Modeling iLUC For Novel Feedstocks

The Macauba Case –
Challenges and Opportunities

November 2025

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World's first fully-integrated SAF/RD solution from macauba

Novel Feedstock	Farming	Milling	Hydrotreating	SAF Distribution

Macauba, a native Brazilian high-yielding species

178,000 ha of degraded pastures in the Northeast of Brazil

Zero waste: residual biomass is used for energy and co-products

Vegetable oils to be processed in HEFA[1] and converted into SAF

California, US, EU, CORSIA and Brazil

TRACEABILITY FROM SEED TO FUEL

EXPECTED FIGURES	SAF PRODUCED (BPD)	PLANTED AREA (ha)	JOBS CREATED[2]	CAPEX
1ST UNIT	20k	178k	85k	$3.0bn
5 UNITS (SCALED PROJECT)	100k	~1.0m	450k	$15.0bn[3]

[1] HEFA unit hydrotreatment is a process that uses hydrogen to refine vegetable oils, fats, or waste oils into sustainable aviation fuel (SAF)
[2] Estimated values by FGV
[3] To be potentially reduced with gains of scale

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WHY MACAUBA?

Macauba is a **native Brazilian plant** that can help move the biofuel industry **in a more sustainable direction**, generating **positive environmental, social, and economic impacts**

REGENERATIVE
Macauba thrives on degraded land, restoring soil health and contributing to carbon sequestration with low iLUC risk

RESILIENT
Botanical and physiological characteristics that favor the efficient use of water and soil

PRODUCTIVE
Significantly more oil production per ha than soybean, promoting more efficient use of land

VALUE CHAIN
Incipient value chain with strong potential for full fruit utilization (little waste), creating solutions for hard-to-abate sectors

IMPACT
The cultivation of macauba will create social impact and employment opportunities on a large scale

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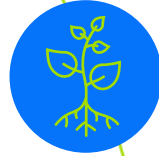# But current models do not fully reflect these benefits

REGENERATIVE
Macauba thrives on degraded land, restoring soil health and contributing to carbon sequestration with low iLUC risk

» **Degraded lands are not a defined category** in GTAP AEZ-EF, preventing accurate representation of land restoration benefits

RESILIENT
Botanical and physiological characteristics that favor the efficient use of water and soil

» **GTAP normally groups thousands of species under generic crop types** and does not distinguish specific traits such as drought tolerance or low-input adaptability, hindering new crop development
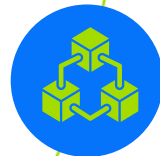
PRODUCTIVE
Significantly more oil production per ha than soybean, promoting more efficient use of land

» The model assumes **average cropland productivity and resource use**, underestimating yields and efficiency of high-performance perennials like macauba

VALUE CHAIN
Incipient value chain with strong potential for full fruit utilization (little waste), creating solutions for hard-to-abate sectors

» To accurately reflect macauba's emerging value chains, **new sectors will need to be created**, adding complexity while supporting improved model fidelity

IMPACT
The cultivation of macauba will create social impact and employment opportunities on a large scale

» GTAP **treats labor as a single aggregated factor**, ignoring new specialized jobs in bioeconomy, new jobs in rural communities, income distribution, and social co-benefits of regenerative crops
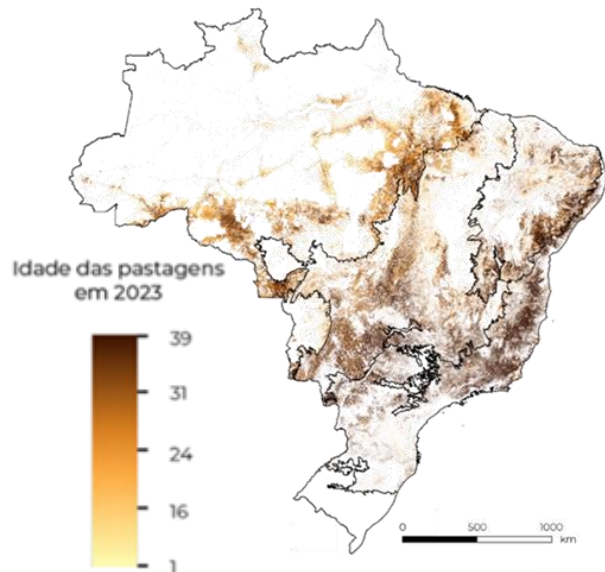
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Zoom in: Brazil's degraded pastures present a unique opportunity
With over 100 million hectares of degraded land, macauba offers a solution to regenerate soil and capture carbon — without triggering deforestation or displacing agriculture

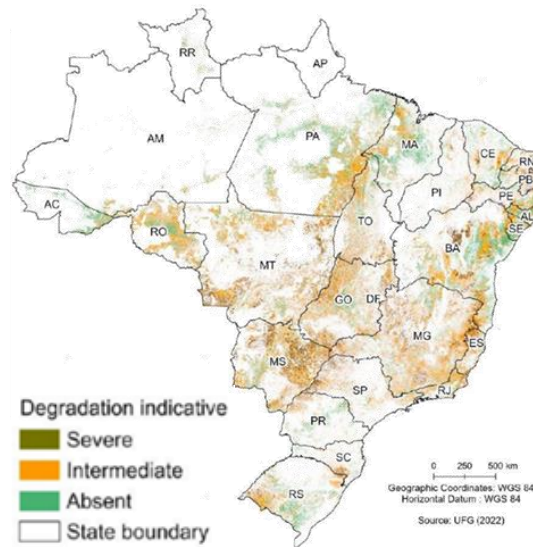**MapBiomas and LAPIG highlight degradation in a significant portion of the country's pasturelands in 2022**

⧗ Pastureland age[1]

Idade das pastagens em 2023

39
31
24
16
1

Based on **Landsat satellite imagery (30 m resolution)**

❄ Pastureland degradation

Degradation indicative
- Severe
- Intermediate
- Absent
- State boundary

0   250   500 km

Geographic Coordinates: WGS 84
Horizontal Datum: WGS 84

Source: UFG (2022)

Current Model Scope

» Ongoing research efforts better represent degraded lands, although **GTAP does not yet include degraded land as a specific category**

» As renewable fuel feedstocks are increasingly expanding to degraded lands, **integrating this dimension will enhance the model's accuracy and relevance**

» Without this refinement, **the model cannot fully capture the true impact of regenerative crops like macauba** as part of the energy transition

Approaches Under Assessment

» Map Biomas is a collaborative initiative producing **annual land cover and land use maps**

» Served as an **input layer** for the IIASA[2] study that modeled the AEZ-EF LUT for macauba cultivation on degraded lands

Sources: Lapig UFG (research group within the Federal University of Goiás); MapBiomas Brasil (Brazilian network of geotechnology experts); Aval Technical Services Inc.
1. Santos, C.O.d.; Mesquita, V.V.; Parente, L.L.; Pinto, A.d.S.; Ferreira, L.G., Jr. Assessing the Wall-to-Wall Spatial and Qualitative Dynamics of the Brazilian Pasturelands 2010–2018, Based on the Analysis of the Landsat Data Archive. Remote Sens. 2022, 14, 1024. https://doi.org/10.3390/ rs14041024.
2. Fischer, G., Reeler, J., Tramberend, S., & van Velthuizen, H. (2024). Sustainable aviation biofuels for South America: A systems analysis investigation into opportunities for sustainable biofuel feedstock production to 2050. International Institute for Applied Systems Analysis & World Wide Fund for Nature – South Africa.
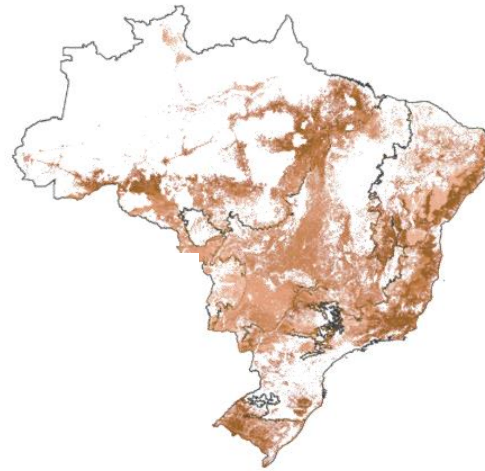
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Zoom in: GTAP's carbon assumptions would benefit from greater granularity

While GTAP relies on average values, field data highlights crop-specific soil carbon dynamics that are key to more accurate assessments

🔍 Pasture vigor[1]

- 20% Low
- 42% Medium
- 39% High
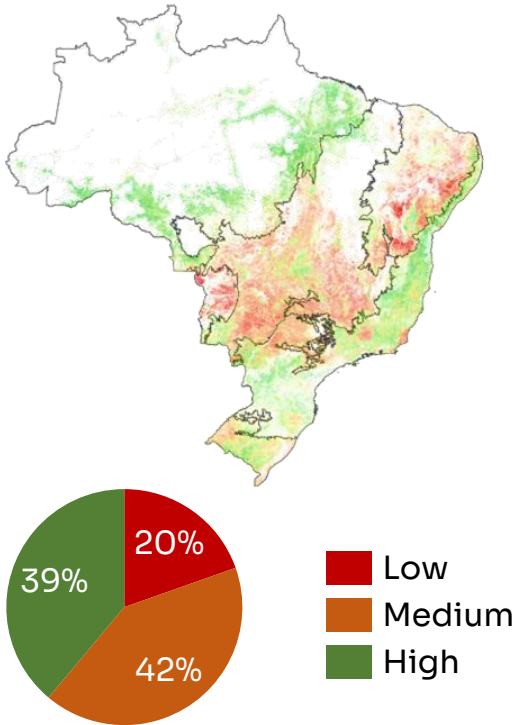
🌱 Soil carbon

Tons of carbon per hectare:

≤ 20	30 − 40
20 − 30	> 40

Model Considerations

» GTAP provides a **simplified view of soil and ecosystem dynamics** that does not reflect real-world complexities

» The model relies on **average carbon values for cropland, pasture, and forest**, which do not capture site-specific variations

» GTAP **assumes carbon decreases when land is converted to macauba**, though in practice the crop contributes to soil carbon gains

» **Emissions from macauba are overestimated**, as the model treats it like a typical annual crop rather than a perennial that can enhance carbon storage

🔍 **AcelenR standard practice is to define a soil carbon baseline and conduct continuous MRV**

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Advancing renewable fuels iLUC modeling through strong partnerships

Acelen Renewables is working with leading national and international researchers to enhance models, integrate Brazil-specific dynamics, and support the development of sustainable value chains for low-carbon fuel production

Macauba plays a key role in surfacing the challenges for novel feedstocks while upholding sustainability integrity Ensuring its accurate representation in models is essential to reflect its true environmental potential

ACELEN RENEWABLES INITIATIVES

MODELING EXISTING DATA ON GTAP

eco engineers
GTAP-BIO AEZ-EF

- **Preliminary study** of the project's iLUC carried out in April 2024
- New scenarios are **currently being updated** with results expected by Q1 2026

COMPREHENSIVE STUDY ON MACAUBA PRODUCTION IMPACT

- **Strategic project** to analyze the CI score of macauba biofuels in Brazil
- **Three analytical models** to determine carbon emissions from production and land-use change
- **Comprehensive sustainability assessment** of the macauba biofuel value chain

LOCAL RESEARCH NETWORK

Embrapa   **FGV AGRO**   **LAPIG**   **ESALQ**

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THANK YOU!

Patricia Grossi Reis
patricia.grossi@acelen.com