Supplementary Information for Fujimori et al.

Supplementary Tables

Supplementary Table 1 Regional categories

Code	Region
CHN	China (incl Hong-Kong, Macao)
IND	India
OAS	Other Asia (incl. Other Oceania)
SSA	Sub−Saharan Africa
ROW	Rest of the world
SEA	South-East Asia (incl. Japan, Taiwan)

Supplementary Table 2 Model characteristics

	AIM	MAGNET-IMAGE	CAPRI	GCAM	GLOBIOM	FARM
Afforestation representation	The key driver is carbon pricing on land carbon stock. Not only emissions but also carbon stock on land is priced which changes the land price.	Driven by carbon pricing - maximum rate of afforestation on agricultural land allowed of 0.4% per year	-	Carbon pricing of land carbon stock	The key driver is carbon pricing on land carbon stock	The key driver is productivity growth rate of forest products. Forests expand relative to cropland if forest productivity growth rate is less than crop productivity. Natural forests are protected.
Bioenergy representation	Endogenously determined by energy system side	Endogenously determined by MAGNET CGE model, order of magnitude in line with protocol	-	Endogenous (from energy system)	Endogenous (from energy system)	Endogenously determined by demand for bio-electricity
Non-CO_2 emissions reduction representation	Carbon pricing with consideration of GWP	Carbon pricing of all agricultural non-CO_2 emissions categories, MAC curves taken into account following Lucas et al., 2007	Carbon pricing of all agricultural non-CO_2 emissions categories, MAC curves taken into account following Lucas et al., 2007. Deactivated mitigation technologies	Price response from emissions rate multiplied by GWP multiplied by carbon price; exogenous marginal abatement curves based on EPA global mitigation analysis	Carbon pricing with consideration of GWP. Emission reduction from technologies, structural change and production effects.	none
Carbon price	Same as the protocol	Same as the protocol	Same as the protocol	Same as protocol except SSP1	Based on MESSAGE-GLOBIOM runs (for all SSPs)	Same as the protocol
Number of crop producs	7	8 (16 in IMAGE)	8 (35 in CAPRI)	17	8 (18 in GLOBIOM)	7
Number of livestock products	3	5	3 (15 in CAPRI)	5	3 (6 in GLOBIOM)	4
Number of regions	17	28 (26 in IMAGE)	13 (81 in CAPRI)	32	18 (37 in GLOBIOM)	13
Food demand determinants and assumptions	LES function which parameters are calibrated by income elasticities and price elasticities can be derived from its function	CDE function with income elasticities decreasing when PPP GDP per capita is increasing. Function is calibrated in such a way that maximal number of calories available for consumption is about 3200 kcal/cap/day.	Indirect utility functions depending on consumer prices and per capita income. The function is increasing in income given the Generalized Leontief formulation of the price functions. The utility function is calibrated to projected quantities and prices in the simulation year.	Income and prices; income elasticities are scenario-specific	Income and prices; income elasticities are scenario-specific	Two-level consumer demand system. The top level is a linear expenditure system (LES) calibrated to income elasticities. Second level is constant elasticity of substitution (CES).
Land competition	Multi-nomial logit	4-levels CET allocation tree.	Bi-level land supply function where the second level follows a likelihood Gamma density used to model transitions between land classes. Land supply is inelastic so that price increase of agricultural commodities rather increases land prices and not so much land use. The land demand function is parameterized based on yield and land price elasticities. The land supply and demand balance define the land rent that clears the balance.	Weibull-based logit function based on profitability of different land uses	Expansion cost considering land rent/profitability of different land uses	Land market for each agro-ecological zone (AEZ). Land is allocated among competing uses until rates of return to land are equal.
GWPs	CH_4:25, N_2O:298	CH_4:25, N_2O:298	CH_4:25, N_2O:298	CH_4:25, N_2O:298	CH_4:25, N_2O:298	CH_4:25, N_2O:298

Supplementary Table 3 Policy option combinations for core scenarios

	Baseline	Climate mitigation			
		Afforestation	Bioenergy expansion	Non-CO2 emissions reduction	Non-AgLU related mitigation
Baseline					
Mit_wAfff		√			
Mit_wBio			√		
Mit_wNonCO_2				√	
Mit_Full		√ *	√ *	√ *	√ *

* This scenario is only run by AIM, GCAM, FARM which represents explicit energy system.

Supplementary Table 4 Policy option combinations for sensitivity scenarios (only for AIM and GLOBIOM)

	Baseline	Climate mitigation			
		Afforestation	Bioenergy expansion	Non-CO2 emissions reduction	Non-AgLU related mitigation
Baseline					
Mit_woAfff			√	√	√ **
Mit_woBio		√		√	√ **
Mit_woNonCO_2		√	√		√ **

** Only AIM implemented

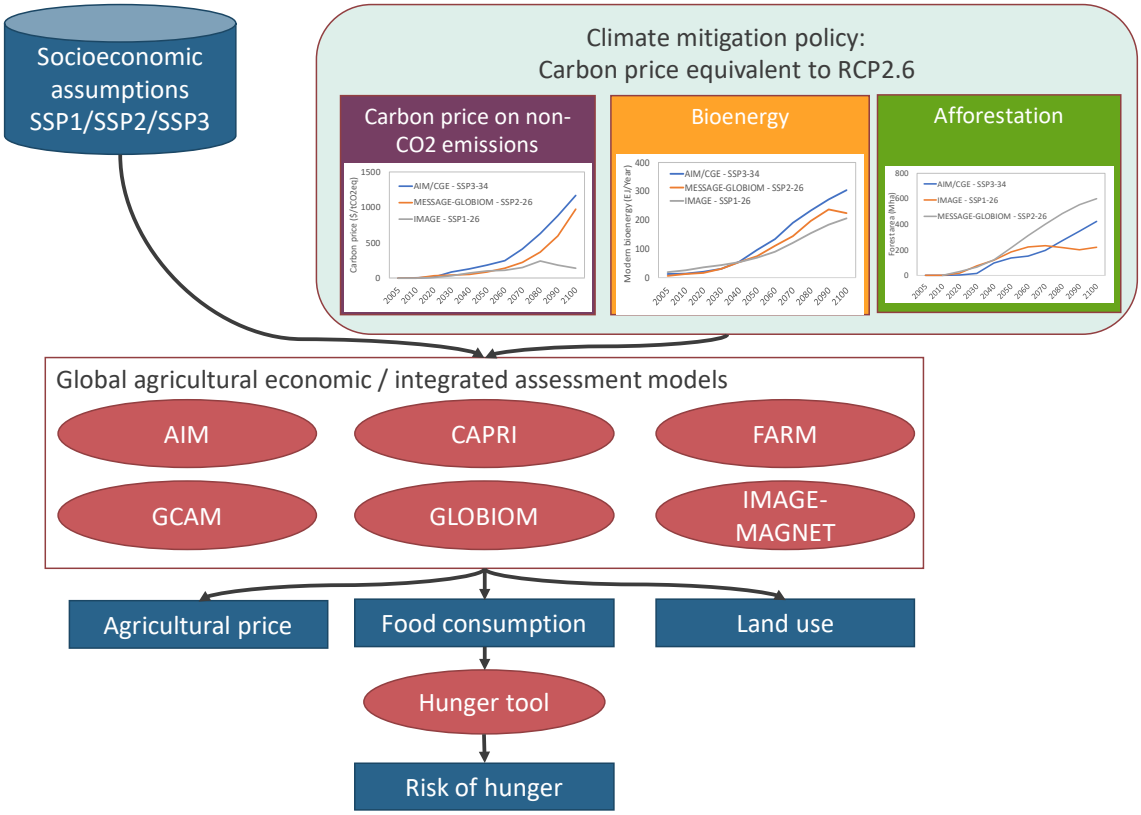
Supplementary Table 5 Scenario submission status by models

	AIM			CAPRI			FARM			GCAM			GLOBIOM			MAGNET-IMAGE		
Scenario names	SSP1	SSP2	SSP3	SSP1	SSP2	SSP3	SSP1	SSP2	SSP3	SSP1	SSP2	SSP3	SSP1	SSP2	SSP3	SSP1	SSP2	SSP3
Baseline	√	√	√	√	√	√		√		√	√	√	√	√	√		√	
Mit_wAfff	√	√	√					√		√	√	√	√	√	√		√	
Mit_wBio	√	√	√					√		√	√	√	√	√	√		√	
Mit_wNonCO_2	√	√	√	√	√	√				√	√	√	√	√	√		√	
Mit_Full	√	√	√					√		√	√	√	√	√	√		√	
Mit_woAfff		√												√				
Mit_woBio		√												√				
Mit_woNonCO_2		√												√				

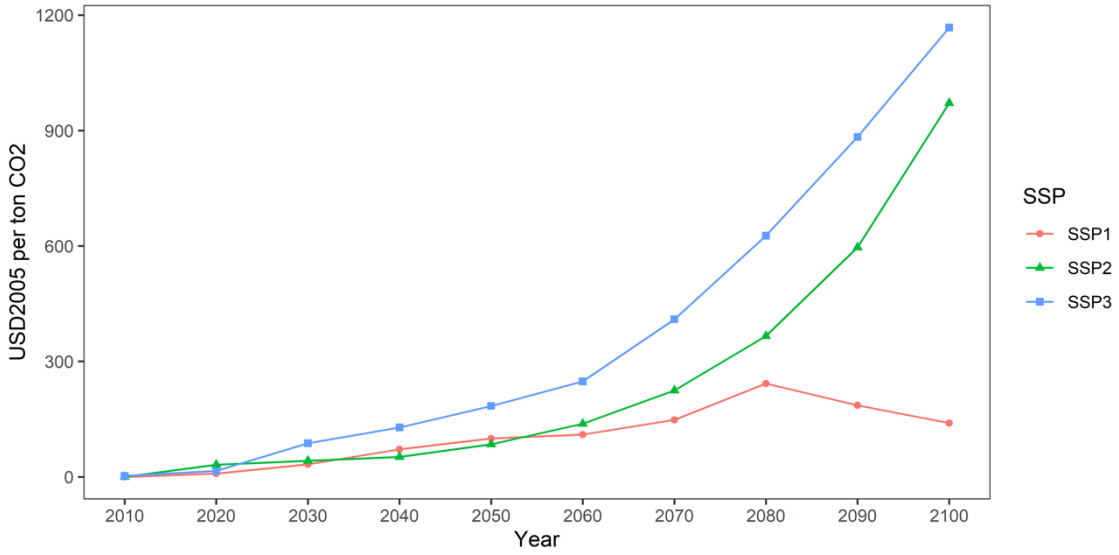
Supplementary Table 6 Decomposition method

Models	Difference from baseline	Difference from full mitigation
	Core scenarios	
GLOBIOM, CAPRI, IMAGE-MAGNET	$NonCO_2$ = Mit_w$NonCO_2$ - Baseline	Bio + Aff = Mit_Full - Mit_w$NonCO_2$
	Bio = Mit_wBio - Baseline	$NonCO_2$ + Aff = Mit_Full - Mit_wBio
	Aff = Mit_wAff - Baseline	$NonCO_2$ + Bio = Mit_Full - Mit_wAff
	Full = Mit_Full - Baseline	Full = Mit_Full – Baseline
AIM, GCAM, FARM	$NonCO_2$+non-AgLU=Mit_w$NonCO_2$- Baseline	Arithmetically equivalent with “difference from baseline”
	Bio + non-AgLU=Mit_wBio-Baseline	
	Aff + non-AgLU = Mit_wAff - Baseline	
	Full = Mit_Full - Baseline	
	Sensitivity scenarios	
GLOBIOM, CAPRI, IMAGE-MAGNET	Bio + Aff = Mit_wo$NonCO_2$ - Baseline	$NonCO_2$ = Mit_Full - Mit_wo$NonCO_2$
	$NonCO_2$ + Aff = Mit_woBio - Baseline	Bio = Mit_Full - Mit_woBio
	$NonCO_2$ + Bio = Mit_woAff - Baseline	Aff = Mit_Full - Mit_woAff
	Full = Mit_Full - Baseline	Full = Mit_Full – Baseline
AIM, GCAM, FARM	Arithmetically equivalent with “difference from full mitigation”	$NonCO_2$ = Mit_Full - Mit_wo$NonCO_2$
		Bio = Mit_Full - Mit_woBio
		Aff = Mit_Full - Mit_woAff
		Full = Mit_Full – Baseline

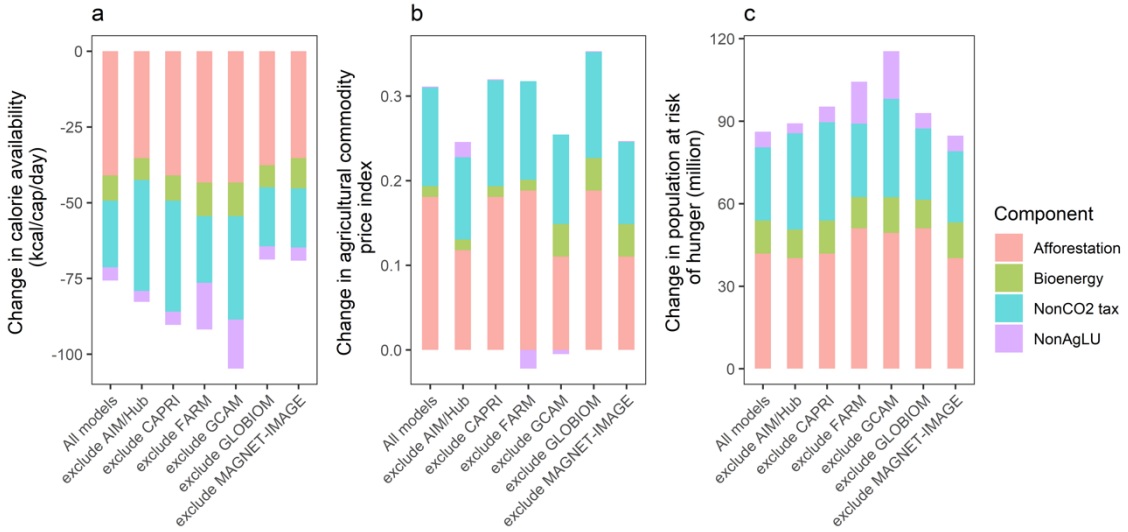
Supplementary figures



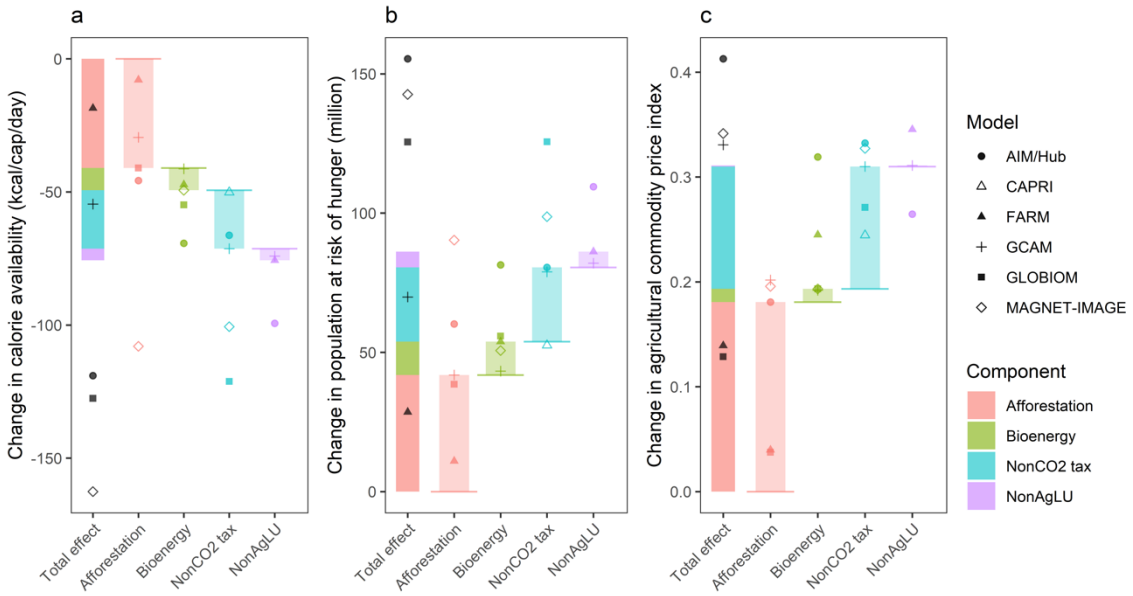
Supplementary Figure 1 Overall research framework



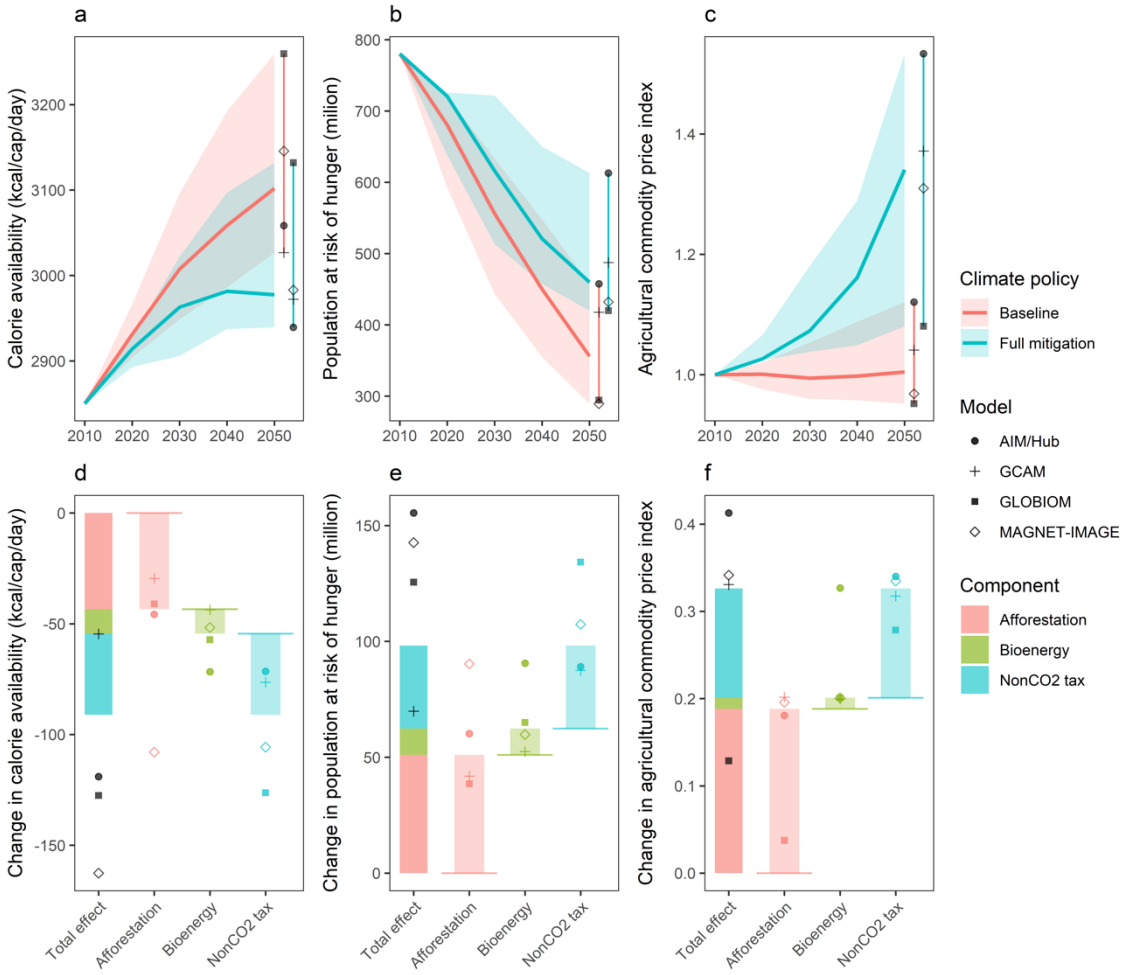
Supplementary Figure 2 Carbon price pathways for mitigation scenarios equivalent to RCP2.6 or well below 2 °C climate stabilization for each SSP



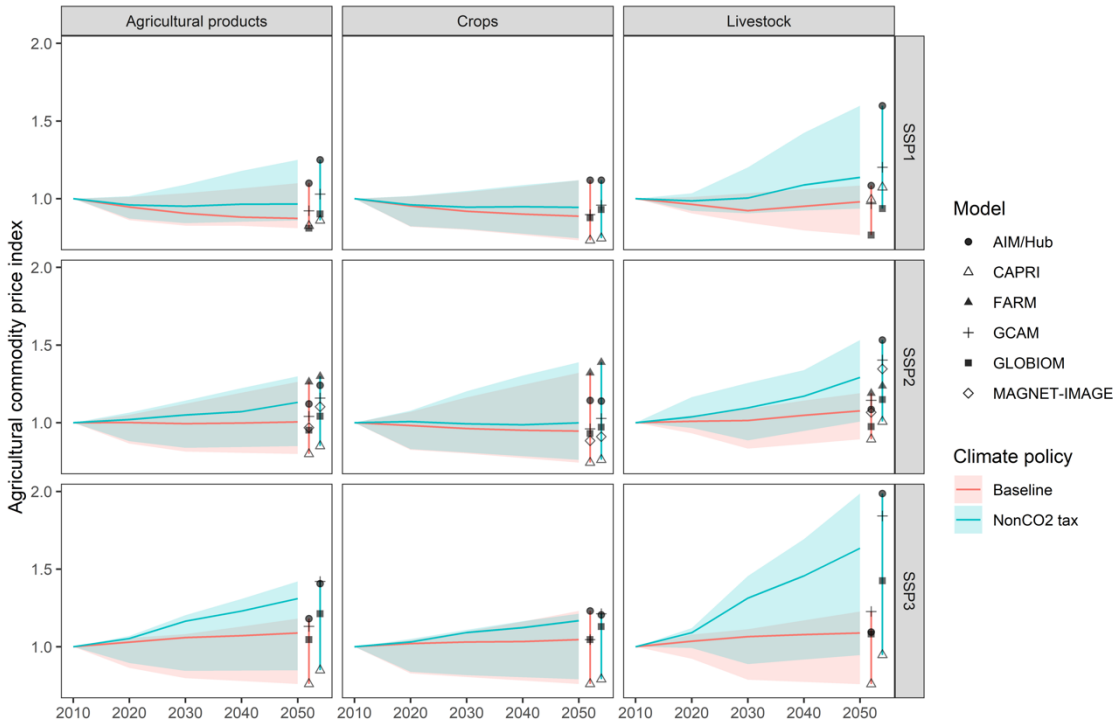
Supplementary Figure 3 A sensitivity test results of decomposition of effects of three mitigation measures on calorie intake, agricultural price index and risk of hunger for SSP2 by extracting one model for each.



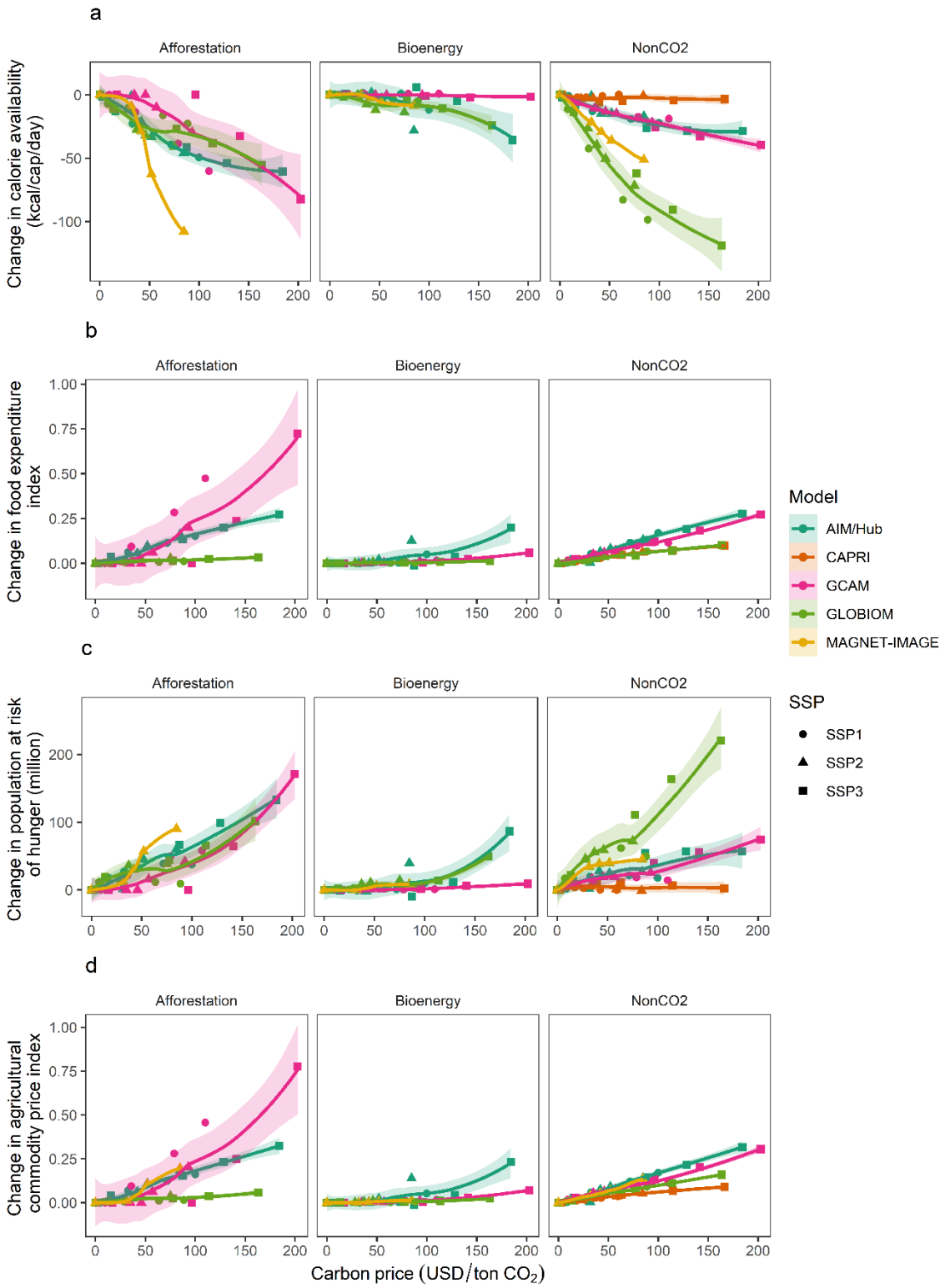
Supplementary Figure 4 Global decomposition results with non-agricultural and non-land use effect in 2050 for SSP2.



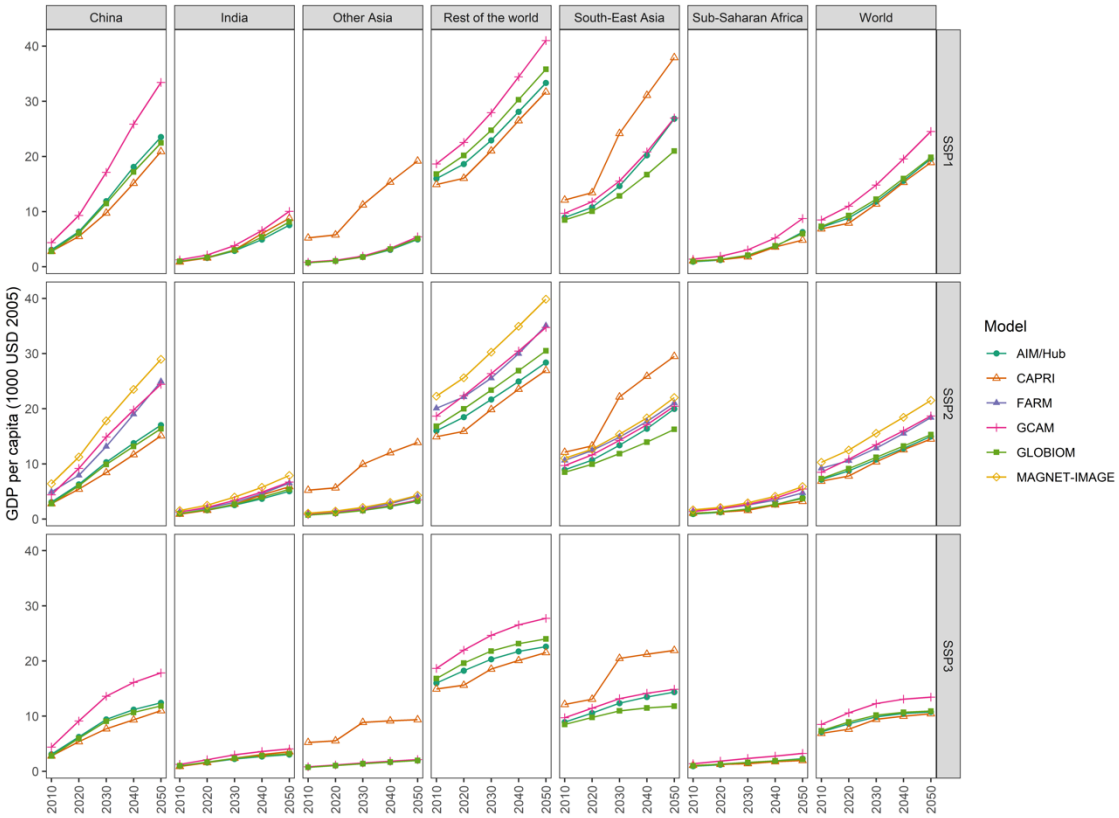
Supplementary Figure 5 Calorie availability (a), population at risk of hunger (b), and agricultural commodity price (c) in baseline and full mitigation scenarios, and the effects of each land-based mitigation measures on their change (d-f) for SSP2. All panels are based on four models with complete scenarios.



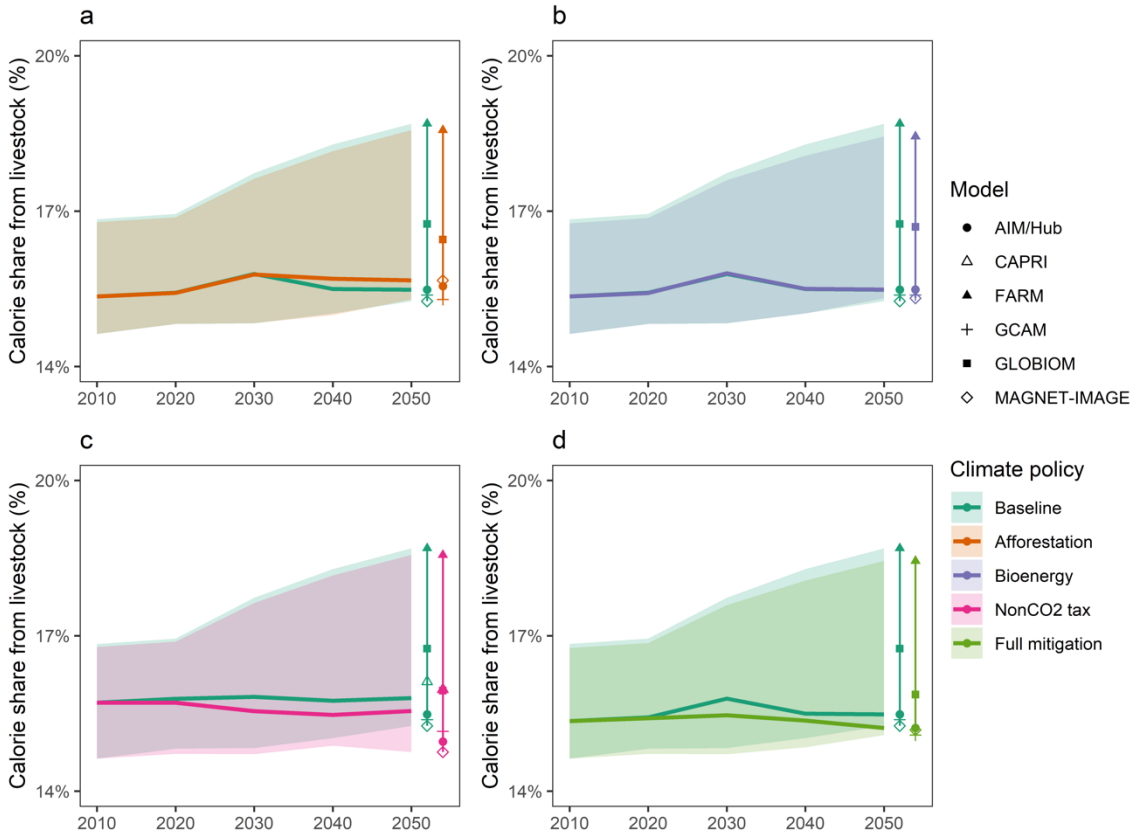
Supplementary Figure 6. Change in price index for agricultural products, crops and livestock by non CO_2 tax policy



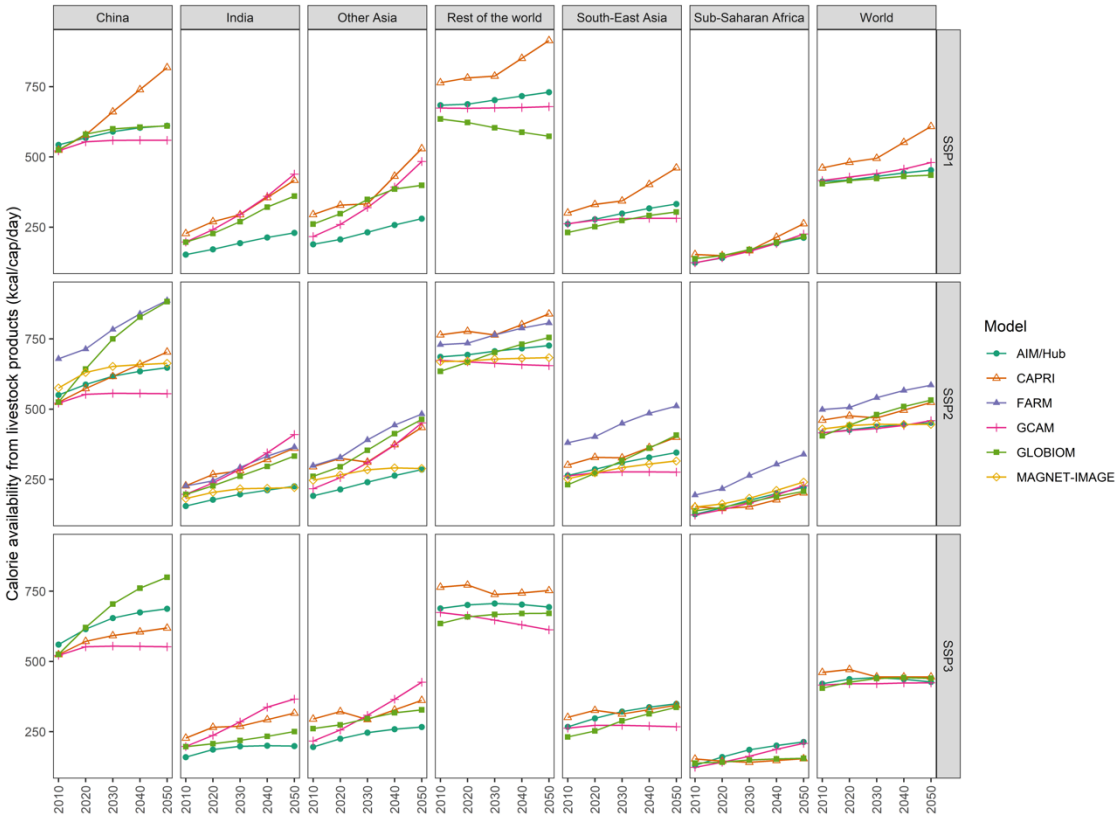
Supplementary Figure 7 Effects of each land-based mitigation measures on calorie availability (a), food expenditure index (b), population at risk of hunger (c), and agricultural commodity price index (d).



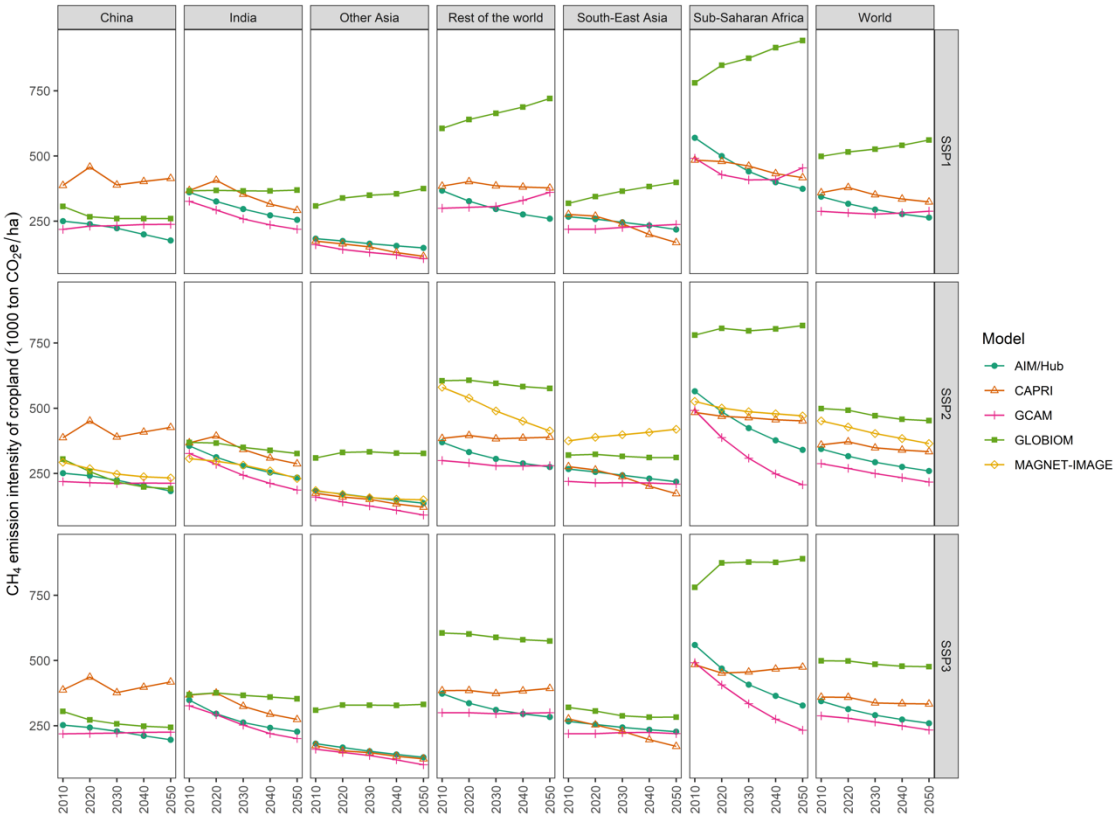
Supplementary Figure 8 GDP per capita in baseline scenarios by regions.



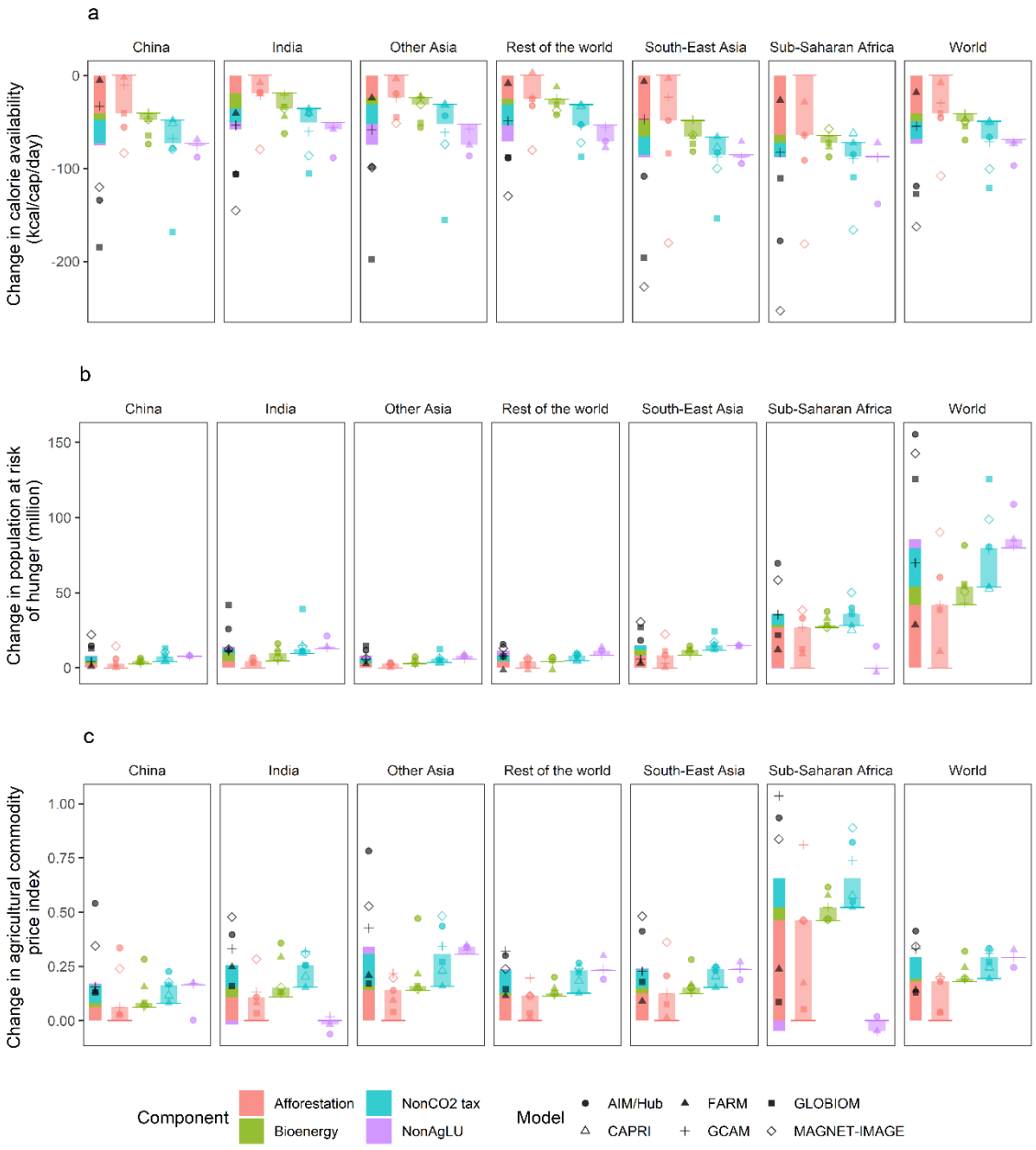
Supplementary Figure 9. Calorie share from livestock products in baseline and afforestation policy scenario (a), bioenergy scenario (b), non-CO_2 tax scenario (c), and full mitigation scenario (d).



Supplementary Figure 10 Calorie availability from livestock products in baseline scenario



Supplementary Figure 11 CH_4 emission intensity of cropland in baseline scenarios



Supplementary Figure 12 Regional decomposition results with non-agricultural and non-land use effect (NonAgLU) in 2050 for SSP2.