

Assessing deforestation risk and carbon emission mitigation in commodity frontiers through integrated land system modelling

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Background and Motivation:



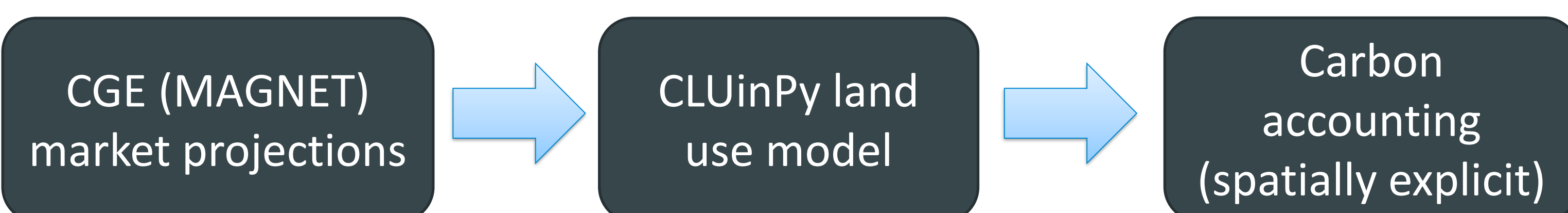
Figure 1: Exemplary image of an integrated pasture, cattle and forestry system in Mato Grosso (AI generated due to copyright issues; based on original photos and checked for plausibility).

- **Mato Grosso is Brazil's leading agricultural state**, dominating national production of soy, corn, and cattle for both export and domestic markets
- High historical rates of **deforestation in past decades due to agricultural expansion**
- Despite recent land use change slowdown, **pressure for further land use change** persists (e.g. 33% soybean area increase until 2033 according to state projections)
- **Integrated production systems** frequently proposed as a mechanism for **optimized land use**, promoted through Embrapa + ABC plan
- Specifically, silviculture plantations (e.g. Eucalyptus) are combined with cattle ranching and crop cultivation (**IPCF = Integrated pasture, cattle and forestry systems**)
- **IPCF** still at an experimental/low-adoption stage

→ **What could be the potential of IPCF for the future landscape of Mato Grosso and its role in mitigation of deforestation and CO₂ emissions?**

Methods:

Soft-coupled modelling approach:



- MAGNET projections are used as external demand in CLUinPy
- Comparison of a reference and IPCF scenario runs between 2022-2040
- Implementation of IPCF scenario through yield estimations (dos Reis et al. 2025)

Study area:

- Mato Grosso is about 2.5 times the size of Germany
- Located in the center of South America between Cerrado (savannah) and Amazon biome
- Largest soy producer of Brazil and top producer of beef

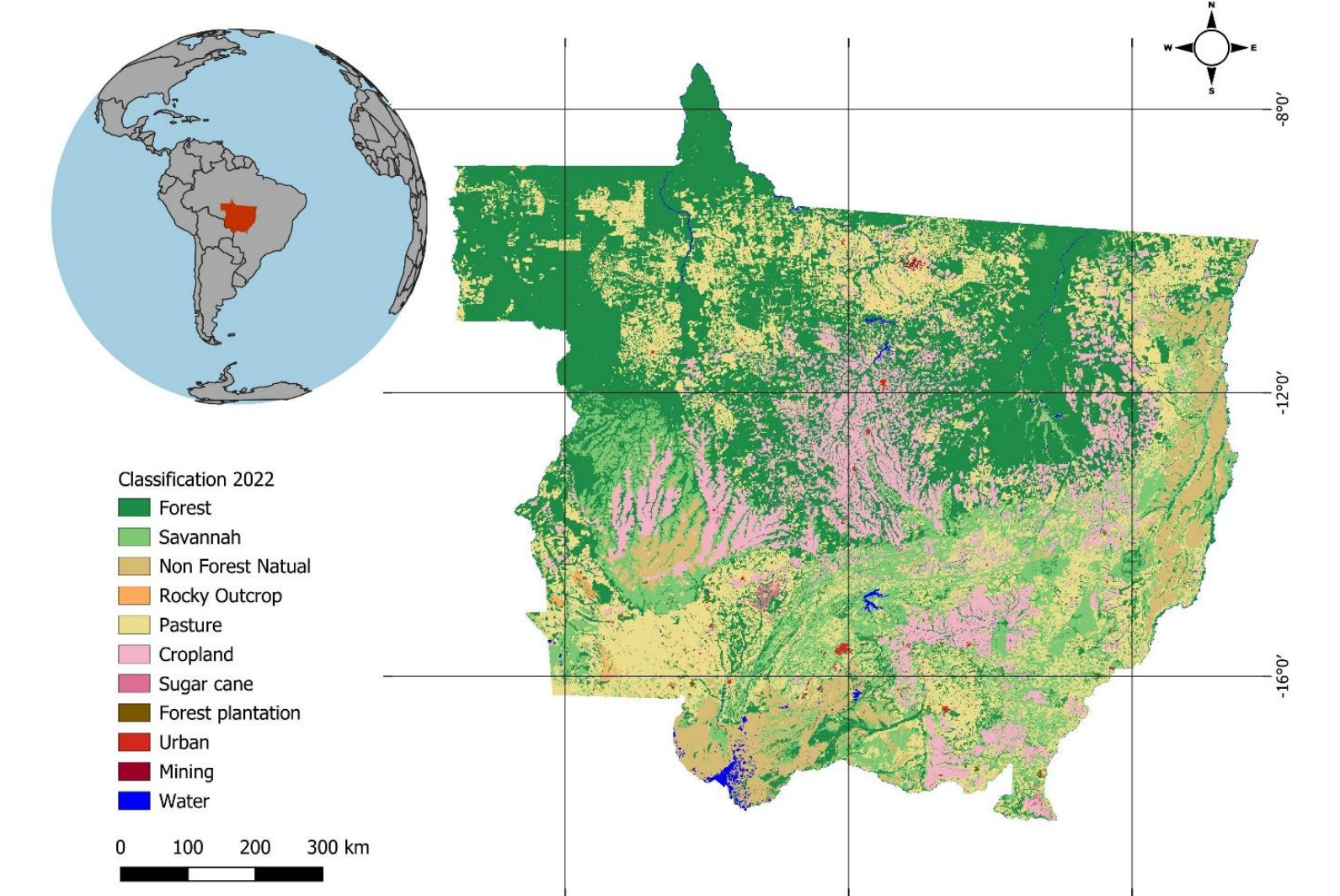


Figure 2: Land use map of the study area Mato Grosso (Brazil) for the year 2022, based on MapBiomass data (Souza et al. 2020).

Results and Discussion:

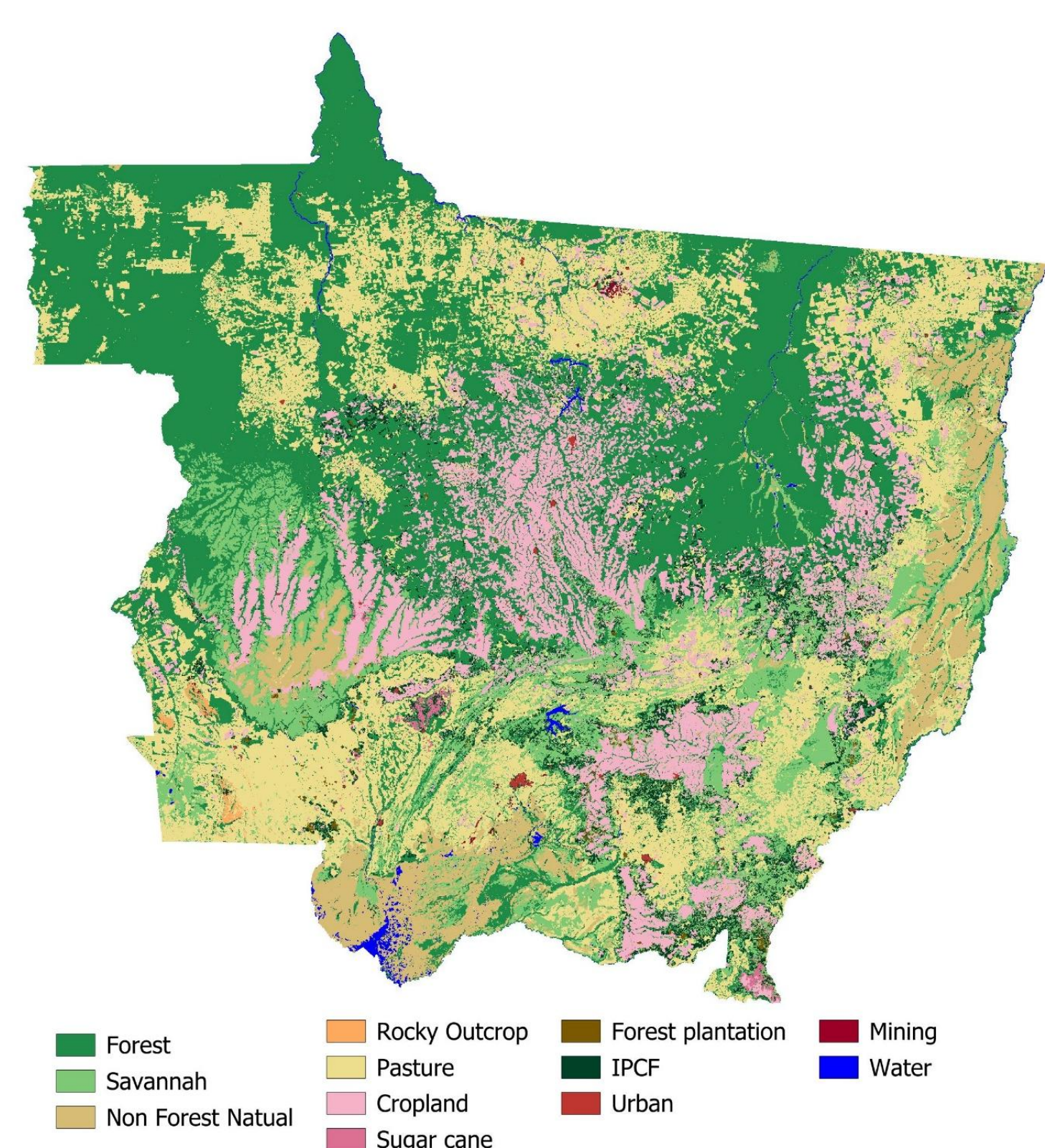


Figure 3: Map with allocated IPCF systems in 2040 (CLUinPy output).

Key results:

- The model allocates **3.7 mio ha IPCF** until 2040
- This **reduces forest loss by ~35%** compared to reference scenario
- Consequently, **CO₂ emission can be reduced by two thirds** in an IPCF scenario compared to reference scenario

Discussion:

- IPCF can help to curb forest loss and CO₂ emissions in the future in Mato Grosso
- But only effective in combination with strict policy aims to mitigate rebound effect (efficiency gains)
- Eucalyptus plantations provide little benefit for biodiversity and it remains unclear how they will resist future climate conditions (e.g., increasing heat and water stress) in Mato Grosso
- Modelling perspective: Investment costs for IPCF appear to be difficult to integrate adequately

Net change in land-use area, 2022-2040 (km²)

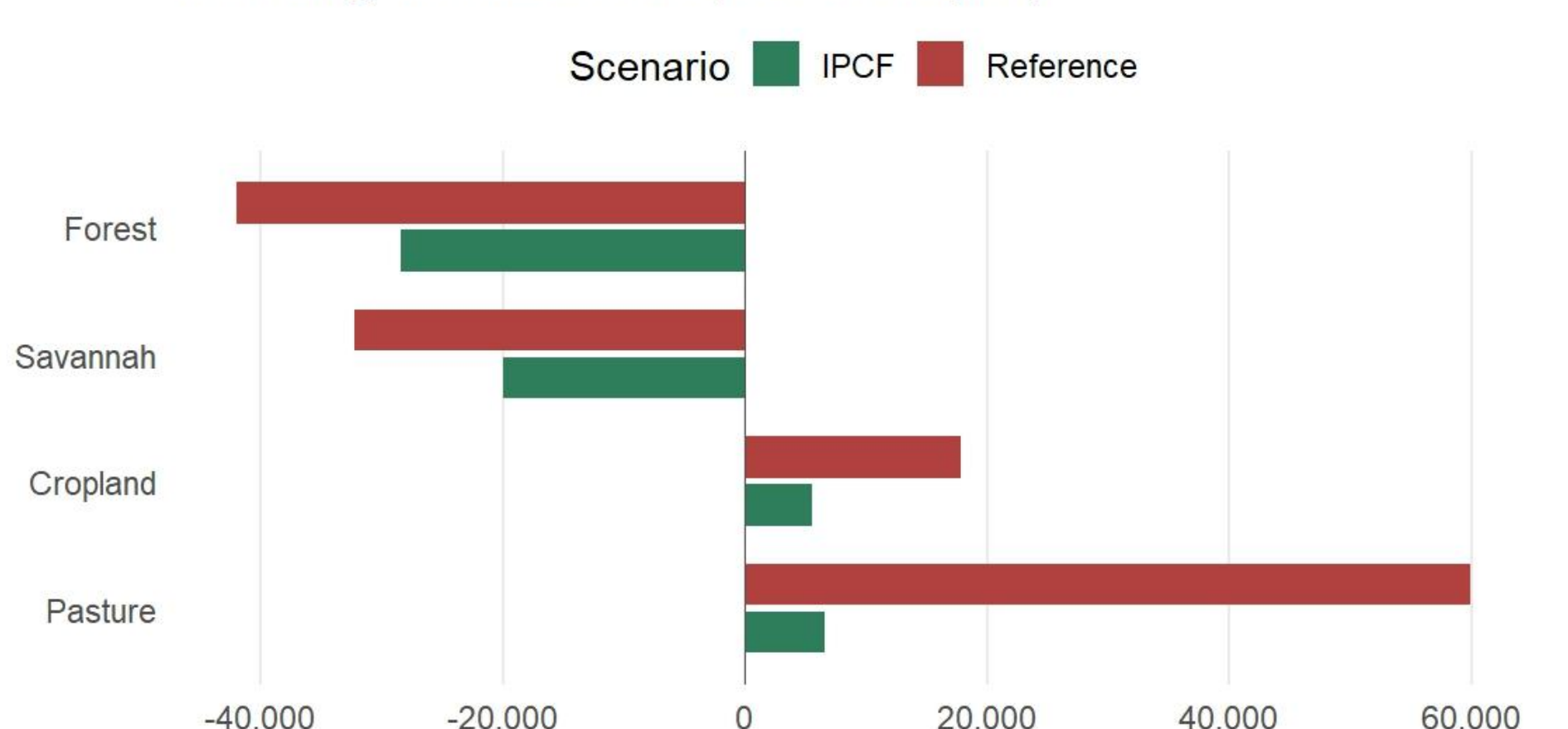


Figure 4: Differences in projected land use change between 2022-2040 between reference and IPCF scenario.

Key References:

- Reis, Júlio César dos, Mariana Yumi Takahashi Kamoi, Miqueias Michetti, Flávio Jesus Wruck, Renato de Aragão Ribeiro Rodrigues, and Austecilio Lopes de Farias Neto. 2023. "Economic and Environmental Impacts of Integrated Systems Adoption in Brazilian Agriculture-Forest Frontier." *Agroforestry Systems* 97 (5): 847–63.
- Reis, Julio Cesar dos, Mariana Yumi Takahashi Kamoi, Tarik Marques do Prado Tanure, et al. 2025. "Integrated Crop-Livestock-Forest Systems: A Path to Improved Agro-Economic Performance in the Brazilian Amazon and Cerrado." *Frontiers in Sustainable Food Systems* Volume 9 - 2025. <https://doi.org/10.3389/fsufs.2025.1518747>.
- Souza, Carlos M., Julia Z. Shimbo, Marcos R. Rosa, et al. 2020. "Reconstructing Three Decades of Land Use and Land Cover Changes in Brazilian Biomes with Landsat Archive and Earth Engine." *Remote Sensing* 12 (17): 2735. <https://doi.org/10.3390/rs12172735>.
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