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Strengthening the bioeconomy in tropical countries while preserving soil organic carbon stocks by recycling recalcitrant coproducts: A case study for Ecuador

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The results are available upon request. Do not hesitate to contact the lead author.

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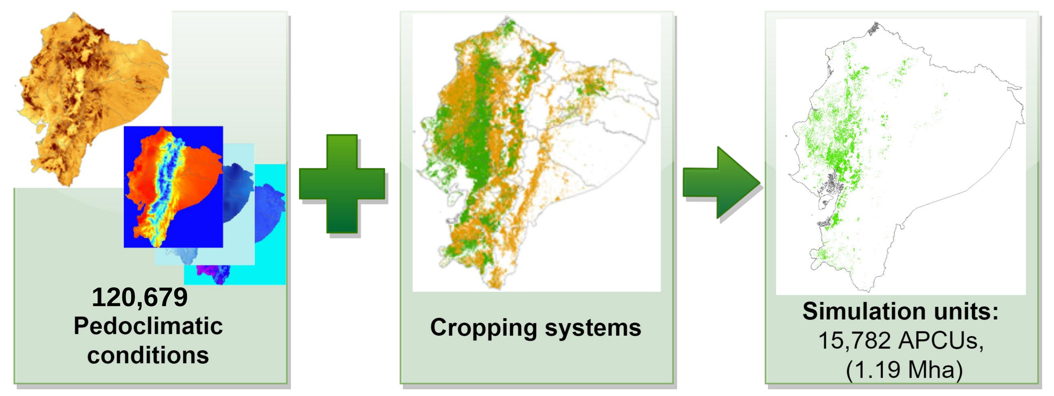
1. INTRODUCTION

- How much crop residues can we harvest in Ecuador without losing SOC stocks, if we consider their use in bioeconomy pathways and the return of the coproducts to soil? We call this the C-neutral harvest potential.
- **Pathways investigated** (coproducts): **Pyrolysis** (biochar/pyrochar), **gasification** (char/gaschar), **hydrothermal liquefaction** (hydrochar), and **anaerobic digestion** (digestate) are returned to soils.
- A spatially explicit SOC simulation was performed for croplands in Ecuador as a representative case of a tropical context. This study builds on a companion study [1] on temperate conditions.

2. METHODOLOGY

1. Defining simulation units
1.1 Quanitfy C inputs



2. Adapting RothC for bioeconomy
2.1. Modeling SOC dynamics bioeconomy vs BAU (2020-2070)

3. Sensitivity Analysis (SA)
- Carbon conversion (C_C)
- Carbon recalcitrance: Recalcitrant fraction (C_R), priming effect (PE), mineralization rate (k)

Scenarios

BAU: Residues are left on fields.
Bioeconomy: Crop residues are harvested to supply bioeconomy and coproducts are returned.

Climate data

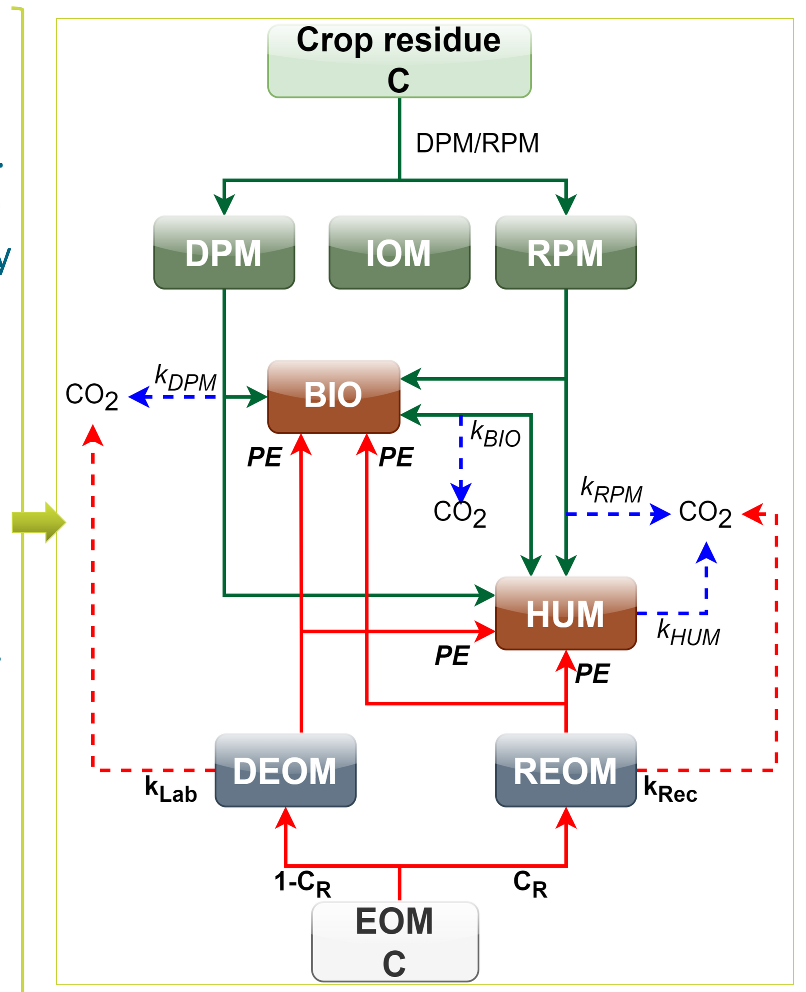
T (°), Rain (mm), Evapotranspiration (mm). RCP4.5

(Kindly provided by: Secretary of Climate change of Ecuador)

Soil data

SOC initial (tC.ha^{-1}), clay (%)

(Kindly provided by: Ministry of Agriculture of Ecuador)



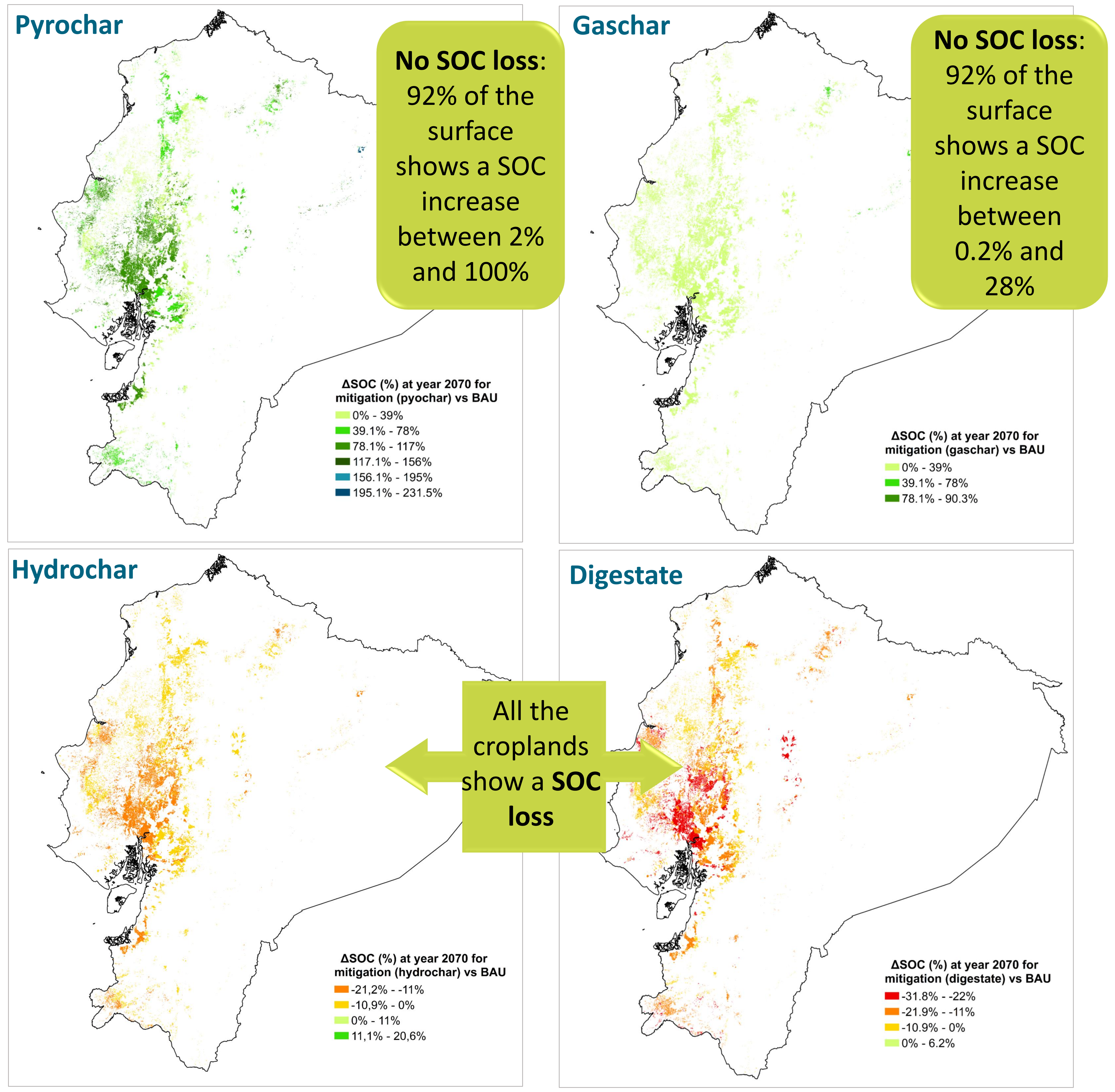
Adapted RothC for bioeconomy

BAU: Business as usual
APCU: Agricultural pedoclimatic units
DPM, IOM, RPM, BIO, HUM: Soil pools in standard RothC
EOM: exogenous organic matter
DEOM, REOM: pools for allocating C inputs from EOM
kLab: mineralization rate of the labile fraction
kRec: mineralization rate of the recalcitrant fraction

Relative modeling: Bioeconomy vs BAU
Timescope: 50 years
Geographical scope: Ecuador

3. RESULTS

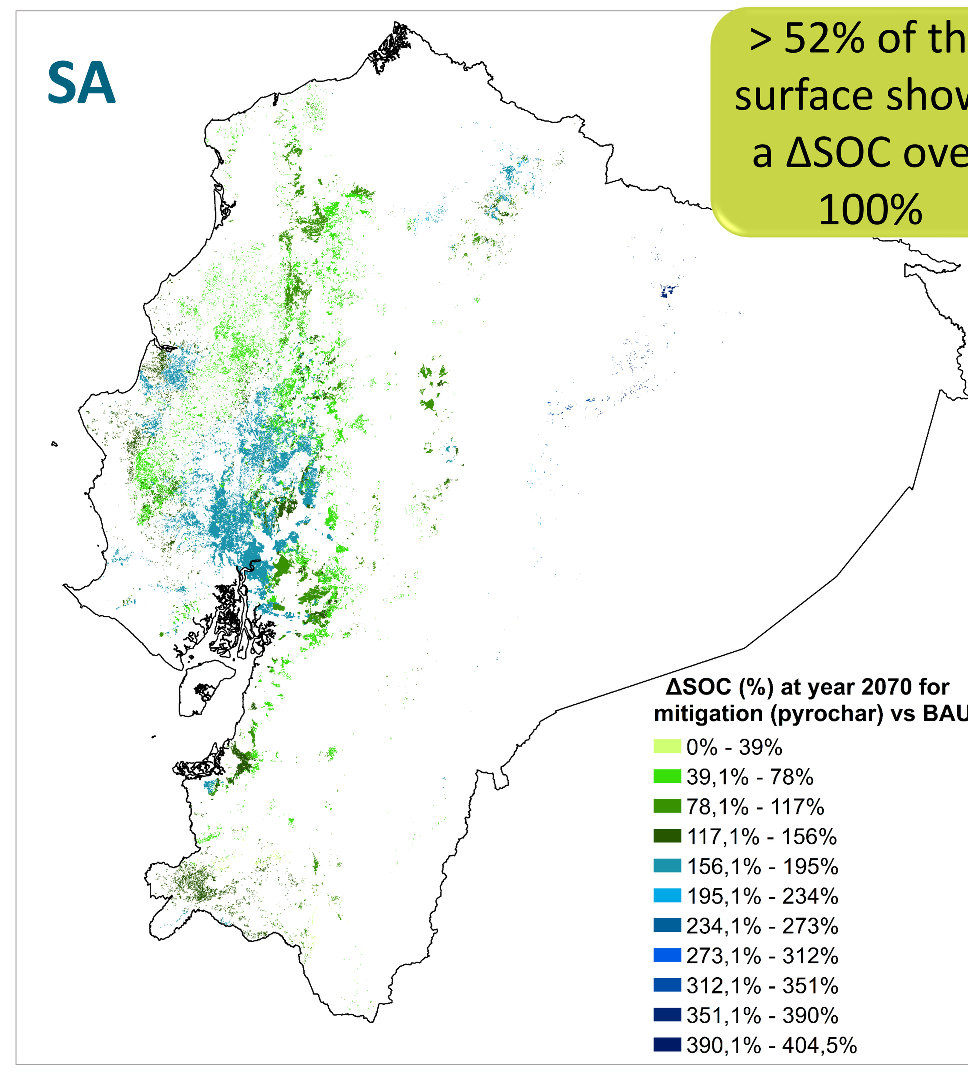
ΔSOC per coproduct return (Bioeconomy vs BAU). No PE considered



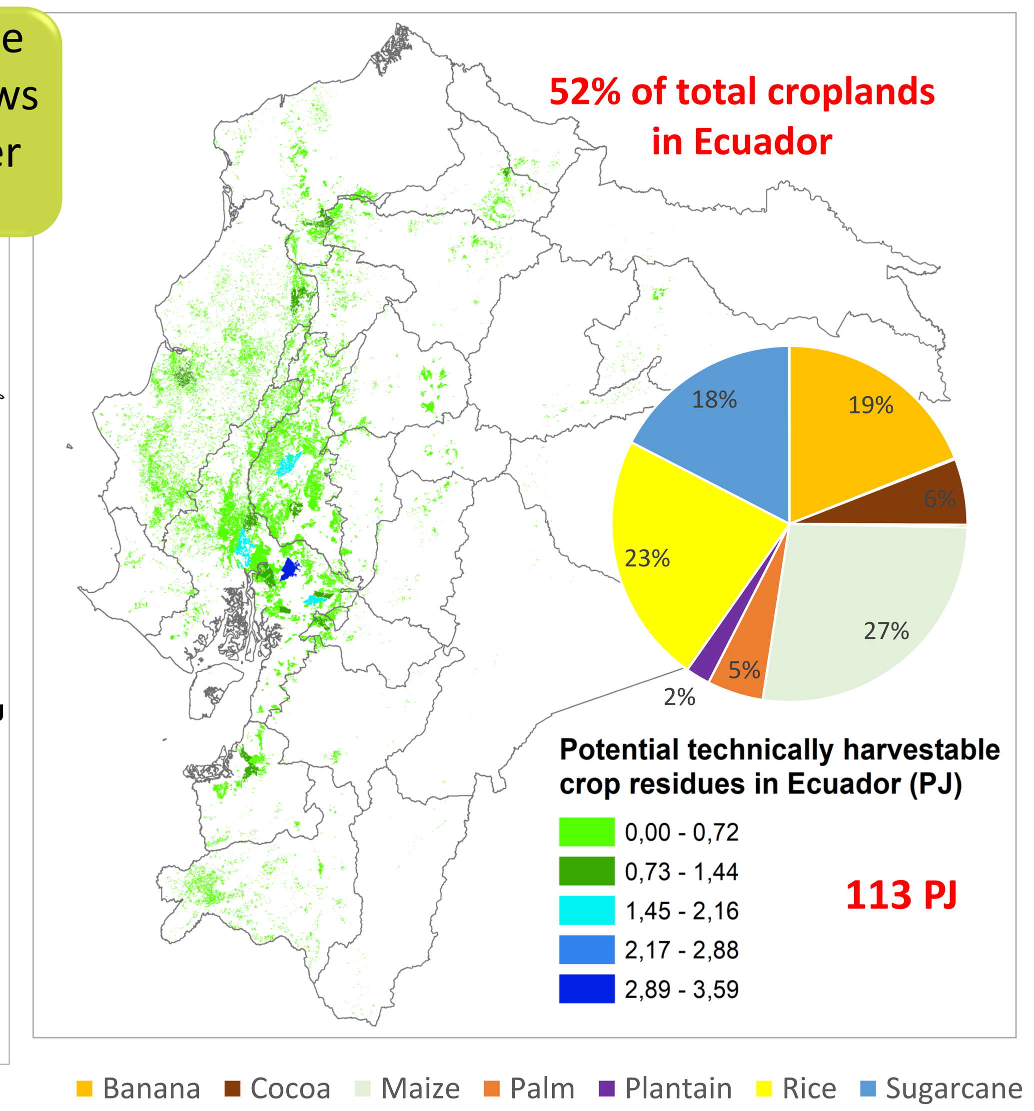
SCENARIO	Bioeconomy vs BAU at year 2070			
	Total National ΔSOC	National ΔCO2	Mean National ΔSOC (per PCU)	National ΔCO2
	Mt C		%	
BAU*	-0.8 [-0.3 - 1.7]	305	7% [-90% - 1168%]	
Pyrolysis	44.7 [0.0 - 1.3]	-127	64% [2% - 231%]	-40%
Gasification	12.0 [0.0 - 0.5]	-128	15% [0.2% - 90%]	-40%
HTL	-6.4 [0- - 0.2]	-101	-9% [-21% - 21%]	-32%
AD	-10.5 [-0.3 - 5E-05]	-63	-15% [-32% - 6%]	-20%

*Results for BAU scenario represent the ΔSOC from 2020 to 2070, under the current croping systems.

Pyrochar considering a negative PE of 71% (instead of 0%)



C-neutral harvest potential for pyrolysis and gasification pathways



3. CONCLUSIONS

- The simulated APCUs can deliver **extra 113 PJ** biomass from crop residues to supply the bioeconomy in Ecuador, **with no SOC losses expected**, for the **pyrolysis** and **gasification** scenarios, compared to the BAU. In fact, SOC is expected to double in 8% of the cropland surface in the pyrolysis scenario.
- Among the parameters tested, the PE has the biggest influence on the SOC stocks evolution. For instance, **a negative priming effect of 71,4% produces a 2-fold increase in the C-sequestration potential of biochar in Ecuadorian croplands**. Therefore, documenting the PE of bioeconomy residues is of tremendous importance"
- In Ecuador (taken as a representative of tropical context), harvesting residual biomass with return of the co-products brings GHG mitigation in comparison to leaving the residues on land, translating into **20-40% reduction of CO_2 emissions over 50 years**, depending on the bioeconomy pathway (soil perspective only; not accounting processes emissions and gains by substitution).

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REFERENCES [1] https://doi.org/10.1016/j.apenergy.2022.120192