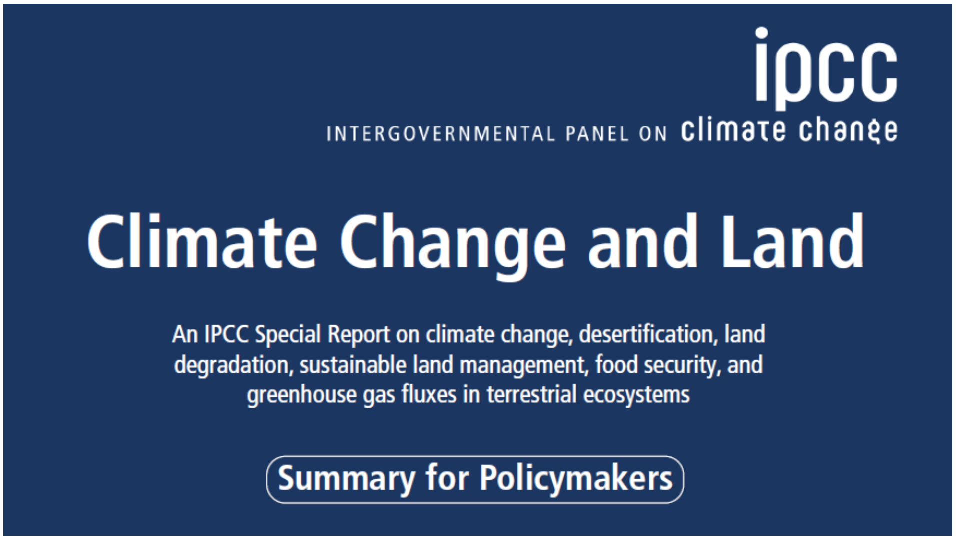


IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems

Summary for Policymakers (SPM) 07 August 2019 (Note: the SPM is approved by all world governments)

A1.5. **About a quarter of the Earth's ice-free land area is subject to human-induced degradation**. **Soil erosion** from agricultural fields is estimated to be currently 10 to 20 times (no tillage) to more than 100 times (conventional tillage) higher than the soil formation rate. **Climate change exacerbates land degradation, particularly in low-lying coastal areas, river deltas, drylands and in permafrost areas.** Over the period 1961-2013, the annual area of **drylands in drought h**as increased, on average by slightly more than 1% per year, with large inter-annual variability. In 2015, about 500 (380-620) million people lived within areas which experienced desertification between the 1980s and 2000s. The highest numbers of people affected are in South and East Asia, the circum Sahara region including North Africa, and the Middle East including the Arabian peninsula. Other dryland regions have also experienced desertification. People living in already degraded or desertified areas are increasingly negatively affected by climate change

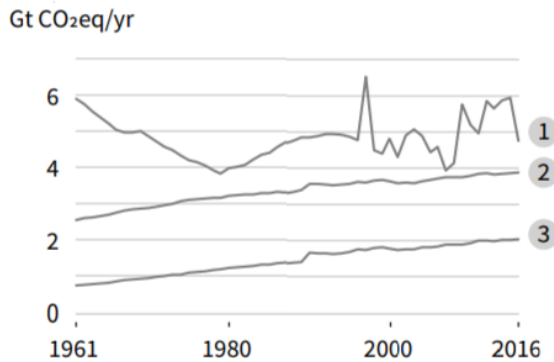
Note: Drylands currently cover about 46.2% (±0.8%) of the 7 global land area and are home to 3 billion people.

D**. Agricultural production**

Land use change and rapid land use intensification have supported the increasing production of food, feed and fibre. Since 1961, the total production of food (cereal crops) has increased by 240% (until 2017) because of land area expansion and increasing yields. Fibre production (cotton) increased by 162% (until 2013).

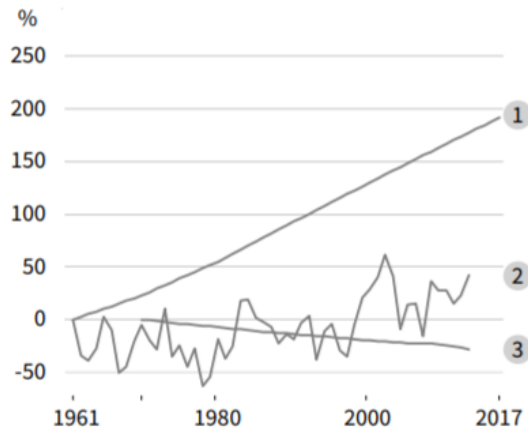
B. GHG emissions
An estimated 23% of total anthropogenic greenhouse gas emissions (2007-2016) derive from Agriculture, Forestry and Other Land Use (AFOLU).

CHANGE in emissions rel. to 1961
1. Net CO_2 emissions from FOLU (Gt CO_2/yr)
2. CH_4 emissions from Agriculture (Gt CO_2eq/yr)
3. N_2O emissions from Agriculture (Gt CO_2eq/yr)



F. Desertification and land degradation
Land-use change, land-use intensification and climate change have contributed to desertification and land degradation.

CHANGE in % rel. to 1961 and 1970
1. Population in areas experiencing desertification
2. Dryland areas in drought annually
3. Inland wetland extent



A 2. Since the pre-industrial period, **the land surface air temperature has risen nearly twice as much as the global average temperature.**

Climate change, including increases in frequency and intensity of extremes, has adversely impacted food security and terrestrial ecosystems as well as contributed to desertification and land degradation in many regions

A2.2. **(Extreme weather) Warming has resulted in an increased frequency, intensity and duration of heat related events, including heat waves in most land regions**. **Frequency and intensity of droughts has increased in some regions** (including the Mediterranean, west Asia, many parts of South America, much of Africa, and north-eastern Asia) and there has been an **increase in the intensity of heavy precipitation events at a global scale**

A2.5. In some dryland areas, increased land surface air temperature and evapotranspiration and decreased precipitation amount, in interaction with climate variability and human activities, have contributed to **desertification**. These areas include Sub-Saharan Africa, parts of East and Central Asia, and Australia

A2.7. **Climate change can exacerbate land degradation** processes including through increases in rainfall intensity, flooding, drought frequency and severity, heat stress, dry spells, wind, sea-level rise and wave action, …Ongoing coastal erosion is intensifying and impinging on more regions with sea level rise adding to land use pressure in some regions

A2.8. **Climate change has already affected food security** due to warming, changing precipitation patterns, and greater frequency of some extreme events. In many lower-latitude regions, yields of some crops (e.g., maize and wheat) have declined, …Climate change has resulted in lower animal growth rates and productivity in pastoral systems in Africa. There is robust evidence that agricultural pests and diseases have already responded to climate change resulting in both increases and decreases of infestations. Based on indigenous and local knowledge, climate change is affecting food security in drylands, particularly those in Africa, and high mountain regions of Asia and South America

A 3. **(Emissions)** Agriculture, Forestry and Other Land Use (AFOLU) activities accounted for around 13% of CO2, 44% of methane (CH4), and 82% of nitrous oxide (N2O) emissions from human activities globally during 2007-2016, representing **23% of total net anthropogenic emissions of GHGs**

A3.1. **Land is simultaneously a source and a sink of CO2** due to both anthropogenic and natural drivers, making it hard to separate anthropogenic from natural fluxes. **Global models estimate net CO2 emissions of 5.2 ± 2.6 GtCO2 yr-1 (likely range) from land use and land-use change during 2007-16.**

Table SPM1. Net anthropogenic emissions due to Agriculture, Forestry, and other Land Use (AFOLU)

	Total net anthropogenic emissions (AFOLU + non-AFOLU) by gas	AFOLU as a % of total net anthropogenic emissions, by gas	AFOLU as a % of total net anthropogenic emissions, by gas
Panel 1: Con			
	E = C + D	F = (C/E)*100	F = (C/E)*100
CO_2[2]	**39.1 ± 3.2**	~13%	~13%
CH_4[3,8]	**363 ± 111**		
	10.1 ± 3.1	~44%	~44%
N_2O[3,8]	**10.4 ± 2.7**		
	2.8 ± 0.7	~82%	~82%
Total (GHG)	**52.0 ± 4.5**	**~23%**	**~23%**

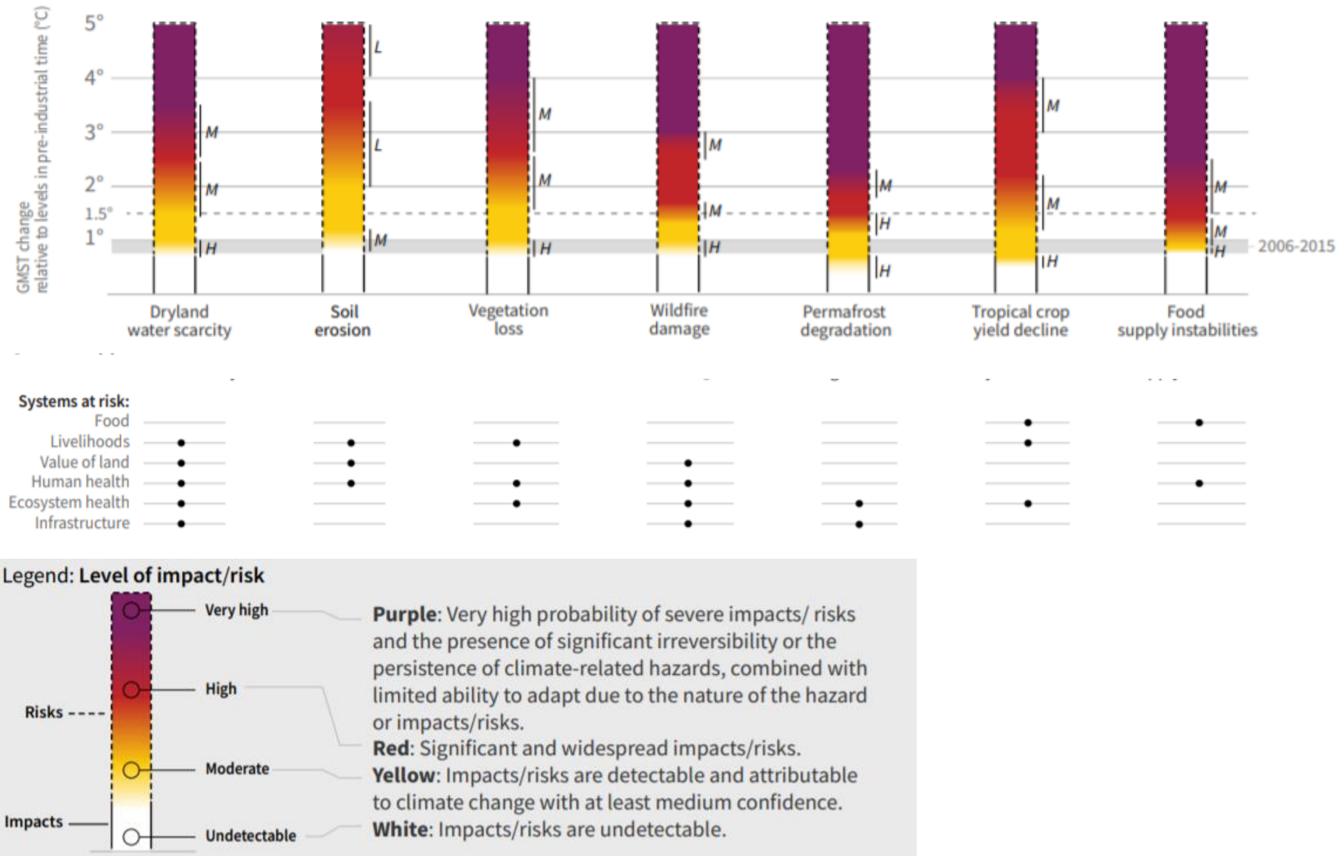
A3.4 Methane CH4 The globally averaged atmospheric concentration of methane shows a steady increase between the mid-1980s and early 1990s, slower growth thereafter until 1999, a period of no growth between 1999-2006, followed by a resumption of growth in 2007. Biogenic sources make up a larger proportion of emissions than they did before 2000. Ruminants and the expansion of rice cultivation are important contributors to the rising concentration

A3.5 Nitrous oxide N2O Anthropogenic N2O emissions from soils are **primarily due to nitrogen (fertilizer)application** including inefficiencies (over-application or poorly synchronised with crop demand timings). Cropland soils emitted around 3 Mt N2O yr-1 (around 795 MtCO2-eq yr-1) during the period 2007-2016. There has been a major growth in emissions from managed pastures due to increased manure deposition. **Livestock on managed pastures and rangelands accounted for more than one half of total anthropogenic N2O emissions**

A4.4. **Desertification amplifies global warming** through the release of CO2 linked with the decrease in vegetation cover.

A. Risks to humans and ecosystems from changes in land-based processes as a result of climate change

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.



A 5. **Climate change creates additional stresses on land**, exacerbating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems. Increasing impacts on land are projected under all future GHG emission scenarios. Some regions will face higher risks, while some regions will face risks previously not anticipated. **Cascading risks with impacts on multiple systems and sectors** also vary across regions

A5.1. With increasing warming**, the frequency, intensity and duration of heat related events including heat waves are projected to continue to increase through the 21st century. The frequency and intensity of droughts are projected to increase particularly in the Mediterranean region and southern Africa**. **The frequency and intensity of extreme rainfall events are projected to increase in many regions**

A5.2. With increasing warming, climate zones are projected to further shift poleward in the middle and high latitudes . In high-latitude regions, warming is projected **to increase disturbance in boreal forests, including drought, wildfire, and pest outbreaks**. In **tropical regions**, under medium and high GHG emissions scenarios, warming is projected to result in the emergence of **unprecedented climatic conditions by the mid to late 21st century**

A5.3. Current levels of global warming are associated with moderate risks from increased dryland water scarcity, soil erosion, vegetation loss, wildfire damage, coastal degradation and tropical crop yield decline. Risks, including cascading risks, are projected to become increasingly severe with increasing temperatures. At around 1.5°C of global warming the risks from dryland water scarcity, wildfire damage, and food supply instabilities are projected to be high.

Risks from droughts, water stress, heat related events such as heatwaves simultaneously increase between 1.5°C and 3°C warming.

A5.4. **The stability of food supply is projected to decrease as the magnitude and frequency of extreme weather events that disrupt food chains increases** .

Increased atmospheric CO2 levels can also lower the nutritional quality of crops

A5.5**. In drylands**, climate change and desertification are projected to cause reductions in crop and livestock productivity. Under SSP2, the dryland population vulnerable to water stress, drought intensity is projected to reach 178 million people by 2050 at 1.5°C warming, increasing to 220 million people at 2°C warming, and 277 million people at 3°C warming.

A5.6. Asia and Africa are projected to have the highest number of **people vulnerable to increased desertification**. North America, South America, Mediterranean, southern Africa and central Asia may be increasingly affected by wildfire.

The tropics and subtropics are projected to be most vulnerable to crop yield decline.

Land degradation resulting from the combination of sea level rise and more intense cyclones is projected to jeopardise lives and livelihoods in cyclone prone areas

A6.1. **All assessed future socio-economic pathways result in increases in water demand and water scarcity (high confidence**)

A6.2. In Shared Socioeconomic Pathway 3 the transition from moderate to high risk occurs between 1.2°C and 1.5°C

B1.4**. Land based options that deliver carbon sequestration in soil or vegetation, such as afforestation, reforestation, agroforestry, soil carbon management on mineral soils, or carbon storage in harvested wood products do not continue to sequester carbon indefinitely** (high confidence).

Peatlands, however, can continue to sequester carbon for centuries.

When vegetation matures or when vegetation and soil carbon reservoirs reach saturation, the annual removal of CO2 from the atmosphere declines towards zero, while carbon stocks can be maintained

However, accumulated carbon in vegetation and soils is at risk from future loss (or sink reversal) triggered by disturbances such as flood, drought, fire, or pest outbreaks,.

B3.1. If applied at scales necessary to remove CO2 from the atmosphere at the level of several GtCO2/year , **afforestation, reforestation and the use of land to provide feedstock for bioenergy** with or without carbon capture and storage, or for biochar, could **greatly increase demand for land conversion** (high confidence).

B3.3 **The production and use of biomass for bioenergy can have , adverse side effects, and risks for land degradation, food insecurity, GHG emissions and other environmental and sustainable development goals** (high confidence).

B5.2. The following options also have mitigation co-benefits. Farming systems such as agroforestry, perennial pasture phases and use of perennial grains, can substantially reduce erosion and nutrient leaching while building soil carbon (high confidence). The application of certain biochars can sequester carbon (high confidence), and improve soil conditions in some soil types/climates

B5.4. **Sustainable forest management can maintain or enhance forest carbon stocks, and can maintain forest carbon sinks, including by transferring carbon to wood product**s, thus addressing the issue of sink saturation. Where wood carbon is transferred to harvested wood products, these can store carbon over the long-term and can substitute for emissions-intensive materials reducing emissions in other sectors. Where biomass is used for energy, e.g., as a mitigation strategy, the carbon is released back into the atmosphere more quickly

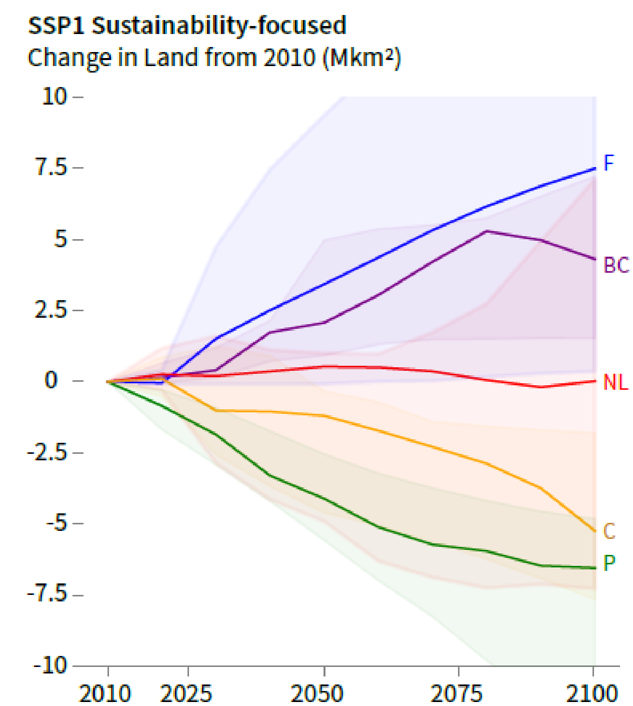
B5.5. **Climate change can lead to land degradation, even with the implementation of measures intended to avoid, reduce or reverse land degradation** (high confidence).

B6.2. Diversification in the food system (e.g., implementation of integrated production systems, broad-based genetic resources, and diets) can reduce risks from climate change **Balanced diets,** featuring plant-based foods, such as those based on coarse grains, legumes, fruits and vegetables, nuts and seeds, and animal-sourced food 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

B7.2. Modelled pathways limiting global warming to 1.5°C and 2ºC project a 2 million km$_2$ reduction to a 12 million km$_2$ **increase in forest area** in 2050 relative to 2010

A. Pathways linking socioeconomic development, mitigation responses and land

A. Sustainability-focused (SSP1)
Sustainability in land management, agricultural intensification, production and consumption patterns result in reduced need for agricultural land, despite increases in per capita food consumption. This land can instead be used for reforestation, afforestation, and bioenergy.



All much the same in direction of changes

CROPLAND PASTURE BIOENERGY CROPLAND FOREST NATURAL LAND

Chapter 5: Food Security
Executive summary

Since 1961, food supply per capita has increased more than 30%, accompanied by greater use of nitrogen fertilisers (increase of about 800%) and water resources for irrigation (increase of more than 100%). However, an estimated 821 million people are currently undernourished, 151 million children under 5 are stunted, 613 million women and girls aged 15 to 49 suffer from iron deficiency, and billion adults are overweight or obese. The food system is under pressure from non-climate stressors (e.g., population and income growth, demand for animal-sourced products), and from climate change.

Observed climate change is already affecting food security through increasing temperatures, changing precipitation patterns, and greater frequency of some extreme events

Food security will be increasingly affected by projected future climate change. Across scenarios global crop and economic models projected (up to a) 29% cereal price increase in 2050 due to climate change (RCP 6.0)(=NDCS), which would impact consumers globally through higher food prices

Distributions of pests and diseases will change, affecting production negatively in many regions

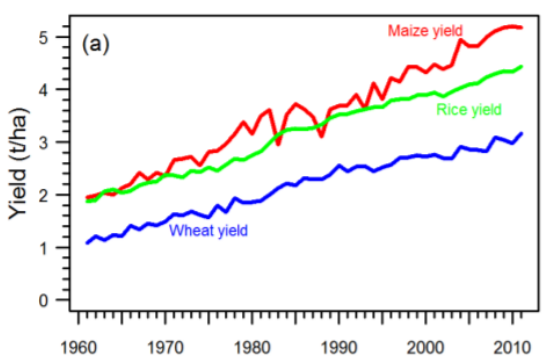
Vulnerability of pastoral systems to climate change. Pastoralism is practiced in more than 75% of countries by between 200 and 500 million people

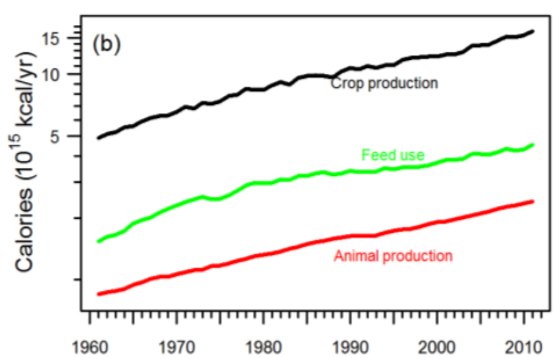
Fruit and vegetable production, a key component of healthy diets, is also vulnerable to climate change. Declines in yields and crop suitability are projected under higher temperatures, especially in tropical and semi-tropical regions.

25-30% of total GHG emissions are attributable to the food system. These are from agriculture and land use, storage, transport, packaging, processing, retail, and consumption

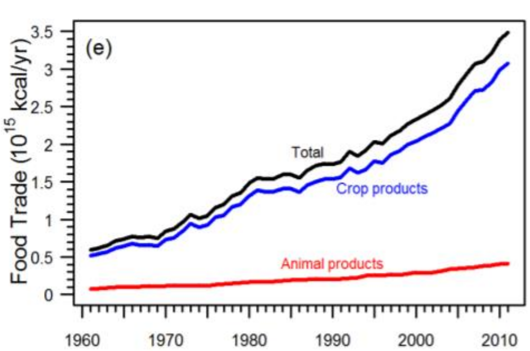
Without intervention, **these are likely to increase by about 30%–40% by 2050**,

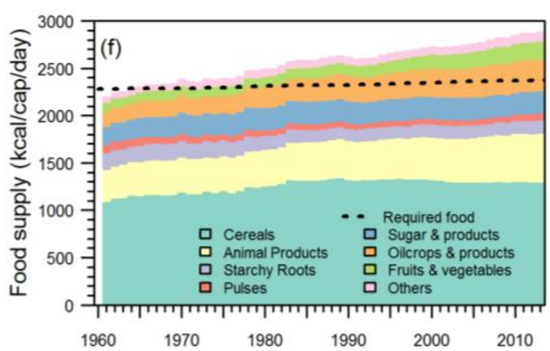
Consumption of healthy and sustainable diets presents major opportunities for reducing GHG emissions from food systems and improving health outcomes (high confidence). Examples of healthy and sustainable diets are high in coarse grains, pulses, fruits and vegetables, and nuts and seeds; low in energy-intensive animal-sourced and discretionary foods (such as sugary beverages); and with a carbohydrate threshold. Meat analogues such as imitation meat (from plant products), cultured meat, may help in the transition to more healthy and sustainable diets



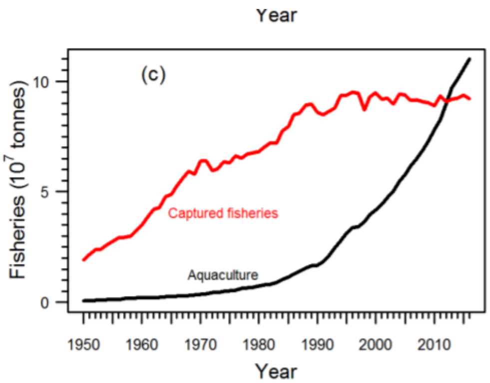


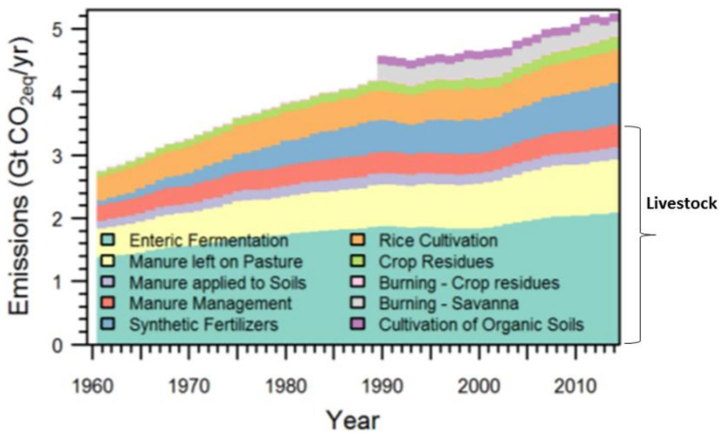
(b) production of crop & animal calories. and use of crop calories as livestock feed





Enteric fermintation is mainly from cattle





Fisheries are exhausted from over fishing

Majority of emissions are from livestock-meat industry

Chapter 2: Land-Climate Interactions

Executive Summary

For the 1880–2018 period, when four independently the LSAT increase was 1.41°C
Anthropogenic warming has resulted in shifts of climate zones, primarily as an increase in dry climates and decrease of polar climates
Ongoing warming is projected to result in new, hot climates in tropical regions

high-latitude warming is projected to accelerate permafrost thawing and increase disturbance in boreal forests through abiotic (e.g., drought, fire) and biotic (e.g., pests, disease) agents

The frequency and intensity of some extreme weather and climate events have increased as a consequence of global warming and will continue to increase

Recent heat-related events, e.g., heat waves, have been made more frequent or intense due to anthropogenic greenhouse gas emissions in most land regions and the frequency and intensity of drought has increased in Amazonia, north-eastern Brazil, the Mediterranean, Patagonia, most of Africa and north-eastern China

Heat waves are projected to increase in frequency, intensity and duration in most parts of the world

drought frequency and intensity is projected to increase in some regions that are already drought prone, predominantly in the Mediterranean, central Europe, the southern Amazon and southern Africa.

These changes will impact ecosystems, food security and land processes including greenhouse gas (GHG) fluxes

Climate change is playing an increasing role in determining **wildfir**e regimes along-side human activity (medium confidence), with future climate variability expected to enhance the risk and severity 4 of wildfires in many biomes such as tropical rainforests (high confidence). Fire weather seasons have 5 lengthened globally between 1979 and 2013