PhD Position

Dynamic counterfactual modeling of Land Use and Land Use Change GHG emissions for consequential Life Cycle Assessment

CONTEXT

The BIOCaP-LCA[1] project aims to advance consequential Life Cycle Assessment (LCA) methods to evaluate the environmental impacts of bioeconomy deployment scenarios at the scale of France. While LCA is widely used to assess products or compare technologies, it has limitations when applied to large-scale, long-term transitions that involve complex socio-economic and biophysical dynamics. The project focuses on some key challenges specific to the bioeconomy, including accounting for land-use and land-use change (LULUC), impacts on climate and biodiversity, and feedback loops between natural systems (the ecosphere) and human systems (the technosphere), which are not well captured in traditional LCA. To address these issues, BIOCaP-LCA proposes an innovative approach that combines LCA with biophysical and socio-economic models in a dynamic and forward-looking framework.
The project is funding three PhD theses that will lead to methodological advances in these research areas, including the PhD thesis described in this offer.

PhD OBJECTIVES

LULUC are responsible for 12% of annual global GHG emissions[2] and play a central role in biodiversity loss. Despite decades of methodological development, LCA approaches aiming at quantifying environmental impacts still struggle to represent these land use impacts in a way that is both dynamic and causally meaningful, a necessity for consequential LCA (CLCA)[3]. Yet, as climate change increasingly alters soil processes and agricultural systems, it is essential to understand how land-use decisions contribute to system destabilization, in order to steer global food production toward lower impacts.
This PhD project addresses a key gap: the lack of process-based, counterfactual modeling of LULUC carbon emissions. While CLCA requires impacts to be defined as the difference between a world with and without a given demand for agricultural products, current LCA practice relies largely on static, retrospective, and rule-based methods that fail to capture ecosystem dynamics[4].

The core novelty of this project lies in the integration of land surface models, mainly ORCHIDEE[5], to explicitly simulate counterfactual land-use scenarios. This framework will model carbon trajectories under both:

- a *factual* pathway with land demand, and
- a *counterfactual* pathway where ecosystems evolve without this demand

By leveraging land-surface and crop models' capacity to simulate soil–vegetation–atmosphere interactions under varying climatic and land-use conditions, the project will generate spatially explicit, time and climate dependent carbon dynamics. This enables the derivation of LULUC emission factors consistent with the foundational definition of impact in CLCA.

---

[1] An ANR-funded PEPR project bringing together INRAE, CEA, IFPEN and CIRAD to advance LCA modeling for the bioeconomy: https://www.pepr-bioproductions.fr/eng/funded-projects/axis-4-cross-cutting-methodologies-and-tools/biocap-lca
[2] https://doi.org/10.5194/essd-15-5301-2023
[3] https://doi.org/10.1016/B978-0-323-90386-8.00001-2
[4] http://hdl.handle.net/10138/37049
[5] https://doi.org/10.1029/2003GB002199

The PhD is positioned at the interface between two complementary fields:

- Biophysical modeling, using land surface models to simulate ecosystem carbon dynamics under climate change
- Conceptual and methodological development in CLCA, to translate these dynamics into robust, decision-relevant impact indicators

The candidate will be jointly supervised by experts in each domain, ensuring both state-of-the-art process modeling and rigorous LCA framework development. Key research challenges include:

- Defining consistent initial and reference ecosystem states
- Constructing counterfactual scenarios of land evolution under different climate trajectories
- Conceptual modeling to translate dynamic carbon fluxes into CLCA-compatible impact metrics
- Quantifying uncertainties from model structure, parameters, and climate projections

The expected outcome is a new methodological framework for LULUC in CLCA, supported by dynamic, spatialized emission factors for land transformation and occupation, and a transparent treatment of uncertainty. Overall, this work contributes to a paradigm shift toward dynamic, prospective, and counterfactual assessment of land-use impacts, grounded in process-based ecosystem modeling.

WHO WE ARE LOOKING FOR

We are seeking a curious and proactive candidate, motivated by research and holding a Master's degree (M2).

Experience with quantitative modeling is required, may it be in land surface modeling, ecosystem dynamics modeling, or LCA. Experience in both fields (biophysical modeling, and LCA) is not required, but an interest to bridge the gap between both disciplines.

Candidates must be fluent in English.

WORK ENVIRONMENT

The PhD work will be co-directed by an interdisciplinary duo: Dr. Nicolas Viovy (Research Director, LSCE, CEA), who is part of the ORCHIDEE development team, and a specialist of biogeochemical modeling, and Dr. Pierre Jouannais (Chargé de Recherche/Associate Professor, INRAE), whose research focuses on advancing LCA methodology towards consequential and prospective approaches.

The PhD student can be hosted within the ELSA team in Montpellier or in Paris-Saclay, depending on the student's profile and preferences.

↘ Terms & conditions

- Location: Montpellier and/or Paris-Saclay
- Contract: PhD Position
- Duration: 36 months
- Beginning: Autumn 2026
- Salary: 2,700€ gross monthly

↘ How to apply

Send a CV and motivation letter (references are also appreciated) to:

pierre.jouannais@inrae.fr

and

nicolas.viovy@lsce.ipsl.fr

Application deadline: **19 June 2026**