Land use implications of BECCS in Brazil: an intercomparison study

Letícia Gonçalves Lorentz, Ana Carolina Oliveira Fiorini, Pedro R. R. Rochedo

Summary

Bioenergy with carbon capture and storage (BECCS) is largely applied in scenarios of integrated assessment models (IAM) with ambitious mitigation targets. However, bioenergy production may lead to negative impacts related to land use change. A possible solution is the use of marginal lands to grow energy crops since these would not compete with food production or affect biodiversity. We tested this hypothesis in Brazil with results of IAMs that participated on the CD-Links project through a comparison of required land to grow biomass and the marginal land available.

Abstract

Deep mitigation scenarios consistent with the Paris Agreement are highly dependent on carbon dioxide removal technologies, especially those that deliver negative emissions such as bioenergy with carbon capture and storage (BECCS) (Rogelj et al. 2018; Minx et al. 2018). The increasing role of these technologies on integrated assessment models (IAM) results is due to an array of constraints and assumptions of these models. On the one hand, deployment of BECCS makes ambitious mitigation targets feasible and with lower overall cost from 2050 onwards (Köberle 2019). On the other hand, the reliance on this solution often does not consider the negative impacts, both socioeconomic and environmental, that may arise from its application.

Conversion of land for bioenergy production purposes can induce direct and indirect land use change (LUC) that can cause greenhouse gas emissions due to carbon stock present in vegetation and soil of converted land (Fajardy et al. 2019). This is especially harmful when the energy crops production leads to conversion of forests, negatively affecting biodiversity (Minx et al. 2018). Furthermore, production requires intense use of water and fertilizer, which can harm soil and water quality (Fajardy et al. 2019). The combination of these negative impacts can further accentuate food security

issues, since diverted focus from food crops production may lead to reduction in food access and result in price volatility (Robledo-Abad et al. 2017; Creutzig et al. 2015).

The perception of the impacts varies across countries and tends to be more negative in regions with favourable conditions to cultivate biomass for BECCS' development, i.e., Africa and Latin America (Daioglou et al. 2020; Nemet et al. 2018). In this context, Brazil emerges as an emblematic case given its continental dimension and importance for global agriculture. In fact, many IAMs acknowledge this relevance by having the country as a representative region within their global climate change mitigation strategy. However, it is important to account for the sustainability of land use for BECCS application in Brazil.

Here we propose a comparison of IAMs results to evaluate land use implications of BECCS in the Brazilian context. We selected IAMs that participated in the CD-Links project (McCollum et al. 2018; Roelfsema et al. 2020) because the data are publicly available. Additionally, we chose the models that have Brazil as a representative region: 4 global models - AIM/CGE V2.1, COPPE-COFFEE 1.0, IMAGE 3.0 and POLES CDL; and one national model - BLUES. From these IAMs, we selected information about (1) carbon sequestration through biomass and (2) land cover changes from 2010 to 2050 in different carbon budget scenarios.

We multiplied the quantity of carbon removed through biomass by land use intensity coefficients for bioenergy crops found in literature (e.g., Smith et al. 2016), and therefore, and estimate the area required for BECCS in scenarios of global temperature increase limited to 1.5ºC and 2.0ºC. The challenge then would be to estimate the total area available for energy crop production, once it is important to guarantee that agriculture production and areas set aside for biodiversity conservation are not affected. We chose the concept of marginal land because these areas are often suggested as a solution for reducing land use conflicts. Marginal lands are the intersection of under-utilised and neglected lands, usually with low productivity rates and socio-economic value (Fajardy, Chiquier, and Mac Dowell 2018).

Brazilian marginal lands available for bioenergy production within sustainability limits were estimated by Lossau et al. (2015). The approach used by these authors consisted of allocating statistically recorded extents of cropland, pasture, forest, urban area, water bodies and barren areas to a spatial grid, to denote the remainder area as marginal land (Lossau et al. 2015). They categorized their results in 3 types of marginal lands. Type I includes marginal land that avoids direct competition with existent food production and deforestation, Type II is a fraction of the first and safeguards areas of high biodiversity values, and Type III excludes the Amazon biome from the land balance.

We used the marginal land types to calculate the available land over the analysed time horizon in IAMs results. That is, assuming that urban areas, water bodies, barren areas and protected areas are kept constant throughout time, the marginal fraction would be the balance that results from the dynamics of land use change of forest, cropland and pasture observed in the models' results. The difference between marginal land and land required to grow energy crops results in our estimation of the potential sustainable BECCS implementation in Brazil (Figure 1).

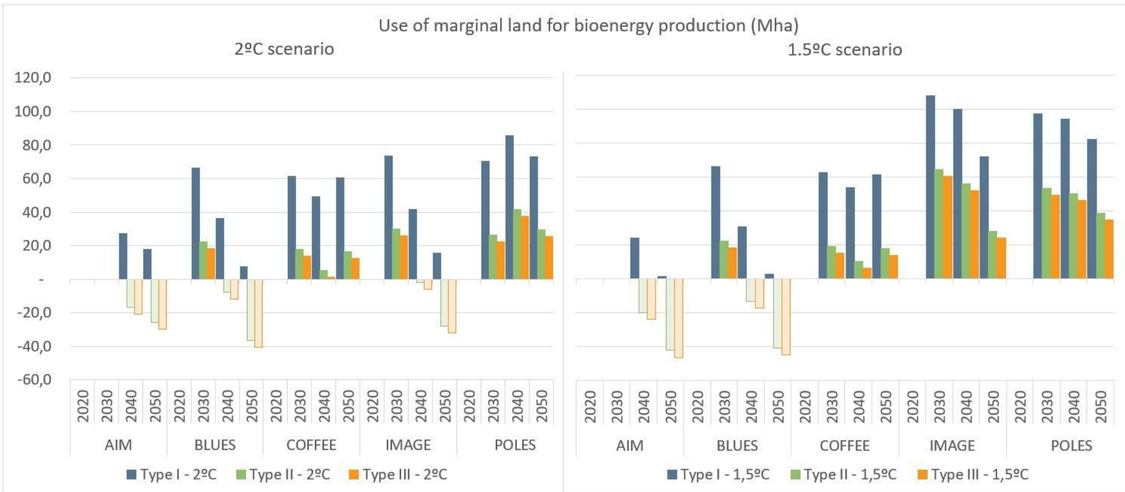

Figure 1 - Use of marginal land for bioenergy production different scenarios

Preliminary results for a general set biomass feedstock, as presented on Figure 1, points to the possibility that the soil can be used to generate bioenergy without aggravation of land use conflicts. Nevertheless, AIM, BLUES and IMAGE results show negative values in Figure 1, which indicates displacement of other land uses, either environmental protection areas or areas dedicated to food production, to implement BECCS. In the case of BLUES, previous studies (Köberle et al. 2020; Rochedo et al. 2018) have shown that pasture recuperation is a major source of arable land for bioenergy.

Nonetheless, the present work adds concern on the large-scale deployment of BECCS as a viable climate mitigation strategy (Fuss et al. 2018).

Future assessments should enhance and align land-based assumptions of IAM, to understand the implications of bioenergy expansion and overall socioeconomic and environmental impacts of large-scale deployment of BECCS in Brazil. For instance, impacts on food prices, direct and indirect land-use carbon emissions, and other environmental criteria, such as biodiversity indicators, could also be estimated and evaluated. Finally, the assessment could greatly benefit from spatially explicit evaluation of land-use change scenarios for BECCS, for instance from an evaluation in the BLOEM model (Tagomori et al. 2020) developed jointly by Cenergia and PBL.

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