Global Land-use and Sustainability Implications of Bioenergy Supply under China's 2060 Carbon Neutrality Target

Yazhen Wu[1,2], Andre Deppermann[2], Petr Havlík[2], Stefan Frank[2], Ming Ren[1], Hao Zhao[2,3,4], Lin Ma[3], Chen Fang[1], Qi Chen[1], Hancheng Dai[1,*]

[1] Peking University, Beijing, China. [2] International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria [3] Chinese Academy of Sciences, Shijiazhuang, China.

[4] University of Chinese Academy of Sciences, Beijing, China; Email: *dai.hancheng@pku.edu.cn

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Introduction

- Using bioenergy and BECCS for climate change mitigation has been extensively studied over the last 20 years, but is still under heated debate.
- One of the key concerns is the feasibility of sustainable biomass supply at large scale, and the induced land-use impacts of bioenergy expansion.
- The land-use tradeoffs can be even more complex when it comes to regional bioenergy strategies in a global context; however, the global impacts alongside regional bioenergy developments remain poorly understood.
- We investigate the land-use effects of different bioenergy supply schemes triggered by China's 2060 carbon neutrality commitment with GLOBIOM.

Methodology

1. **Calibrating historical bioenergy production:** data from IEA and FAOSTAT
2. **Projecting future bioenergy demand under China's carbon-neutrality target:** data from literature and IAMC scenario database
3. **Designing a series of compatible bioenergy supply or import scenarios** (table below)
4. **Quantifying the global land-use and sustainability implications for each scenario**: GLOBIOM modeling <www.globiom.org>

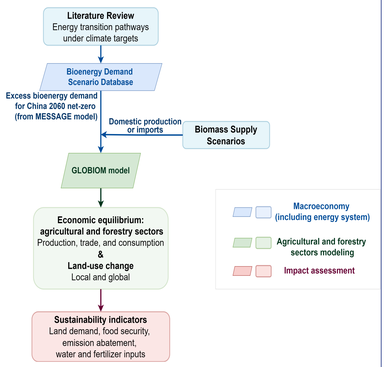

Fig.1 Research Framework

Scenario design

Trade settings	No.	Scenario Names	Source region of excess biomass
Reference scenario (**Ref**, no excess biomass demand)			
(1) Fixed trade: Trade of all commodities in all scenarios and time is fixed at Ref levels;	1	BioCHN_DOM	Domestic (China)
	2	BioCHN_SAS	South Asia
	3	BioCHN_LAM	Latin America and the Caribbean
	4	BioCHN_NAM	North America
	5	BioCHN_EUR	Europe
	6	BioCHN_CIS	The Former Soviet Union
(2) Free trade: trade of agricultural or forestry commodities are free	7	BioCHN_SSA	Sub-Saharan African
	8	BioCHN_World	All world regions (propotional)
	9	BioCHN_Optim	Flexible choice of import sources (endogenous – economic efficiency)

Results

1. Heterogenous sustainability implications in different world regions

- **Scaling up bioenergy production in any single region might induce significant land-use changes**; however, the major sustainability concerns with excess bioenergy production would be different across regions.
- **For domestic production:** expansion of energy plantations would take up 1/6 of China's cropland by 2060, which might contradict China's current farmland protection regulations.
- **For biomass imports:** large areas of forest management (Former Soviet Union, North America); significant induced GHGs (Latin America, North America); food security concerns (South Asia, Sub-Saharan Africa)

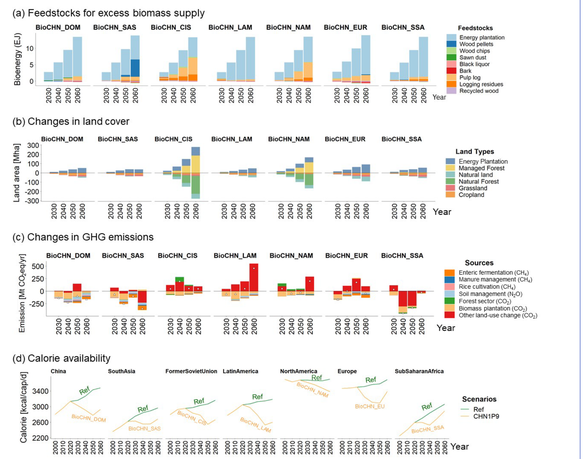

Fig.2 Land sustainability indicators in different scenarios compared with Ref under "Fixed trade"

2. Global spillover sustainability impacts induced by iLUC

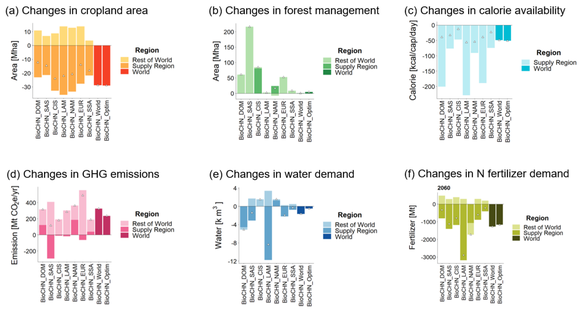

Fig.3 Changes in local and global land use and sustainability indicators compared with Ref under "Free trade"

- **With "Free trade", adjustments in the trade of agricultural and forestry products alongside excess bioenergy supply will introduce significant spillover sustainability impacts worldwide via indirect land-use changes (iLUC).**
- Compared with local effects in regions supplying excess biomass, global spillover impacts in other world regions can be even greater.
- Accounting for the second-order spillover effects, importing biomass from other regions to China does not necessarily induce greater global land-use footprints than scaling up domestic bioenergy production.

Discussions & Conclusions

- Fulfilling China's carbon neutrality target could trigger excess bioenergy demand of ~13 EJ by 2060. Although it contributes to only a 20% increase in global reference bioenergy level (≈70 EJ), non-negligible food security and other sustainability concerns might happen worldwide if the bioenergy strategy is not implemented wisely.
- Considering the interconnected global market, the overall global footprints of scaling up domestic bioenergy production might even be greater than biomass imports, indicating biomass trade as a better alternative in specific conditions.
- Nevertheless, only when potential leakage effects are addressed by adequate and reasonable land-use regulation can bioenergy trade help achieve national carbon neutrality without threatening regional and global land-use sustainability.

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