SUPPLEMENTARY MATERIALS

Macroeconomic impacts of climate change associated with changes in crop yields

1. Supplementary Figures
2.

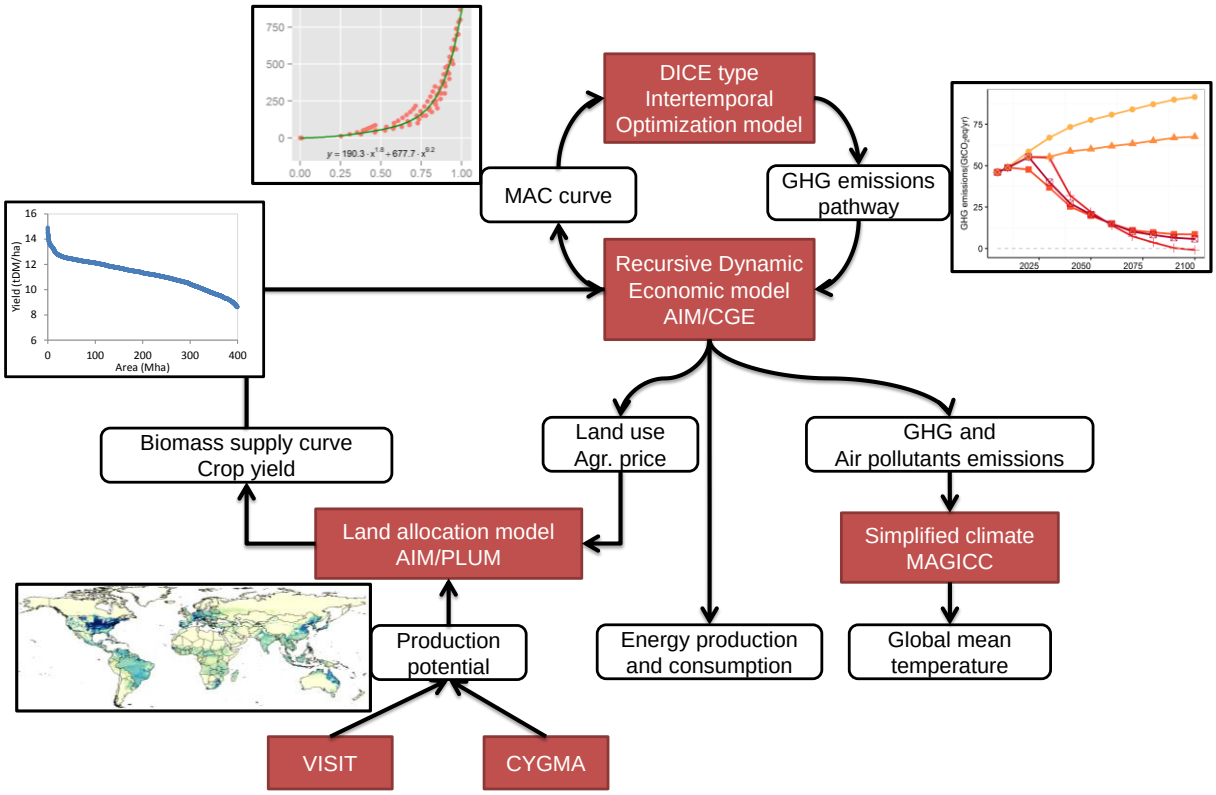

Figure S1. Asia-Pacific Integrated Model (AIM) modeling framework.

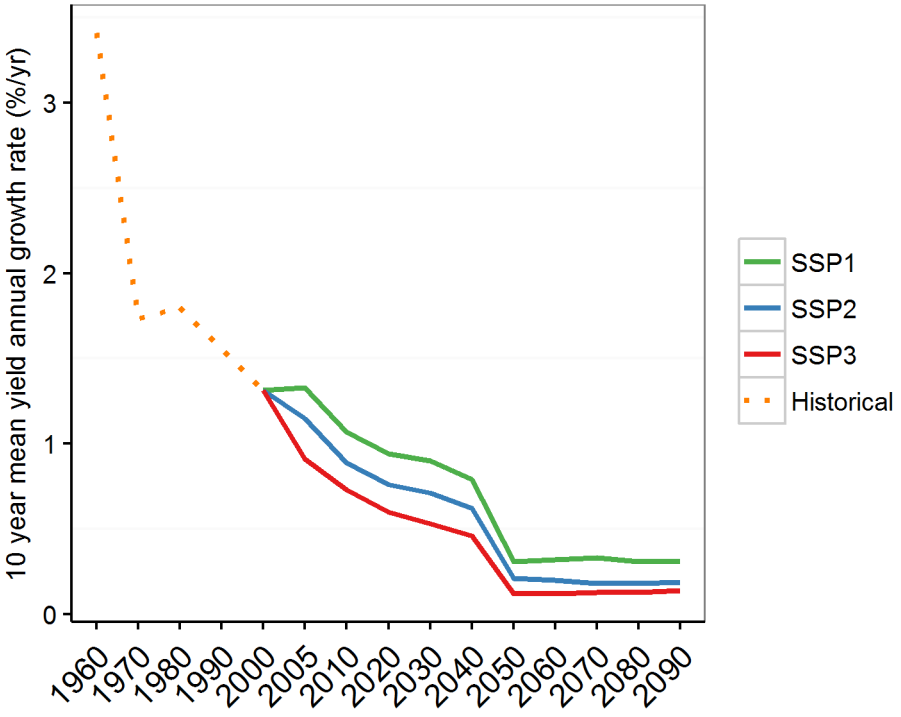

Figure S2. Ten-year mean annual yield growth rate for the SSP1, SSP2, and SSP3 baseline scenarios. The

x-axis represents each decadal period (i.e., 1960 means the 1960s). This figure is adapted from Fujimori et al. (2017) [1].

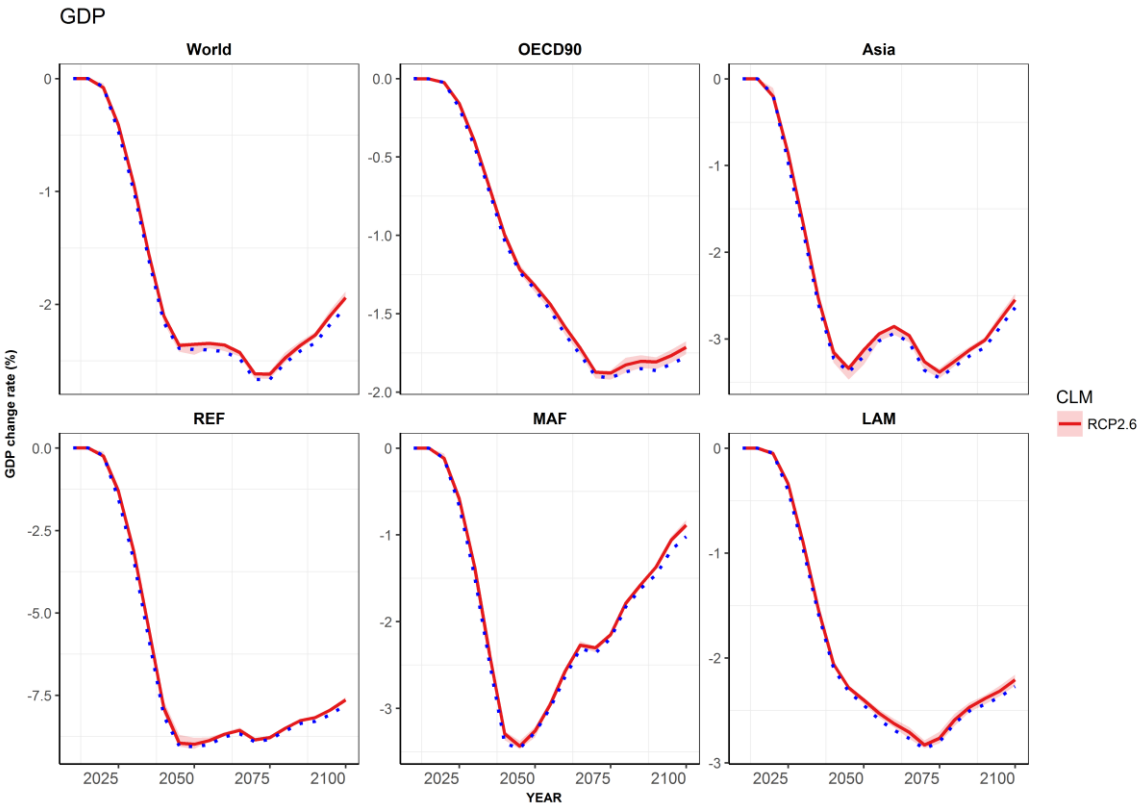

Figure S3. The macroeconomic impact due to mitigation policy (RCP2.6 equivalent) and agricultural yield change for RCP2.6 for five regions and the global total. All cases considered a mitigation policy, but the dotted line indicates no consideration of climate change (NoCC), while the red colored ribbon indicates the cases where the impact of climate change was considered. The red line is the median of the climate change impact cases. Regional codes are OECD90, OECD regions; Asia, Asia; REF, Reforming region; MAF, Middle East and Africa; and LAM, Latin America. (The mapping procedure from 17 regions is shown in Table S1.)

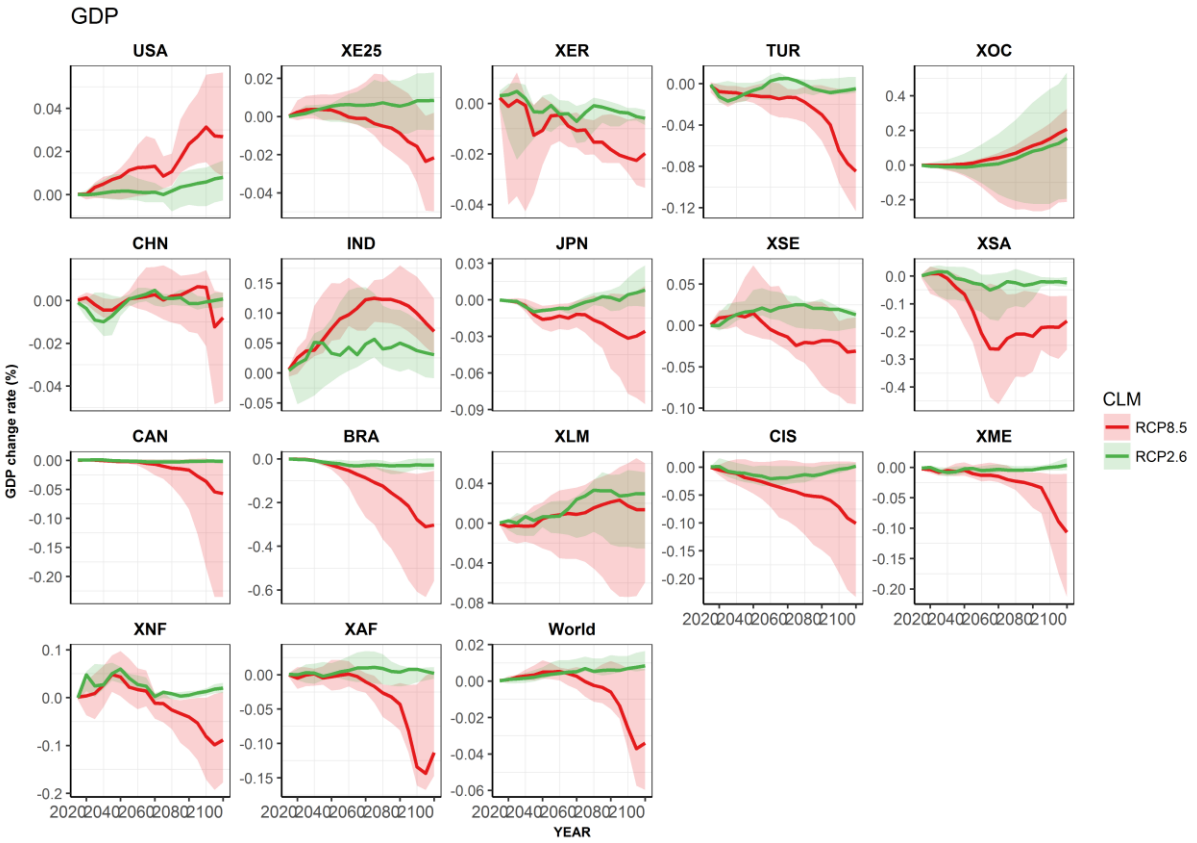

Figure S4. Macroeconomic impact due to changes in agricultural yield in SSP2 in five regions and as a global total. The colors represent climate change level (RCPs). The shaded area is the general circulation model (GCM) range of uncertainty (five GCMs for RCP8.5, and RCP2.6). The lines are the median of five GCMs for each RCP2.6 and RCP8.5. The scenarios in which CO_2 fertilization and land-use change are both included are shown. Regional codes are shown in Table S1.

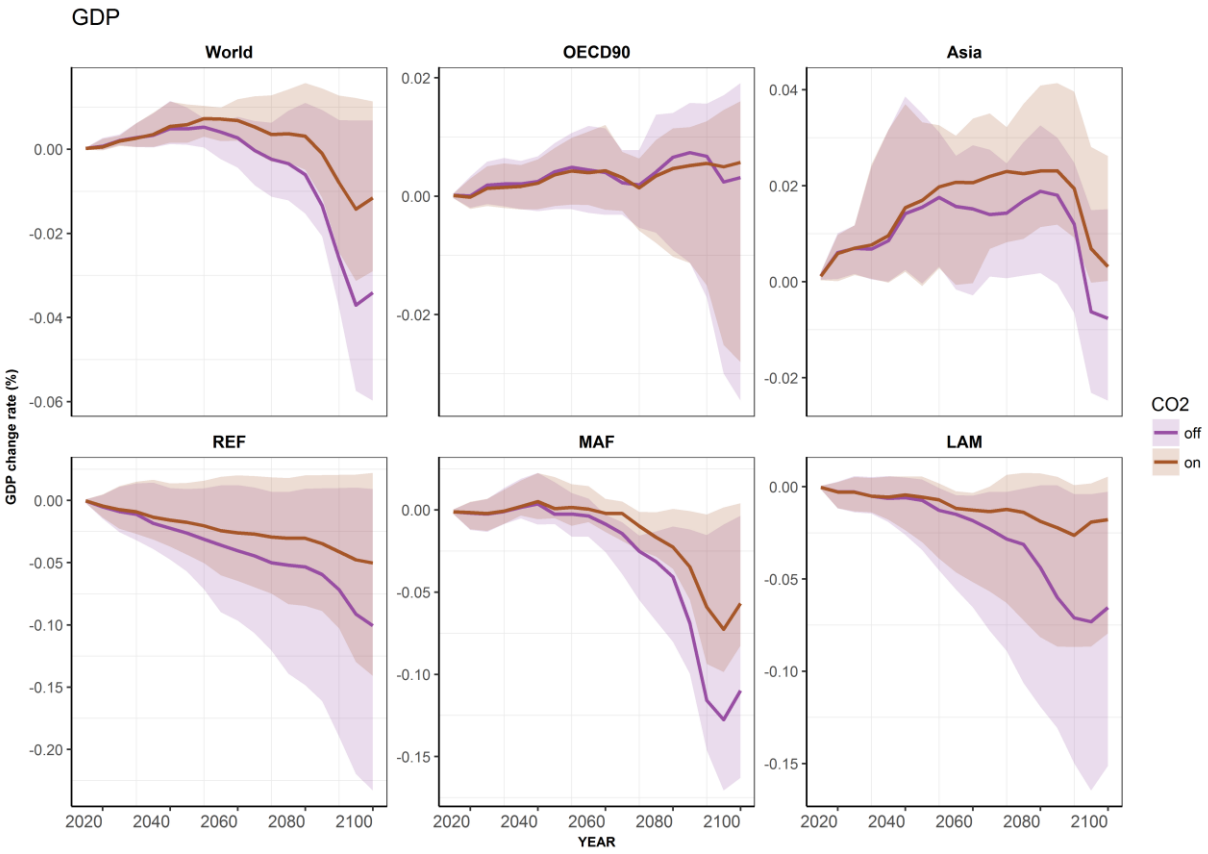

Figure S5. The macroeconomic impact due to changes in agricultural yield for RCP8.5 with and without CO_2 fertilization for five regions and the global total. The red and purple colored ribbons indicate the cases with and without consideration of CO_2 fertilization. The line is the median for each case. Regional codes are OECD90, OECD regions; Asia, Asia; REF, Reforming region; MAF, Middle East and Africa; and LAM, Latin America. (The mapping procedure from 17 regions is shown in Table S1.)

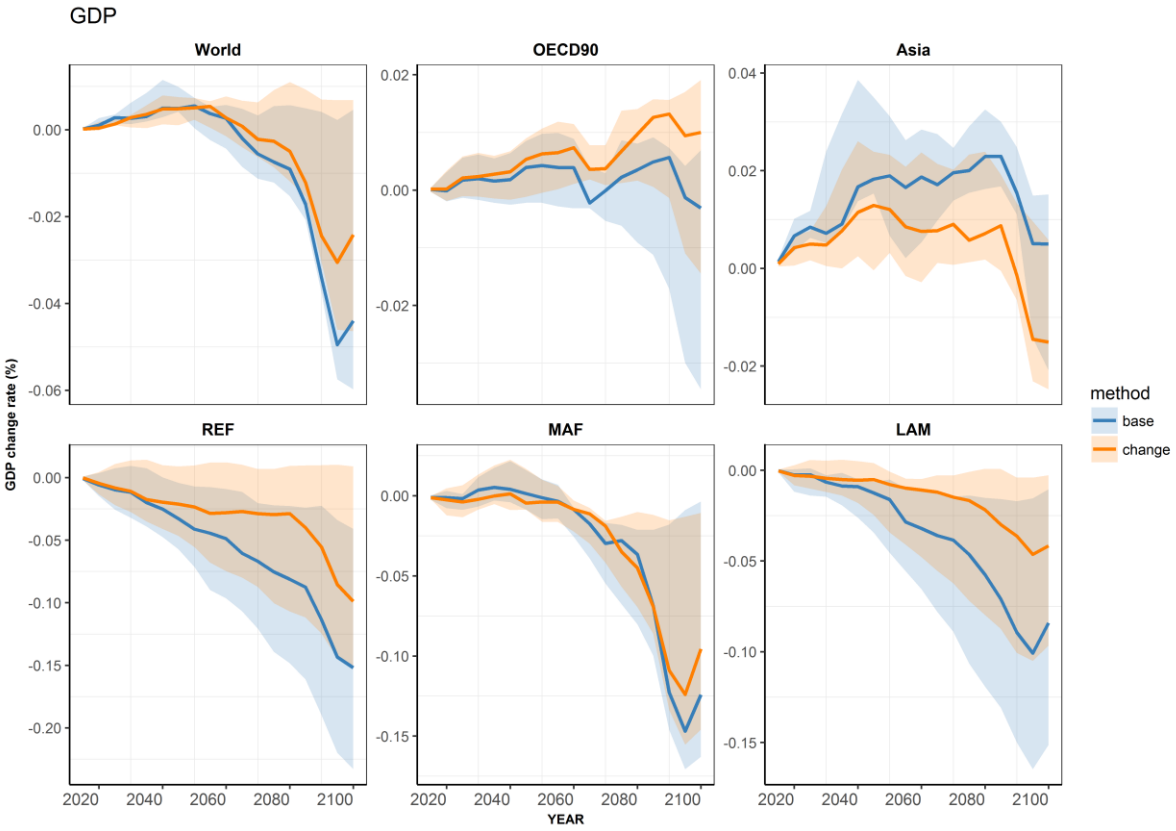

Figure S6. The macroeconomic impact due to changes in the agricultural yield for RCP8.5 with and without consideration of land-use change for five regions and the global total. The orange and blue colored ribbons indicate the cases with and without land-use change (change, with land-use; base, without land-use). The line is the median for each case. Regional codes are OECD90, OECD regions; Asia, Asia; REF, Reforming region; MAF, Middle East and Africa; and LAM, Latin America. (The mapping procedure from 17 regions is shown in Table S1.)

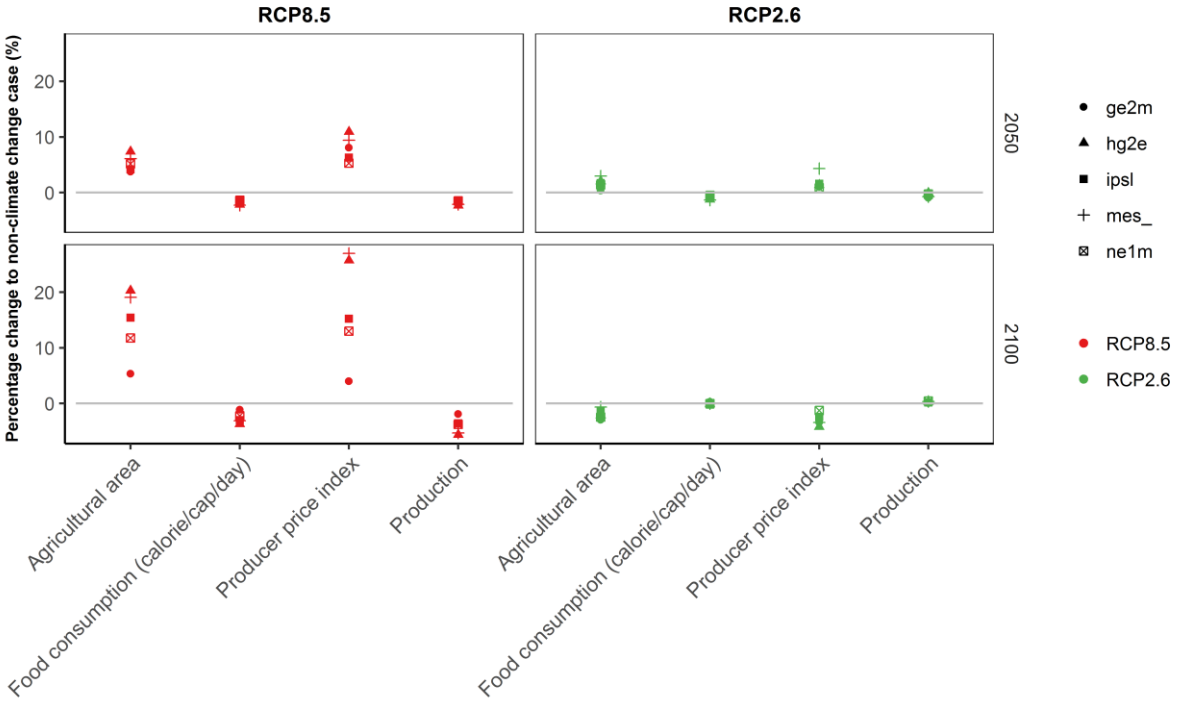

Figure S7. Global main indicators' changes for RCP2.6 (right) and RCP8.5 (left) in 2050 (top) and 2010 (bottom). The main indicators the main indicators here are agricultural area, food consumption, producer price, and production. The values are all presented as percentage changes compared to baseline no climate change cases.

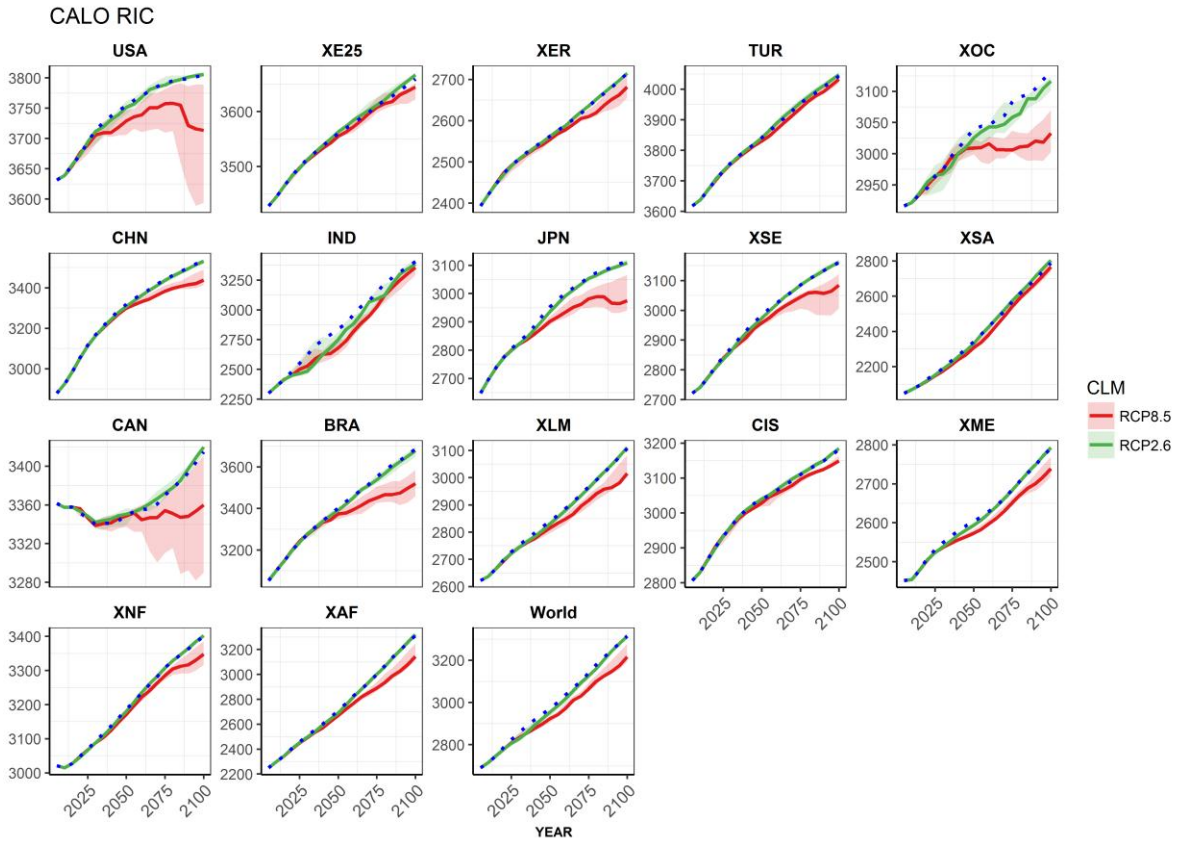

Figure S8. Food consumption as colorific in take per capita, per day change for the 17 regions of the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two climate change cases (green; RCP2.6 and red; RCP8.5) and the no climate change (NoCC) case (blue dot). The ribbon indicates the range of uncertainty of five general circulation models (GCMs). The unit is t/ha.

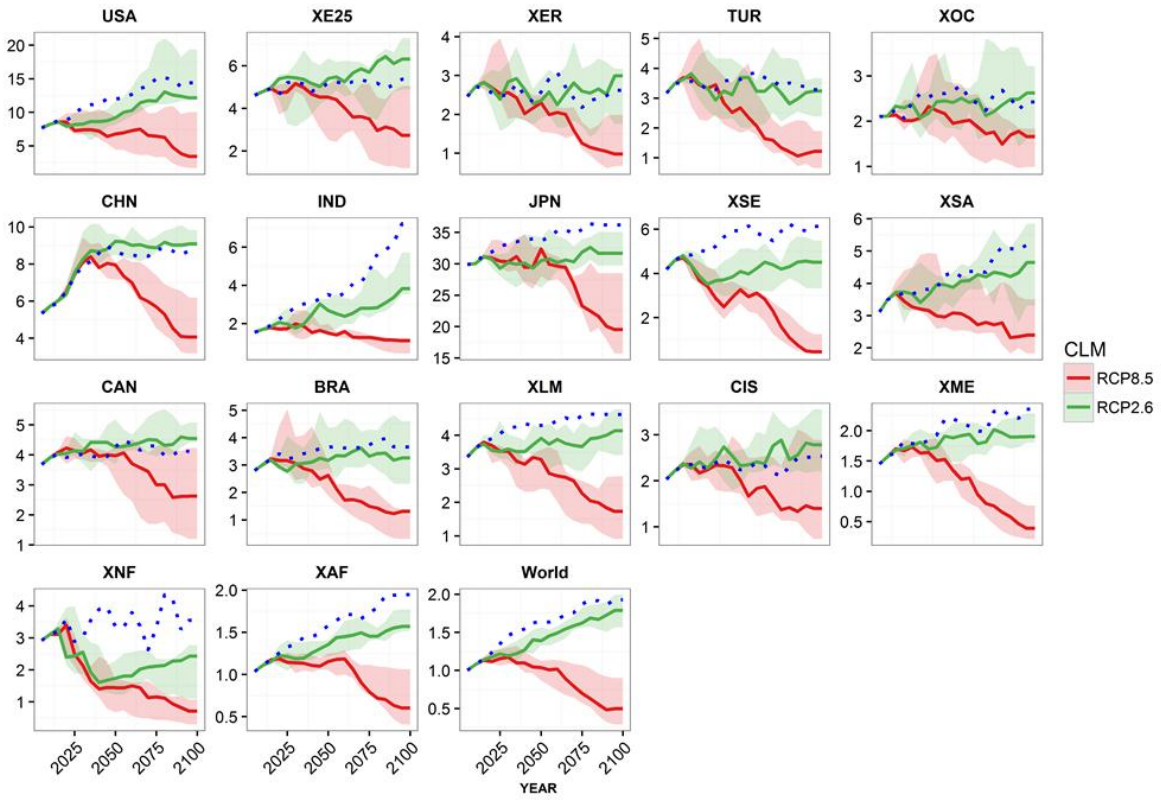

Figure S9. Yield change of coarse grains for the 17 regions of the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two climate change cases (green; RCP2.6 and red; RCP8.5) and the no climate change (NoCC) case (blue dot). The ribbon indicates the range of uncertainty of five general circulation models (GCMs). The unit is t/ha.

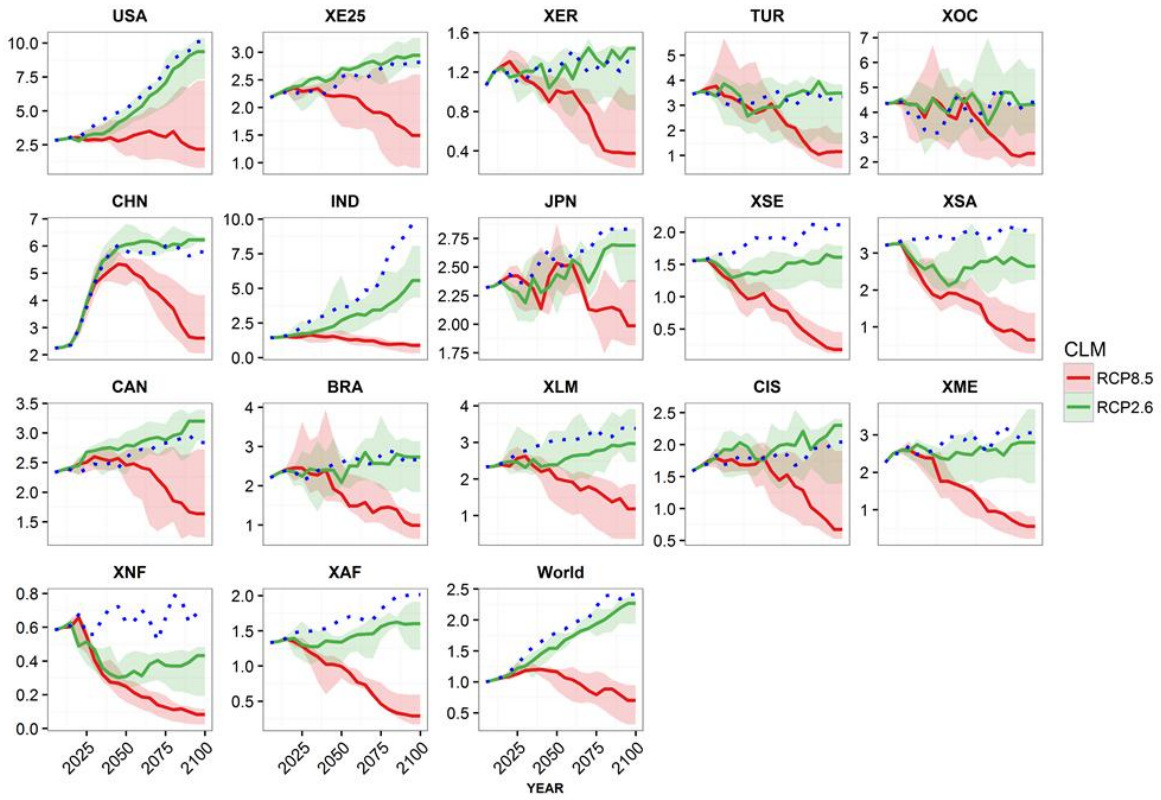

Figure S10. Yield change of oil seeds for the 17 regions of the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two climate change cases (green; RCP2.6 and red; RCP8.5) and the no climate change (NoCC) case (blue dot). The ribbon indicates the range of uncertainty of five general circulation models (GCMs). The unit is t/ha.

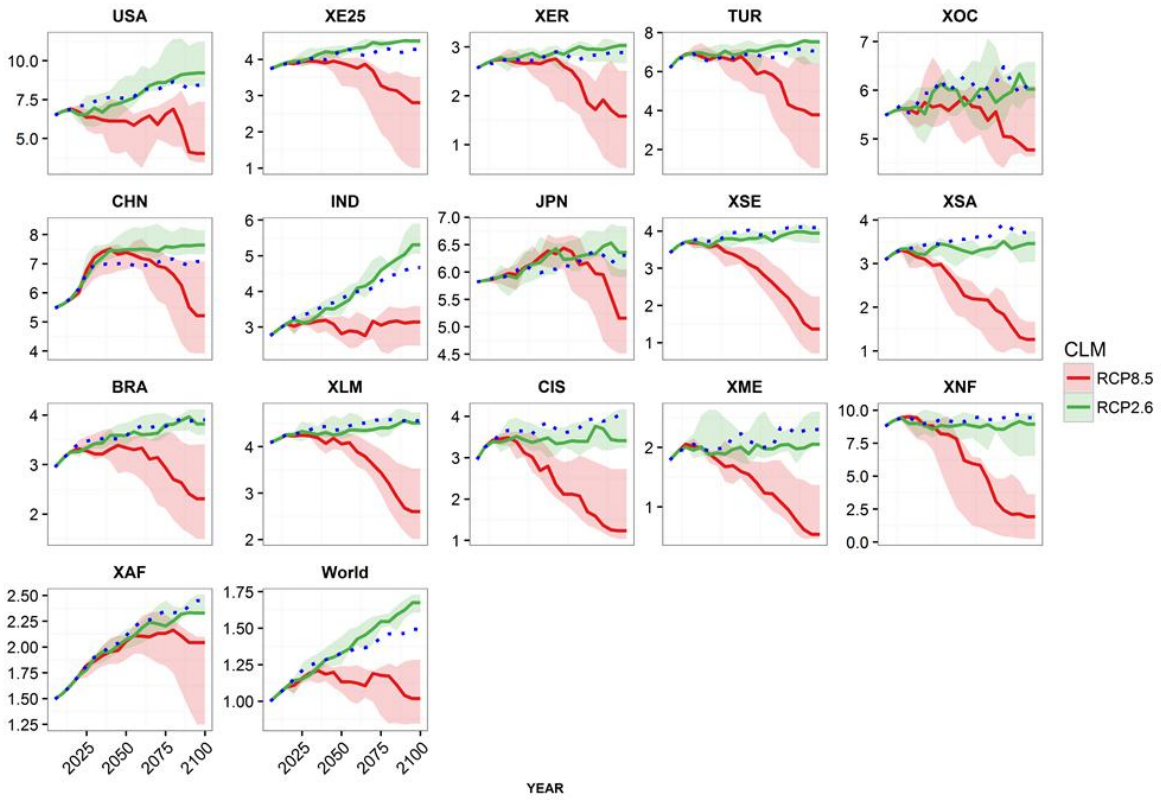

Figure S11. Yield change of rice for the 17 regions of the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two climate change cases (green; RCP2.6 and red; RCP8.5) and the no climate change (NoCC) case (blue dot). The ribbon indicates the range of uncertainty of five general circulation models (GCMs). The unit is t/ha.

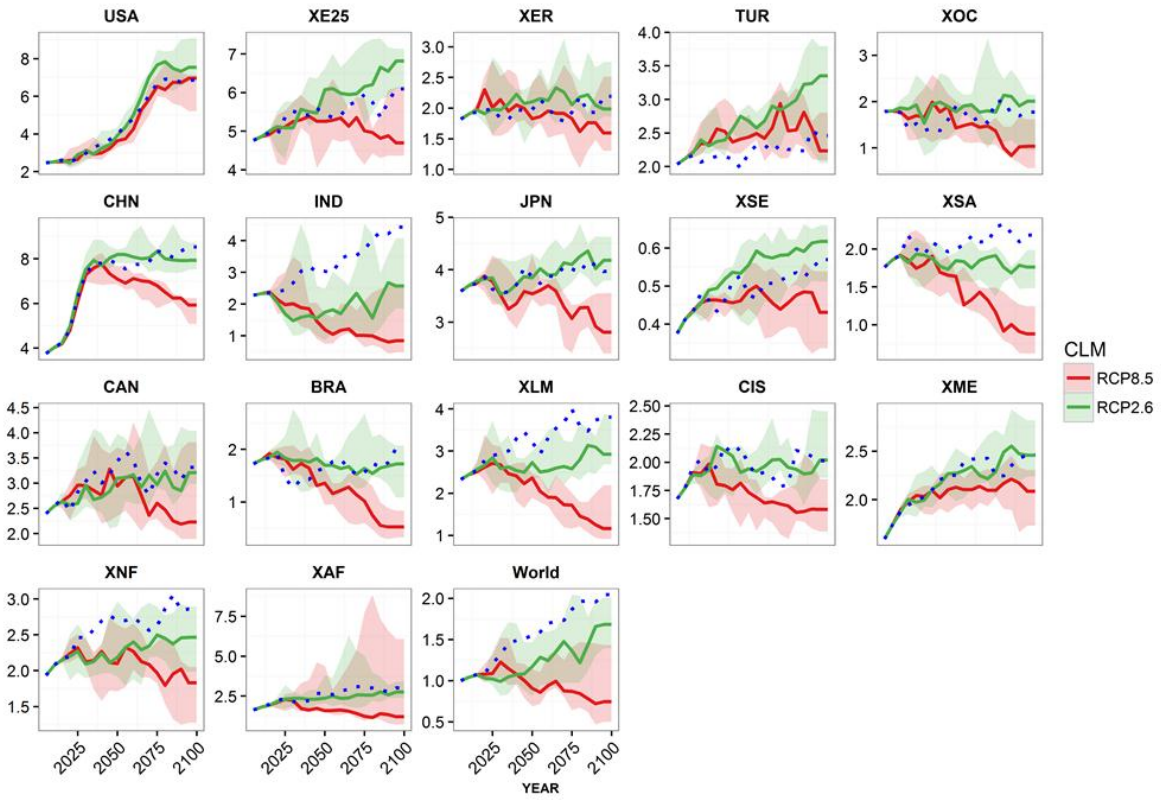

Figure S12. Yield change of wheat for the 17 regions of the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two climate change cases (green; RCP2.6 and red; RCP8.5) and the no climate change (NoCC) case (blue dot). The ribbon indicates the range of uncertainty of five general circulation models (GCMs). The unit is t/ha.

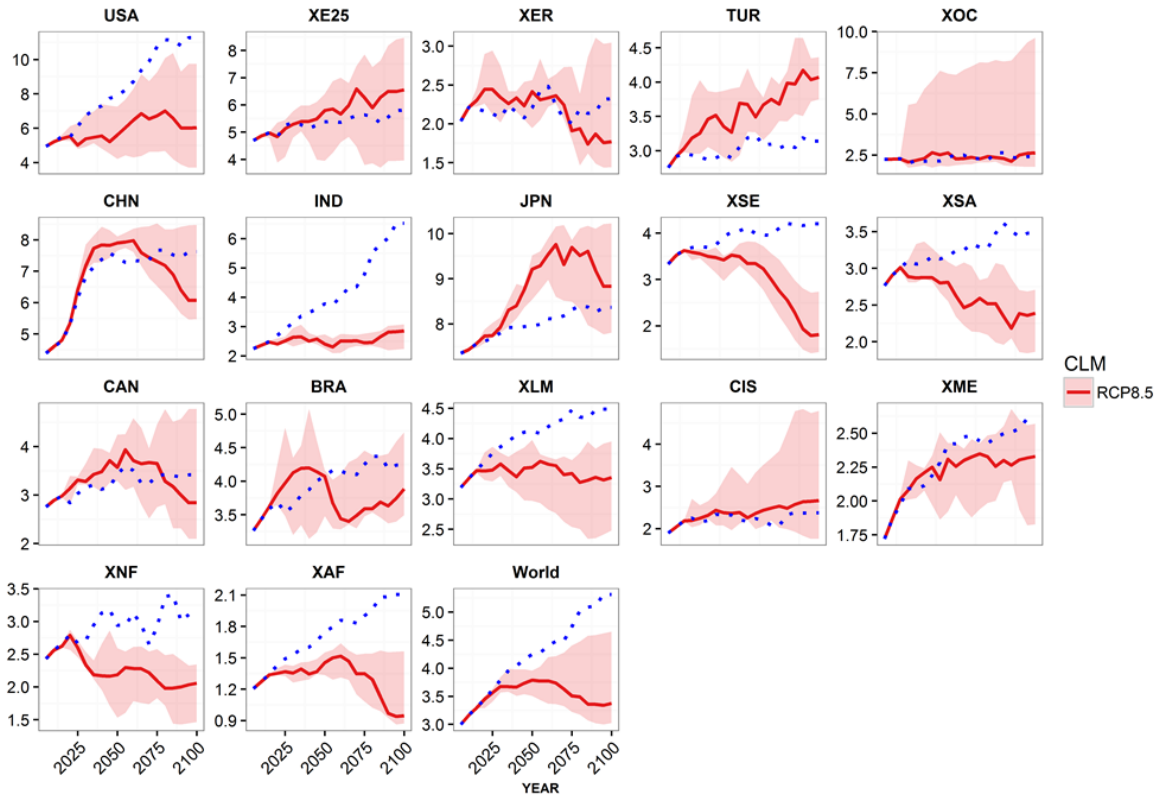

Figure S13. Yield change of five major crops for the 17 regions of the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in a climate change (RCP8.5) case and the no climate change (NoCC) cases (blue dot). The ribbon indicates the range of uncertainty of five general circulation models (GCMs). The unit is t/ha. Here, CO_2 fertilization is considered.

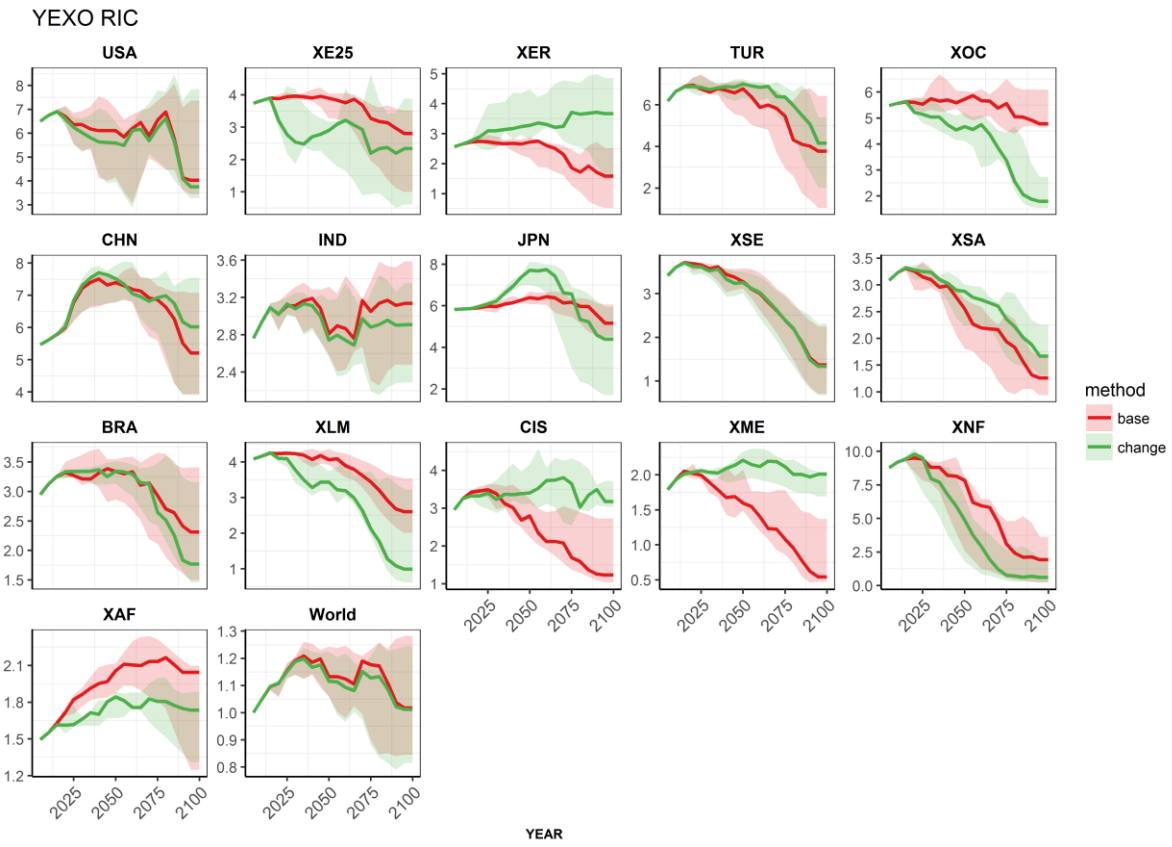

Figure S14. Rice yield for 17 regions in the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two gridded yield aggregation method associated with land-use change (red; fixed as base year harvested area and red; changed dynamically) under RCP8.5 and non-CO_2 fertilization cases. The ribbon indicates the range of uncertainty for five general circulation models (GCMs). The units are t/Ha.

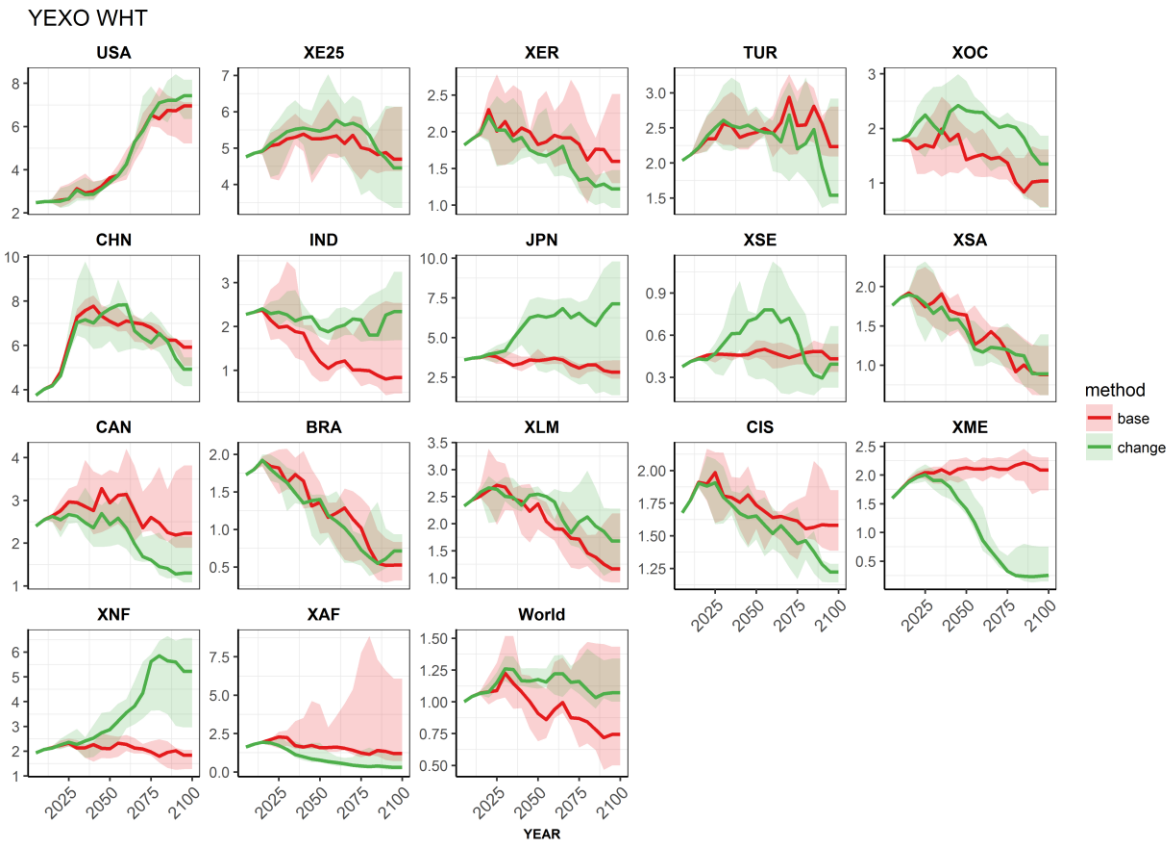

Figure S15. Wheat yield for 17 regions in the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two gridded yield aggregation method associated with land-use change (red; fixed as base year harvested area and red; changed dynamically) under RCP8.5 and non-CO_2 fertilization cases. The ribbon indicates the range of uncertainty for five general circulation models (GCMs). The units are t/Ha.

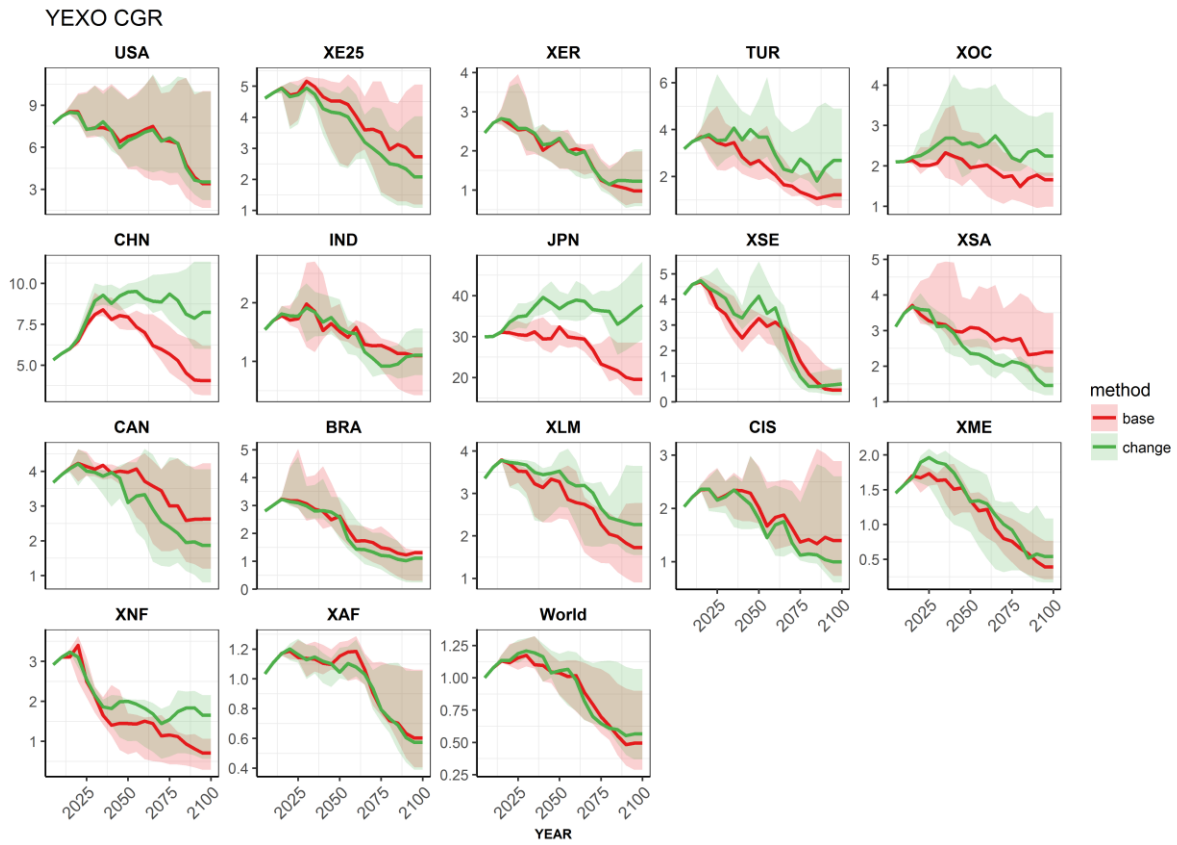

Figure S16. Coarse grain yield for 17 regions in the Asia-Pacific Integrated Model/Computable General Equilibrium (AIM/CGE) and the global average in two gridded yield aggregation method associated with land-use change (red; fixed as base year harvested area and red; changed dynamically) under RCP8.5 and non-CO_2 fertilization cases. The ribbon indicates the range of uncertainty for five general circulation models (GCMs). The units are t/Ha.

2. Supplementary Tables

Table S1. Regional classifications.

Code	Region	Code	Region
JPN	Japan	TUR	Turkey
CHN	China	CAN	Canada
IND	India	USA	United States
XSE	Southeast Asia	BRA	Brazil
XSA	Rest of Asia	XLM	Rest of South America
XOC	Oceania	XME	Middle East
XE25	EU25	XNF	North Africa
XER	Rest of Europe	XAF	Rest of Africa
CIS	Former Soviet Union		

Table S2. Land use classification.

Cropland	Wheat, irrigated
	Other coarse grains, irrigated
	Oil crops, irrigated
	Sugar crops, irrigated
	Rice, rainfed
	Wheat, rainfed
	Other coarse grains, rainfed
	Oil crops, rainfed
	Sugar crops, rainfed
	Other crops
	Bioenergy crops
Afforestation	
Settlement	
Ice and water	
Other land use	
Forest	
Pasture	
Other natural vegetation	

Table S3. Industrial classification.

Agricultural sector	Energy supply sector	Other production sector
Rice	Coal mining	Mineral mining and other quarrying
Wheat	Oil mining	Food products
Other grains	Gas mining	Textiles, apparel, and leather
Oil seed crops	Petroleum refinery	Wood products
Sugar crops	Coal transformation	Paper, paper products, and pulp
Other crops	Biomass transformation (1st generation)	Chemical, plastic, and rubber products
Ruminant livestock	Biomass transformation (2nd generation with energy crop)	Iron and steel
Raw milk	Biomass transformation (2nd generation with residue)	Nonferrous products
Other livestock and fisheries	Gas manufacture distribution	Other manufacturing
Forestry	Coal-fired power	Construction
	Oil-fired power	Transport and communications
	Gas-fired power	Other service sectors
	Nuclear power	CCS service
	Hydroelectric power	
	Geothermal power	
	Photovoltaic power	
	Wind power	
	Waste biomass power	
	Other renewable energy power generation	
	Advanced biomass-power generation	

Table S4. List of general circulation models (GCMs).

Code	Model name
ge2m	GFDL-ESM2M
hg2e	HadGEM2-ES
ipsl	IPSL-CM5A-LR
mes_	MIROC-ESM
ne1m	NorESM1-M

Table S5. Share of primary sector's value added in total GDP for SSP1, SSP2, and SSP3.

		SSP1		SSP2		SSP3	
	2005	2050	2100	2050	2100	2050	2100
United States	1.2%	0.6%	0.6%	0.7%	0.6%	0.7%	0.8%
EU25	2.0%	1.0%	0.5%	1.0%	0.5%	1.2%	0.9%
Rest of Europe	3.4%	1.4%	0.6%	1.4%	0.6%	1.9%	1.5%
Turkey	11.0%	4.9%	2.2%	4.9%	2.2%	6.9%	6.7%
Oceania	3.6%	2.4%	2.2%	2.4%	2.2%	2.4%	2.6%
China	12.5%	3.2%	2.4%	3.2%	2.4%	4.1%	4.0%
India	18.6%	5.4%	1.5%	5.4%	1.5%	11.3%	10.4%
Japan	1.5%	0.6%	0.3%	0.6%	0.3%	0.7%	0.5%
Southeast Asia	6.8%	2.3%	1.0%	2.3%	1.0%	3.5%	3.0%
Rest of Asia	18.5%	7.4%	2.1%	7.4%	2.1%	14.5%	13.5%
Canada	1.9%	1.2%	0.7%	1.2%	0.7%	1.2%	0.8%
Brazil	6.1%	2.2%	1.1%	2.2%	1.1%	3.2%	3.5%
Rest of South America	6.0%	3.4%	1.6%	3.4%	1.6%	4.6%	4.1%
Former Soviet Union	6.6%	2.4%	1.3%	2.4%	1.3%	3.0%	2.5%
Middle East	4.8%	2.5%	1.4%	2.5%	1.4%	3.6%	3.7%
North Africa	11.4%	4.2%	1.7%	4.2%	1.7%	6.6%	5.9%
Rest of Africa	16.2%	6.8%	2.6%	6.8%	2.6%	11.7%	11.8%
World	3.7%	2.3%	1.3%	2.3%	1.3%	3.2%	3.9%

Table S6. Price elasticity in 2050 baseline case. The numbers are derived from LES (Linear Expenditure System) consumption function.

	Wheat	Oil seed	Rice	Other grains	Other crops	Ruminant	Non-ruminant	Dairy product
USA	0.00	–0.05	0.00	0.00	0.00	–0.04	–0.04	–0.04
XE25	0.00	–0.05	0.00	0.00	0.00	–0.04	–0.04	–0.04
XER	0.00	–0.13	0.00	0.00	0.00	–0.06	–0.06	–0.06
TUR	–0.01	–0.05	–0.01	–0.01	–0.01	–0.10	–0.10	–0.10
XOC	0.00	–0.05	0.00	0.00	0.00	–0.05	–0.05	–0.05
CHN	0.00	–0.09	0.00	0.00	0.00	–0.05	–0.05	–0.05
IND	–0.02	–0.13	–0.02	–0.02	–0.09	N/A	–0.13	–0.13
JPN	0.00	–0.05	0.00	0.00	0.00	–0.07	–0.07	–0.07
XSE	0.00	–0.05	0.00	0.00	–0.04	–0.10	–0.11	–0.10
XSA	–0.02	–0.13	–0.02	–0.02	–0.09	–0.13	–0.13	–0.13
CAN	0.00	–0.05	0.00	0.00	0.00	–0.04	–0.04	–0.04
BRA	–0.02	–0.11	–0.02	–0.02	0.00	–0.05	–0.05	–0.05

XLM	–0.02	–0.11	–0.02	–0.02	0.00	–0.07	–0.07	–0.07
CIS	0.00	–0.13	0.00	0.00	0.00	–0.06	–0.06	–0.06
XME	–0.01	–0.08	–0.01	–0.01	–0.01	–0.13	–0.13	–0.13
XNF	–0.01	–0.08	–0.01	–0.01	–0.01	–0.12	–0.12	–0.12
XAF	–0.02	–0.14	–0.02	–0.02	–0.10	–0.18	–0.18	–0.18

Table S7. Income elasticity in 2050 baseline case. The numbers are derived from LES (Linear Expenditure System) consumption function.

	WHT	OSD	RIC	CGR	OCR	RUM	NRM	DRY
USA	0.01	0.09	0.01	0.01	0.01	0.07	0.07	0.07
XE25	0.01	0.09	0.01	0.01	0.01	0.07	0.07	0.07
XER	0.01	0.25	0.01	0.01	0.01	0.12	0.12	0.12
TUR	0.01	0.10	0.01	0.01	0.01	0.19	0.19	0.19
XOC	0.01	0.09	0.01	0.01	0.01	0.09	0.09	0.09
CHN	0.01	0.17	0.01	0.01	0.01	0.10	0.10	0.10
IND	0.03	0.25	0.03	0.03	0.17	NA	0.25	0.25
JPN	0.01	0.09	0.01	0.01	0.01	0.13	0.13	0.13
XSE	0.01	0.09	0.01	0.01	0.07	0.20	0.20	0.20
XSA	0.03	0.26	0.03	0.03	0.18	0.25	0.25	0.25
CAN	0.01	0.09	0.01	0.01	0.01	0.08	0.08	0.08
BRA	0.03	0.21	0.03	0.03	0.01	0.10	0.10	0.10
XLM	0.03	0.22	0.03	0.03	0.01	0.13	0.13	0.13
CIS	0.01	0.25	0.01	0.01	0.01	0.11	0.11	0.11
XME	0.01	0.16	0.01	0.01	0.01	0.26	0.26	0.26
XNF	0.01	0.16	0.01	0.01	0.01	0.23	0.23	0.23
XAF	0.03	0.26	0.03	0.03	0.18	0.33	0.33	0.33

Reference

1. Fujimori, S.; Hasegawa, T.; Masui, T.; Takahashi, K.; Herran, D.S.; Dai, H.; Hijioka, Y.; Kainuma, M. SSP3: AIM implementation of Shared Socioeconomic Pathways. *Glob. Environ. Chang.* **2017**, *42*, 268–283.