Project 104(B) Methodology for Assessing Changes in Soil Organic Carbon

Purdue University

Project Lead Investigator

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University Participants

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- P.I.: Farzad Taheripour, Research Professor
- FAA Award Number: 13-C-AJFE-PU-058
- Period of Performance: December 3, 2024, through December 31, 2025
- Tasks:
  1. Review the literature and data sources and establish benchmark datasets for land cover and soil carbon content by land types at a global scale by country.
  2. Improve the agro-ecological zone emission factor (AEZ-EF) model and continue to investigate potential gains in soil carbon content due to improvements in land management practices. Special attention will be made to improvements in soil carbon content due to new technologies that improve crop plants root systems to sequester more carbon into soils.

Project Funding Level

This project received funding from the Federal Aviation Administration (FAA) as follows:
Amendment 58: $426,323.00

Current cost sharing for this project year was provided by Neste US, Inc.

Investigation Team

Prof. Farzad Taheripour (P.I.), All Tasks
Prof. Dominique van der Mensbrugghe (co-P.I.), Tasks 2, 3
Prof. Qianlai Zhuang (co-P.I.), All Tasks
Research Assistant Prof. Maksym Chepeliev, (co-P.I.), Tasks 1 and 2
Research Associate Prof. Uris Baldos (co-P.I.), All Tasks
Angel Aguiar (research economist), Tasks 1 and 2
Associate Prof. Mohsen Mohammadi (co-P.I.), Task 3
Shuo Chen (PhD student), Tasks 1 and 2
Xiangyu Liu (PhD student), Tasks 3
Ye Yuan (PhD student), Tasks 1 and 2
Lauren Benavidez (PhD student), All Tasks

Project Overview

The project focused on various activities including updating the AEZ-EF model to adopt the 2019 Intergovernmental Panel on Climate Change (IPCC) guidelines in assessing lands use emission factors, assessing the existing data and approaches that provide land use emission factors used in the AEZ-EF model; and studying and proposing a methodology to measure, check, and verify changes in the soil carbon content of cropland including soil organic carbon (SOC) at the farm level due to production of sustainable aviation fuels (SAF) or other biofuels. It also considers impacts of improvements in crop roots on soil carbon content.

Task 1 – Review the Literature and Data Sources and Establish Benchmark Datasets for Land Cover and Soils Carbon Content by Land Types at a Global Scale by Country

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Objectives

The objectives of this task are to review the existing data sources that have been commonly used in determining land use emissions factors in assessing indirect land use change (ILUC) emissions for biofuels, including SAF, and to develop a database that traces land use changes at the global scale by country at 500 m between 2001 and 2020. Use the results of these activities to establish a benchmark dataset that represents SOCs by land types at a global scale by country and review the existing methodologies that have been used by the regulatory agencies across the world to measure, check, and verify changes in SOC at a farm level due to changes in agricultural practices.

Research Approach

This task will study the existing research in this field and find the relevant available data including satellite data sources and their content. Additionally, this task will develop proper cods to read the available data and process and analyze them.

Milestones

- Review of various satellite data on land cover has been accomplished,
- Review of global datasets on SOC data has been accomplished,
- Several papers have been developed.

Major Accomplishments

- Prepared a land cover dataset for 2001 to 2020 to be used in the Global Trade Analysis Project (GTAP)-BIO model.
- Provided the required data to update the AEZ-EF model.

Publications

Chen, S., Zhuang, Q., Taheripour, F., Yuan, Y., & Benavidez, L. (2025). Assessment of global land cover changes using satellite data: intermittent and long-term land cover changes from 2001 to 2020. *Environmental Research Letters*, *20*(3). http://dx.doi.org/10.1088/1748-9326/adb5a3

Chen, S., Taheripour, F., Baldos, U. L., Zhuang, Q., Yuan, Y., & Benavidez Hernandez, L. (2025, December 15-19). *Global pastureland changes from 2001 to 2020* [Conference presentation]. AGU Fall Meeting 2025, New Orleans, Louisiana.

Yuan, Y., Taheripour, F., Baldos, U. L., Chen, S., & Zhuang, Q. (2025, December 15-19). *Improving forest carbon accounting in economic models: Updating GTAP land cover with recent remote sensing products* [Conference presentation]. AGU Fall Meeting 2025, New Orleans, Louisiana.

Liu, X., Zhuang, Q., Taheripour, F., & Benavidez, L. (2025, December 15-19). *Global Marginal Land Mapping and Impact of Agricultural Management Practices on Marginal Land Soil Organic Carbon* [Conference presentation]. AGU Fall Meeting 2025, New Orleans, Louisiana.

Outreach Efforts

The results of this research will be used in ILUC assessment for Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) and other national and state biofuel policies.

Awards
None.

Student Involvement
- EhsanReza Sajedinia, current PhD student Purdue University, for data collection and running simulations.
- Lauren Benavidez, current PhD student, Purdue University, for data collection and working with land use data, emission data, and models.
- Shuo Chen, current PhD student, Purdue University, for data collection and working with land use data, emission data, and models.
- Xiangyu Liu, current PhD student, Purdue University, for data collection and working with land use data, emission data, and models.
- Ye Yuan, current PhD student, Purdue University, for data collection and working with land use data, emission data, and models.

Plans for Next Period
- Finish the soil and vegetation carbon assessments at the global scale using satellite data sources to update this data component of the AEZ-EF model.
- Complete the Threat and Error Management (TEM) simulations in (1) measuring the impacts of the land management practices on the SOC content of cropland and (2) measuring the consequences of plants' root improvements on the soil carbon content of cropland.

Task 2 – Improve the AEZ-EF model and Continue to Investigate Potential Gains in Soil Carbon Content due to Improvements in Land Management Practices

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Objectives
The objectives of this task are to (1) improve the AEZ-EF model to operate based on the most recent available databases using the results of Task 1 to provide more accurate ILUC assessments, (2) use the TEM model to investigate potential gains in soil carbon content due to implementation of advanced land management practices, and (3) evaluate carbon savings due to improvements in crops root systems using the TEM model.

Research Approach
This task will convert the results of task 1 to the AEZ-EF format to update this model. It also calibrates the TEM model to the collected datasets in task 1 and runs various simulations to achieve the goals of this project.

Milestone
- Updated the AEZ-EF model to follow the IPCC 2019 guidelines and use the most recent version of the Harmonized World Soil Database and several national maps. The first revision has been already adopted by the Working Group 5 (WG5) of CORSIA in ILUC assessment. The second revision is expected to be approved by the WG5 in 2026 to be used in the next round of ILUC assessment.

Major Accomplishments
- Implemented the results of this work to revise the ILIUC values for about 50 regional and global SAF pathways of CORSIA. The results of this work have also been used in calculating several ILUC values for the 45Z provision of the Inflation Reduction Act of 2022.

Publications
Peer Reviewed Journal Publications

Benavidez-Brouk, L., Taheripour, F., Baldos, U., Zhuang, Q., & Chen, S. (2026). Updates in assessing soil organic carbon and their implications for evaluating land use change emissions. Environmental Research Communications, 8(2). https://doi.org/10.1088/2515-7620/ae3d84

Liu, X., Taheripour, F., Zhuang, Q., & Benavidez Hernandez, L. (2026, under review). Global marginal land mapping and the impact of agricultural management practices on marginal land soil organic carbon. *Environmental Research Letters*.

Outreach Efforts

- Dr. Taheripour has reviewed many academic papers for various journals that provide publications in research areas associated with Task 2.
- Dr. Taheripour, Dr. Chepeliev, Dr. Aguiar, Sajedinia, Chen, and Yuan attended the ASCENT Advisory Group meetings in Spring 2025 and Fall 2025 and discussed the findings of this task with members of this community.

Awards

None.

Student Involvement

See the list under Task 1.

Plans for Next Period

- Finalize the modifications in the AEZ-EF model.
- Complete the TEM simulations.