The IPCC's Special Report on Climate Change and Land

What's in it for Africa?

Climate & Development Knowledge Network

Image: © Yobu Kachiwanda | Weather chasers' tree planting committee members in Malawi prepare for another mission.

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The IPCC's Special Report on Climate Change and Land: What's in it for Africa?

Key messages

1. The climate and land interact with and influence each other
2. Dryland areas are expected to become more vulnerable to desertification in Africa
3. Desertification has implications for food security and poverty in Africa
4. Community and policy responses can combat desertification
5. Managing land, value chains and climate risks can deliver climate adaptation, mitigation and development benefits
6. Insecure property rights and lack of access to credit and agricultural advisory services hamper progress – especially by women
7. The skills and knowledge of women and marginalised groups are not yet sufficiently recognised
8. Integrated governance is needed to maximise the benefits of land and water
9. Emissions reductions in other sectors are vital to relieve pressure on land

About this report

The Intergovernmental Panel on Climate Change (IPCC) published its *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* in 2019 (www.ipcc.ch/srccl). We refer to the IPCC's report in short here as the *Special Report on Climate Change and Land*. The Special Report was a response to proposals from governments and observer organisations to the IPCC. It assesses the existing science to date on how greenhouse gases are released and absorbed by land-based ecosystems, and the science on land use and sustainable land management in relation to climate change adaptation and mitigation, desertification, land degradation and food security. The findings are of great importance to decision-makers across Africa and the world.

This publication offers a guide to the IPCC's *Special Report on Climate Change and Land* prepared for decision-makers in Africa by the Climate and Development Knowledge Network (CDKN), Overseas Development Institute (ODI) and SouthSouthNorth (SSN). This is not an official IPCC publication.

The IPCC's own *Summary for Policy-Makers* focuses principally on global issues and trends. This report distils the richest material available on Africa from the 1,300 pages of the Special Report. The publication has not been through the comprehensive governmental approval process that IPCC endorsement requires. However, the expert research team has benefited from review by IPCC lead authors in their personal capacities and other expert reviewers to ensure fidelity to the original report (see *Acknowledgements*).

In a few places, we have included supplementary material from recently published research that extends and explains the points made in the IPCC's Special Report. We have clearly labelled this supplementary material 'Beyond the IPCC'. This guide responds to widespread demand among CDKN's African partner networks for region-specific information.

Please visit **www.cdkn.org/landreport** for slides, images and infographics you can use in association with this guide.

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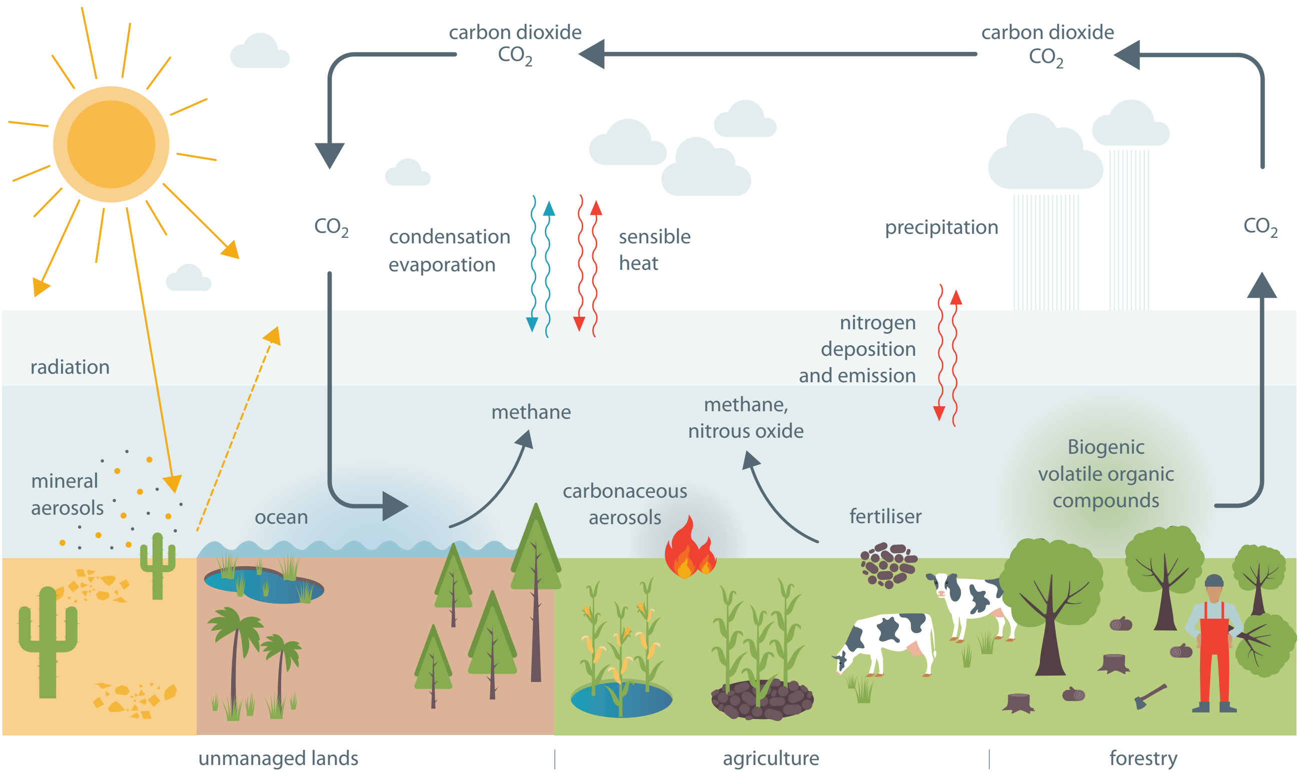
"About a quarter of the Earth's ice-free land area is subject to human-induced degradation (medium confidence) … Climate change exacerbates land degradation, particularly in low-lying coastal areas, river deltas, drylands (high confidence)."[1]

FIGURE 1: How land and climate interact[2]



Box 1: Glossary of terms for Figure 1

Aerosols: A suspension of airborne solid or liquid particles, with a typical size between a few nanometres and 10 micrometres or microns (μm) that reside in the atmosphere for *at least* several hours – and often longer, especially for volcanic and desert dust, which are more influential on the climate. The bulk of aerosols are of natural origin and can include mineral aerosols (such as desert dust).[3]

Carbonaceous aerosols are small particles that are rich in carbon. They come from vehicle exhausts as well as the soot and remnants of burned wood, etc.[4]

BVOC: The term biogenic volatile organic compounds includes organic atmospheric trace gases other than carbon dioxide and monoxide.[5]

Nitrogen deposition: Nitrogen deposition describes what happens when reactive nitrogen passes from the atmosphere to the biosphere either as a gas (dry deposition) or through precipitation (wet deposition).[6]

Sensible heat: Sensible heat is thermal energy whose transfer to or from a substance or body results in a change of temperature (such as between one layer of atmosphere and another).

1 The climate and land interact with and influence each other

Climate change affects land-based ecosystems[7]. Climate change is expected to alter:

- the distribution of land cover
- biodiversity and the mix of plant and animal species in ecosystems
- vegetation structure and productivity and
- nutrient and water cycles.[8]

At the same time, land plays an important role in the climate system. The physical, ecological and hydrological conditions of land all influence its interaction with the atmosphere. This includes the composition of rocks, soils and man-made surfaces, the vegetation cover, and the amount of water or ice on the land. The land conditions which influence the climate can be a result of direct human management and use, e.g. deforestation, afforestation, urbanisation, irrigated agriculture, as well as land state (i.e. degree of wetness, degree of greening, amount of snow, amount of permafrost).[9] Land can be both a source of greenhouse gas emissions, and a sink for emissions, meaning that land both releases and absorbs greenhouse gases. See Figure 1 opposite.

When the condition of the land changes – either because people change land use directly, or because climate change affects land conditions – this, in turn, affects global and regional climates.[10]

"Land changes influence regional climates."[11]

The links between land and the *global* climate have long been known, but scientists now recognise that land changes have a greater role in influencing *regional* climates than was previously thought. Changes in land conditions can reduce or accentuate regional warming. They can affect the intensity, frequency and duration of extreme weather events, including heat waves, droughts and rainfall. The magnitude and direction of these changes vary with location and season.[12]

Large-scale forestation scenarios of West Africa and the Sahara desert concluded that regional surface cooling is expected wherever trees are grown (–2.5°C in the Sahel and –1°C in the Savanna area of West Africa, up to –8°C in western Sahara). These studies found that countries could cancel out the effects of greenhouse gas induced warming, locally and regionally, through tree planting.[13]

Climate models show that irrigating land can change rainfall patterns, too. When farmers irrigate in the Sahel region of West Africa during the monsoon period, rainfall decreases over the irrigated area and increases to the south-west. Irrigation affects the circulation of the monsoon winds.[14]

Box 2: The IPCC's confidence levels

This matrix helps explain what the IPCC means by high, medium or low confidence.[15] High confidence means that there is a high level of agreement and evidence in the literature to support the categorisation as high, medium or low. Low confidence denotes that the categorisation is based on only a few studies. Medium confidence reflects medium evidence and agreement.[16] Confidence increases towards the top-right corner as suggested by the increasing strength of shading.

Agreement			
	High agreement Limited evidence	***High agreement Medium evidence***	***High agreement Robust evidence***
	Medium agreement Limited evidence	***Medium agreement Medium evidence***	***Medium agreement Robust evidence***
	Low agreement Limited evidence	***Low agreement Medium evidence***	***Low agreement Robust evidence***

Evidence (type, amount, quality, consistency)

higher

lower

Confidence Scale

Image: © Neil Palmer (CIAT)/Flickr | The IPCC Special Report defines land degradation as loss of the land's biological productivity, ecological integrity and/or value to humans. Soil conservation measures, as shown here, can reverse land degradation.

"About a quarter of the climate change mitigation pledged by countries in their initial Nationally Determined Contributions (NDCs) is expected to come from land-based options (medium confidence)."[17]

One study found that irrigation in India has an effect on rainfall in East Africa. The evapotranspiration of irrigated crops produces a large amount of water vapour, which is carried towards the south-west by prevailing winds, where it increases rainfall over the Horn of Africa. This implies that if irrigation were to decrease in India, it would result in lower rainfall in Eastern Africa.[18]

"Planting trees will always result in capturing more atmospheric CO_2 and thus in mean annual cooling of the globe."[19]

Unsustainable land management contributes to global warming

Human over-exploitation is depleting land resources.[20] Globally, demand for meat and vegetable oil, as well as fibre, fuel and other natural resources, has leaped in recent decades. These changes in production are linked to consumption: 2 billion people globally are overweight, even as 821 million people are undernourished.[21] Climate change adds to these stresses on land and speeds up the rate of land depletion.

At present, land is a source of greenhouse gases into the atmosphere, contributing to human-made climate change. It does not have to be this way.

Agriculture, forestry and other types of land use account for 23% of human greenhouse gas emissions. At the same time, natural land processes absorb carbon dioxide equivalent to almost a third of carbon dioxide emissions from fossil fuels and industry.[22]

If countries fully carry out their Nationally Determined Contributions (NDCs) under the Paris Agreement, as submitted in 2016, then land use change could turn global land from a *net source* of human greenhouse gas emissions during 1990–2010 to a *net sink* by the year 2030.[23]

Image: © jbdodane, Flickr | The IPCC Special Report calls for more sustainable forms of forest management.

Climate change is already reducing the productivity of land

Since pre-industrial times, the air temperature over the land's surface has risen by 1.5°C, compared to a1°C average rise over land and oceans together.[24]

The impacts of global warming on the productivity of land fall most heavily on the world's poorest people. The majority of those affected will continue to be in the global South.

By increasing stresses on land, climate change worsens existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure and food systems.[25] These increasing impacts on land are predicted under all future greenhouse gas scenarios. The frequency and intensity of droughts are expected to increase under all scenarios, particularly in Southern Africa.[26]

Figure 2 shows how climate-related risks to land will increase with every further degree of average global warming. These risks include dryland water scarcity, soil erosion, vegetation loss, wildfire damage, permafrost degradation, declines in the yields of tropical crops and instability of food supply.

At around 1.5°C of average global warming, the global level of risks from dryland water scarcity, wildfire damage, permafrost degradation and food supply instabilities are projected to be high. At around 2°C of global warming, the risk from food supply instabilities are projected to be very high. Additionally, at around 3°C of global warming, the risk from vegetation loss, wildfire damage and dryland water scarcity are also projected to be very high.[27]

Global warming is already decreasing crop productivity and disrupting food systems. For example, in recent years, yields of staple crops such as maize, wheat and sorghum, and fruit crops such as mangoes, have decreased across Africa, widening food insecurity gaps. In Nigeria, climate change has impacted the livelihoods of arable crop farmers. The Sahel region of Cameroon has experienced increasing levels of malnutrition, partly as a result of extreme drought, which has negatively affected agricultural production.[28] For every 1°C of average warming, globally there will be:

- a 6% decrease in wheat yields
- a 3.2% decrease in rice yields
- a 7.4% decrease in maize yields.

FIGURE 2: Risks to humans and ecosystems from every 1°C of average global warming[29]

Increases in global mean surface temperature (GMST), relative to pre-industrial levels, affect processes involved in **desertification** (water scarcity), **land degradation** (soil erosion, vegetation loss, wildfire, permafrost thaw) and **food security** (crop yield and food supply instabilities). Changes in these processes drive risks to food systems, livelihoods, infrastructure, the value of land, and human and ecosystem health. Changes in one process (e.g. wildfire or water scarcity) may result in compound risks. Risks are location-specific and differ by region.

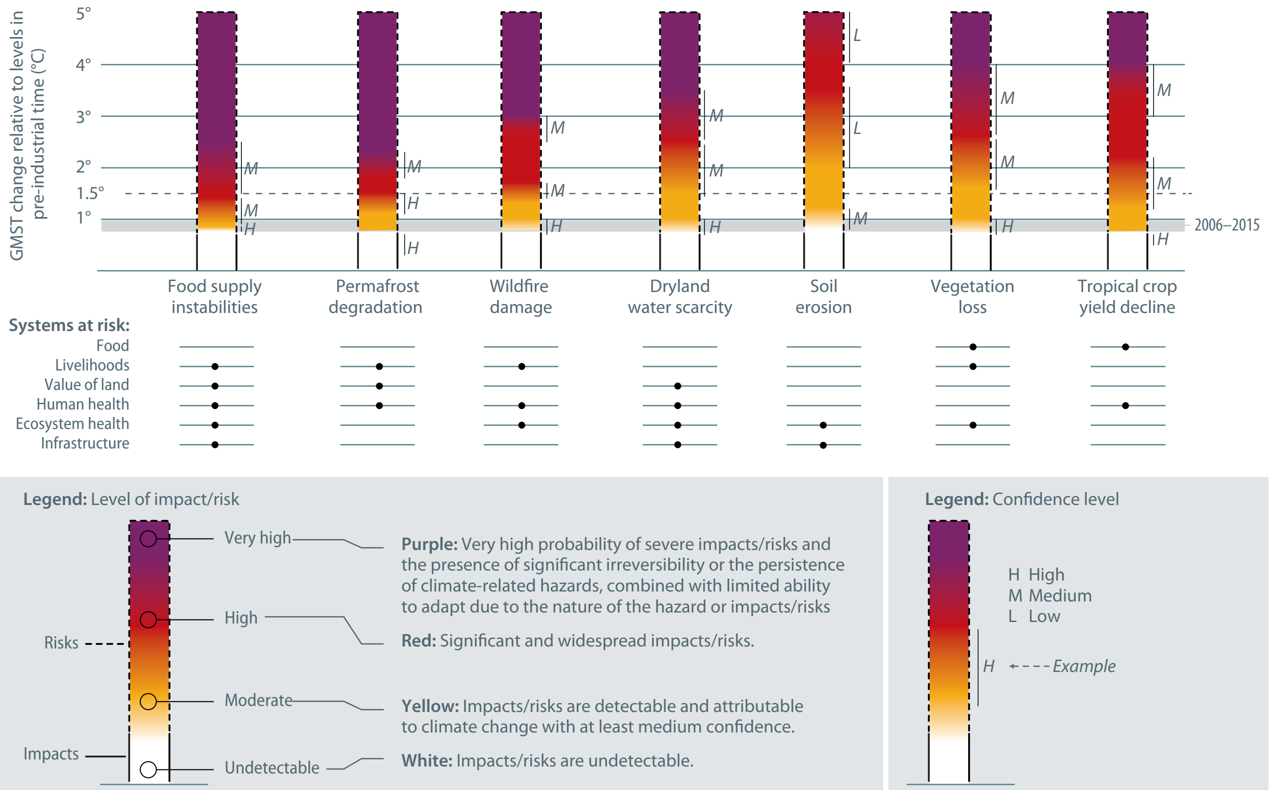
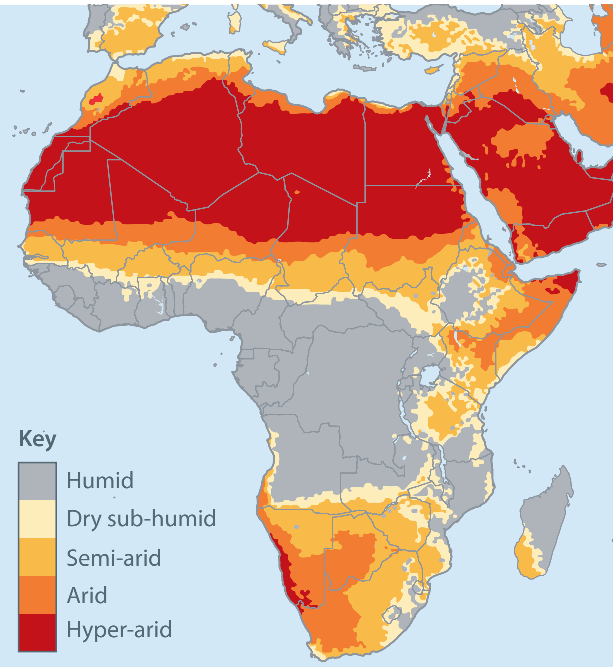
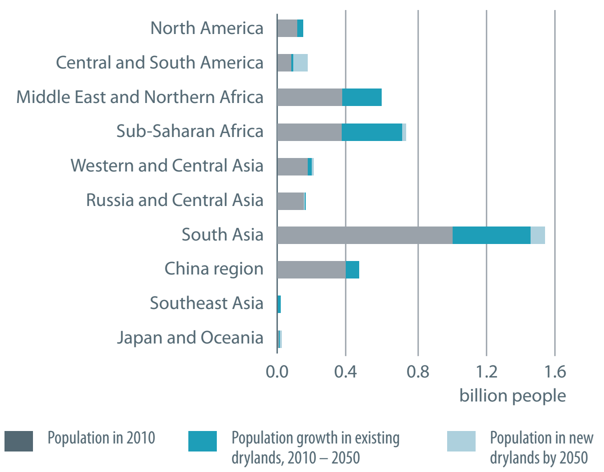


Image: © Synergos Institute/Flickr | Climate change is already disrupting crop yields in Africa.

2 Dryland areas are expected to become more vulnerable to desertification in Africa

FIGURE 3: Drylands in Africa[30]





Under a middle-of-the-road climate change and socioeconomic development scenario, called the SSP2 scenario, which assumes a continuation of current trends in population, economic development and technology

TABLE 1: Increasing population and water stress in Africa[31]

Indicator	Sub-Saharan Africa		Middle East and North Africa	
	2010	Change, 2010–2050	2010	Change, 2010–2050
Population	0.86 billion people	+109%	0.38 billion people	+61%
Dryland population	371 million people	+100%	373 million people	+60%
Water stress (from low to high)	234 million people exposed	+109%	262 million people exposed	+67%

Under a middle-of-the-road climate change and socioeconomic development scenario, called the SSP2 scenario, which assumes a continuation of current trends in population, economic development and technology

Drylands are defined by how how much water or 'aridity' they have. Drylands have low average rainfall and low levels of available freshwater – and this is a long-term feature of a region. Drought, by contrast, is not a long-term feature, but a temporary climate event. Desertification refers generally to land degradation in drylands (see Box 3).

Box 3: What is desertification?

Desertification is land degradation in drylands. Desertification comes about as a result of both processes that involve living things and processes which do not involve living things. Biological processes include changes in vegetation cover and composition, including over- and under-grazing, deforestation, biodiversity loss and the degradation of soil structures.

Desertification can also happen through physical processes, including soil erosion by water and wind, and soil structure degradation; and chemical processes, including salinisation and nutrient depletion.

Desertification can be caused directly by human mismanagement and also by the climate.[32]

“The interaction of climate change and desertification reduces the provision of dryland ecosystem services and lowers ecosystem health, including loss of biodiversity, affecting food security and human wellbeing (high confidence).”[33]

Image: © David Jensen (UN Environment)/Flickr | Unsustainable land management, particularly when coupled with droughts, has contributed to higher dust storm activity.[34]

Africa is already substantially affected by desertification:

- Desertification is affecting 46 of 57 nations in Africa.[35]
- The Sahara desert expanded by 10% in the 20th century.[36]
- Moderate or higher severity degradation over recent decades has been identified in many river basins including the Nile (42%), the Niger (50%), the Senegal (51%), the Volta (67%), the Limpopo (66%) and Lake Chad (26%).[37]
- The Horn of Africa is getting drier and this is exacerbating the desertification that is already happening there.[38]
- The annual costs of soil degradation were estimated at about 1% of Gross Domestic Product (GDP) in Algeria and Egypt, and about 0.5% in Morocco and Tunisia.[39]
- There has been a greening trend in the Sahel belt.
- Greening can be associated with desertification if it involves a decrease in species diversity, changes in species composition and shrub encroachment.[40]

Future climate change – which will see more frequent and intense extreme weather events, such as droughts and heatwaves – is expected to worsen the vulnerability and risk of humans and ecosystems to desertification. Warming of more than 1.5°C substantially increases the risk of aridity for Southern Africa.[41]

Meanwhile, one study predicts that warming and increased moisture from the ocean will lead to increases in rainfall in the central Sahel – with more intense rainfall from the West African monsoon.[42]

3 Desertification has implications for food security and poverty in Africa

"Desertification processes, coupled with climate change, are expected to cause reduction in crop and livestock productivity (high confidence)."[43]

Desertification processes overall (which are caused by a combination of unsustainable land management and climate change) are driving losses in agricultural productivity and incomes in drylands.[44] Local and national studies show how desertification is already causing farmers to suffer losses in income and wellbeing. In Ghana, land degradation decreased agricultural incomes by US$4.2 billion between 2006–2015, which increased the national poverty rate in 2015 by 5.4%.[45] Land degradation increased the probability of household poverty by 35% in Malawi and 48% in Tanzania.[46]

About 821 million people globally were food insecure in 2017, of whom 31% are in Africa. Sub-Saharan Africa had the highest share of undernourished populations in the world in 2017, at 28%. In Eastern Africa, 31.4% of the population are undernourished.[47]

The main way that climate change affects food security in drylands is by reducing crop productivity. The World Bank projected that climate change will reduce the mean yields for 11 major global crops – millet, field pea, sugar beet, sweet potato, wheat, rice, maize, soybean, groundnut, sunflower and rapeseed – by 15% in sub-Saharan Africa by 2046–2055 compared with 1996–2005[48]. A separate meta-analysis suggested a similar order of reduction in yields in Africa due to climate change by 2050.[49]

Reduced crop yields will drive up the prices of agricultural goods. The specific impacts of climate change on poverty and food security vary significantly, depending on whether the household is a net agricultural buyer or seller. As agricultural prices increase, urban dwellers and rural households who are 'net food buyers' suffer the greatest losses in food security. Those who are 'net food producers' are less worse off.

Women will be more affected by land degradation than men as a result of gender-specific roles and responsibilities. For example, water scarcity was found to affect women in rural Ghana more than men, as they spent more time fetching water – and this affected the time left for other activities.[50] In spite of women's key roles in natural resource management, land restoration programmes have tended, to date, to be gender-blind.

Meanwhile, pastoral households worldwide are becoming more food insecure as a result of climate change. One of the ways that climate change drives land degradation and food insecurity is by affecting the vegetation available for livestock grazing. Plant species are taking over which have lower nutritional quality for livestock, which reduces livestock productivity. Furthermore, competition over land for cropland is fragmenting rangelands in many places, forcing pastoralists to switch livelihoods or migrate elsewhere.[51] Restrictions on pastoralists' mobile lifestyles are reducing their resilience to extreme and variable weather conditions, including climate change and drought.[52]

There is high evidence and high agreement that both climate change and land degradation can affect livelihoods and poverty through their threat multiplier effect.[53] 'Threat multiplier' here means that that they make already-precarious situations worse.

“The level of risk posed by climate change depends both on the level of warming and on how population, consumption, production, technological development and land management patterns evolve (high confidence).” [54]

Beyond the IPCC: Climate change in semi-arid regions is changing people’s livelihood strategies

Home to hundreds of millions of people, the semi-arid regions of Africa are particularly vulnerable to climatic and non-climatic impacts and risks. To adapt to such dynamic and challenging environments, people may shift or diversify their livelihoods. The Adaptation at Scale in Semi-Arid Regions (ASSAR) project found that doing so can affect people in both positive and negative ways.[55]

Women are not necessarily victims or powerless; they often diversify their livelihoods. Sometimes this can enhance their position in terms of economic contributions and social status. Women’s increased exposure to information and new networks as a result of working outside the home and having new sources of income at times increase their control over their own lives, and their voices. However, in many cases, men remain in charge of how income is used.

Livelihood diversification sometimes leads to people feeling overwhelmed and stretched for time, so their wellbeing and resilience suffer. Workloads have increased for both men and women in the areas studied by ASSAR in Botswana, Ethiopia, Ghana, Kenya and Mali.

Furthermore, women and men sometimes choose risky livelihoods out of desperation. This impacts negatively on their long-term health and safety, including such onerous and unsafe work as brick kiln labour and sex work.

In conclusion, livelihood diversification is often promoted as an adaptation and risk management strategy, yet *what people diversify into* is critical.

To counter any negative outcomes, regulated labour laws, improved infrastructure, improved social protection and the provision of safety nets should accompany livelihood diversification.[56]

Image: © World Fish Center

Image: © Ralf Steinberger | Mali women pounding cereals.

4 Community and policy responses can combat desertification

Many dryland households and communities are already responding to land degradation in drylands (desertification). Some of these individual and community-level responses are detailed here. However, the big picture is that population pressure and climate change are already pushing people beyond their 'resilience thresholds' (see Glossary, page 32), requiring new technologies and policies to help people adapt successfully.[57]

Increasing human pressures on land combined with climate change are likely to push dryland populations further beyond their limits to adapt, requiring site-specific technological solutions to strengthen their resilience and adaptive capacities.[58]

Proven technologies

The IPCC has identified that the following technologies play a role in combatting desertification today, and have the potential to tackle future desertification in a changing climate:

- Integrated crop-soil-water management
- Grazing and fire management in drylands
- Clearance of bush encroachment
- Rainwater harvesting
- Incentivising sustainable land management and restoration
- Planting salt-tolerant crops to revegetate salinised lands.[59]

These include specific measures to combat soil erosion, which is a risk across the world (see page 16) and integrated water resource management approaches, which are considered important in restoring land-based ecosystems (see Box 9: Limpopo, page 28).

Indigenous and local knowledge has enabled dryland residents to cope with climate variability historically. This indigenous knowledge, coupled with scientific innovation, can prevent and reduce desertification and contribute to climate adaptation and mitigation. The case studies opposite provide examples of this.

Policy measures such as Payments for Environmental Services and support for households to diversify their livelihoods can also play a role (see pages 13 and 26).

"Using indigenous and local knowledge for combating desertification could contribute to climate change adaptation strategies."[60]

Image: © International Maize and Wheat Improvement Center | Green manure cover crops fix nitrogen in the soil.

Box 4: Integrated crop, soil and water management in East and Central Africa

In integrated crop-soil-water management, various cropping methods can be used to increase production, increase the diversity of species, maintain cover over a larger part of the year, increase soil nitrogen and decrease the abundance of pests.[61]

In drylands of East and Central Africa, the intercropping of maize and sorghum with *Desmodium* (an insect repellent forage legume) and *Brachiaria* (an insect trapping grass) is being promoted as more climate smart and profitable than conventional practices. This practice has increased the productivity of maize two- to three-fold, and 80% of stem borer pests have been removed.[62]

Cropping methods include changing crop rotations, intercropping (planting interspersed companion crops at the same time) and relay cropping (planting companion crops at different times on the same land).

A wide variety of traditional soil and water conservation methods including *zai* (small basins traditionally used to capture surface runoff), micro basins, earthen bunds and ridges, *fanya juus* infiltration pits and contour stone bunds are used in response to drought and climate variability in Africa.

The use of various forms of planting pits has been shown to increase yields by up to 300% in South African drylands, while *zai* in combination with contour stone bunds, applying manure and planting trees can result in enhanced crop and biomass production. Up to 94% of cultivated land has been rehabilitated in areas where these methods were implemented for an extended period of time.[63]

Box 5: The Great Green Wall of the Sahara and the Sahel

The Great Green Wall is an initiative of the Heads of State and Government of the Sahelo-Saharan countries to mitigate and adapt to climate change, and to improve the food security of the Sahel and Saharan peoples. Since 2007, this project has aimed to restore Africa's degraded arid landscapes, reduce the loss of biodiversity and support local communities in their sustainable use of forests and rangelands. The Great Green Wall focuses on establishing plantations and associated re-greening projects covering a distance of 7,775 km from Senegal to Eritrea on the Red Sea coast, with a width of 15 km. The wall passes through Djibouti, Eritrea, Ethiopia, Sudan, Chad, Niger, Nigeria, Mali, Burkina Faso and Mauritania and Senegal.

The choice of woody and herbaceous species to restore degraded ecosystems is based on biophysical and socio-economic criteria, including socio-economic value (food, pastoral, commercial, energetic, medicinal, cultural); ecological importance (carbon sequestration, soil cover, water infiltration) and species that are resilient to climate change and variability.

The Pan-African Agency of the Great Green Wall was created in 2010 under the auspices of the African Union and the Community of Sahel-Saharan States to manage the project. The initiative is implemented in each country by a national structure. A monitoring and evaluation system has been defined, allowing nations to measure outcomes and to propose any necessary adjustments.

In the past, reforestation programmes in the arid regions of the Sahel and North Africa that aimed to stop desertification were poorly studied and cost a lot of money without significant success. Today, countries have changed their strategies and opted for land restoration initiatives that are well integrated with rural development, such as managing water bodies for livestock and crop production and promoting fodder trees that reduce runoff.

The implementation of the initiative is underway in several countries. For example, the FAO's Action Against Desertification project was restored 18,000 hectares of land in 2018 by planting native tree species in Burkina Faso, Ethiopia, the Gambia, Niger, Nigeria and Senegal. Experts estimate that 166 million hectares can be restored in the Sahel, requiring the restoration of 10 million hectares per year to achieve Land Degradation Neutrality targets by 2030.[64] Almost every African government has signed up to this target, under the United Nations Convention to Combat Desertification.[65] Despite these efforts, the achievement of the planned targets will be challenging without significant additional funding.[66]

Beyond the IPCC: Participatory scenario planning in Niger

The Strengthening Resilience to Social and Environmental Shocks (Projet de renforcement de la résilience contre les chocs environnementaux et sociaux, or PRESENCES) project has developed interactive, multi-stage participatory scenario planning in the highly climate-vulnerable Niger. Droughts, floods, pests and diseases are increasingly common in Niger's rain-fed farming and pastoral activities, causing huge risk in this agriculture-dependent nation. The project is based in Tillaberi, with a target group of beneficiaries of just under 450,000 people.

Based on previous experience in scenario planning, this innovation introduces seasonal forecasts and agricultural technical advice into farmers' and herders' planning processes for the coming year. Communities and individuals work closely with technical staff to integrate understandings of seasonal forecasts, climate risks and long-term change with farmers' experience of climate change. This informs planning and farming activities. Degraded land may be rehabilitated through structural works such as zai pits, and yields and soil may be improved through intercropping, using improved seeds and organic manures, and avoiding flood risk zones.[67]

Participatory scenario planning has now been used widely as an approach to support community-based action for climate change adaptation across Africa. It continues to be explored and applied by communities, often facilitated by non-governmental organisations and others.[68]

Image: © Sean Sheridan for Mercy Corps | Nigerian woman, community garden.

Measures to combat soil erosion

Soil erosion is a major form of desertification occurring in varying degrees in all dryland areas across the world, with negative effects on dryland ecosystems. There are several ways in which climate change could make erosion worse:

- More frequent heavy rainfall events and rainfall variability under climate change, and more intense flood events, can intensify erosion processes.
- Sea level rise and increased storm surge intensities can increase erosion.
- Glacier retreat can increase soil erosion in some regions.[69]

Numerous conservation measures can help reduce soil erosion. Such soil management measures include afforestation and reforestation, rehabilitation of degraded forests, erosion control measures, prevention of overgrazing, diversification of crop rotations, and improvement in irrigation techniques, especially in sloping areas. Effective measures for soil conservation can also use spatial patterns of plant cover to reduce sediment connectivity, and the relationships between hillslopes and sediment transfer in eroded channels.[70] A case study of good practice from Africa is from Algeria (see Box 6).

Box 6: Algerian government prioritises the fight against erosion

In Algeria, desertification affects the steppes of arid and semi-arid regions where the economy is based on pastoral farming. These areas have large variability in rainfall from one year to another.

In the past century, rainfall has declined by 18–27% and the dry season has increased by two months. Floods also occur often, which increases vulnerability to soil erosion. Wind erosion is also an issue; prevailing winds carry fine sand and clay particles away. Livestock trampling and soil compaction increase the risk of erosion.

The population of the steppes region is also growing rapidly – by an average 2.5% per year.

In total, a vast area of the steppe and the pre-Saharan area of Algeria is at risk of erosion (and 600,000 hectares are so degraded that they cannot be biologically recovered). Combating soil erosion has been a priority goal of government authorities since the early 1970s, attracting investment via a plethora of ecological and socioeconomic programmes. These aim to revitalise degraded areas and improve the management of livestock and natural resources.

The Last National Reforestation Assessment documented the successful reforestation of 60% of the area (8985,260 hectares) that started in 2000. Additional work is planned to extend the forested area for the protection and restoration of rangelands.[71]

5 Managing land, value chains and climate risks can deliver climate adaptation, mitigation and development benefits

A range of policies and practices has been identified which can, at the same time, help people adapt to climate change, mitigate against further climate change, combat land degradation and desertification, and improve food security.

The policies and practices fall into three broad categories:

- Sustainable land management
- Value chain management
- Risk management.

The IPCC has divided the set of policies and practices into those which either (1) relieve pressure or minimise pressure on land; or (2) have the potential to increase pressure on land – although mitigating measures can be taken to reduce the pressure.

Some actions minimise pressure on land

Table 2, on page 18, lists a range of actions for decision-makers to consider that promote food security and climate mitigation and adaptation, and combat desertification and land degradation. Importantly, these activities do not create further pressures on land. They may even relieve pressures for the multiple uses of land.

Many of the options identified are 'no regrets' or 'low regrets' options, meaning that to take these measures makes economic and financial sense – irrespective of the climate benefits.

'No regrets' options that save money and are economically beneficial include value chain management measures, such as reducing post-harvest losses and food waste at retail and consumer level. Another 'no regrets' option involves changing diets to eat less highly processed food produced at an industrial scale (such as highly processed red meat).[72]

On the land management side, low regrets options include, for example, restoring peatlands and avoiding their conversion to cropland. (In Africa, peatlands may be known locally by other terms, such as wetlands, swamplands or moorlands, depending on the context.[73]) This increases carbon sinks, avoids ongoing carbon dioxide emissions from degraded peatlands and yields benefits for climate adaptation because peatlands hold and regulate water.[74]

Image: © Eric Robert | Mabamba swamp, a type of peatland, in Uganda. Protecting peatlands offers many climate and development benefits.

TABLE 2: Actions that minimise pressure on land

The IPCC Special Report's Chapter 6 on 'Interlinkages between desertification, land degradation, food security and greenhouse gas fluxes, synergies, trade-offs and integrated response options' assesses each of the options shown in the table in detail. The report explains the positive and potential negative impacts of each measure, with best practices on how to manage down-side risks.

Both the benefits and the adverse side effects of the different actions are shown quantitatively based on the *high end* of their potential – as assessed by IPCC scientists. Letters H, M and L inside the cells show the level of scientific confidence about the degree of positive or negative impact caused by each action. (See Box 2, page 5 for an explanation of scientific confidence.)

Response options based on land management

	Response option	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Agriculture	Increased food productivity	L	M	L	M	H	—
Agriculture	Agro-forestry	M	M	M	M	L	●
Agriculture	Improved cropland management	M	L	L	L	L	●●
Agriculture	Improved livestock management	M	L	L	L	L	●●●
Agriculture	Agricultural diversification	L	L	L	M	L	●
Agriculture	Improved grazing land management	M	L	L	L	L	—
Agriculture	Integrated water management	L	L	L	L	L	●●
Agriculture	Reduced grassland conversion to cropland	L	—	L	L	– L	●
Forests	Forest management	M	L	L	L	L	●●
Forests	Reduced deforestation and forest degradation	H	L	L	L	L	●●
Soils	Increased soil organic carbon content	H	L	M	M	L	●●
Soils	Reduced soil erosion	↔ L	L	M	M	L	●●
Soils	Reduced soil salinization	—	L	L	L	L	●●
Soils	Reduced soil compaction	—	L	—	L	L	●
Other ecosystems	Fire management	M	M	M	M	L	●
Other ecosystems	Reduced landslides and natural hazards	L	L	L	L	L	—
Other ecosystems	Reduced pollution including acidification	↔ M	M	L	L	L	—
Other ecosystems	Restoration & reduced conversion of coastal wetlands	M	L	M	M	↔ L	—
Other ecosystems	Restoration & reduced conversion of peatlands	M	—	na	M	– L	●

Response options based on value chain management

	Response option	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Demand	Reduced post-harvest losses	H	M	L	L	H	—
Demand	Dietary change	H	—	L	H	H	—
Demand	Reduced food waste (consumer or retailer)	H	—	L	M	M	—
Supply	Sustainable sourcing	—	L	—	L	L	—
Supply	Improved food processing and retailing	L	L	—	—	L	—
Supply	Improved energy use in food systems	L	L	—	—	L	—

Response options based on risk management

	Response option	Mitigation	Adaptation	Desertification	Land Degradation	Food Security	Cost
Risk	Livelihood diversification	—	L	—	L	L	—
Risk	Management of urban sprawl	—	L	L	M	L	—
Risk	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
Positive	Moderate	0.3 to 3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
Positive	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
Negative	– Moderate	–0.3 to –3	1 to 25	0.5 to 3	0.5 to 3	1 to 100
Negative	– 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

Relative costs for each option. See the IPCC's Summary for Policy Makers for cost ranges in US$.

●●● High cost
●● Medium cost
● Low cost
— No data

“Near-term action to address climate change adaptation and mitigation, desertification, land degradation and food security can bring social, ecological, economic and development co-benefits (high confidence). Co-benefits can contribute to poverty eradication and more resilient livelihoods for those who are vulnerable (high confidence).”[75]

Beyond the IPCC: A Value Chain Methodology for Resilience in Drylands in Senegal, VC-ARID

Home to nets A three-step, innovative methodology called Value Chain Analysis for Resilience in Drylands (VC-ARID) was developed by the Pathways to Resilience in Semi-arid Economies (PRISE) Project. It enabled researchers, farmers, agricultural processors and businesses to identify climate risks, adaptation options and opportunities for private sector development.

Semi-arid lands have enough rainfall to support rain-fed agriculture, as opposed to arid lands, which support pastoralism but cannot support crops without irrigation.[76]

At each step of each value chain, climate risk is assessed using both qualitative and quantitative methods. VC-ARID explicitly considers rainy and dry season variability in arid lands. Significant economic activity takes place in semi-arid lands, with approximately 2 billion people making a living in these areas. However, these areas have been relatively marginalised both politically and economically and much production and trading activity is informal. Therefore the VC-ARID methodology incorporates both informal and formal value chains. It also accounts for significant gender dimensions, exploring opportunities for diversification of value chains in a way that includes both men and women.

The methodology has three principal steps:

- **Step one:** Mapping the value chain
- **Step two:** Assessing climate risks at each level of the value chain
- **Step three:** Identifying adaptation and private sector investment options for climate-resilient value chain transformation.

The method was applied to Senegal’s cow’s milk value chain, where it investigated a traditional (mostly informal) chain primarily run by women, and a more industrialised milk production (formal) chain.

Image: © IFPRI | Cattle, Senegal.

An assessment showed climate risks and negative impacts at each step of the dairy value chain. Analysis found that the collection, storage and distribution of milk is a challenge, especially in the face of climate variability and change. This affects milk quality and prices. 84% of dairy producers said that cattle grazing areas are declining as rainfall declines, which affects the quantity and quality of milk produced. Exotic cattle breeds deliver higher returns in the short term because they are more productive, but they may not be climate resilient in the long term.

Awareness of climate change has not yet, however, changed farmers’ behaviour: 27% of producers decided not to change their behaviour in the face of changing rainfall and 65% decided not to change in response to temperature trends.

Farmers say that lack of knowledge and lack of financial support are the main reasons for failing to take adaptation action. The researchers conclude that ‘there is a need to support the tailoring of services to close this gap [by providing] financial, climate information and animal health services.’[77]

Box 7: Sustainable land management: Experience from Tigray province, Ethiopia

Multiple measures are required to create more sustainable, land-based production systems. The drought-prone Tigray region of Northern Ethiopia, which suffers from severe land degradation, provides one such case study.

Recurrent droughts and famines are recorded from the late 19th through late 20th centuries in Tigray, and most recently during the strong El Nino event of 2015–16. Many children under the age of five are stunted or underweight.[78] Most of the land is managed as cropland and around 90% of households cultivate the land on a small scale using ploughs. Slopes are heavily marked by gullies, often more than two metres deep and five metres across at the top. Satellite imagery shows increased erosion rates in the 1980s and 1990s.[79]

Since around the turn of the millennium, soil and water conservation measures, integrated catchment management, conservation agriculture and indigenous tree regeneration have been implemented. This suite of measures is now beginning to show positive effects on the vegetation cover, and by 2010 had led to the stabilisation of about 25% of the gullies.[80]

Since 1991, farmers have provided labour for soil and water conservation every January as a free service for 20 consecutive working days, followed by food for work for the remaining days of the dry season. Most of the degraded landscapes have been restored, with positive impacts over the last two decades on soil fertility, water availability and crop productivity. However, misuse of fertilisers, low survival of tree seedlings and lack of income may affect the sustainability of the land restoration measures.[81]

Beyond the IPCC Report: Innovations for sustainable land management: New directions in the Sahel

Farmers in the Sahel now need to contend with farming conditions that go beyond previous generations' experience. Scientific knowledge needs to be combined with current local experience to make it possible to understand and plan better ways to cope with these changes, in an ever more challenging external environment.

BRACED, the Building Resilience and Adaptation to Climate Extremes and Disasters programme, documented how Sahelian communities are combining traditional and indigenous knowledge with scientific insight to create more resilient livelihoods.

Examples of recent innovations benefiting the region include seed security systems; dairy hubs (where smallholders are directly linked to dairy processors); biotechnology improvements; deep placement of fertiliser for better plant nutrient uptake; digital soil maps for sub-Saharan Africa (African Soil Information Service); mobile phone applications for livestock and agricultural advice; and new feeding and corralling systems for livestock (e.g. managed, rotational, intensive grazing and rangeland models).[82]

BRACED PROJECT NAME/ COUNTRY	INTERVENTION	WHAT IS INNOVATIVE ABOUT IT?
Improving community resilience through climate smart agriculture, health, and early warning systems (BRICS) Sudan and Chad	Conservation agriculture	**Newness, Adaptation and Knowledge:** Co-developing improved and new techniques for agriculture **Interactions:** Focusing on low-cost and participatory approach (interactions)
Projet de Résilience face aux Chocs Environnementaux et Sociaux au Niger (PRESENCES)	Participatory scenario planning for crop and livestock farming	**Newness:** Users receive forecast information **Interaction:** Users plan together with advisers about their response, building trust and choosing from a set of possible activities **Knowledge:** Local knowledge is integrated with scientific knowledge
Renforcement des Initiatives Communautaires pour la Résilience aux Extrêmes Climactiques (RIC$_4$REC) Mali	Telephones as tools for distributing accurate climate information and farm advice	**Newness:** New to this geographical area **Adaptation:** Using new technology, tailoring information in local languages, interface design that can get responses **Interaction:** Users interact and test the accuracy of forecasts; direct information from agricultural experts by text **Technical knowledge** is tailored and adapted: Information provided responds to specific questions from the user **Partnerships** are developed between private companies and government meteorological services and extension agents
Scaling-Up Resilience for 1 Million People in the Niger Basin River of Niger and Mali (SUR$_1$M) Niger	Savings and credit scheme at local level (VSLA)	**Newness:** Introducing local savings groups to regions **Interactions:** Increasing social capital and networks; members choose the VSLA structure and rules; decisions are made by the group as a whole **Knowledge and Uptake:** Leaders are trained to spread these groups privately from within, ensuring sustainability
Zaman Lebidi/Internews Burkina Faso	Integrating climate information into community radio	**Newness and Knowledge:** Integrating climate information into local language radio programmes; weather forecast information is relayed by satellite to regions in a creative use of technology (SMS-IVR Platform) **Interactions:** Clubs of listeners discuss programmes and actions to take; develop public-private partnerships **Knowledge:** Training broadcasters in climate information

"Large-scale implementation of dedicated biomass production for bioenergy increases competition for land with potentially serious consequences for food security and land degradation (high confidence)."[83]

Some actions increase pressure on land – best practices can help

Some measures that are intended to achieve climate mitigation and adaptation, combat desertification and land degradation and enhance food security risk are creating more pressures on land. There are 'best practice' ways to approach these options to ensure that they are environmentally and socially sustainable. For example, afforestation and reforestation are considered important ways to remove carbon dioxide from the atmosphere and help stabilise the climate. A 'best practice' way of afforestation (see Table 3, below) is to use native tree species and involve local people fully in implementation so that their food supplies are secure. A potentially harmful way of afforesting would be to use non-native species and exclude local people. (See also Box: REDD+… Madagascar, page 22.)

TABLE 3: Climate actions that increase competition for land – and 'best practices' that can reduce the pressure

Bioenergy and Bioenergy with Carbon Capture and Storage (BECCS)

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
H	L			L	

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.

Reforestation and forest restoration

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

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.

Afforestation

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

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.

Biochar addition to soil

Mitigation	Adaptation	Desertification	Land degradation	Food security	Cost
M	—	—	L	L	

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.

Beyond the IPCC: Impacts of biofuel crop production in Southern Africa[84]

Unravelling the effects of land use change on ecosystem services improves our understanding of the local impacts of biofuel crop production on poverty alleviation and food security.

Biofuel crop production causes changes in land use, and by extension affects the provision of various ecosystem services. Crop type, scale of production and the original land use are key factors in determining whether changes in ecosystem services are negative or positive over a given timeframe. For example, the conversion of agricultural land and partly degraded woodland to large sugarcane plantations in Malawi and Swaziland has had carbon sequestration benefits through carbon stock gains. Similar effects are observed in areas of Malawi where jatropha was promoted as a hedge crop in small family farms. In contrast, the conversion of savanna woodland for a large jatropha plantation in Mozambique has caused substantial decline in carbon stocks.

Sugarcane is a mature industrial crop with a long history in southern Africa. Its production can contribute positively to local poverty alleviation and food security. This was observed in both plantation and smallholder settings in Malawi and Swaziland. While the actual effects vary between the various groups involved in sugarcane production, these groups tend to be better off compared to groups not involved in sugarcane production.

Jatropha is a relatively new and unproven crop in southern Africa and hence its poverty reduction benefits remain unproven. While workers in jatropha plantations could experience some economic benefits (with positive ripple effects on poverty alleviation and food security), these benefits are somewhat precarious considering the almost total collapse of the jatropha sector in southern Africa. On the other hand, considering the low achieved yields, jatropha cultivation in smallholder settings in Malawi does not seem to offer any significant poverty alleviation and food security benefits to adopting farmers.

Image: © Rod Waddington | Taking sugarcane to market

Beyond the IPCC: How to ensure that REDD+ is sustainable – insights from Madagascar[85]

A Ecosystem Services for Poverty Alleviation project provided recommendations to the government and other stakeholders in Madagascar to ensure that both environmental and livelihoods considerations are taken into account within its national programme for reducing emissions from deforestation and forest degradation (REDD+).

Madagascar's forests store globally important volumes of carbon and provide incredible biodiversity. The Malagasy government is using REDD+ to contribute to its global climate mitigation efforts.

Shifting cultivation (locally known as *tavy*) has traditionally provided access to fertile soils for hundreds of thousands of small farmers. Conservation restrictions aimed at protecting forests by preventing *tavy* have the potential to negatively impact poor people's livelihoods.

The ESPA P4GES project investigated how international ecosystem service payment schemes (including REDD+) can most effectively reduce poverty. It found that conservation that produces global benefits has local costs, borne most heavily by the poorest. This raises critical issues for Malagasy policymakers about how people's access to natural resources should be recognised and valued, and what conditions should be placed on REDD+ schemes to ensure that the poorest benefit and do not suffer harm – including appropriate compensation if people's access to natural resources is restricted.

Findings of the research have been shared with numerous stakeholders, raising considerable interest and laying the foundations for future impact.

Image: © Mahesh Poudyal, P4GES project | Traditional *tavy* system in Madagascar, alongside terraced rice agriculture.

Coordinated action to address climate change and end hunger

At present, around 25–30% of total global greenhouse gas emissions come from the food system. come from the food system – agriculture and land use, storage, transport, packaging, processing, retail and consumption.

Policies that operate across the food system can support more sustainable land use management, enhanced food security and low-emissions development. This includes policies that reduce food loss and waste and influence dietary choices. More sustainable diets are high in coarse grains, pulses, fruits and vegetables, and nuts and seeds; they are low in discretionary foods (such as sugary beverages) which are becoming more prevalent in modern diets and can contribute to obesity.

"Agriculture and the food system are key to global climate change responses. Combining supply-side actions such as efficient production, transport and processing with demand-side interventions such as modification of food choices, and reduction of food loss and waste, reduces greenhouse gas emissions and enhances food system resilience (high confidence)."[86]

Combining large-scale climate change adaptation and mitigation strategies across the supply and demand sides is possible, in ways that manage the competition for land for food production and combat higher food prices effectively.

This can be achieved by intensifying agriculture, but it must be *sustainable intensification* – ways of managing inputs (such as water and fertilisers) to increase agricultural production, but without depleting and polluting soils and larger ecosystems and undermining their ability to support agriculture for future generations.[87]

On the supply side, resilience to increasing frequency of extreme weather events can be achieved through economic instruments that share and transfer risk, such as insurance markets and index-based weather insurance.

Policy measures to tackle climate change adaptation and mitigation, reduce land degradation, desertification and poverty, and improve public health simultaneously include:

- improving access to markets
- securing land tenure
- factoring environmental costs into food prices
- making payments for ecosystem services, and enhancing local and community collective action.[88]

Policy measures should be equitable, providing benefits for women and girls as well as men and boys, and explicitly addressing women's barriers to participation (see Box 8, right, and Section 7).[89]

On the demand side, public health policies to improve nutrition – such as school procurement, health insurance incentives, and awareness-raising campaigns – can potentially change demand, reduce healthcare costs, and contribute to lower greenhouse gas emissions.[90]

"Without combined food system measures in farm management, supply chains and demand, adverse effects would include an increased number of malnourished people and impacts on smallholder farmers. Just transitions are needed to address these effects."[91]

Box 8: Women's empowerment and food security: Evidence from Africa

Empowering and valuing women increases their capacity to improve food security in a changing climate and substantially improve the wellbeing of themselves, their families and their communities.

Women's empowerment includes economic, social and institutional arrangements and may include targeting men in integrated agriculture programmes to change gender norms and improve nutrition. Empowerment through collective action in the near term has the potential to equalise relationships on the local, national and global scale. Empowered women are crucial to creating effective synergies among adaptation, mitigation and food security.

In Western Kenya, widows in their new role as main livelihood providers invested in sustainable innovations like rainwater harvesting systems and agroforestry (which can serve as both adaptation and mitigation), and worked together in formalised groups of collective action to ensure food and water security. Integrated nutrition and agricultural programmes have increased women's decision-making power and control over home gardens in Burkina Faso with positive impacts on food security.[92]

6 Insecure property rights and lack of access to credit and agricultural advisory services hamper progress – especially by women

A number of factors contribute to desertification. These include land tenure insecurity, lack of property rights, lack of access to markets and to agricultural advisory services, lack of technical knowledge and skills, agricultural price distortions, and lack of agricultural support and subsidies.[93] Women's lack of access to these services (for social and cultural reasons), in particular, hampers their ability to be more effective agents of sustainable change.

Tackling this range of knowledge gaps and distorting policies will be key to sustainable stewardship of land, which will, in turn, be key to successful climate adaptation and mitigation.[94]

Policy responses to desertification that are widely discussed in the literature and particularly in the context of climate change, are:[95]

- improving market access
- gender empowerment
- expanding access to rural advisory services
- strengthening land tenure security
- payments for ecosystem services[96]
- decentralisation of natural resource management (but only when done in a democratic way that does not further concentrate power in the hands of local elites);
- investing in research and development
- investing in monitoring of desertification and desert storms
- developing modern renewable energy sources (especially those which replace fuelwood/biomass) and
- diversifying dryland economies – including by investing in irrigation and agricultural commercialisation and structural transformations.

"Improving capacities, providing higher access to climate services, including local-level early warning systems, and expanding the use of remote sensing technologies are high-return investments for enabling effective adaptation and mitigation responses that help address desertification (high confidence)."[97]

***Beyond the IPCC:* Climate services for more productive land management in Kenya**

In Western Kenya, the Kenya Meteorological Department (KMD) has tailored weather services to the county level, targeting the four counties of Kakamega, Siaya, Kisumu and Trans Nzoia. These were chosen because they have relatively high rainfall and unpredictable weather. The KMD pinpointed a range of stakeholders working in climate- and weather-sensitive sectors, including personnel from county governments, forestry businesses, sugar companies and farmers. First, meteorological officers were offered critical skills training in climate modelling, communications and how to develop forecasts that would benefit end users.

Weather and Climate Information Services in Africa (WISER) provided essential equipment and software, including laptops, cameras and smartphones, to county meteorological directors to document weather events and user feedback. This has allowed them not only to communicate easily with end users, but also to produce weather services and forecasts specific to each county. KMD issued a 36-hour fishers' forecast at 16:00 every day – and a simple traffic light system was developed to signify potential hazards.

In the past, county governments lost money when roads were washed away by torrential rainfall. With improved local forecasting, they could plan ahead and avoid financial losses. Farmers, too, were able to take timely action to increase crop yields, ultimately leading to greater food security. Anecdotal evidence shows that the accuracy of forecasts has had a huge impact, with reports of agricultural production across Tranz Nzoia increasing by up to 20%. Through radio, SMS messaging and the internet, the project has reached up to 400,000 people across Western Kenya, transforming the quality and usability of climate information.[98]

7 The skills and knowledge of women and marginalised groups are not yet sufficiently recognised

It is well recognised that people are differently affected by the impacts of climate change and by society's responses to climate change, and that women may be particularly affected. Women, indigenous people and other typically marginalised groups have vital knowledge and are demonstrating ingenuity in land management practices to adapt to climate change.

Most of the literature focuses on the greater vulnerability of women and other socially marginalised groups to the negative impacts of climate change. However, it is important not to fall into framing people as 'victims'. Narratives should recognise the real strengths and ingenuity of women, indigenous people and other marginalised groups, particularly in adapting to climate change. Also, it should be recognised that women often assume new leadership roles in adapting to already-felt impacts of climate change.

"[The] collective action and agency of women, including widows, has led to the prevention of crop failure, reduced workload, increased nutritional intake, increased sustainable water management, diversified and increased income, and improved strategic planning."[99]

A broad approach to gender issues

There is insufficient research to date on how climate *mitigation* activities are empowering or disempowering women and affecting women's and girls' wellbeing. This is a priority area for further enquiry. For land-based climate mitigation, there is some evidence that these activities 'may interfere with traditional livelihoods in rural areas, cause conflicts, lead to a decline in women's livelihoods and reinforce existing inequities and social exclusions if elite capture is not prevented.'[100] These include cultivating biofuel crops, Reduced Emissions from Deforestation and forest Degradation and related forest conservation activities for financing on global markets (REDD+) and other policies such as solar farms requiring large areas of land.

Although women's needs in a changing climate often call for special attention to ensure that climate policies and programmes are not designed for a 'man's world', it is useful to understand issues through the lens of gender more broadly. Gender approaches recognise that some climate change impacts and responses to climate change impact on men and masculinity in ways that need to be better understood.

Despite known differences between women and men, land restoration and rehabilitation efforts have tended to be 'gender-blind'.[101]

Tackling inequality

Inequality is one of the greatest overall challenges in the context of land management and sustainable development in a changing climate. Effective and reliable social safety nets are required to address the impacts of climate change on the poorest. Social protection coverage is currently low, especially for poor rural people. There is a need to explore how local support institutions could be strengthened to extend social protection.[102]

"There is medium evidence and high agreement that one of the greatest challenges is posed by inequalities that influence local coping and adaptive capacity."[103]

Image: © EU/ECHO/Anouk Delafortrie/Flickr | Children in microburst in Ethiopia.

People's diverse needs and talents

Intersectional approaches are growing in importance as a more nuanced way of looking at how climate policies and programmes affect the agency and wellbeing of different groups of people. This means looking at the many ways in which people could be vulnerable to climate change and are able to respond effectively – based not only on gender but on income, age, ethnicity, (dis)ability and other social and physical attributes.

Women's and men's responses to climate change tend to be very context specific. For example, in the drylands of sub-Saharan Africa, climate change is expected to contribute to widespread shortages of freshwater. Women are the primary natural resource managers and providers of food security in the region and are often expected to collect water and fuelwood from increasingly remote areas. By contrast, men migrate to nearby towns or other countries for better opportunities, leaving women behind with more responsibilities.[104] These socially-defined gender-specific roles are not static but shaped by factors such as wealth, age, ethnicity and formal education.[105]

Effective climate change adaptation and mitigation strategies recognise and respond to people's differences, and consider how to build on people's strengths.

Beyond the IPCC: The diversity of ways in which people experience climate change impacts and can be part of the solution

According to analysis by the BRACED programme, intersectional approaches offer a way 'to understand and respond to the ways different factors, such as gender, age, disability and ethnicity, intersect to shape individual identities, thereby enhancing awareness of people's needs, interests, capacities and experiences. This in turn will help in targeting policies and programmes.'[106]

The authors suggest that, for practical purposes of designing and implementing climate adaptation and resilience programmes, it is not helpful to consider social groups as homogenous (e.g. 'women') as all the same or static. Intersectional approaches recognise people's complexity 'by taking historical, social, cultural and political contexts into account.'

A BRACED study in Kenya looked at women and men with and without political representation, from majority and minority clans. Not only were gender aspects at play, but individuals' clan membership had a bearing on their access to resources from local government and other actors. Clans in the majority – at ward level – were at an advantage, while those in the minority were disadvantaged. All respondents were living in Wajir county, Kenya, and facing recurrent and widespread drought.

The research used an index based on four components of resilience: economic, social, infrastructural and institutional, as well as focus groups and interviews. It explored the different experiences of the four groups of people: their climate-related concerns, and the policies and processes that build their resilience to climate hazards.[107]

In Wajir county, Kenya, the statistics demonstrated no differences between women's climate resilience and men's, or between majority clan and minority clan members. Men (in both social groups) had a slightly higher score for social resilience and food security, and higher access to information through newspapers. Nonetheless, focus group discussions and interviews showed clearly how gender inequalities create major constraints for women. Women have less access to and

Image: © USAID | Woman leader, Wajir county.

control of natural resources; they have less opportunity to earn an income, access education and training and participate in decision-making processes; and they do not have equal rights to inherit assets. Gender-based violence also impairs women's wellbeing and life opportunities. Tackling these gender inequalities at both the structural (legal, institutional) and behavioural level is not only important in its own right, for women's and girls' overall wellbeing, but is inseparable from their ability to adapt and become more resilient to climate change. Women's and girls' empowerment is both a development and a climate change issue.

8 Integrated governance is needed to maximise the benefits of land and water

Integrated governance across sectors and scales is needed to manage the pressure on land and water, both to meet the requirements of people and biodiversity and relieve the increased pressures caused by climate change.

Integrated governance makes it more likely that the co-benefits of development and climate change adaptation/mitigation will be maximised.[108] Integrated governance is especially important at national, river basin and ecosystem levels.

There are gaps in the Sustainable Development Goals; for example, there is no goal to protect and restore freshwater ecosystems. Thus other frameworks need to be considered beyond the SDGs, such as the 'Nature's Contribution to People' approach used by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Nature's Contribution to People is about the contributions, both positive and negative, of living nature – the diversity of organisms, ecosystems, and their ecological processes – to people's quality of life.[109]

A mix of coherent policies helps deliver sustainable development in the context of natural resource pressures and a changing climate. The importance of a mix of coherent policies is shown when farmers are helped to respond to drought. A mix of crop insurance, sustainable land management practices, bankruptcy and insolvency measures, co-management by communities for water and disaster planning, and water infrastructure programmes have proven effective when combined.

Similarly, a mix of coherent policies was found to be effective for responding to floods: flood zone mapping, land use planning, flood zone building restrictions, business and crop insurance, disaster assistance payments, preventative instruments such as soil and water management measures for farms and farm infrastructure projects, and bankruptcy measures to help farmers recover from debilitating economic losses.[110]

"Many sustainable development efforts fail because of lack of attention to societal issues including inequality, discrimination, social exclusion and marginalisation … citizen engagement is important in enhancing natural resource service delivery."[111]

Adaptive, iterative decision-making is increasingly in use to explore synergies and trade-offs between goals and targets.[112] Adaptive approaches can help tackle the negative impacts of land use change and climate change. It can achieve progress in halting species decline and habitat loss, managing competing land interests and managing land more sustainably, conserving biodiversity, increasing carbon storage and improving livelihoods.

However, adaptive management is hard to achieve in practice, due to social uncertainties, donor preferences and shifting objectives. Boosting people's participation, using indicators effectively, and taking intentional steps to avoid 'maladaptation' are all important components of adaptive management. Maladaptation is a kind of unsustainable adaptation and policy incoherence.[113]

Image: © Shutterstock | Limpopo River crossing the desert landscape of Mapungubwe National Park.

Box 9: Limpopo River Basin: Climate risk governance across and within borders

The Limpopo River Basin spans parts of Botswana, South Africa, Zimbabwe and Mozambique. The condition of the river basin and its management demonstrate the combined effect of desertification and climate change, and why integrated watershed management may be a crucial component of reducing climate risk.

The basin falls mostly in a semi-arid area. Rainfall is both highly seasonal and variable. El Nino and the Southern Oscillation Index have a prominent impact, leading to severe droughts. The basin is also exposed to tropical cyclones that sweep in from the Mozambique Channel; this often results in extensive casualties and the destruction of infrastructure. Scientists expect that the region will become warmer and drier. There is a need to address people's exposure to floods in the basin.

Water scarcity is already acute, and is predicted to worsen. Without the additional impact of climate change, the basin is rapidly reaching a point where all available water has been allocated to users. The urgency of the situation, and a need for improved coordination and governance, was identified several decades ago by the countries of the basin. The Limpopo Watercourse Commission was established to guide the development, utilisation and conservation of the river's resources.

Recent reviews of integrated watershed management in the basin recognise:

1. There are capacity and resource constraints at most levels. Limited capacity within the Limpopo Watercourse Commission and national water management authorities constrains the implementation of integrated watershed management. Whereas strategy development is often relatively well funded and resourced through donor funding, long-term implementation is often limited due to competing priorities.
2. Adequate representation of all parties is needed in order to address existing inequalities and ensure full integration of water management. For example, within Mozambique, significant strides have been made towards the decentralisation of river basin governance and integrated watershed management. Despite good progress, it has been found that the system may enforce existing inequalities, as not all stakeholders, particularly smallholder farmers, are adequately represented in emerging water management structures. They are often inhibited by financial and institutional constraints. Recognising and addressing people's inequalities and ensuring that all social groups' interests are considered can increase the chances that integrated watershed management will be implemented successfully.[114]

9 Emissions reductions in other sectors are vital to relieve pressure on land

Land must be managed to provide food security as the world's population increases and to support other sustainable development goals. This means there are limits to the contribution of land to climate change mitigation by, for example, cultivating bioenergy crops and afforesting land to sequester carbon dioxide from the atmosphere.[115] It also takes time for trees and soils to store carbon effectively.[116]

If bioenergy crops and trees are planted on a scale that would deliver millions of gigatons per year of carbon sequestration, then land conversion would increase greatly. This could lead to adverse side effects for climate change adaptation, desertification, land degradation and food security.[117] Without the widespread uptake of sustainable land management, deployment of bioenergy crops and tree plantations at this scale could jeopardise the achievement of Sustainable Development Goals (SDGs) that depend on land-based ecosystem services.[118]

Bioenergy and afforestation need to be carefully managed to avoid these risks. Desirable outcomes will depend on locally appropriate policies and governance systems.

Lowering greenhouse gas emissions in other sectors and areas of human behaviour can ease the pressure on land.[119]

"Land cannot do it all."[120]

Conclusion

In summary, if we care for the land, it will care for us. If we nurture healthy soils and productive and diverse ecosystems, the land can more effectively regulate the local, regional and global climate. It is possible to manage land responsibly to provide food, fibre, fuel and the other benefits that sustain human resilience and wellbeing directly. However, sustainable land management needs to happen in the context of cross-cutting policies and governance that relieve pressure on the land and enable human society to pursue its other vital goals in less 'land hungry' ways.

Image: © Charlie Zajicek, Low Emission Development Strategies Global Partnership | There is an urgent need to deploy low- and zero-emission technologies for producing energy, which make minimal use of land and reduce competition for land.

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Image: © EU/ECHO/Martin Karimi/Flickr | In the arid region of Isiolo, Kenya, an irrigation scheme supports communities as they adapt to new farming practices and diversify income, to improve their resilience to recurring droughts.

Glossary

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.[121]

Afforestation: Conversion to forest of land that historically has not contained forests.[122]

Agroforestry: Land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or timed sequence. In agroforestry systems there are both ecological and economical interactions among the different components.[123]

Albedo: The proportion of sunlight (solar radiation) reflected by a surface or object, often expressed as a percentage. Clouds, snow and ice usually have high albedo; soil surfaces cover the albedo range from high to low; vegetation in the dry season and/or in arid zones can have high albedo, whereas photosynthetically active vegetation and the ocean have low albedo. The Earth's planetary albedo changes mainly through varying cloudiness, snow, ice, leaf area and land cover changes.[124]

Aridity: A long-term climatic feature whereby there is low average rainfall or available water in a region.[125]

Biochar: Relatively stable, carbon-rich material produced by heating biomass in an oxygen-limited environment. Biochar is distinguished from charcoal by its application: biochar is added to soil with the aim of improving soil functions and to reduce greenhouse gas emissions from biomass that would otherwise decompose rapidly.[126]

Bioenergy: Energy derived from any form of biomass (organic matter) or its metabolic by-products.[127]

Bioenergy with carbon dioxide capture and storage (BECCS): Carbon dioxide capture and storage (CCS) technology applied to a bioenergy facility. CCS is when carbon dioxide (CO_2) from industrial and energy-related sources is separated, conditioned, compressed and transported to a storage location to be isolated from the atmosphere.[128]

Biofuel: A fuel, generally in liquid form, produced from biomass. Biofuels include bioethanol from sugarcane, sugar beet or maize, and biodiesel from the oil of canola, jatropha or soybeans.

Carbon dioxide (CO_2) fertilisation: This is an effect whereby increased CO_2 levels encourage photosynthesis and plant growth. However, this phenomenon does not necessarily enrich land-based ecosystems (it may contribute to the growth of scrub vegetation) and overall, CO_2 fertilisation tends to decrease the nutritional content of crops.[129]

Confidence: The robustness of a finding based on the type, amount, quality and consistency of evidence and on the degree of agreement across multiple lines of evidence. In this report, confidence is expressed qualitatively.[130]

Deforestation: Conversion of forest to non-forest.[131]

Desertification: Land degradation in arid, semi-arid, and dry sub-humid areas resulting from many factors, including climatic variations and human activities.[132]

Drought: A period of abnormally dry weather long enough to cause a serious hydrological imbalance.[133]

Ecosystem: A functional unit consisting of living organisms, their non-living environment and the interactions within and between them. Ecosystem boundaries can change over time.

Ecosystem services: Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as (1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food or fibre, (3) regulating services such as climate regulation or carbon sequestration, and (4) cultural services such as tourism or spiritual and aesthetic appreciation.[134]

Evapotranspiration: The combined processes through which water is transferred to the atmosphere from open water and ice surfaces, bare soil, and vegetation that make up the Earth's surface.[135]

Food security: The situation when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.[136]

Global warming: An increase in global mean surface temperature (GMST) averaged over a 30-year period, or the 30-year period centred on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified.[137]

Greenhouse gases (GHG): Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation and cause the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O and CH_4, the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Land cover: The biophysical coverage of land (e.g. bare soil, rocks, forests, buildings and roads or lakes). Land cover is often categorised in broad land-cover classes (e.g. deciduous forest, coniferous forest, mixed forest, grassland, bare ground).[138]

Land degradation: This is defined in the IPCC's Special Report on Climate Change and Land as a 'negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity or value to humans.' In this definition, land degradation applies to all lands, including forested lands, and not only drylands.[139]

Land restoration: Aiding the recovery of land from a degraded state.[140]

Nationally Determined Contributions (NDCs): A term used under the United Nations Framework Convention on Climate Change (UNFCCC) whereby a country that has joined the Paris Agreement outlines its plans for reducing its emissions. Some countries' NDCs also address how they will adapt to climate change impacts, and what support they need from, or will provide to, other countries to adopt low-carbon pathways and to build climate resilience.[141]

Paris Agreement: The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted on December 2015 in Paris, France by 196 parties to the UNFCCC. As of September 2019, 185 Parties have ratified the Agremeent.[142] One of the goals of the Paris Agreement is 'Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels'. The Paris Agreement is due to go into force in 2020.

Peatlands: Peatland is a land where soils are dominated by peat.[143]

Primary production: The synthesis of organic compounds by plants and microbes, on land or in the ocean, primarily by photosynthesis using light and carbon dioxide as sources of energy and carbon.[144]

Productivity: In ecology, productivity refers to the rate at which biomass is generated in an ecosystem, e.g. the mass of carbon generated, in number of grams per metre per day).[145]

Resilience: The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including by ensuring the preservation, restoration, or improvement of its essential basic structures and functions.[146] Resilience is also defined as the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance.[147] A 'resilience threshold' is passed when the basic structures and functions can no longer be preserved, restored or improved.

Sink: Any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.[148]

Source: Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere.[149]

Sustainable intensification (of agriculture): Increasing yields from the same area of land while decreasing negative environmental impacts of agricultural production and increasing the provision of environmental services. [Note: this definition is based on the concept of meeting demand from a finite land area, but it is scale-dependent. Sustainable intensification at a given scale (e.g., global or national) may require a decrease in production intensity at smaller scales and in particular places (often associated with previous, unsustainable intensification) to achieve sustainability.][150]

Sustainable land management: The stewardship and use of land resources, including soils, water, animals and plants, to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.[151]

Vegetation structure: Communities of species (in this case, plant species) and how they interact with each other in a particular area or habitat.[152]

Endnotes

All references are for chapters and pages in the IPCC's *Special Report on Climate Change and Land* unless otherwise stated.

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41 Chapter 3, p3-41.
42 Chapter 3, p3-41.
43 Chapter 3, page 3-4.
44 Chapter 3, pp3-33 – 3-34.
45 Chapter 3, p3-34.
46 Chapter 3, p3-34.
47 Chapter 3, p 3-35.
48 Chapter 3, p3-44.
49 Chapter 3, p3-44.
50 Chapter 3, p3-36.
51 Chapter 3, p3-39.
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53 Chapter 4, Section 4.7.1.
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