Implementing an agricultural Life Cycle Assessment (LCA) at the regional scale in southwest Michigan

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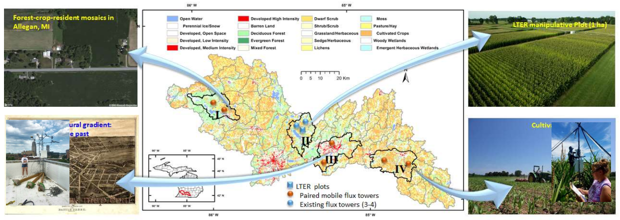


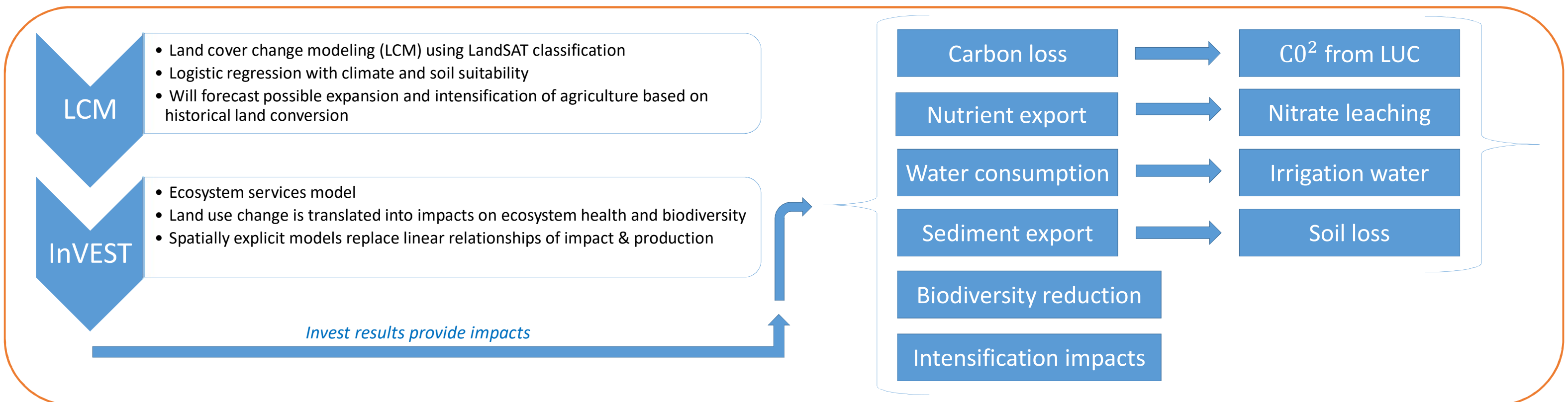
Fig. 1. Current land cover of the Kalamazoo Watershed (NLCD), which includes 127 sub-watersheds (USGS). The watershed will be examined for the changes of CO_2^{eq} during a 40-year period (1978–2018) using Landsat/Sentinel, with climate and human activities following our working framework (Fig. 1). Four contrasting landscapes will be quantified with high-resolution RS data, historical records, and survey statistics over an 80-year period (1938–2018). A flux tower collecting in situ measurements has been installed in each landscape. Figure credit: Chen (2017).

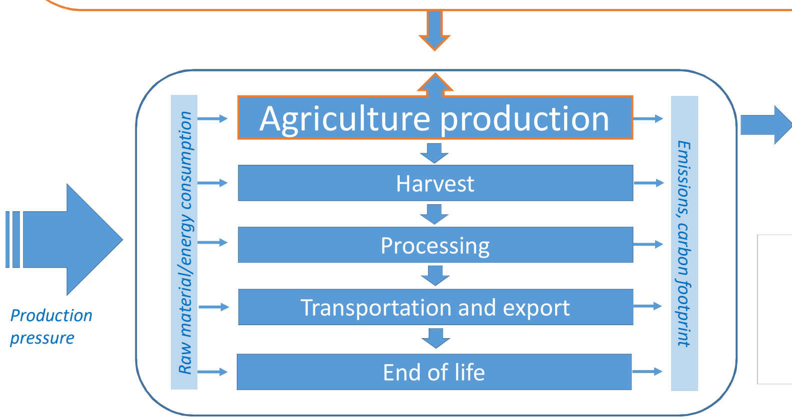
Study Landscapes and Approaches

The history of southwest Michigan includes regional transitions between agriculture, urban, forest and prairie land. As landscapes change, so do rates of carbon exchange due to tilling, crop rotation, clear cutting and other land management decisions, which raises questions on sustainability and carbon debt. The Kalamazoo Watershed in southwest Michigan (5261 km^2) includes portions of 11 counties: Allegan, Ottawa, Van Buren, Kent, Barry, Kalamazoo, Calhoun, Eaton, Jackson, and Hillsdale. Currently, it is dominated by cultivated crops (32.9%), deciduous forest (20.0%), pasture-hay prairies (15.1%), lakes and wooded wetlands (14.7%), and urban areas (6.8%) (Fig. 1).

The Goal: Quantify the landscape-scale carbon footprint of managed agricultural-forest landscapes and compare it to a footprint incorporating land management and anthropogenic activities (i.e., social carbon).

Task 1: Develop the narrative and understanding of climate change and land use change in the region.
Task 2: Approximate the carbon footprint of the natural and anthropogenic processes in the region's landscape.
Task 3: Diagnose the effects that mechanisms from land use, land cover changes, management practices, climatic change, and climatic extremes have on total CO_2^{eq} fluxes.
Task 4: Compare and validate this carbon footprint with the initial narrative and in situ data.





Impacts of increased agriculture

- Global warming potential
- Eutrophication potential
- Water consumption
- Erosion regulation potential
- Biodiversity damage potential

Decision-making & influence

- CMLCA software
- Sensitivity analysis using survey material
- Target & eliminate uncertainties
- Highlight decisions that are influential
- Compare to initial survey feedback

Challenges and limitations

Inputs may not reflect true units due to approximations or substitutions, for example. More so, it's existence depends on the incorporation of every detail in the product's life cycle, which is a daunting task. However, an LCA in also iterative in nature and can highlight where uncertainty in data must be improved with more detail. Outlining the system boundary will also introduce assumptions.

Fig. 2. Proposed LCA framework and system boundary for detecting the carbon footprint of the Kalamazoo Watershed under agricultural expansion scenarios. The figure is highly adapted from Chaplin-Kramer (2017), as it follows the innovation of incorporating and LCM for predictive land use scenarios known as Land-Use Change Improved (LUCI)-LCA. Satellite imagery from LandSAT derived spatially explicit data, which is then incorporated into InVEST software to determine ecological and biodiversity impacts. Next, impacts are characterized with unit and C02 equivalents and grouped together to represent dynamic agricultural production. This completes the LUCI-LCA framework and feeds into the remaining, typical LCA loop that uses linear regression to estimate impacts with increases. At the end of the product's life, a total carbon footprint can be reviewed and the LCA loop can be reiterated to determine points of vulnerability to land owner decision making.

References

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