# Brazilian Sugarcane Ethanol as an Expandable Green Alternative to Crude Oil Use

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## INTRODUCTION

~14% of global greenhouse gas (GHG) emission comes from transportation sector [1]. Even with aggressive reductions in travel growth, shifts to mass transport modes, strong efficiency improvement and deep market penetration by electric vehicles, there remains a large projected demand for dense liquid fuels in 2050 & beyond [2]. Brazilian sugarcane ethanol and bagasse is one of the few technologies already in place and demonstrated-and most importantly it is capable of expansion in a timely manner in order to reduce GHG emission from transport sector.

## METHODS

### BioCro to predict sugarcane productivity

we projected sugarcane production using the mechanistically rich BioCro model which is effective at handling the interactive effects of different climatic and atmospheric change variables acting at the level of the crop's biophysical, physiological and biochemical processes that underlie yield and responses to atmospheric change.

### Climate and soil data for simulation

We used Brazilian national soil database [3], NCEP (historical) [4], and ISIMIP climate projection from five models(2041-2050) corresponding to business as usual (RCP8.5) scenario [5] to drive sugarcane productivity simulations.

### Land area availability for sugarcane ethanol

| Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|
| Sugarcane expansion is limited to grazing areas within the agroecol-ogical zone identified by Brazilian govern-ment | >Times series projection to estimate land required by major crops of Brazil by 2045. >Time series projection to estimate animal units by 2045. >Time series projection to estimate animal units per hectare by 2045. With improvement in pasture intensity as per historical trends, most micro-region in Brazil should be able to provide land for biofuels despite increased land demand for food crops and increased meat production. | Same as scenario 2 with the addition of natural vegetation which can be legally used for agriculture |
| **All the three scenarios protect forest areas under conservation** | | |

**References:**

[1] https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data ;[2] *Biofuels Bioprod. Bioref.* **9**, 476–483 (2015); [3] *Soil Sci. Soc. Am. J.* **69**, 649–652 (2005); [4] *Bulletin of the American meteorological Society* 77.3 (1996): 437-472; [5] *Proc. Natl Acad. Sci. USA* **111**, 3228–3232 (2014);

**Brazilian sugarcane ethanol** can provide the equivalent of 3.63 to 12.77 million barrels per day of crude oil by 2045 under **projected climate change** while **protecting forests under conservation** and accounting for **future demand of land for food and animal production**. The corresponding range of **$CO_2$ offsets is 0.55 to 2.0 Gigatons year$^{-1}$**.

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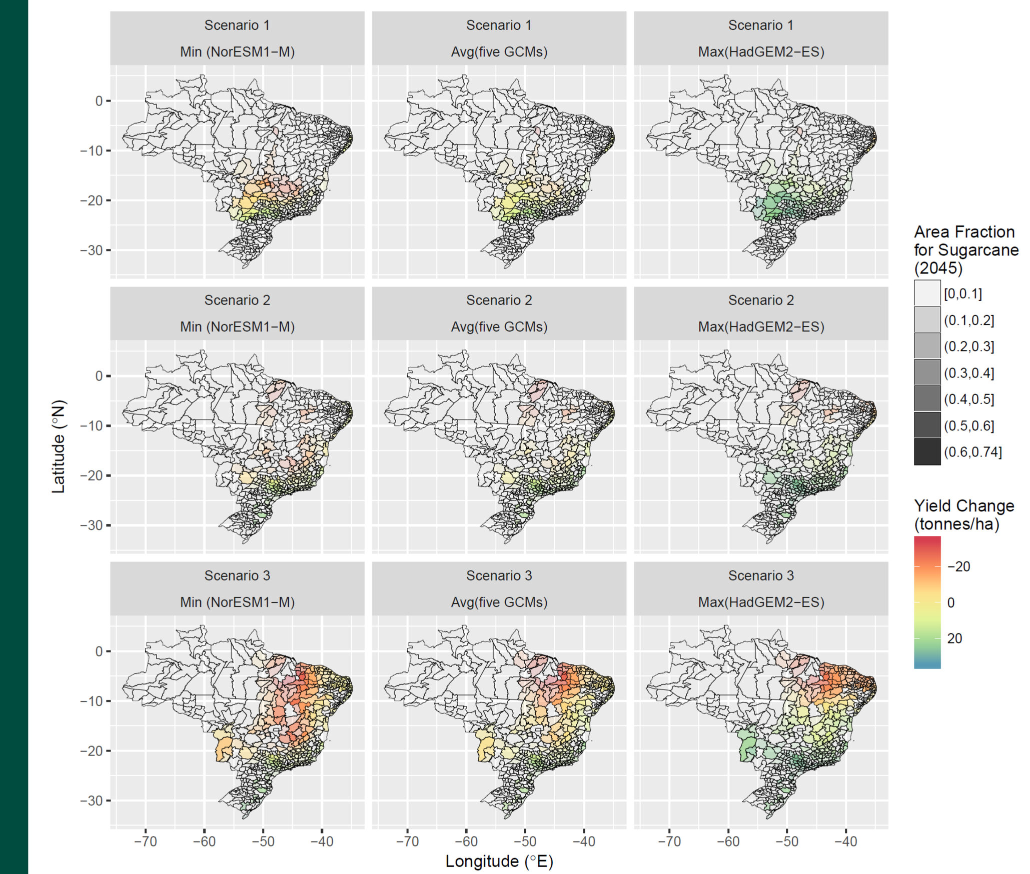
**Land availability and impact of climate change on sugarcane productivity**




**Cellulosic ethanol yield in equivalent in million barrels of oil per day (1st generation yield in bracket)**

| Climate Change Impact | Land use Scenarios | | |
|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 3 |
| Maximum (HadGEM2-ES) | 6.07 (3.02) | 4.45 (2.15) | 12.77 (6.61) |
| Average | 5.00 (2.43) | 3.91 (1.83) | 11.20 (5.8) |
| Minimum (NorESM1-M) | 4.42 (2.11) | 3.63 (1.71) | 10.53 (5.43) |

**Carbon offset in Gigatons year$^{-1}$ due to displacement of crude oil by cellulosic ethanol ( values for 1st generation yield in bracket)**

| Climate Change Impact | Land use Scenarios | | |
|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 3 |
| Maximum (HadGEM2-ES) | 0.95 (0.47) | 0.70 (0.34) | 2.00 (1.03) |
| Average | 0.78 (0.38) | 0.60 (0.29) | 1.75 (0.90) |
| Minimum (NorESM1-M) | 0.69 (0.33) | 0.55 (0.26) | 1.64 (0.85) |

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