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The Role of Agricultural Systems Conservation and Regeneration to Adapt to and Mitigate Climate Change

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National Agriculture and Food Research Organization

Topics

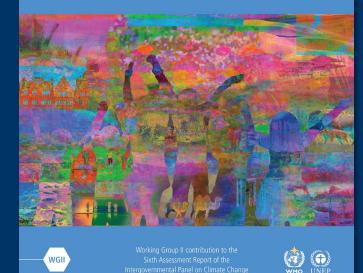


- Messages from IPCC AR6 WG2 report related to sustainable food production
 - Impacts of climate changes and associated risks
 - Assessment of adaptations
- Post-AR6 literature related to climate action using sustainable food production
 - Climate change adaptation
 - Climate change mitigation
- □ Challenges

Note: This presentation will cover several similar approaches to sustainable food transformation without distinction.



Climate Change 2022 Impacts, Adaptation and Vulnerability



A brief summary of the IPCC WG2 AR6:

The scientific evidence is unequivocal: climate change is a threat to human wellbeing and the health of the planet.

Any further delay in concerted global action will miss the brief, rapidly closing window to secure a liveable future.

This report proposes solutions to the world.





INTERGOVERNMENTAL PANEL ON Climate change



Food, fibre, and other ecosystem products

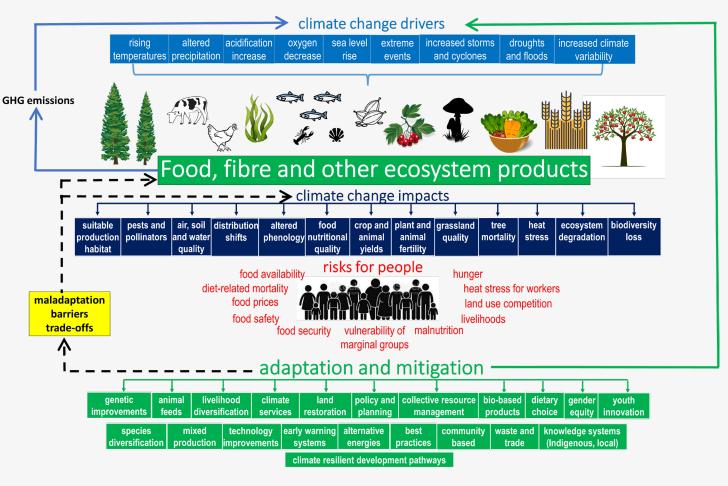
Chapter 5 provides a global assessment of climate change impacts and risks to agriculture, forestry, fisheries and aquaculture, as well as adaptation solutions and limits.

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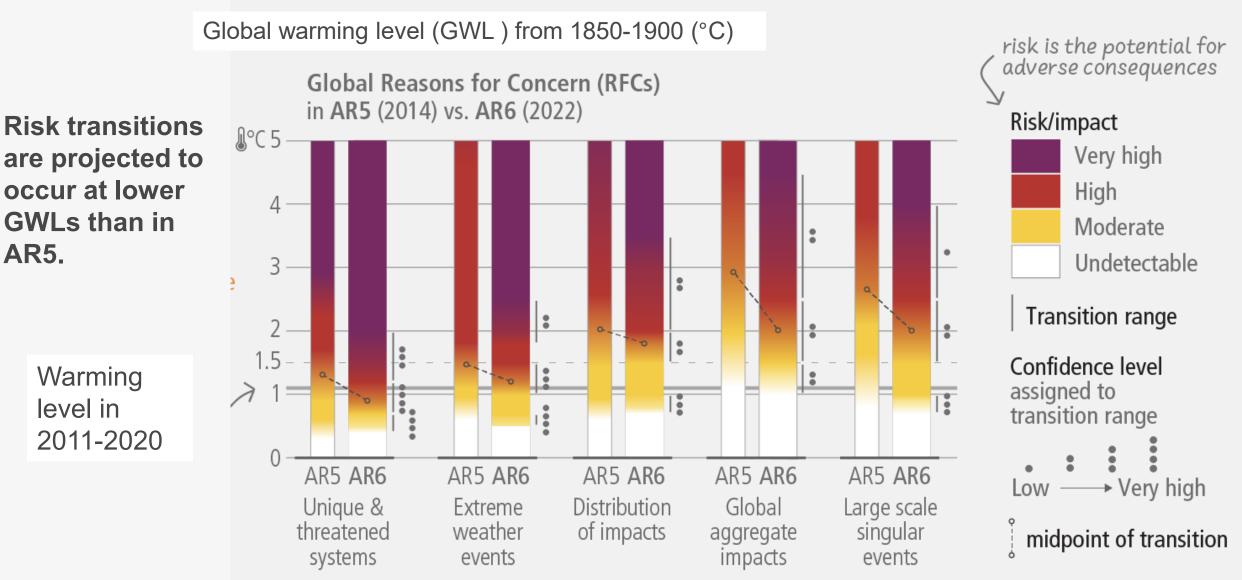


Working Group II – Impacts, Adaptation and Vulnerability

IPCC INTERGOVERNMENTAL PANEL ON CLIMATE CHANEE



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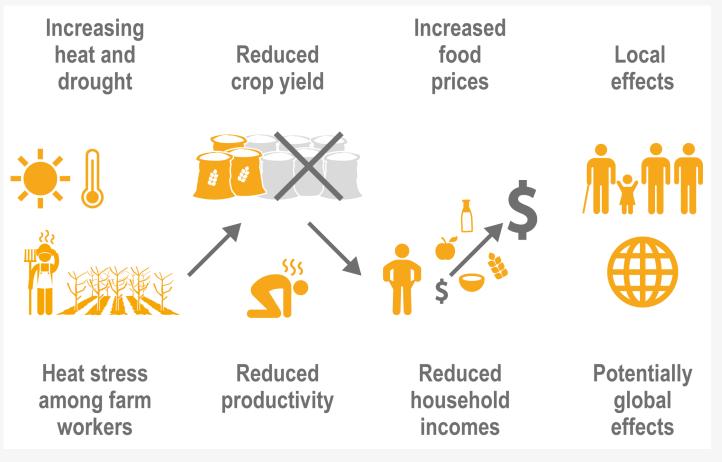


IPCC AR6 Synthesis report SPM figure

INTERGOVERNMENTAL PANEL ON Climate change

UNEP

Many risks are compounding and cascading:



IPCC AR6 WG2

See also this for a review on breadbasket failures.

Hasegawa, T., Wakatsuki, H., Nelson, G.C., 2022. Evidence for and projection of multi-breadbasket failure caused by climate change. Curr. Opin. Environ. Sustain. 58, 101217. https://doi.org/10.1016/j.cosust.2022.101217

INTERGOVERNMENTAL PANEL ON CLIMATE Change

Action on adaptation has increased

Effective options:

- Cultivar improvements
- Agroforestry
- Farm and landscape diversification
- Community-based adaptation
- Strengthening biodiversity

Wider benefits:

- Food security and nutrition
- Health and well-being
- Livelihoods







[Jacquelyn Turner / CCAFS CC BY-NC-SA 2.0; FAO / Riccardo De Luca]

SIXTH ASSESSMENT REPORT

Working Group II – Impacts, Adaptation and Vulnerability

ipcc WMO UNEP INTERGOVERNMENTAL PANEL ON Climate change

Systematic review	Adaptati	daptation options addressing the Sustainable Development Goals													Sustainable Development Goals			
provides evidence of			SDG 1	SDG SDG	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 14	SDG 15	SDG 16		
synergies of adaptation with SDGs.		Infrastructure & technological			•		•		•			•		•	•	0		
	Adaptation	Sustainable intensification			0	0	•	0		0	0	0		.0		0		
	categories	Nature-based adaptation	ŏ			•	•		•		•	•	•		•	0		
		Social, Economic & institutional	Ŏ	•	•	•	•	•	•	•	•	•		•	•	0		
1 POVERTY DESCRIPTION 2 ZERO HUNGER SSS 12 RESPONSIBLE CONSUMPTION AND PRODUCTION		Irrigation		• •	•	•	٠	0	•	•			٠	0		0		
	Adaptation	Fertilizer	•	• •		0		0	•	0	0	0	•	0		0		
	options	Cultivar & species improvement	•	• •	0	0	0	0	•	0	0	0	•	0	•	na		
		Adjustment of planting dates	•	• •	0	na	•	na	•	0	na	0	•	0	0	na		
		Shifting harvest location	•	• •	0	0	•	0	0	0	0	0	•	0	0	0		
		Agricultural diversification		• •	0	0	0	0	۲	0	0	0	•	0		0		
		Agroecology		•	0	0	۲	0	•		0		•		•	0		
		Agroforestry	•	• •	0	0	0.	0	0	0	0	0	•	na	0	0		
		Climate services	•	• •	۰	0	•	0	•		0		٠		0	0		
		Insurance	•	• •	0	0	0	0	•	0	0			0	0	0		
		Other financial mechanisms	•	• •	0	0	•	0	•	0	0	0	•		0	0		
		Livelihood diversification & migration		•	0	0	۲	0	•	0		0	•			0		
		Climate-smart strategies		• •	0	0	0	na	۰	0	0	0		na	na	na		
		Community-based adaptation		• 0	0	0		0	۰	0	0	0	•	0	0	0		
		Amount of evidence Confidence level																
		Allou												na = no data ava				
IPCC WG2 AR6 Chp	. 5	1 10	0 200	>300			Limited or none	Low	Medi	um H	igh INTERGO	OVERNME	NTAL PANE		ιþ	CC		

SIXTH ASSESSMENT REPORT

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- Autonomous adaptation measures are being deployed
- Common strategies include switching crop cultivars, soil organic management, or the timing of crop planting or animal stocking.
- Sustainable approaches are reported particularly in African countries

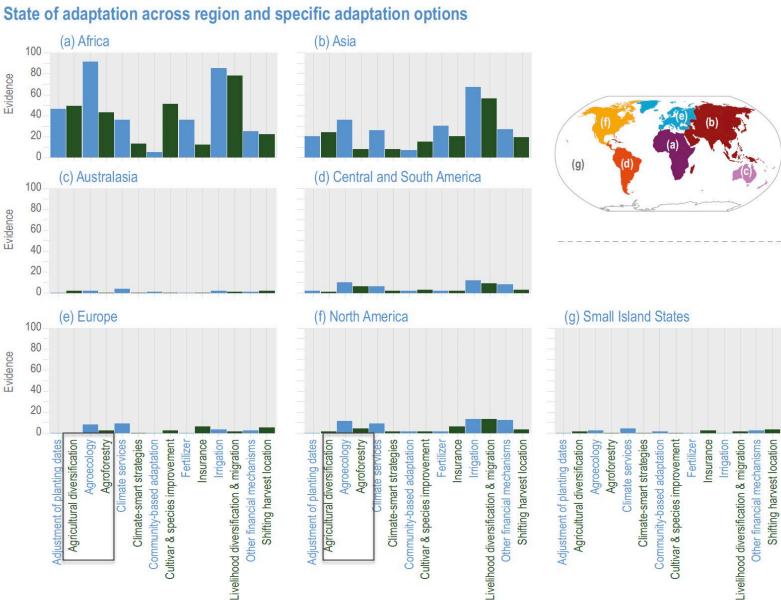


Figure 5.20 | Observed adaptation across regions in food, fibre and other ecosystem products based on the GAMI database (Berrang-Ford et al., 2021a). The bars indicate the number of evidence for the options x region.

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INTERGOVERNMENTAL PANEL ON Climate change

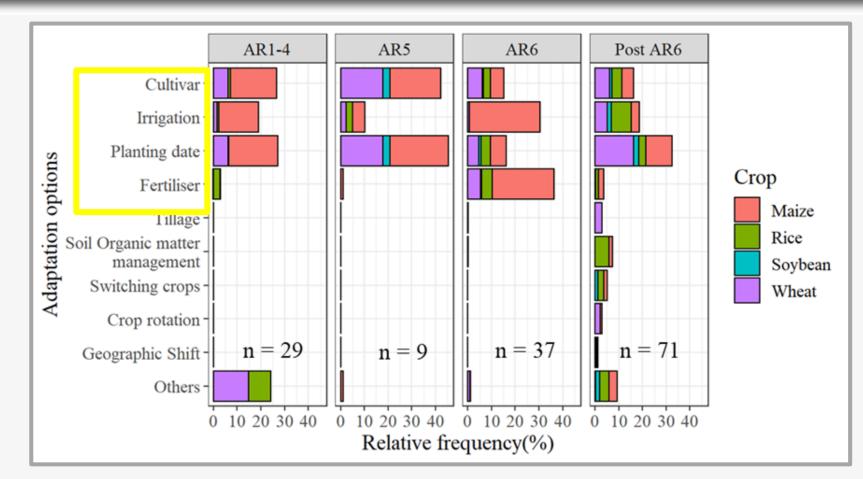
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Some adaptations effects are quantified





A systematic review for the crop simulation studies (Wakatsuki et al., 2023)

These measures are not enough to offset negative impacts and risks.

Few sustainable management practises have been quantitatively assessed using simulation models, but new studies such as 'agroforestry', 'organic farming', 'climate-smart agriculture', and 'cropping system diversification' are emerging.

Adaptation feasibility and effectiveness assessment in AR6

		(a) Feasibility													
Adaptation categories	Adaptation option		Economic	Environmental		Geophysical	Institutional		Social	Technological	(b) Et	ffecti	venes	S
Shift in production	Substitution change plant or animal type	2.8			3.0	2.9	3.0	2.8 2.	6 2.7	2.5	1.77	2.17	2	.75	1.0
ľ	Regional local, food systems strengthening	3.0			2.9		2.6	2.	6	2.0					1.0
Policy and planning	Local governance	2.5			2.8	2.3	2.6	2.	6 2.5	2.6	1.5	2.5	(2.3 2.3	0
	Community based adaptation	2.4	2.4	2.6	2.8	2.3 2.2	2.7	2.7 2.	6 2.6	2.4	2.1	2.6	2.8	2.4 2.2	1.2
Livelihood diversification	Diversification of livelihoods	2.2		2.7	2.6	2.0	2.1		2.5	2.3	1.7	2.3	2.7	2.5	1.3
Genetic improvement	Conventional breeding	2.4	2.7	2.8	2.9	2.0	2.7	2.6	2.5	2.0	2.4	2.7	(2.6	1.6
Collective resource	Community seed/feed/fodder banks	3.0			3.0				3.0	2.3	2.7				1.0
management	Community forest management	2.4	2.7	3.0	2.9	2.6 2.3	2.6	2.2 1.	9 3.0	2.7	1.4	2.9	3.0	2.6 2.3)
Climate services Improving	weather forecasting & early warning systems	2.9		3.0	2.5	2.4 2.1	2.6	1.	8 2.3	2.3	1.3	2.4	2.5	2.9 2.1	1.3
Agronomic management (farm level) Organic management	2.6	1.8	2.9	2.9		1.8	1.0		2.3	2.0		20	1	1.5
	Mixed systems	2.6	2.2	2.8	2.8	2.4 2.1	2.2	1.9 2.	2 5	2.1	2.7	2.7	2.8	5 2.1	1.1
Agricultural	Agroecological approaches	2.8		3.0	3.0	2.6	2.7	2.5 2.	0 0	2.6	2.6	2.1	3.0	6	1.0
diversification	On-farm diversification	2.5	2.6	3.0	2.8	2.8	1.9	1.5 1.	8 5	2.4	2.5	2.8	2.9	5	1.1
	Landscape diversification	2.3	2.2	2.9	2.9	2.8	2.6	2.5 2.	0 7	2.4	2.3	2.8	2.8	3	1.3
Assessement score Low (1)	Medium High (3)	Microeconomic viability-	Macroeconomic viability-	Ecological capacity-	Adaptive capacity/resilience building potential -	Physical feasibility- Transparency & accountability potential-	Political acceptability-	Legal, regulatory feasibility- Institutional canacity & administrative feasibility-		Technical reources availability-	Reduced risk vulnerability-	Enhanced social wellbeing	Improved environment-	Increased economic resources- Strengthen institutions-	Maladaptive
				Ad			Instit								

Most options are technically feasible, with generally high political and social acceptability.

Sustainable approaches generally have high effectiveness in improved environment, but most adaptation options have limited evidence for institutional feasibility.

INTERGOVERNMENTAL PANEL ON Clim

Approaches to sustainable transformation in agriculture



Literature related to Agroecology, regenerative agriculture, and nature-based solutions

Recent history of academic papers containing the three terms, from 2011-21

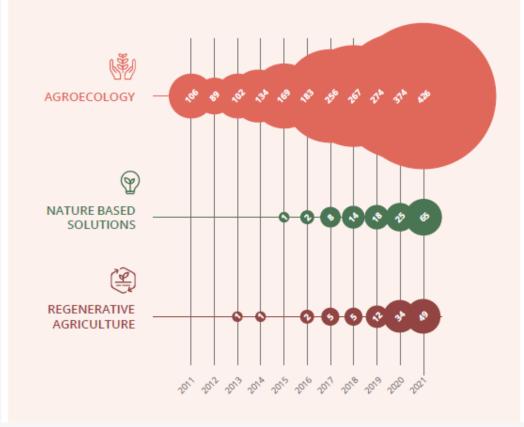


Figure 3 provides an illustration of trends over the last decade, illustrating the predominance of agroecology but the recent rapid expansion of the other terms, particularly nature-based solutions related to agriculture and farming. Section 5 of this report will provide further evidence of this trend by referencing global policy spaces that have adopted this concept.

FIGURE 3

Agroecology has been by far widely used for an extended period.

Source: IDS & IPES-Food, 2022. Agroecology, regenerative agriculture, and nature-based solutions: Competing framings of food system sustainability in global policy and funding spaces., Drawdown. https://www.ipes-food.org/_img/upload/files/SmokeAndMirrors_BackgroundStudy.pdf

Literature related to climate change (climate resilience)



Web of Science literature search using five terms AND (climate change or climate resilience) as of November, 2023

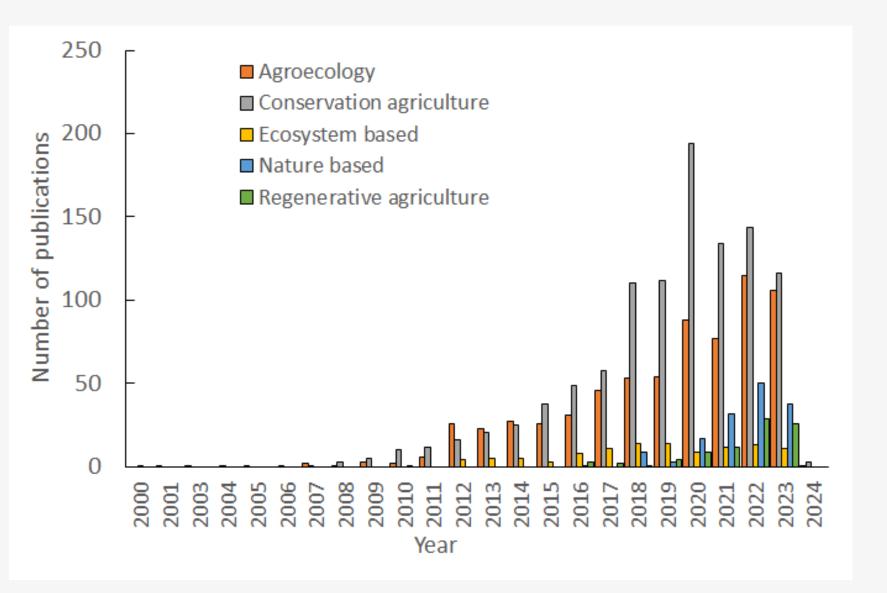
In the context of climate change or climate resilience, **conservation ag and agroecology** have been reported

more frequently than others.

Literature on

regenerative

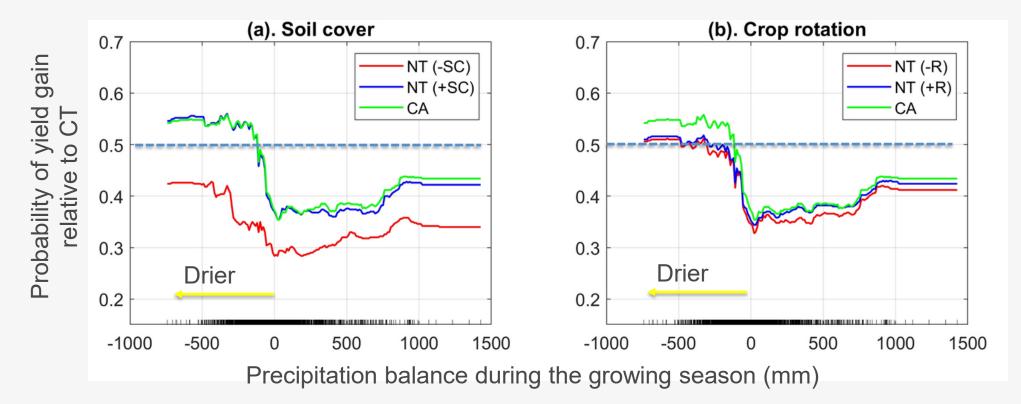
agriculture in the context of CC is emerging.



A global meta-analysis in the context of climate change adaptation



Testing three principles of conservation agriculture (**CA**): permanent soil cover (**SC**), minimising soil disturbance (no till, **NT**), and diversifying crops (Rotation, **R**) relative to conventional tillage (**CT**) (Su et al., 2021).

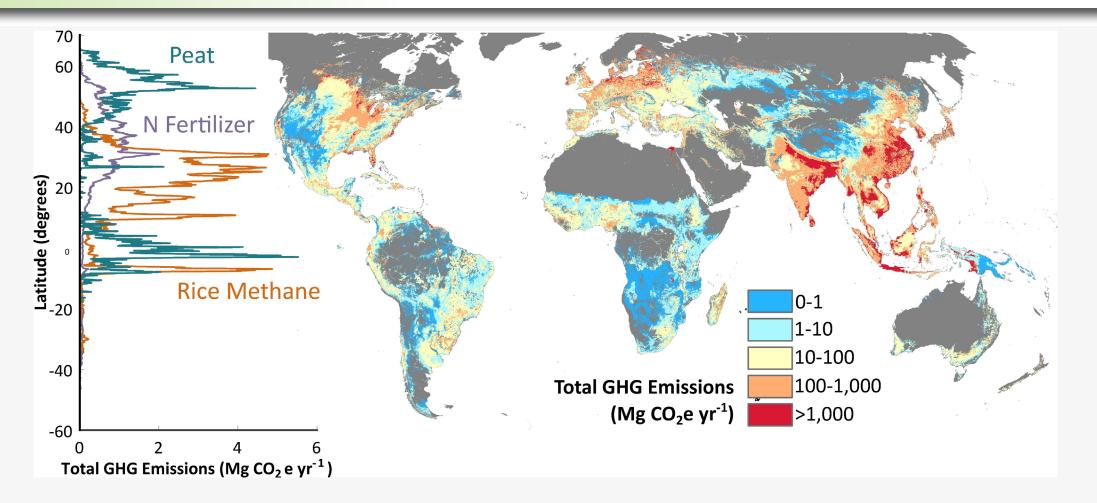


Impact of crop management practices on CA performance, shown in 1-dimension partial dependence plot of the probability of yield gain as a function of precipitation balance (mm). ± SC indicates NT with/without soil cover. ± R indicates NT with/without rotation. ± F indicates NT or CA and CT with/without fertilization. ± WD indicates NT or CA and CT with/without weed and pest control. Plot a compares the productive performance of CA, NT+SC, and NT-SC. Plot b compares the productive performance of CA, NT+R, and NT-R.

Su, Y., Gabrielle, B., Beillouin, D., Makowski, D., 2021. High probability of yield gain through conservation agriculture in dry regions for major staple crops. Sci. Rep. 11, 1–8. https://doi.org/10.1038/s41598-021-82375-1

GHG emissions from cropland



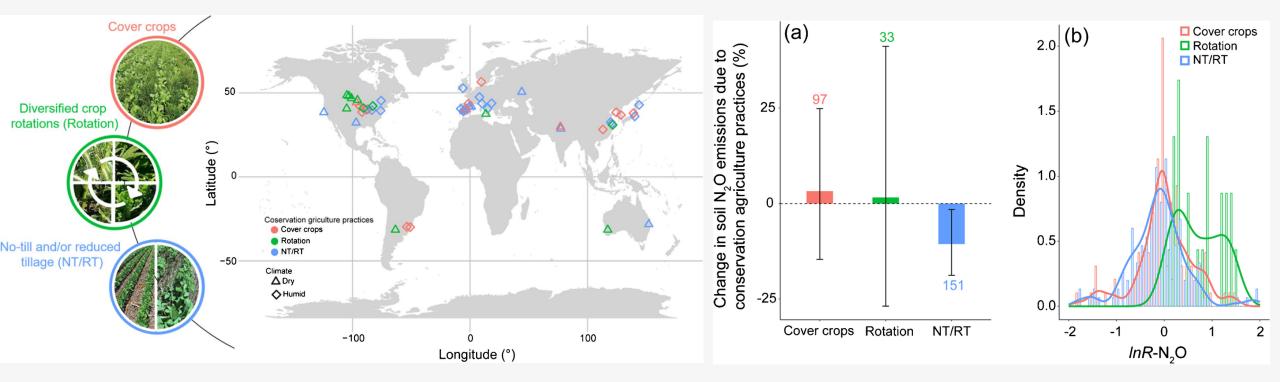


Cropland GHGs consist of CH_4 from rice cultivation, CO_2 , N_2O , and CH_4 from peatland draining, and N_2O from N fertiliser application. Total emissions from each grid cell are concentrated in Asia, and are distinct from patterns of production intensity (Carlson et al. 2017). Emissions related to deforestation or changes in soil carbon are not included.

Mbow, C., Rosenzweig, C., Tubiello, F., Benton, T., Herrero, M., Pradhan, P., Barioni, L., Krishnapillai, M., Liwenga, E., Rivera-Ferre, M., Sapkota, T., & Xu, Y. (2019). IPCC Special Report on Land and Climate Change. Chapter 5: Food Security (pp. 437–550).



The effects of **cover crop**, **no till**, and **crop rotation** on **nitrous oxide emissions** relative to conventional tillage (Li et al., 2023).



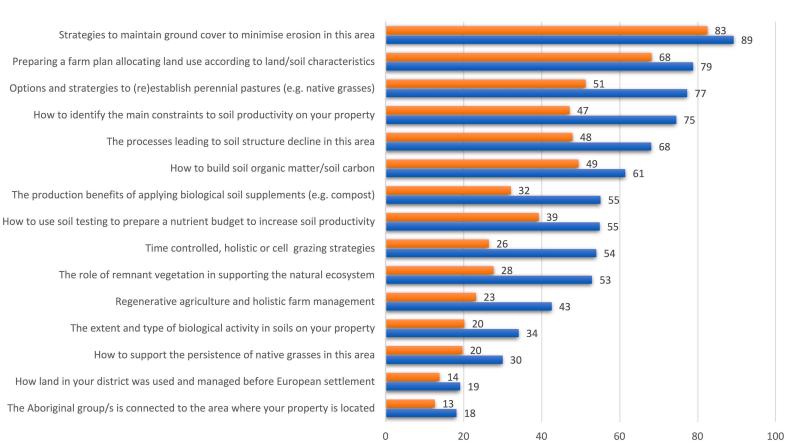
Effects of cover crops, diversified crop rotations (rotation), and no- till and/or reduced tillage (NT/RT) on soil N_2O emissions. (b) Distribution of log- transformed response ratios of soil N_2O emissions (*InR*- N_2O) to cover crops, diversified crop rotations and NT/RT practices. Error bars refer to bootstrap 95% confidence intervals (CIs). The numbers are sample sizes. The fitted curves are from the estimated Gaussian distribution in frequency.

Li, Y., Chen, J., Drury, C.F., Liebig, M., Johnson, J.M.F., Wang, Z., Feng, H., Abalos, D., 2023. The role of conservation agriculture practices 16 in mitigating N2O emissions: A meta-analysis. Agron. Sustain. Dev. 43, 1–13. https://doi.org/10.1007/s13593-023-00911-x

A survey study in Australia: a major driver of adopting RAP



"Self-reported knowledge levels of a range of best practices, divided up by the new groups, with those implementing practices related to regenerative agriculture reporting significantly higher knowledge-levels across all practices."



Knowledge levels (4+5 %)

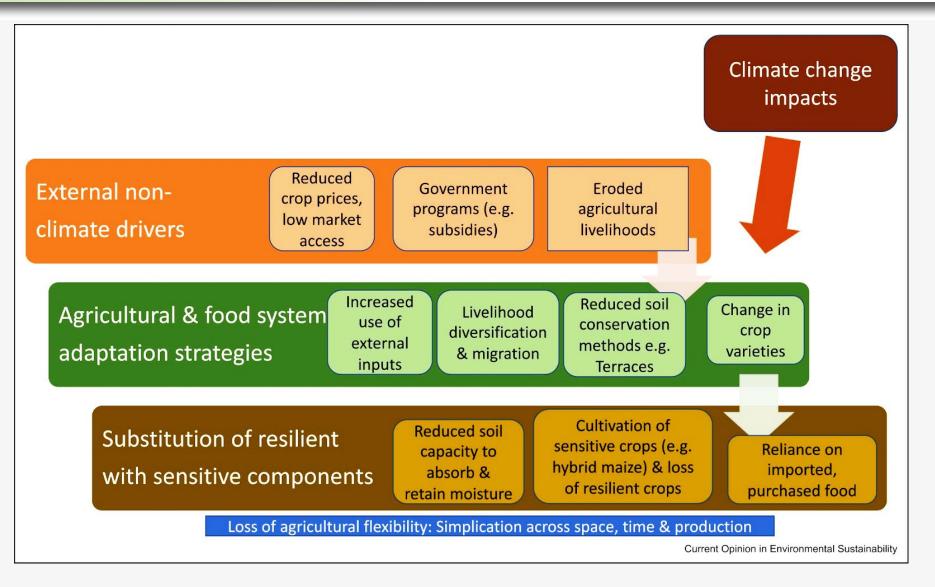
Comparison of two groups: Farmers practising Regenerative Agriculture (RAP) and not practicing it.(Non-RAP)

Note: The distinction between RAP and non-RAP was made by the authors.

Knowledge is a key driver:

Alexanderson, M.S., Luke, H., Lloyd, D.J., 2023. Regenerative farming as climate action. J. Environ. Manage. 347, 119063. https://doi.org/10.1016/j.jenvman.2023.119063 Potential pathways leading to mal-adaptations in food systems





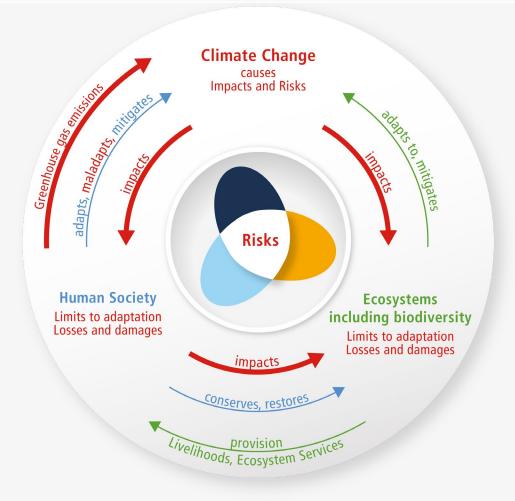
More evidence is reported for maladaptation and/or malmitigation, but it could be avoided using knowledge related to the approaches to sustainable transformation.

Bezner Kerr, R., 2023. Maladaptation in food systems and ways to avoid it. Curr. Opin. Environ. Sustain. 61, 101269. https://doi.org/10.1016/j.cosust.2023.101269

Conclusions



- Approaches to sustainable food transformation are the key climate action to enhancing the climate resilience of food systems.
- The effectiveness of the approaches is contextdependent, but data science can help clarify the contexts.
- Feasibility needs institutional, financial, and political support.
- Scientific evidence is increasing but needs to be more comprehensive to assess the multiple dimensions of the approaches.
- Knowledge is the key driver and can help avoid maladaptation and malmitigation.





Comprehensive Research on Projection of Climate Change Impacts 19 and Evaluation of Adaptation