

## Integrated analysis of land-use, energy and water systems for large-scale biofuel production in Bolivia

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Bolivia is a land-locked country located in the continent of South America. It covers 1,083,301 square kilometers of land with an estimated population of 11.36 million of inhabitants by 2018. Among South American countries, Bolivia has the lowest Human Development Index and its government face compelling challenges regarding poverty eradication, public health, food security and energy access.

Agriculture value added made up the 11.6% of Bolivia's GDP in 2017. The total cultivated area of the country was only 3.5% of the territory, whereas agriculture was estimated to consume 92% of Bolivia's water withdrawals and contributed to 43% increase of GHG emissions for land-use change. The main crops cultivated are sugar cane (48% of total volume production), soy (14.5%), corn (6.3%), potatoes (5.8%) and sorghum (5.1%).

The 84% of the primary energy consumption in Bolivia derives from fossil fuels. In 2016, Bolivia imported the 28% of its production petroleum refined products and subsidize those for domestic demand. Due to limited investments in electricity, gas exploration and oil refinery infrastructure, energy supply has started to be a concern. With the aim to reduce the fiscal burden of fuel subsidies and to reduce the risks of fuel supply shortages and price volatility, the alternative of introducing biofuels has arisen with the recent Law of Biofuels (Law no.1098) promulgated on September 2018.

The purpose of this law is to create the regulatory framework that permits production, storage, transportation, marketing and biofuel blending aiming to gradually reduce imports of gasoline and diesel oil (although prioritizing food and energy security objectives). The alternative to use agricultural crops rich in sugars, starch, cellulose or oils, as well as agroforestry waste, to transform it into ethanol or diesel.

Biofuels are a regular target for energy security policies. In the last decade, many developed and developing countries are encouraging biofuels production by applying significant resources to research for innovation in biofuel technologies, granting subsidies and tax deductions to production, ensuring market through consumption targets, as well as executing protectionist policies to their national productions.

The biofuel industry creates indirectly income and employment opportunities for farmers, with the consequent impact on poverty reduction. Although yield increases may mitigate such competition in the long run, integrated planning is required to assess the numerous and complex interconnections between these resources.

The aim of this study is to evaluate, through the CLEWs framework, alternative biofuels (ethanol and biodiesel) production pathways in Bolivia and to estimate the impacts of the chosen source for biofuel production on deforestation, water deficit and energy sovereignty. The unique geography and diverse climates of Bolivia makes it a unique CLEWs study case. Three systems are modelled in the OSeMOSYS framework, energy, land-use and water. The model represents 25 regions of the country. Soft-linking with data from a detailed hydrological balance, land-use and agro-potential data from the GAEZ methodology was set. The energy model has been simplified in an single node equivalent from a previous model developed by Peña et al 2018 and energy demand projections from Peña et al 2017.