Assessment of long-term mitigation scenarios in Chinese agriculture

Yizhi Deng[1], Jing-Yu Liu[1,2*], Wei Xie[3], Xiaomuzi Liu[4], Jian Lv[1], Runsen Zhang[5], Wenchao Wu[6], Yong Geng[1,2,7,8], Julien Boulange[9]

1 School of Environmental Science and Engineering, Shanghai Jiao Tong University, P. R. China; 2 Shanghai Institute of Pollution Control and Ecological Security, P. R. China; 3 School of Advanced Agricultural Sciences, Peking University, P. R. China; 4 École Polytechnique, France; 5 Graduate School of Frontier Sciences, Tokyo University, Japan; 6 Japan International Research Center for Agricultural Sciences (JIRCAS), Japan; 7 School of International and Public Affairs, Shanghai Jiao Tong University, P. R. China; 8 School of Business, Shandong University, P. R. China; 9 Graduate School of Agriculture, Tokyo University of Agriculture and Technology, Japan

Introduction

China is a large agricultural country, as well as a big emitter of greenhouse gases. China's 'dual carbon' goal seeks to achieve peak CO_2 emissions before 2030 and carbon neutrality before 2060.

In this study, we developed a bottom-up agricultural technology optimization model (ATOM) for GHG mitigation, which aimed to minimize the total cost based on inventories of agricultural GHG emissions and mitigation measures. The model was employed to quantify China's agricultural GHG mitigation potentials under various socioeconomic scenarios and carbon price assumptions.

Methodology

First, we established inventories of agricultural GHG emissions (based on the *Guidelines for the Preparation of Provincial Greenhouse Gas Inventories*) and mitigation measures (screened by investigating technical potentials, prospects, and impacts on agricultural production). In the second step, the ATOM was developed based on these inventories and then employed to quantify China's agricultural GHG mitigation potentials by 2060. Under a series of socioeconomic scenarios and carbon price assumptions, the model simulated the pathways of agricultural GHG mitigation in China. Additionally, only GHG emissions from food-related agricultural production activities were considered.

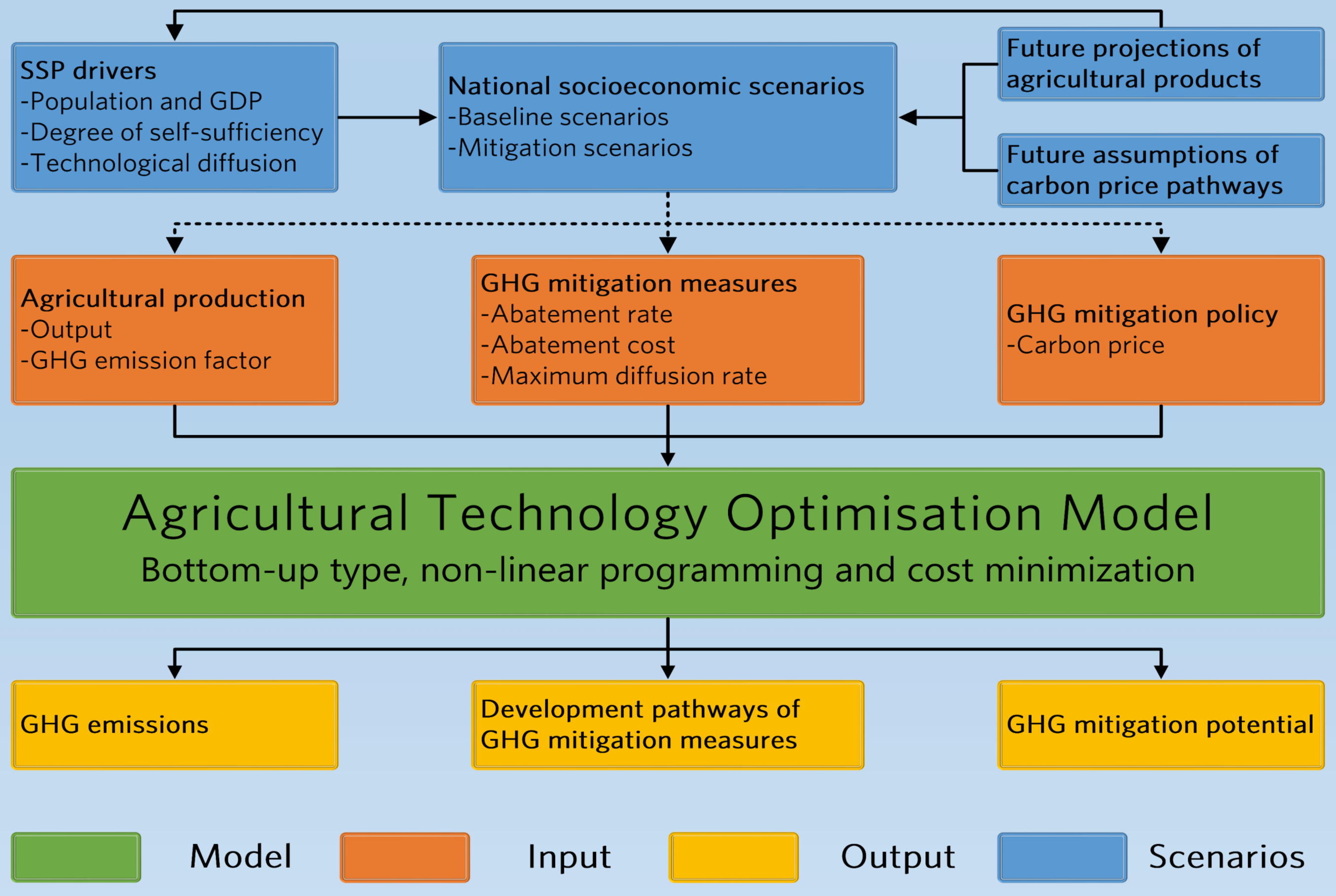


Figure 1 Schematic structure of ATOM

Table 1 Applicable GHG mitigation measures for Chinese agriculture

Code	Mitigation measure	Introduction
C1	Advanced irrigation	Replace mid-season drainage with intermittent irrigation to reduce CH4 emissions in rice cultivation
C2	Enhanced-efficiency fertilizers	Promote nitrification inhibitors, urease inhibitors, and controlled-release fertilizers to reduce N2O emissions in farmland
C3	Better nitrogen management	Use the soil nitrogen test to determine the optimal nitrogen rate (right rate), increase the frequency of nitrogen fertilization (right time), or use fertilizer deep placement (right place) to reduce N2O emissions in farmland.
C4	Return of crop straw and residues	Return crop straw and residues to the field to increase SOC
C5	Biochar addition	Add biochar to the field to increase SOC
C6	Organic manure	Replace nitrogen fertilizers with organic manure to increase SOC
L1	Anaerobic digestion of manure	Use anaerobic digestion technology to reduce direct CH_4 and N2O emissions in the storage and treatment of livestock manure
L2a	Dietary additives: tea saponins	Add tea saponins to ruminant diets to reduce CH_4 emissions in enteric fermentation
L2b	Dietary additives: probiotics	Add probiotics to ruminant diets to reduce CH_4 emissions in enteric fermentation
L2c	Dietary additives: lipids	Add lipids to ruminant diets to reduce CH4 emissions in enteric fermentation
L3	Silage feed promotion	Promote silage feed to reduce CH_4 emissions in enteric fermentation

C means GHG mitigation measures for crop production and L for livestock production

Results

Negative-cost mitigation measures can help achieve considerable GHG mitigation, but greater emission reductions are achievable with carbon pricing.

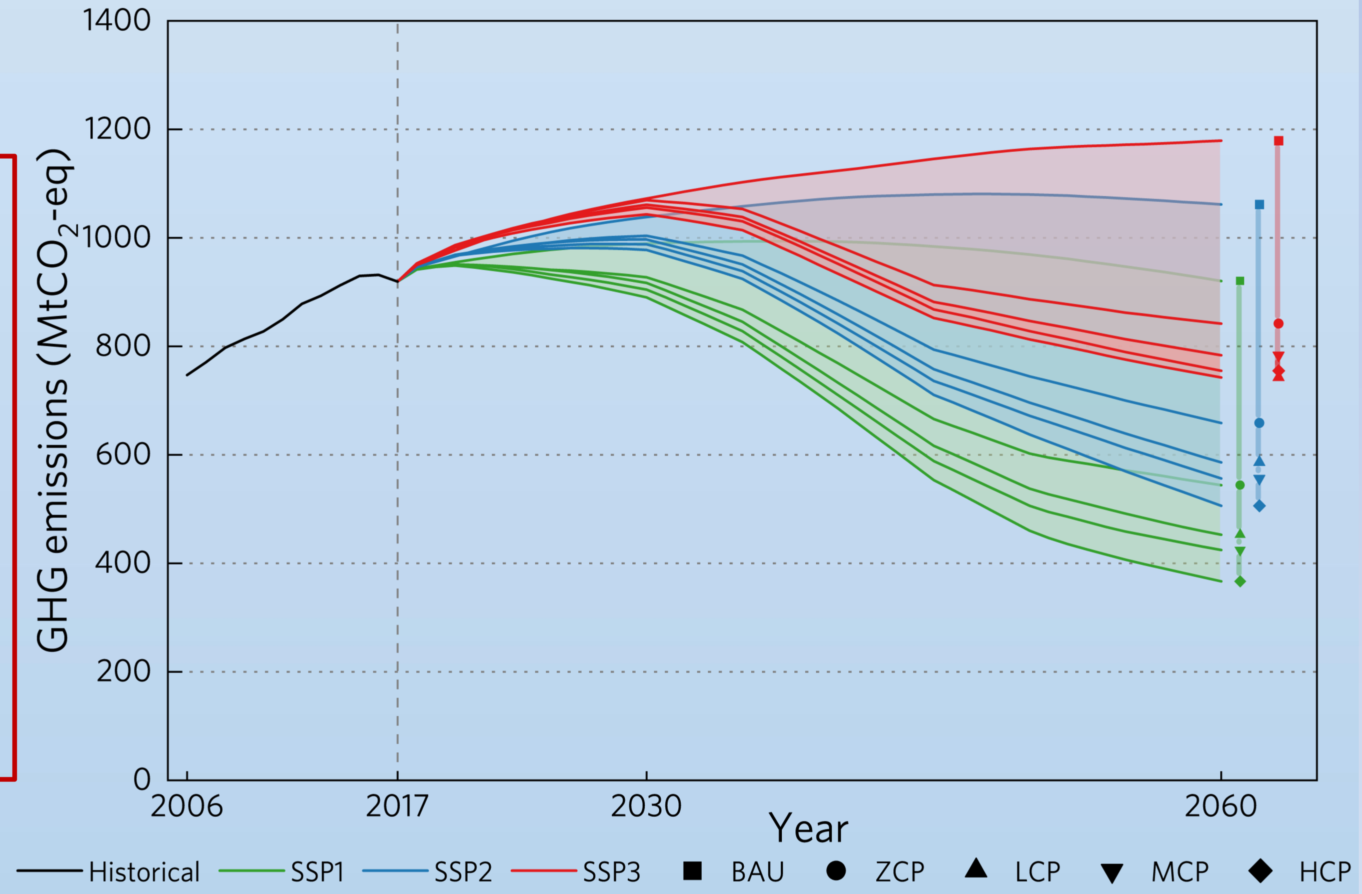
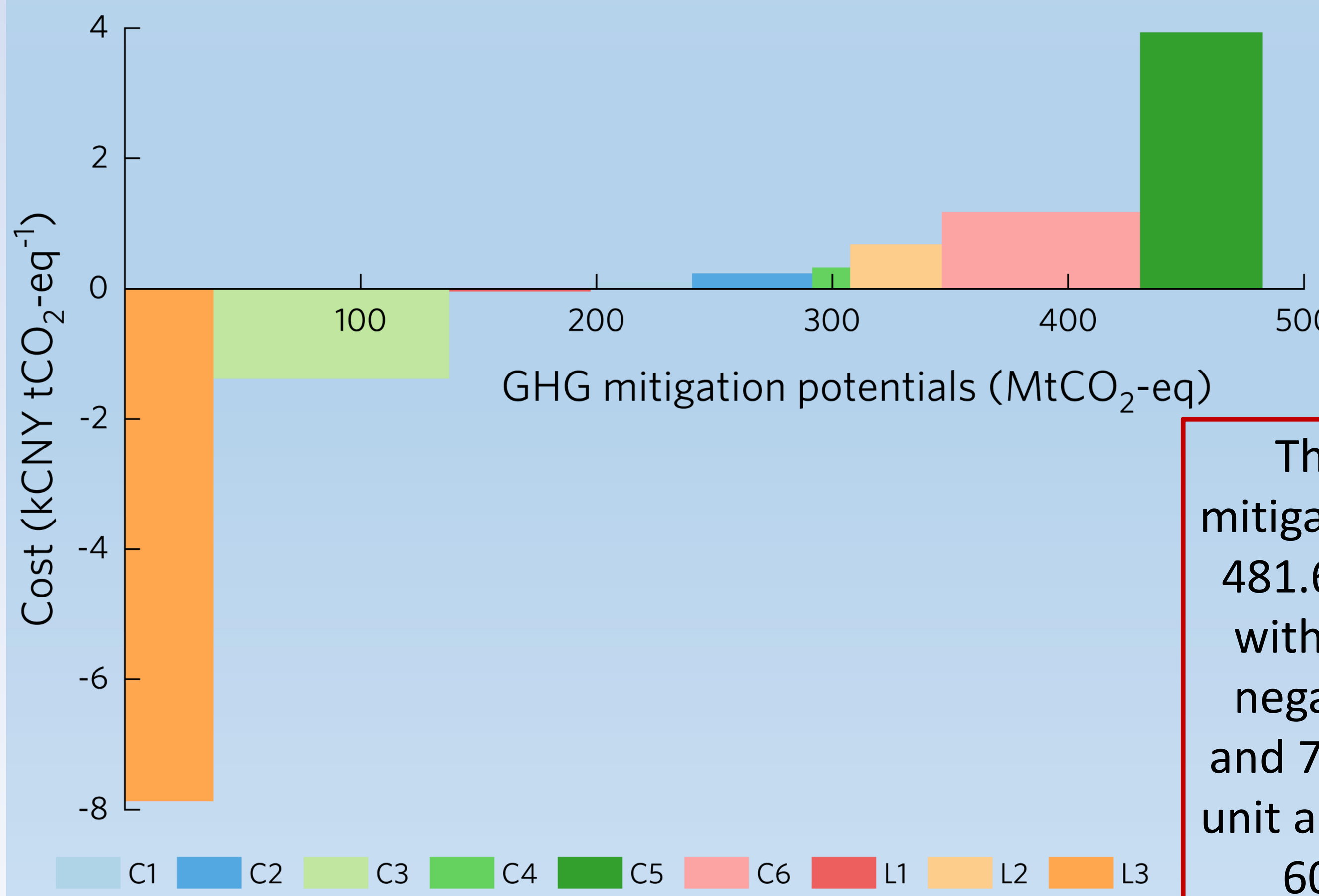
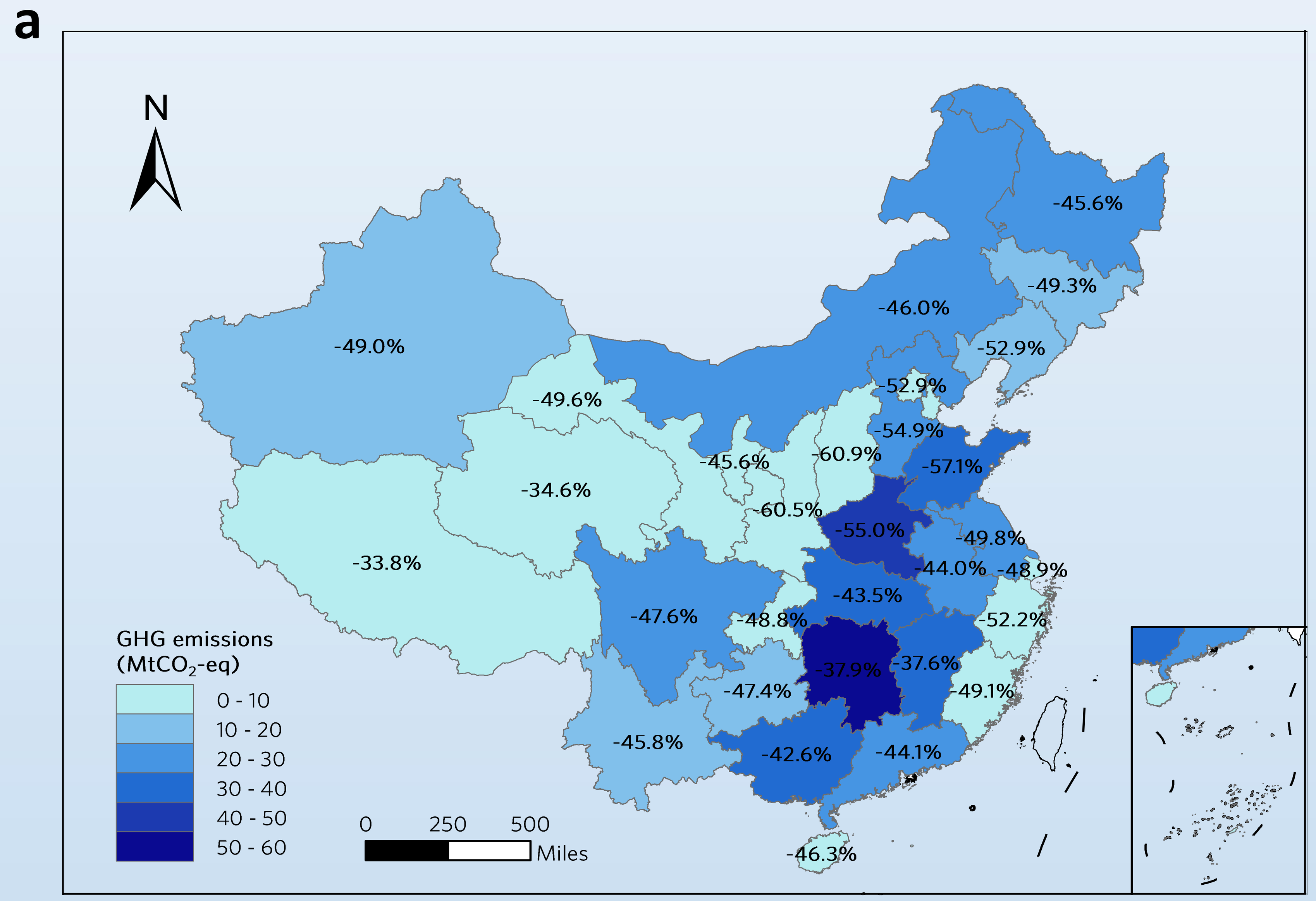


Figure 2 GHG emissions in Chinese agriculture from 2006 to 2060



The maximum GHG mitigation potential will be 481.6 $MtCO_2$-eq in 2060, with 40.7% achieved by negative-cost measures and 72.2% achievable at a unit abatement cost below 600 CNY tCO_2-eq^{-1}.

Figure 3 Marginal abatement cost curve for Chinese agriculture in 2060 based on the SSP2 scenario assumptions.



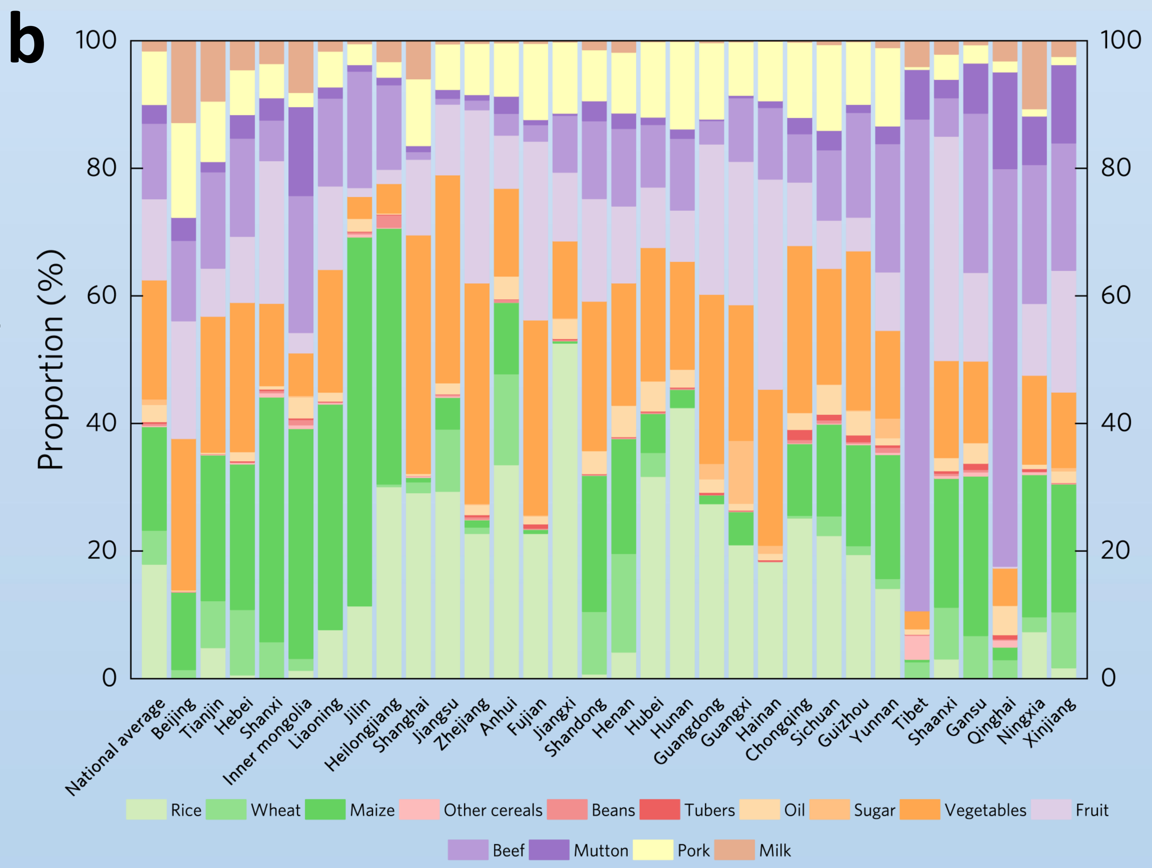


Figure 4 Agricultural GHG mitigation potentials in different regions.

a) China's provincial agricultural GHG emissions and abatement rate in 2060 under the SSP2-MCP scenario;

b) Proportion of China's provincial agricultural GHG emission reductions in 2060 under the SSP2-MCP scenario.

Conclusions

- Chinese agriculture possesses considerable potential for GHG mitigation in theory. But the implementation of agricultural GHG mitigation measures in China may be hindered by socioeconomic obstacles. The Chinese government should immediately adopt countermeasures to promote the diffusion of feasible mitigation measures.
- Existing agricultural GHG mitigation measures are insufficient to achieve carbon neutrality in Chinese agriculture by 2060. The government should aim to achieve more GHG mitigation in other sectors or on the demand side.
- There is significant heterogeneity in the mitigation potential within Chinese agriculture. The government should plan and guide the implementation of agricultural GHG mitigation measures depending on the specific circumstances.