CORDEX-Flagship Pilot Study LUCAS) entitled: 'Biogeophysical impacts of forestation in Europe: first results from the LUCAS (Land Use and Climate Across Scales) regional climate model intercomparison'. In this paper, they present a framework to harmonise LCLM implementation across various regional climate models. Within LAMACLIMA, we successfully applied this framework to harmonise the LCLM options across the three global-scale Earth System models.

- Two further publications by ETH on the MESMER emulator establish the technical basis for the development of the emulator within LAMACLIMA:

    - Beusch, L., Gudmundsson, L., and Seneviratne, S. I. (2020): Emulating Earth system model temperatures with MESMER: from global mean temperature trajectories to grid-point-level realizations on land, Earth Syst. Dynam., 11, 139–159, https://doi.org/10.5194/esd-11-139-2020
    - Beusch, L., Gudmundsson, L., and Seneviratne, S. I. (2020): Crossbreeding CMIP6 Earth System Models with an emulator for regionally optimized land temperature projections. Geophysical Research Letters, 47, e2019GL086812. https://doi.org/10.1029/2019GL086812

6. Communication and dissemination activities *(max. 1 page)*

Please provide information on the most important communication and dissemination activities since the start of the project. This may include (but not limited to) engagement with the general public (including media and communication), engagement with policy makers, engagement with science communities, decision makers (including the private sector) and elaboration of policy briefs.

Activities until the end of February 2021

- General stakeholder outreach for participation in webinars and workshops: Through a screening and mapping of the network of LAMACLIMA consortium partners and members,

that of Climate Analytics obtained via previous stakeholder engagement activities, and a targeted Google search for experts in related areas, the Climate Analytics stakeholder engagement team reached a group of approximately 400 stakeholders for its public webinar series (May-June 2020), and 22 key stakeholders for further engagement via stakeholder webinars (February-March 2021) and a workshop (April 2021) aiming at co-designing future LCLM scenarios.

- The Lead Project Investigator Carl-Friedrich Schleussner as well as the WP1 and WP3 leaders Wim Thiery and Quentin Lejeune attended the JPI AXIS Project Launch Meeting in Brussels on November 5-6, 2019, where they exchanged with representatives from the funding agencies and from other projects funded by JPI-AXIS. They subsequently reported about the outcomes of this meeting to the LAMACLIMA project partners.
- One paper led by CA with contributions from LAMACLIMA consortium partners was published in an open-access journal in 2020: Lejeune, Q., Davin, E. L., Duveiller, G., Crezee, B., Meier, R., Cescatti, A., and Seneviratne, S. I.: Biases in the albedo sensitivity to deforestation in CMIP5 models and their impacts on the associated historical radiative forcing, Earth Syst. Dynam., 11, 1209–1232, https://doi.org/10.5194/esd-11-1209-2020, 2020

Public webinars

- A series of public webinars were held from May-June 2020 on the following topics: The Future of Land Cover, Land Management and Climate Change, Effects of Irrigation on Climate Change, and Forest Management and Land Cover Change under Changing Climate. All webinars were recorded, with recordings available on our project webpage. They were advertised through short videos via Twitter and Facebook, leading to a high number of sign-ups (250-400 for each webinar). 250 people eventually attended the webinars in total, but more than 400 people expressed interest in our newsletter. After the webinar was completed, the team published a blog article about the complex relationships between land and climate tackled in LAMACLIMA, and the potential of the project to address those.

LAMACLIMA newsletter

- Following the public webinars, the WP3 team started a LAMACLIMA newsletter to give project updates to interested stakeholders. More than 400 people signed up to receive it. The first edition was distributed in July 2020 and provided updates on new results from the LAMACLIMA consortium, informed about stakeholder engagement activities, advertised the presence of LAMACLIMA partners in conferences and papers recently published by consortium partners. Past and future newsletter editions can be viewed on the LAMACLIMA project page.

Contribution to the JPI newsletters

- LAMACLIMA has contributed to the JPI-Climate newsletters in May, September, and December of 2020 (viewable here). Some of these updates were also shared on the JPI-Climate news page (viewable here).

LAMACLIMA engagement in conferences

- 2020 General Assembly of the European Geosciences Union,
- American Geoscience Union Fall Meeting 2020,
- Gingko Workshop,
- EPFL ML4 Earth Workshop 2020,
- ETHZ Data Science in Climate and Climate Impact Research Workshop 2020.