Estimation of the water footprint of sugarcane in Mexico: is ethanol production an environmentally feasible fuel option?

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ABSTRACT

Energy policies are taken throughout the world to reduce fossil fuel emissions from transportation sources. Agriculturally based biofuels are currently the only alternatives to liquid fossil fuels. However, as biofuel production spreads, so too do its cascading impacts on environment and food security. This paper analyzes the impact of Mexican ethanol-sugarcane policy on water resources. The water footprint of sugarcane (WF_{sc}) was quantified for an agricultural region in Jalisco, Mexico, and used to estimate anthropologic water demand and stress index. This analysis was performed using historical climate data, and for projected changes under scenarios A2 and B1, using ECHAM and GFDL models. The average historical water footprint of sugarcane was estimated as 104.9 m^3/ton, total average water demand as 152.3 Mm^3/year and a historical water scarcity index as 59%. Under climate change, the footprint might increase 2% by 2020 and 3–4% by 2050. The available water is predicted to fall 4–7% by 2020, and 6–8% by 2050, with negative effects on water stress. Due to the strong influence of local factors on water footprint and stress, additional research is needed for all Mexican sugarcane regions, in order to evaluate the feasibility of the policy regarding the use of ethanol for transportation.

Key words | biofuel, climate change, ethanol, sugarcane, water footprint

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INTRODUCTION

Increasing energy use, concerns about air quality, climate change resulting from greenhouse gas (GHG) emissions, and falling global oil reserves make switching to sustainable, low-emissions fuels a high priority. Some proposals to reduce fossil fuel dependence are the use of hydrogen fuel cells, hybrid electric vehicle technologies, and the use of alternative biofuels such as ethanol and biodiesel. Relative to the fossil fuels they displace, Hill *et al*. (2006) suggest that GHG emissions may be reduced 12% by the production and combustion of ethanol, and 41% by biodiesel.

Aggressive renewable energy policies have helped the biofuel industry grow at a rate few could have predicted. Global production of ethanol and biodiesel increased from around 18.2 billion liters in 2000 to 79.5 billion liters in 2008. In the United States alone, the production of corn ethanol was estimated at 34 billion liters in 2008 (Earley & McKeown 2009).

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Agriculturally based biofuels from food crops, such as corn and sugarcane, used to produce ethanol, and soybeans, jatropha and palms, used for biodiesel production, are currently the only alternatives to liquid fossil fuels being produced profitably and in large volumes (Himmel *et al*. 2007), despite the potential of second-generation biofuels such as cellulosic-ethanol and algae-biodiesel.

Biofuel is potentially part of the solution to the world's energy and climate change problems. But as biofuel production spreads around the world and the market for biofuels expands, so too do its cascading indirect impacts in the social, economic, and environmental spheres.

The growing demand for cleaner burning and more sustainable fuels, such as ethanol, is likely to generate changes in agricultural cropping patterns and land management practices. Many feedstocks require a large area, and their efficient