Integration of the sustainability analysis and planetary boundaries assessment: Application in residues valorization.

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Introduction

The Planetary Boundary (PB) concept was introduced in 2009 and updated in 2015 to define the environmental limits where humanity can operate safely [1]. These limits were established through 9 representative control variables that are measured on a global scale. Currently, six of PB have been transgressed, [2].

New proposals to the production model should be evaluated in terms of the impact to the PB, as makes possible to identify on a planetary scale what environmental impact would be, this research focuses on the evaluation of corn stover-based biorefineries in environmental terms using the PB-LCA methodology.

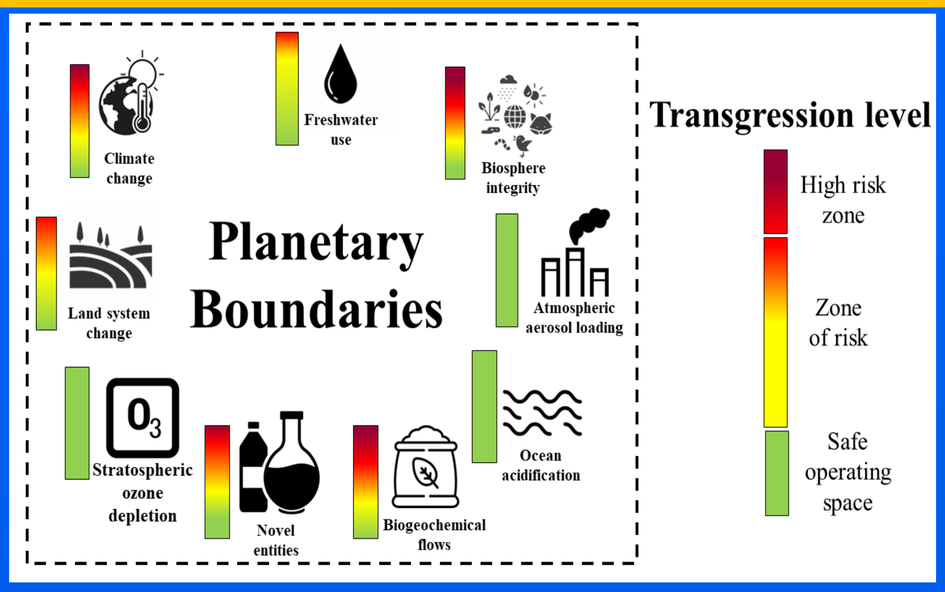
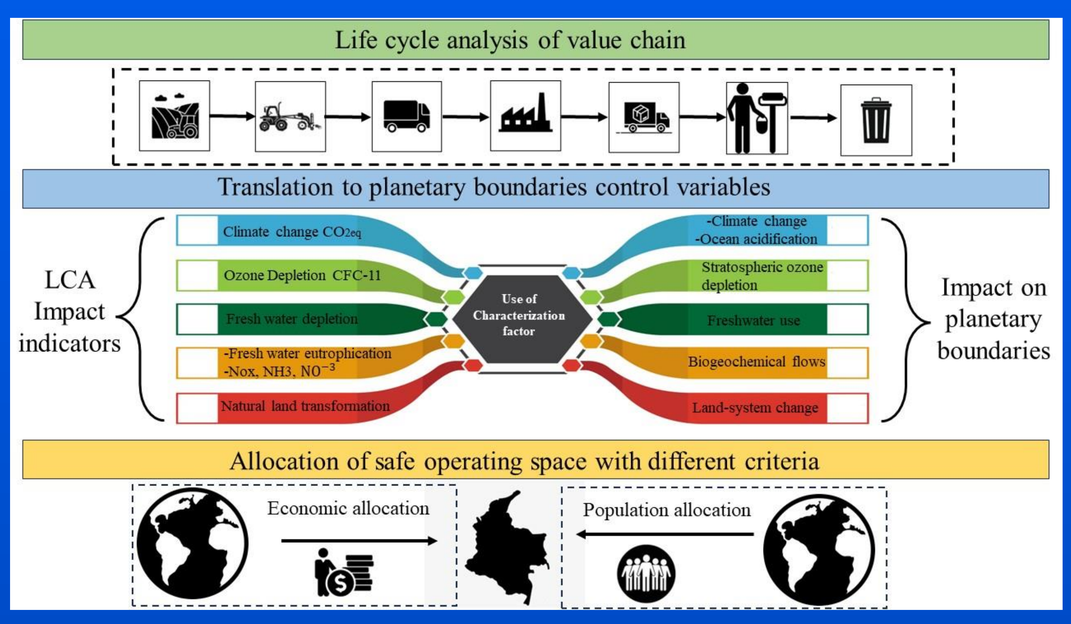


Figure 1: Planetary Boundaries Transgression Level for the year 2023 according to Richardson et al [2]

Methodology



B.C
100% Mulching

S.c2:
70% Mulching;
30% Biorefinery

S.c3:
50% Mulching;
50% biorefinery

S.c4:
30% Mulching;
70% Biorefinery

S.c5:
100% Biorefinery

The impact of different corn stover use in PB was analyzed under two approaches: (i) Mulching techniques and; (ii) Biorefinery to obtain value-added products. A superstructure was formulated. The superstructure was optimized in economics terms (NPV). PB-LCA methodology was used, according to the methodology reported by Ryberg et al [3]

Figure 2: Metodologia PB-LCA analisis.

Sizing: Aspen Process Economic analyzer.

Opex: Raw material costs, supplies, and utilities.

Net Present Value: Tax rate 35%, Project lifetime 20 year.

ECONOMIC METRICS

Allocation criteria	Description
$SOS_n = SOS_T * \frac{P_a}{P_{world}}$	SOS_n: Safe operating space of the activity n. SOS_T: Safe operating space total. P_{world}: population of the world. P_a: population of the region a
$SOS_n = SOS_T * \frac{GDP_n}{GDP_{world}}$	GDP_{world}: gross domestic product of the world GDP_n: gross domestic product of the activity n
$SOS_n = SOS_T * \frac{P_{country}}{P_{world}} * \frac{GDP_n}{GDP_{country}}$	$P_{country}$: population of the country. $GDP_{country}$: gross domestic product of the country.

SAFE OPERATING SPACE CRITERIA

Results

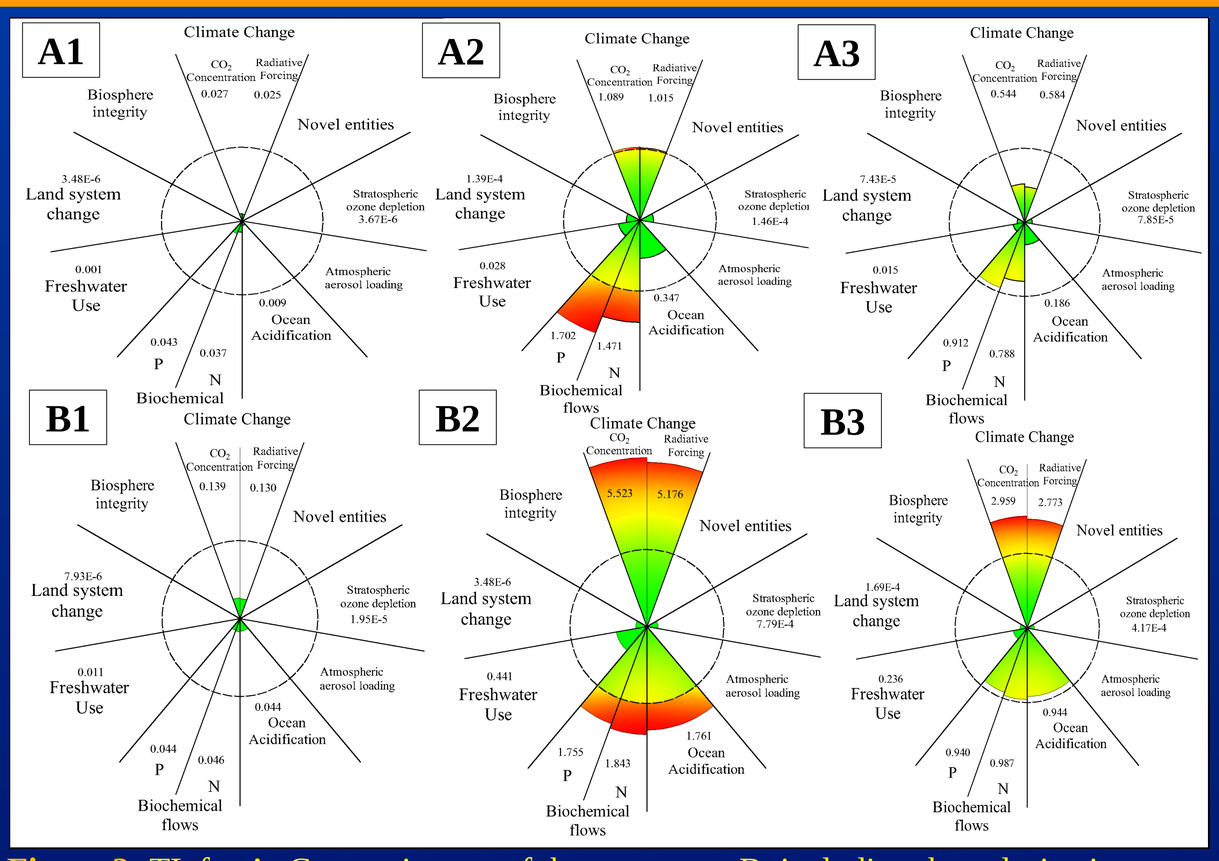


Figure 3: TL for A: Current impact of the corn crop, B: including the valorization stage (SC2), using 1: allocation per capita, 2: allocation with GDP, 3: allocation combining criteria.

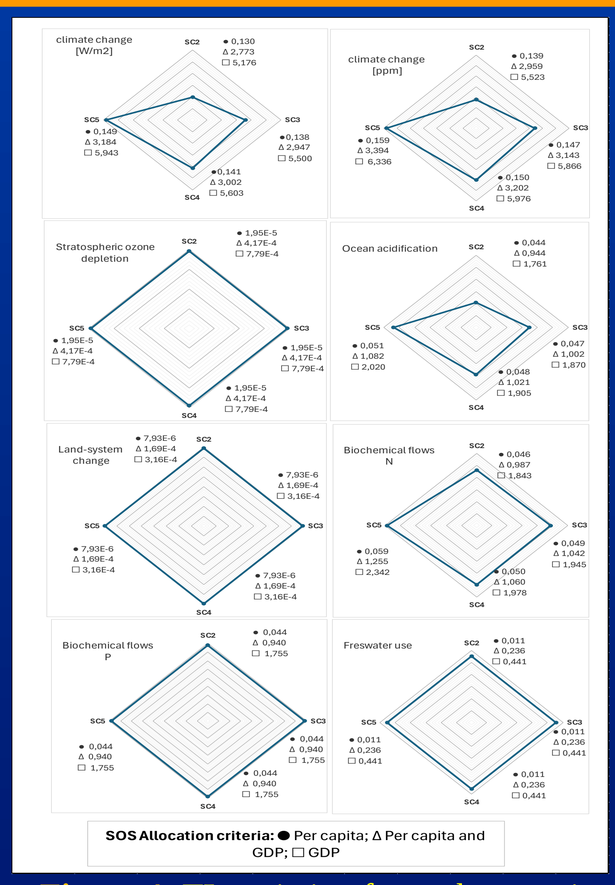


Figure 4: TL variation for each scenario.

The process that maximized NPV was the production of xylitol using acid hydrolysis as pretreatment. climate change, as well as biochemical flows are the most impacted PB. The differences that the choice of an allocation criteria can cause in the analysis are demonstrated. Likewise, has demonstrated that the use of conservation crop practices generate positive impacts in the reduction of the environmental impact of agroindustrial activities and subsequent valorization

Conclusions

The use of the PB-LCA methodology, shows the need to reduce the subjectivity of the results obtained through SOS assignment techniques, that combine both criteria that consider the populations, as well as economic indicators to identify the activities that generate more wealth, and are therefore more susceptible to generate a positive impact on the quality of life of the people involved.

Acknowledgments

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References

[1] W. Steffen *et al.*, *Science (1979)*, vol. 347, no. 6223, Feb. 2015

[2] K. Richardson *et al.*,*Sci Adv*, vol. 9, no. 37, 2023.

[3] M. W. Ryberg et al., Science of The Total Environment, vol. 634, pp. 1406–1416, Sep. 2018