Brief Report

Estimation of the Global Biofuel Production Potential Based on an AEZ Model

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Report received on Oct. 6, 2014

KEYWORDS Biofuel, Global Potential, Agro-ecological Zones Model, Abandoned Agricultural Land

1. Introduction

An Agro-ecological Zones (AEZ) model is a tool to evaluate crop suitability by major crop and by region taking into consideration climate and soil conditions. This model was developed by the International Institute for Applied Systems Analysis (IIASA) and the Food and Agriculture Organization of the United Nations (FAO), who published results[(1)] on crop suitability calculated using average climate data for 1961 to 1990.

In this paper, we first estimated the potential of global biofuel production from nine major crops (cassava, maize, palm, rice, rapeseed, soybean, sugar beet, sugarcane and wheat) as feedstocks, using results from the AEZ model and data on current and historical global land cover and land use. Secondly, we compared the difference in geographical distribution between the results of the AEZ model and the actual crop areas in 2000 to examine the reliability of the model.

2. Evaluation of Biofuel Production Potential

The results of the AEZ model are provided at a spatial resolution of 0.5 × 0.5 degree latitude/longitude grids (see Fischer et al.[(1)] for details of the calculation procedure).

We set two cases of available land area and evaluated biofuel production at the global level. In case 1, potential cropland, meaning land currently not used as cropland but available for this use, was considered available land; in case 2, abandoned cropland, land formerly but not currently used and available as cropland, was considered available land. In both cases, forest was excluded. We used the USGS database for current land cover and land use data. We identified global abandoned land using the results of Goldewijk,[(2)] which estimated the change in spatial distribution of cropland and pasture for 100 years.

We maximized total energy production by selecting the most productive crop for each grid. Based on potential cropland (case 1), the estimated available land potential was 777 Mha and the estimated global biofuel potential was 47.9 EJ per year. This is equivalent to 71% of current fuel consumption in the transport sector. Three crops, maize, sugarcane and cassava, account for 86% of total energy production. Crops for biodiesel production such as palm, soybean and rapeseed are rarely selected due to their low energy productivity per unit land area.

The estimated available land and global biofuel potential based on abandoned cropland (case 2) were respectively 51 Mha and 2.34 EJ per year, values that are 6.6% and 4.9% of the case 1 result, respectively (Mha = 10^6 ha, EJ = 10^{18} J).

The evaluated spatial distribution of the best crops in each case is shown in **Fig. 1**.

3. Examination of Reliability of AEZ Model

We compared the spatial distribution of major crops estimated by Monfreda et al.[(3)] and AEZ's results.[(1)] Monfreda et al. estimated the actual crop areas in 2000 by allocating local-government level statistical data on crop areas of all countries to corresponding grids. To be precise, it is estimated data; however, in view of the purpose of this comparison, it is reasonable to consider it as representing actual crop area.

We found discrepancies in some areas (for example, see **Fig. 2**). On the whole, each crop had a high ratio of land area evaluated as unsuitable (marginal to not suitable) by the AEZ model (**Fig. 3**). Although the estimated current spatial distribution of major crops is determined by irrigation and fertilization, which is not

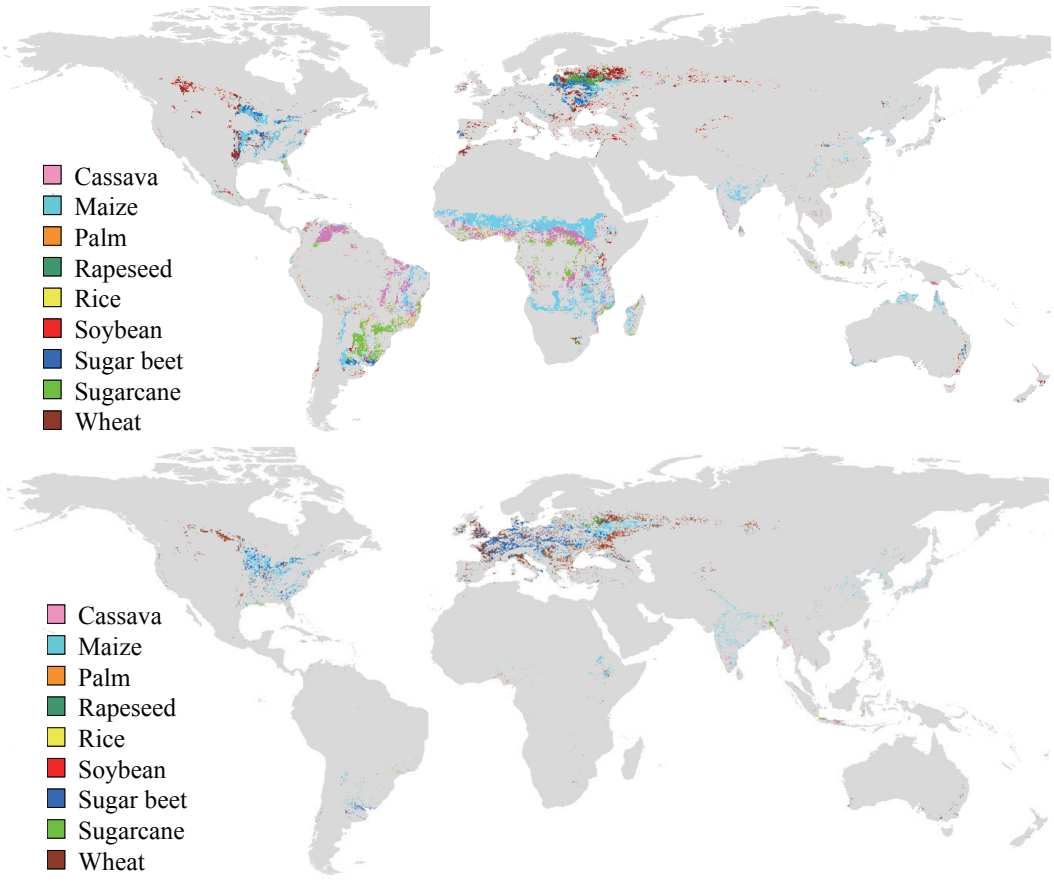

Fig. 1 The evaluated spatial distribution of the most productive crops maximizing total energy production (upper panel: case 1, lower panel: case 2).

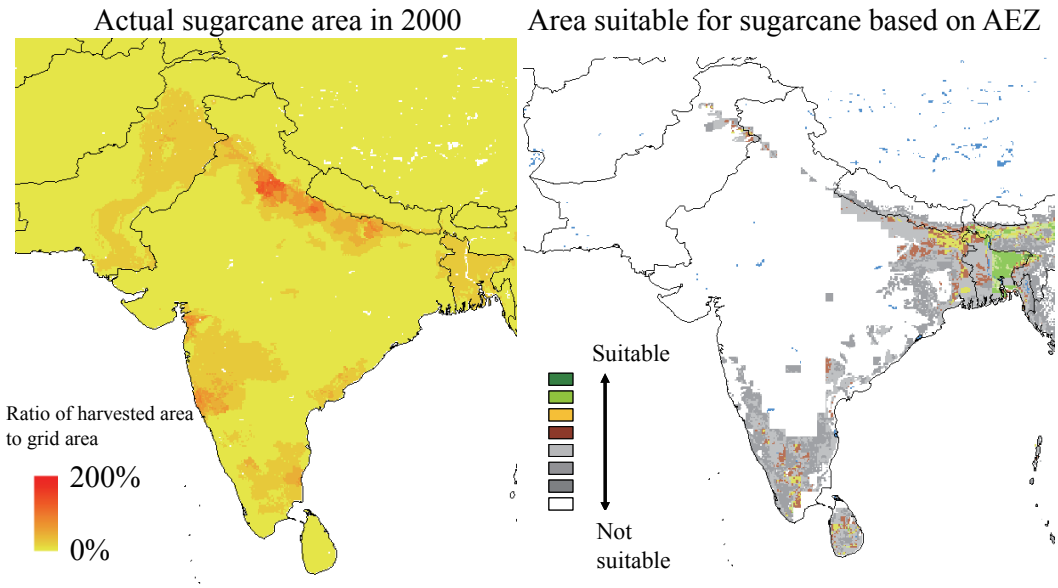

Fig. 2 Comparison of sugarcane harvested area in 2000 (left) and area considered suitable by the AEZ model (right) in south Asia.

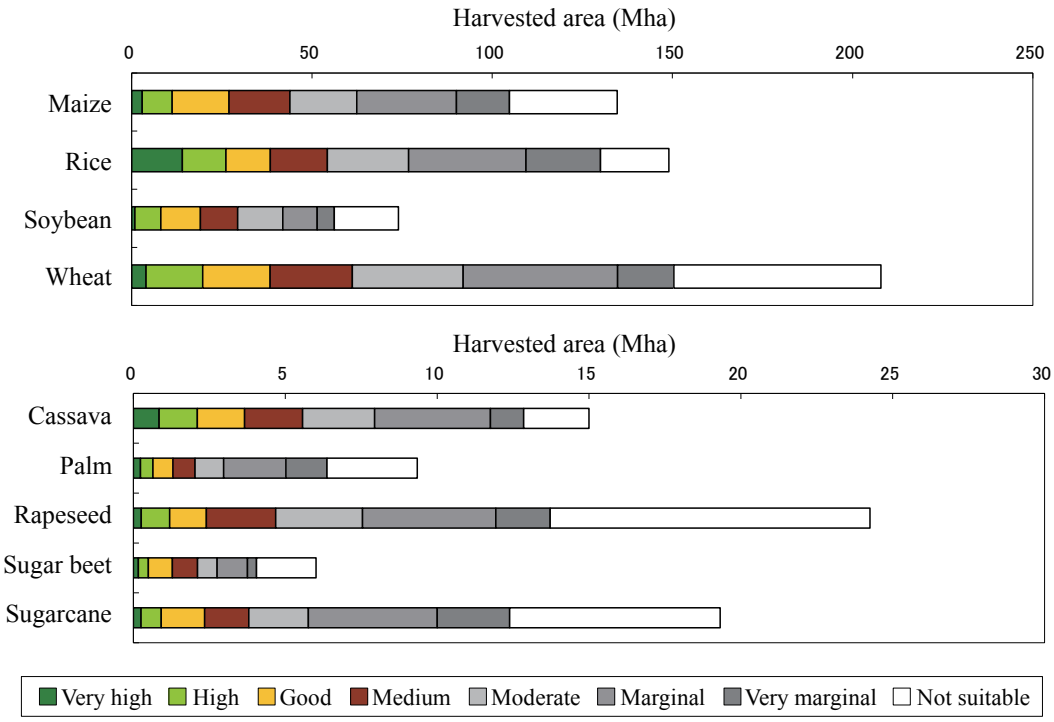

Fig. 3 Breakdown of harvested area based on AEZ's suitability results for major crops.

considered in the AEZ model (AEZ is based on rain-fed crop production), this result implies that AEZ may be not appropriate for some crops and some regions.

References

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(2) Goldewijk, K. K., "Estimating Global Land Use Change over the Past 300 Years: The HYDE Database", *Global Biogeochemical Cycles*, Vol. 15, No. 2 (2001), pp. 417-433.
(3) Monfreda, C. et al., "Farming the Planet: 2. Geographic Distribution of Crop Areas, Yields, Physiological Types, and Net Primary Production in the Year 2000", *Global Biogeochemical Cycles*, Vol. 22, No. 1 (2008), pp. 1-19.

Figs. 1 and 3
Reprinted from Proc. of 28th Annual Meeting of Japan Society of Energy and Resources (2009), (CD-ROM), Hara, T. et al., An Estimation of the Global Biofuel Production Potential Based on AEZ Model (in Japanese),

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