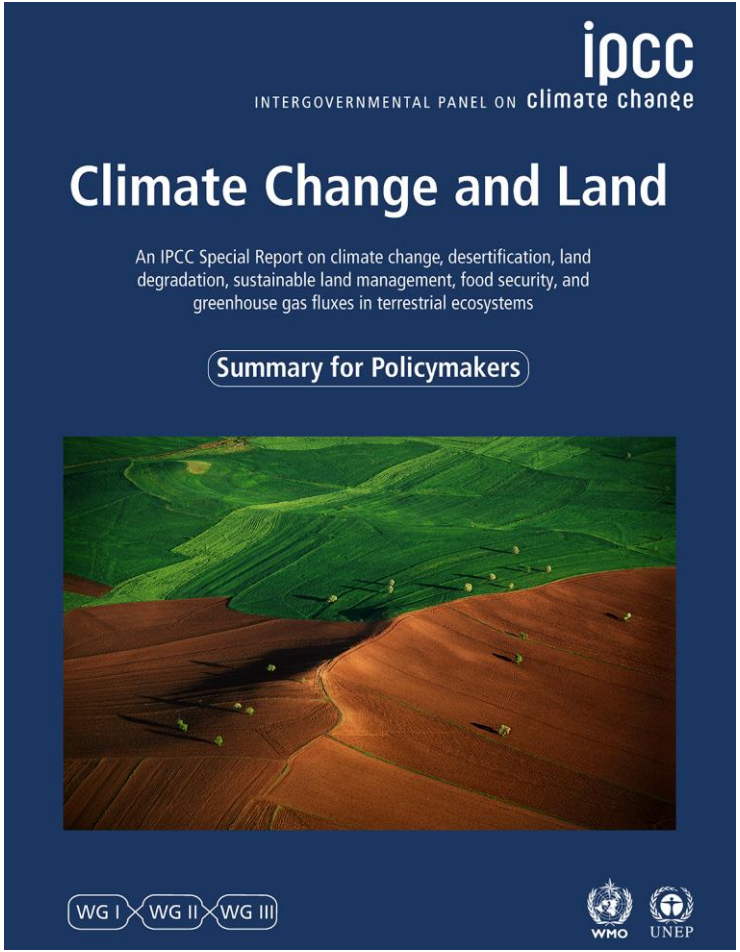
CLIMATE CHANGE AND LAND

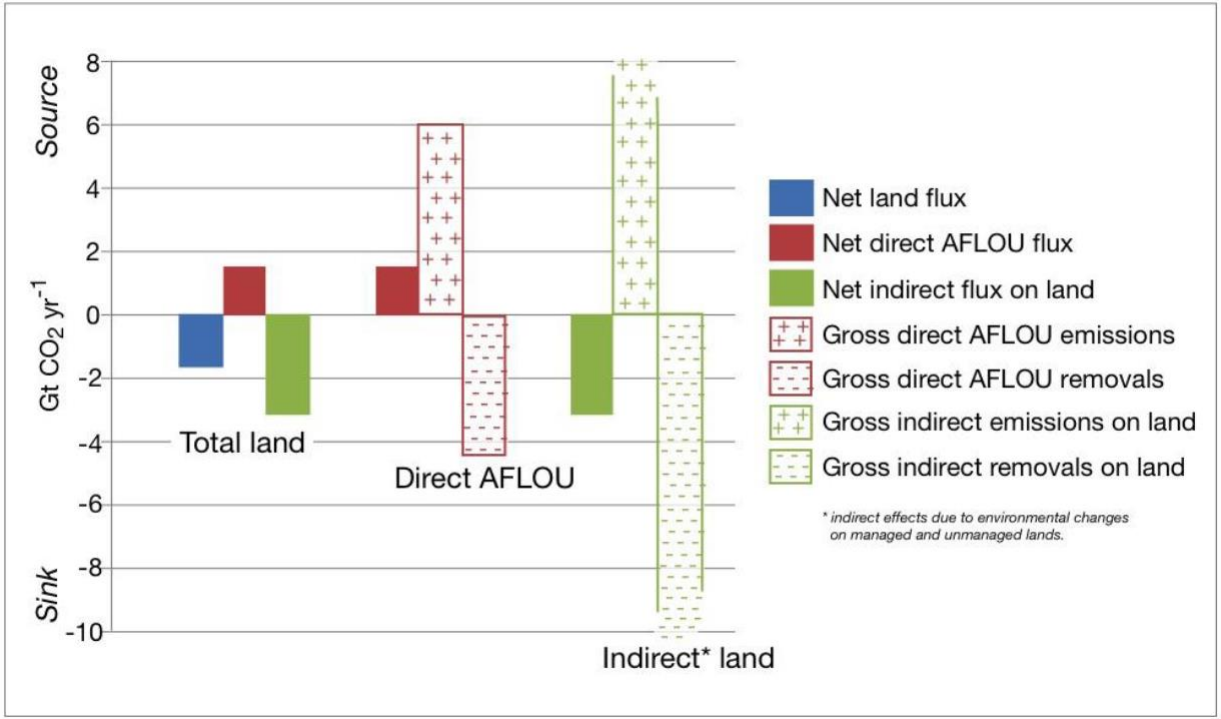
An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

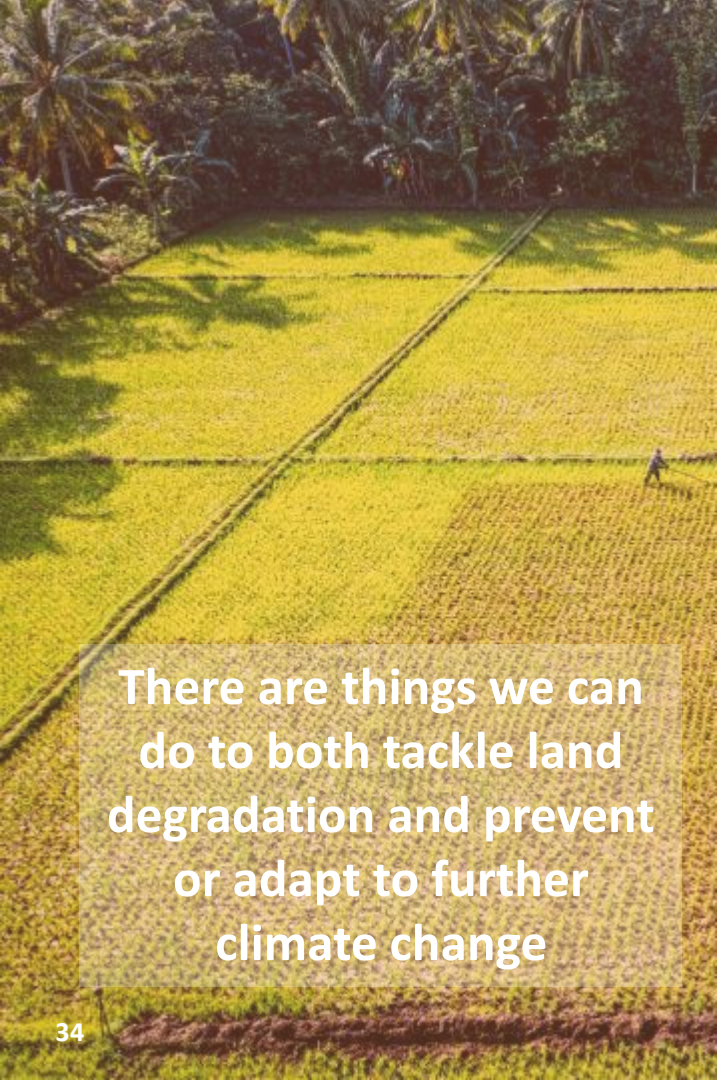


REPORT COVER IMAGE:
Agricultural landscape between Ankara and Hattusha, Anatolia, Turkey (40°00' N – 33°35' E)
©Yann Arthus-Bertrand | **www.yannarthusbertrand.org** | **www.goodplanet.org**

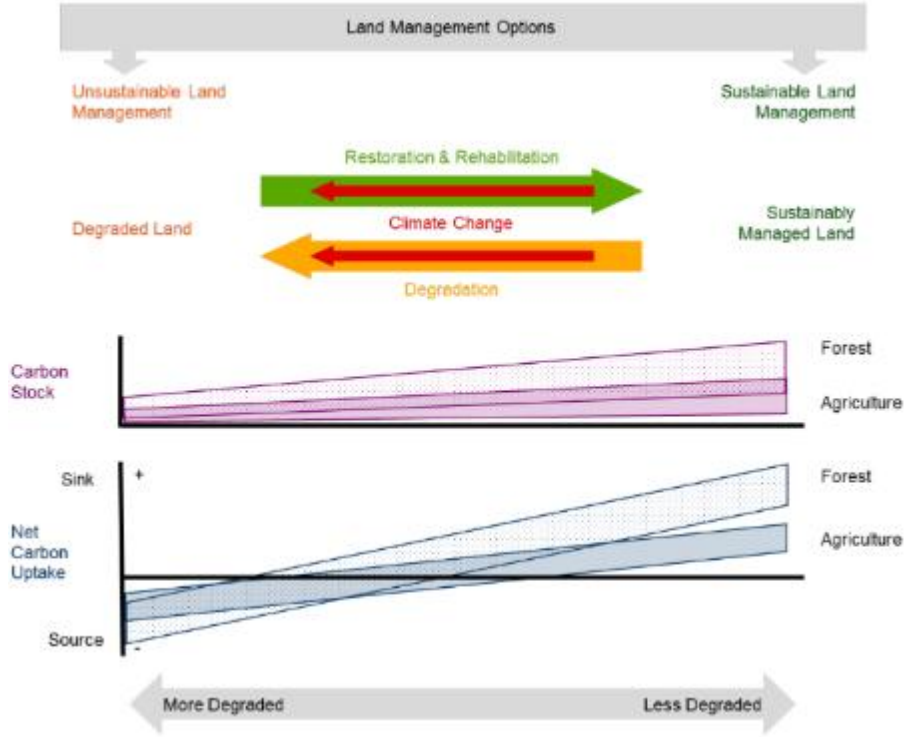
“ **Better land management can play its part** in tackling climate change, but it can’t do it all.

Land is simultaneously a source and a sink of CO2. It is a part of the problem and the solution!





There are things we can do to both tackle land degradation and prevent or adapt to further climate change

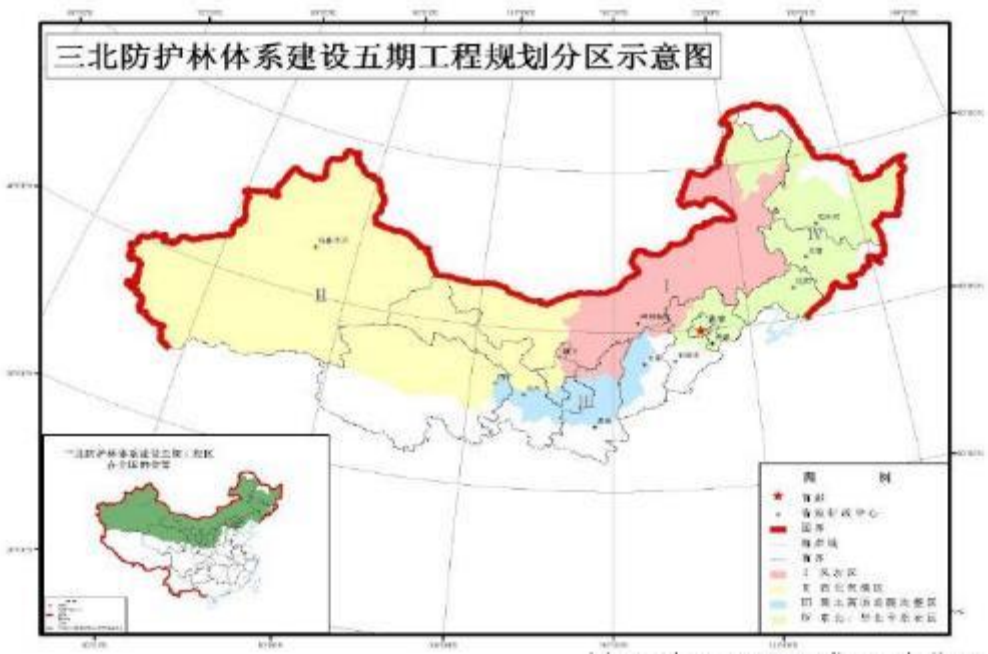


Sustainable land management can help reduce and sometime reverse these adverse impacts.

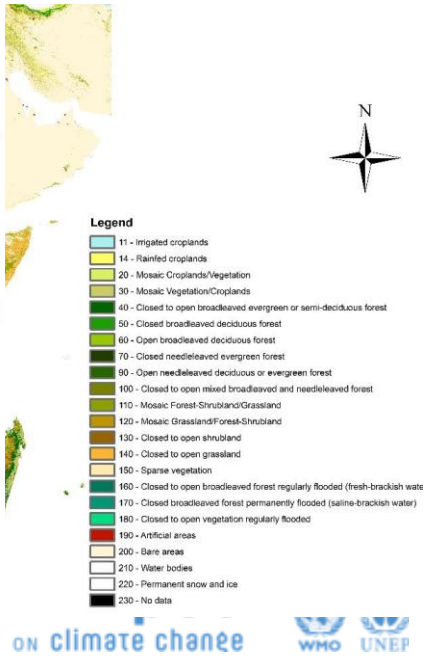
Many land-related responses that contribute to climate change adaptation and mitigation can also combat desertification and land degradation and enhance food security

Green

Three North's Forest Shelterbelt programme in Northeast China, North China, and Northwest China



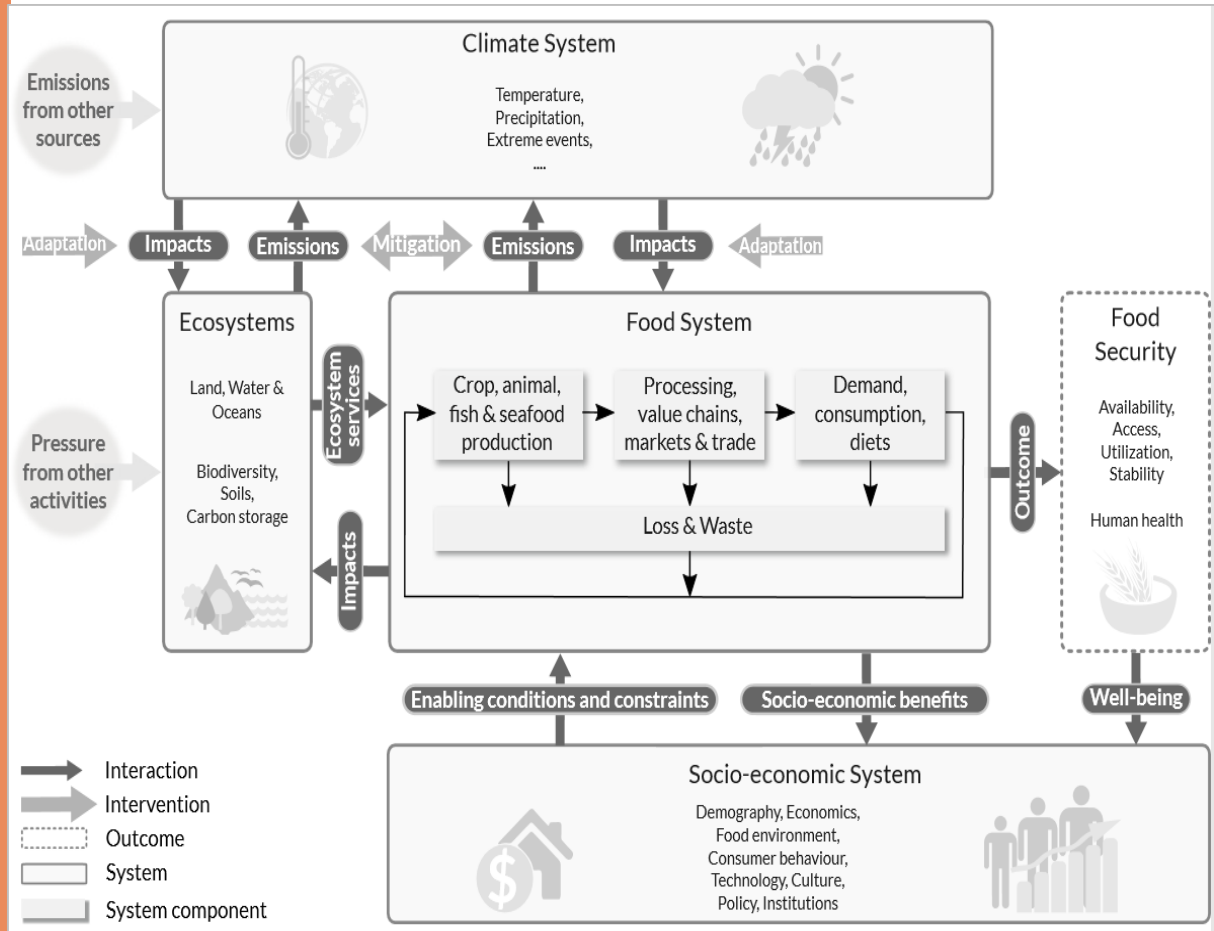
hara and the Sahel



ON climate change WMO UNEP

The Food System

- **25-30%** of food produced is **lost or wasted**.
- Almost **half (41%)** of human-caused methane emissions come from livestock.
- Reducing this loss or waste can help **reduce greenhouse gas emissions** and **improve food security**.
- **Dietary changes** can reduce pressure on land and reduce emissions.



We didn't classify response options by mitigation/ adaptation: many options have multiple benefits

Responses by broad type

- Land management
- Value chain management
- Risk management

Responses by magnitude of impact (technical potential)

- > 3 Gt CO_2eq yr^{-1}
- 0.3 – 3 Gt CO_2eq yr^{-1}
- < 0.3 Gt CO_2eq yr^{-1}

Responses by impact on land competition

- No or limited competition for land
- Those that rely on additional land use change

Potential global contribution of response options to mitigation, adaptation, combating desertification and land degradation, and enhancing food security

Panel A shows response options that can be implemented without or with limited competition for land, including some that have the potential to reduce the demand for land. Co-benefits and adverse side effects are shown quantitatively based on the high end of the range of potentials assessed. Magnitudes of contributions are categorised using thresholds for positive or negative impacts. Letters within the cells indicate confidence in the magnitude of the impact relative to the thresholds used (see legend). Confidence in the direction of change is generally higher.

	Response options based on land management	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	- L	●
Forests	Forest management	M	L	L	L	L	●●
	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
	Reduced soil erosion	↔ L	L	M	M	L	●●
	Reduced soil salinization	—	L	L	L	L	●●
	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
	Reduced landslides and natural hazards	L	L	L	L	L	—
	Reduced pollution including acidification	↔ M	M	L	L	L	—
	Restoration & reduced conversion of coastal wetlands	M	L	M	M	↔ L	—
	Restoration & reduced conversion of peatlands	M	—	na	M	- L	●
	Response options based on value chain management						
Demand	Reduced post-harvest losses	H	M	L	L	H	—
	Dietary change	H	—	L	H	H	—
	Reduced food waste (consumer or retailer)	H	—	L	M	M	—
Supply	Sustainable sourcing	—	L	—	L	L	—
	Improved food processing and retailing	L	L	—	—	L	—
	Improved energy use in food systems	L	L	—	—	L	—
	Response options based on risk management						
Risk	Livelihood diversification	—	L	—	L	L	—
	Management of urban sprawl	—	L	L	M	L	—
	Risk sharing instruments	↔ L	L	—	↔ L	L	●●

Options shown are those for which data are available to assess global potential for three or more land challenges.
The magnitudes are assessed independently for each option and are not additive.

Key for criteria used to define magnitude of impact of each integrated response option

		Mitigation *Gt CO_2-eq yr^{-1}*	Adaptation *Million people*	Desertification *Million km^2*	Land Degradation *Million km^2*	Food Security *Million people*
Positive	Large	More than 3	Positive for more than 25	Positive for more than 3	Positive for more than 3	Positive for more than 100
	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Small	Less than 0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Negligible	No effect	No effect	No effect	No effect	No effect
Negative	Small	Less than -0.3	Less than 1	Less than 0.5	Less than 0.5	Less than 1
	Moderate	-0.3 to -3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
	Large	More than -3	Negative for more than 25	Negative for more than 3	Negative for more than 3	Negative for more than 100

↔ **Variable**: Can be positive or negative — no data — na not applicable

Confidence level
Indicates confidence in the estimate of magnitude category.
H High confidence
M Medium confidence
L Low confidence

Cost range
See technical caption for cost ranges in US$ tCO_2e^{-1} or US$ ha^{-1}.
●●● High cost
●● Medium cost
● Low cost
— no data

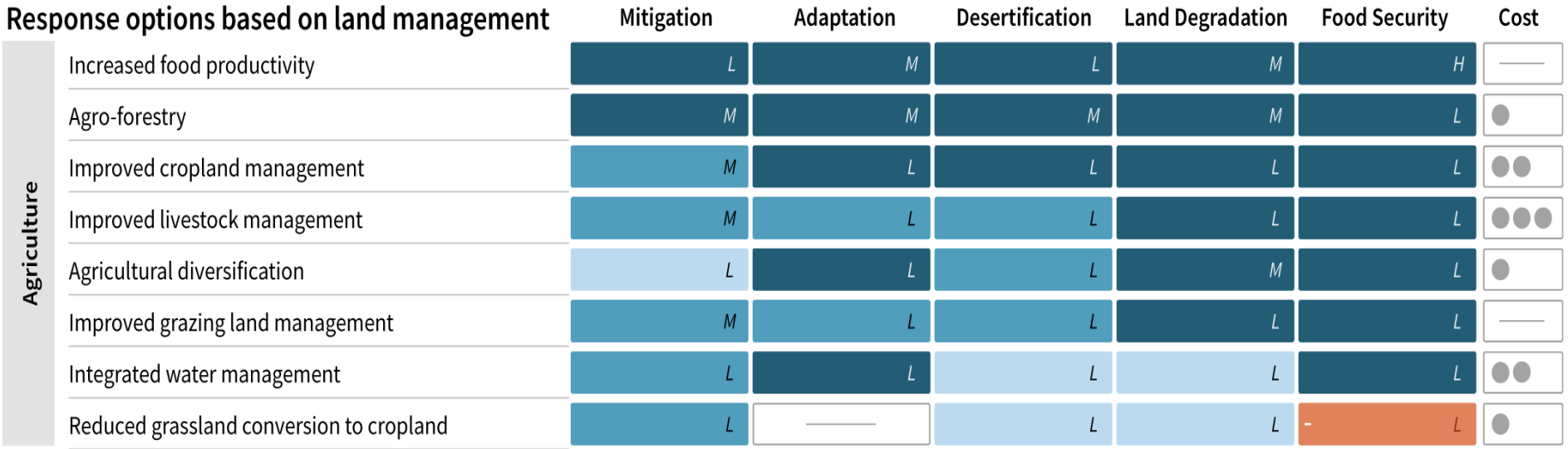
Response options classified into 3 Broad Types: Land Management, Value Chain Management , Risk Management

28 different response options can be implemented with **limited or no competition** for land.

Almost all response options have a positive effect on mitigation, adaptation, desertification, land degradation and **food security.**

SPM Figure 3 – 1

Most land-based response options have a positive effect and co-benefits

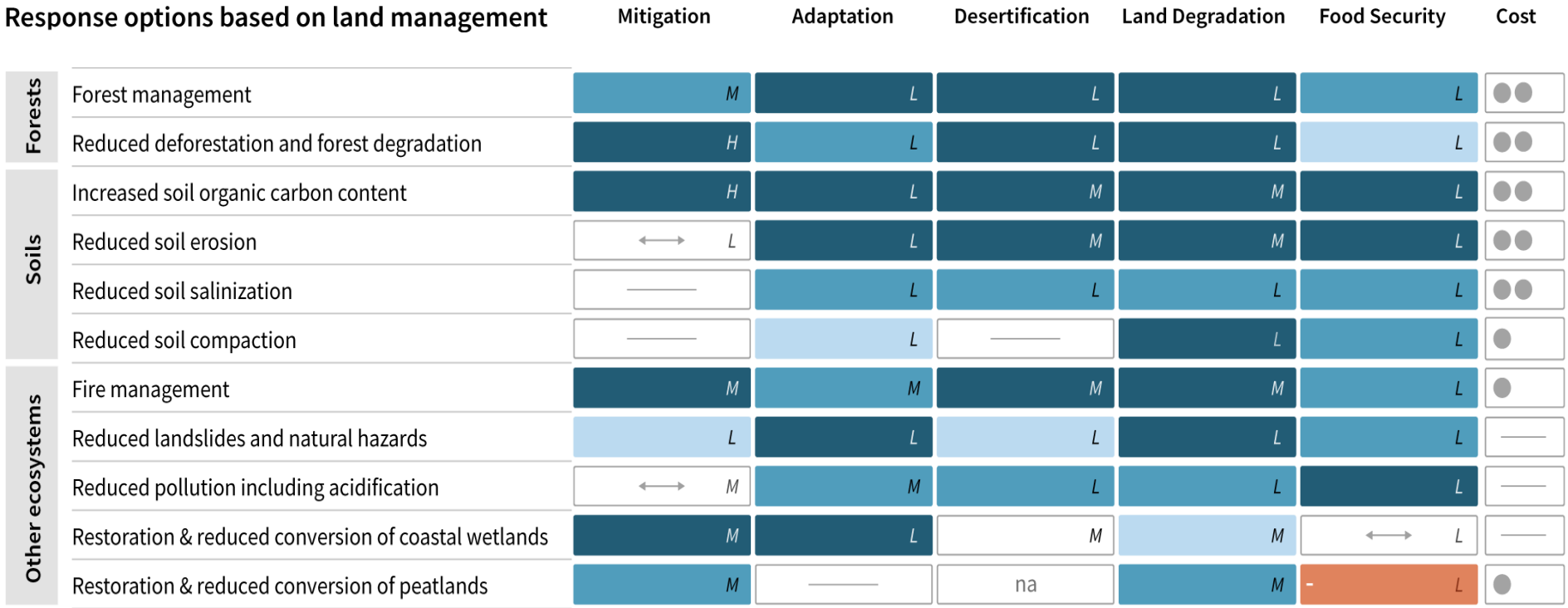


	Response options based on land management	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
	Agro-forestry	M	M	M	M	L	●
	Improved cropland management	M	L	L	L	L	●●
	Improved livestock management	M	L	L	L	L	●●●
	Agricultural diversification	L	L	L	M	L	●
	Improved grazing land management	M	L	L	L	L	—
	Integrated water management	L	L	L	L	L	●●
	Reduced grassland conversion to cropland	L	—	L	L	- L	●

ipcc INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

SPM Figure 3 – 1

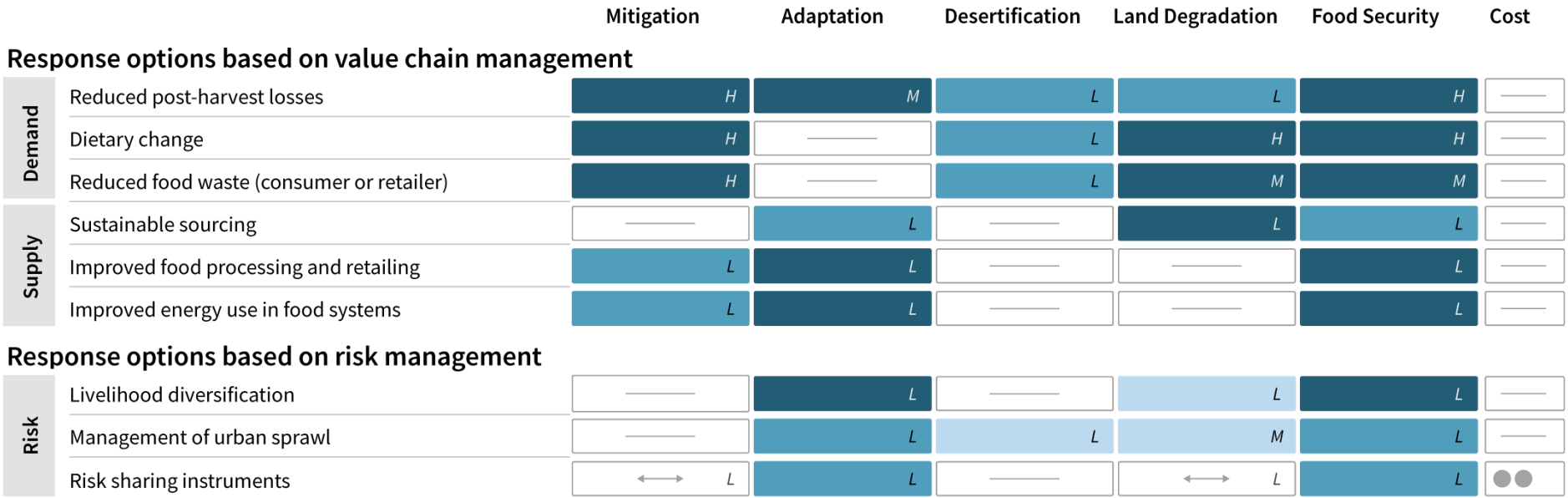
Most land-based response options have a positive effect and co-benefits



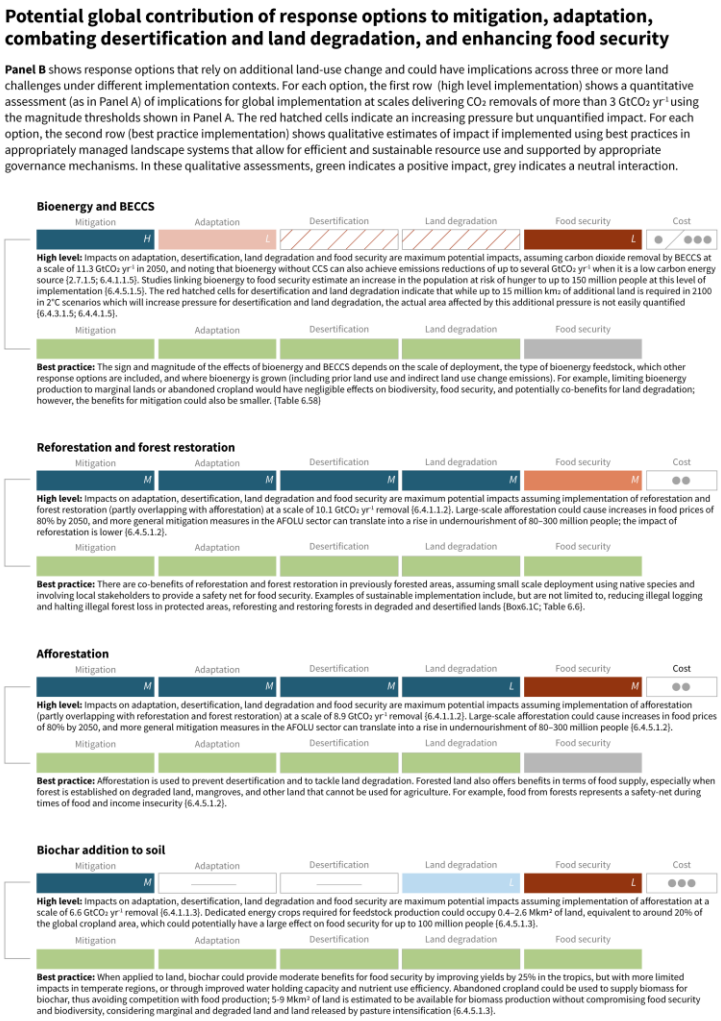
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

SPM Figure 3 – 1

All supply/demand and risk management based response options have a positive effect and many co-benefits



ipcc INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP



Potential global contribution of response options to mitigation, adaptation, combating desertification and land degradation, and enhancing food security

Panel B shows response options that rely on additional land-use change and could have implications across three or more land challenges under different implementation contexts. For each option, the first row (high level implementation) shows a quantitative assessment (as in Panel A) of implications for global implementation at scales delivering CO_2 removals of more than 3 $GtCO_2\ yr^{-1}$ using the magnitude thresholds shown in Panel A. The red hatched cells indicate an increasing pressure but unquantified impact. For each option, the second row (best practice implementation) shows qualitative estimates of impact if implemented using best practices in appropriately managed landscape systems that allow for efficient and sustainable resource use and supported by appropriate governance mechanisms. In these qualitative assessments, green indicates a positive impact, grey indicates a neutral interaction.

Bioenergy and BECCS

Mitigation: H | Adaptation: L | Desertification | Land degradation | Food security: L | Cost

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2\ yr^{-1}$ in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2\ yr^{-1}$ when it is a low carbon energy source {2.7.1.5; 6.4.1.1.5}. Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation {6.4.5.1.5}. The red hatched cells for desertification and land degradation indicate that while up to 15 million km_2 of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified {6.4.3.1.5; 6.4.4.1.5}.

Mitigation | Adaptation | Desertification | Land degradation | Food security

Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. {Table 6.58}

Reforestation and forest restoration

Mitigation: M | Adaptation: M | Desertification: M | Land degradation: M | Food security: M | Cost

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2\ yr^{-1}$ removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.4.5.1.2}.

Mitigation | Adaptation | Desertification | Land degradation | Food security

Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

Afforestation

Mitigation: M | Adaptation: M | Desertification: M | Land degradation: L | Food security: M | Cost

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 $GtCO_2\ yr^{-1}$ removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people {6.4.5.1.2}.

Mitigation | Adaptation | Desertification | Land degradation | Food security

Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during times of food and income insecurity {6.4.5.1.2}.

Biochar addition to soil

Mitigation: M | Adaptation | Desertification | Land degradation: L | Food security: L | Cost

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation at a scale of 6.6 $GtCO_2\ yr^{-1}$ removal {6.4.1.1.3}. Dedicated energy crops required for feedstock production could occupy 0.4–2.6 Mkm^2 of land, equivalent to around 20% of the global cropland area, which could potentially have a large effect on food security for up to 100 million people {6.4.5.1.3}.

Mitigation | Adaptation | Desertification | Land degradation | Food security

Best practice: When applied to land, biochar could provide moderate benefits for food security by improving yields by 25% in the tropics, but with more limited impacts in temperate regions, or through improved water holding capacity and nutrient use efficiency. Abandoned cropland could be used to supply biomass for biochar, thus avoiding competition with food production; 5-9 Mkm^2 of land is estimated to be available for biomass production without compromising food security and biodiversity, considering marginal and degraded land and land released by pasture intensification {6.4.5.1.3}.

SPM Figure 3B

We looked closely at four land-based response options involving land use change with high **mitigation** potential.

Their potential impacts on **adaptation, desertification, land degradation** and **food security** were assessed.

SPM Figure 3 – 3

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Bioenergy and BECCS

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts, assuming carbon dioxide removal by BECCS at a scale of 11.3 $GtCO_2\ yr^{-1}$ in 2050, and noting that bioenergy without CCS can also achieve emissions reductions of up to several $GtCO_2\ yr^{-1}$ when it is a low carbon energy source {2.7.1.5; 6.4.1.1.5}. Studies linking bioenergy to food security estimate an increase in the population at risk of hunger to up to 150 million people at this level of implementation {6.4.5.1.5}. The red hatched cells for desertification and land degradation indicate that while up to 15 million km_2 of additional land is required in 2100 in 2°C scenarios which will increase pressure for desertification and land degradation, the actual area affected by this additional pressure is not easily quantified {6.4.3.1.5; 6.4.4.1.5}.

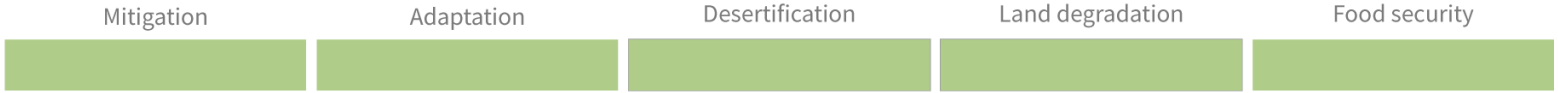
Best practice: The sign and magnitude of the effects of bioenergy and BECCS depends on the scale of deployment, the type of bioenergy feedstock, which other response options are included, and where bioenergy is grown (including prior land use and indirect land use change emissions). For example, limiting bioenergy production to marginal lands or abandoned cropland would have negligible effects on biodiversity, food security, and potentially co-benefits for land degradation; however, the benefits for mitigation could also be smaller. {Table 6.58}

SPM Figure 3 – 4

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Reforestation and forest restoration

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 $GtCO_2\ yr^{-1}$ removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.4.5.1.2}.



Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

SPM Figure 3 – 5

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Afforestation

High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 $GtCO_2$ yr^{-1} removal {6.4.1.1.2}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people {6.4.5.1.2}.

Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during times of food and income insecurity {6.4.5.1.2}.

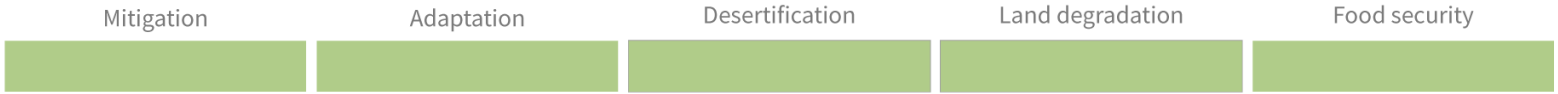
ipcc INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

SPM Figure 3 – 6

When implemented at a suitable scale using best practice, impacts on other land challenges can be positive.

Biochar addition to soil

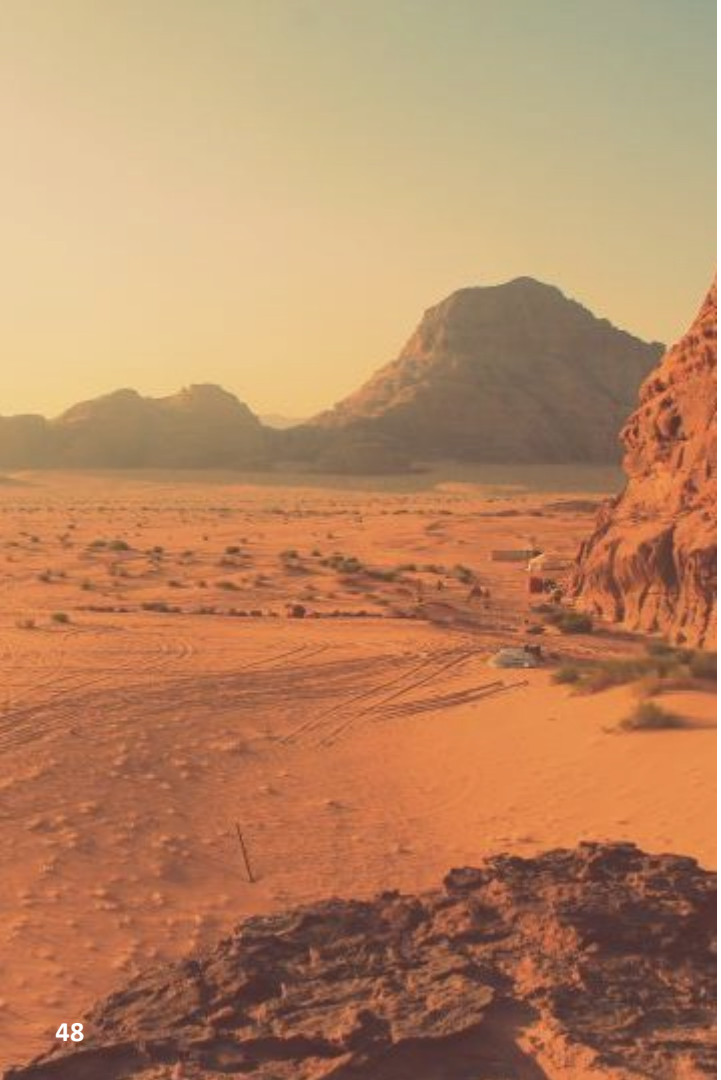
High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation at a scale of 6.6 $GtCO_2\ yr^{-1}$ removal {6.4.1.1.3}. Dedicated energy crops required for feedstock production could occupy 0.4–2.6 Mkm^2 of land, equivalent to around 20% of the global cropland area, which could potentially have a large effect on food security for up to 100 million people {6.4.5.1.3}.



Best practice: When applied to land, biochar could provide moderate benefits for food security by improving yields by 25% in the tropics, but with more limited impacts in temperate regions, or through improved water holding capacity and nutrient use efficiency. Abandoned cropland could be used to supply biomass for biochar, thus avoiding competition with food production; 5-9 Mkm^2 of land is estimated to be available for biomass production without compromising food security and biodiversity, considering marginal and degraded land and land released by pasture intensification {6.4.5.1.3}.

Co-benefits

- Response options are **site** and **regionally specific**
- Activities that combat desertification can contribute to adaptation with mitigation co-benefits and can halt biodiversity loss
- Solutions that help adapt to and mitigate climate change while contributing to combating desertification include water harvesting and micro-irrigation, using drought-resilient ecologically appropriate plants, and agroforestry
- Avoiding, reducing and reversing land degradation in rangelands, croplands and forests can help to **eradicate poverty** and ensure **food security**



Combatting Degradation and Desertification

- Reducing deforestation and forest degradation lowers GHG emissions and can contribute to adaptation goals
- Sustainable land management can prevent, reduce and in some cases reverse land degradation.
- Climate change can lead to land degradation, even with the implementation of measures intended to avoid, reduce or reverse land degradation
- Technological solutions are available to avoid, reduce and reverse desertification while also contributing to climate change mitigation and adaptation.
- Investment in sustainable land management and land restoration in drylands has positive economic returns.
- Indigenous and local knowledge can often enhance resilience to climate change and combat desertification.
- Preventing desertification is preferable to restoration of degraded land.

Response options throughout the food system can be deployed and scaled up to advance adaptation and mitigation

- The total technical mitigation potential from crop and livestock activities, and agroforestry is estimated as 2.3-9.6 GtCO2e.yr-1 by 2050.
- The total technical mitigation potential of dietary changes is estimated as 0.7-8 GtCO2e.yr-1 by 2050.
- Diversification in the food system can reduce risks from climate change.

Dietary Choices

- **Balanced diets**, featuring plant-based foods, produced in resilient, sustainable and low-GHG emission systems, present **major opportunities** for **adaptation and mitigation** while generating significant co-benefits in terms of **human health**.

- Transitions towards **low-GHG emission diets** may be influenced by local production practices, technical and financial barriers and associated livelihoods and cultural habits.

Food loss and waste

- Global food loss and waste accounts for 8-10% of total anthropogenic GHG emissions. 25-30% of food produced is lost or wasted. Causes of food loss and waste differ substantially between developed and developing countries, as well as between regions.
- Reduction of **food loss** and **waste** can lower GHG emissions and contribute to adaptation through reduction in the land area needed for food production.
- **Technical options** such as improved harvesting techniques, on-farm storage, infrastructure, transport, packaging, retail and education can reduce food loss and waste across the supply chain.