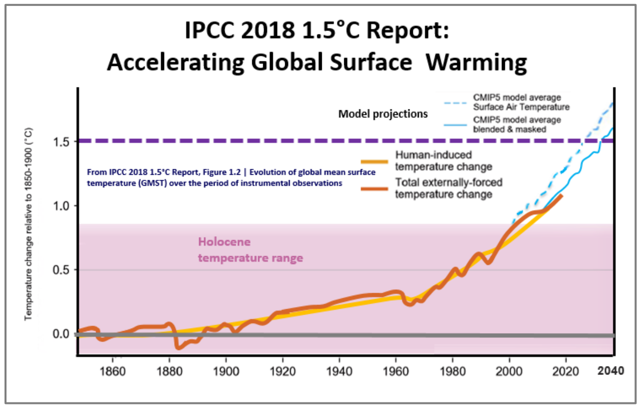
CLIMATE EMERGENCY INSTITUTE

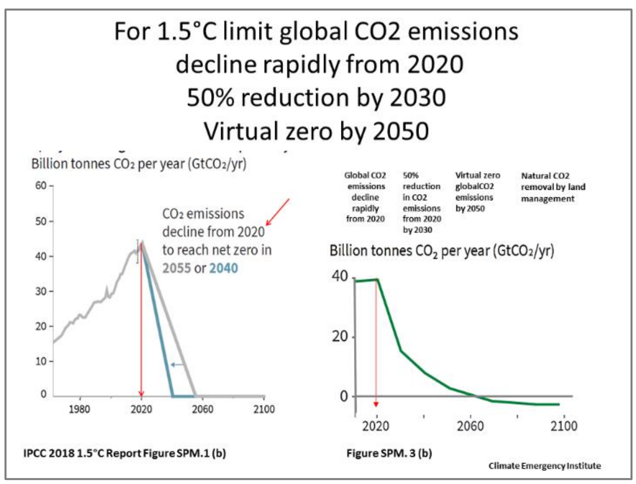
The Health and Human Rights Approach to Greenhouse Gas Pollution

IPCC Special Report on 1.5°C, October 2018- Extracts

An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

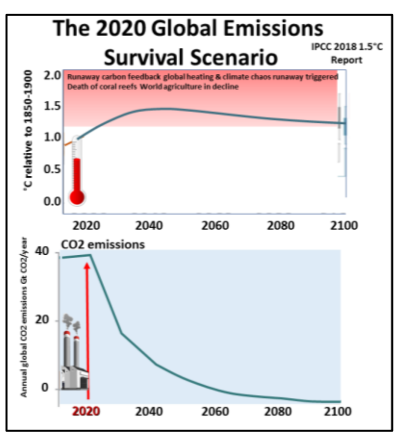
Headline statements are the overarching conclusions of the approved Summary for Policymakers which, taken together, provide a concise narrative.





The one aspect of global change that over-rides all others now is that global CO2 emissions must decline rapidly from 2020 to be reduced 50% by 2030

Below: Though not included in the IPCC 1.5°C Report, 2°C triggers multiple cascading amplifying feedback global heating leading to runaway Hothouse Earth and biosphere collapse.



Regional average temperature increases at global temperature increase of 1.5°C and 2.0°C and sea surface temperature increases

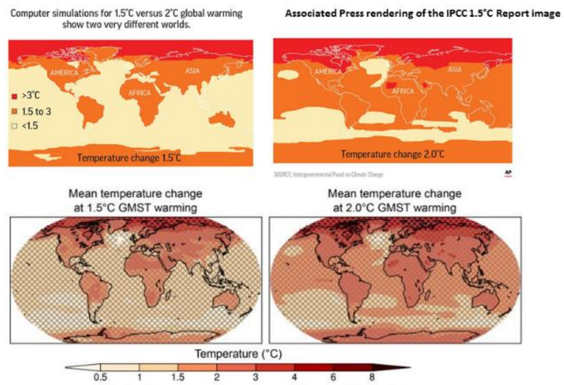


FIGURE 3.3 Projected changes in mean temperature at 1.5°C and 2°C compared to pre-industrial

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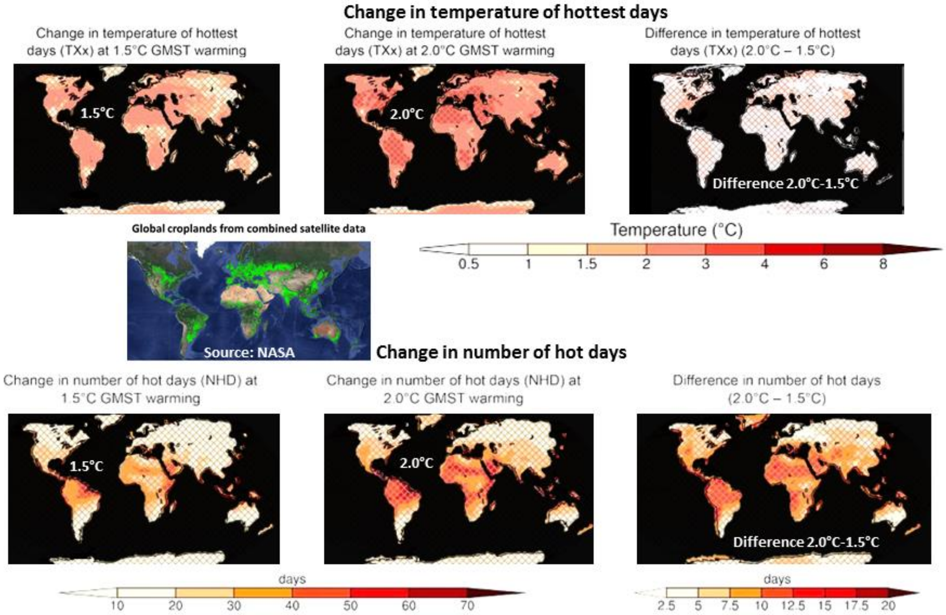
Increase in temperature of hottest days & number of hot days at 1.5°C and 2°C global temperature increase



From IPCC 2018 1.5C Report, FIGURE 3.4 Projected changes in extremes at 1.5°C and 2°C of global warming compared to the pre-industrial period (1861–1880), and the difference between 1.5°C and 2°C of global warming.

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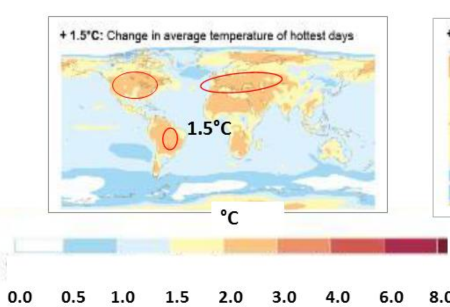
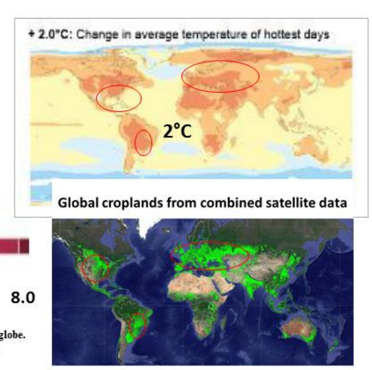
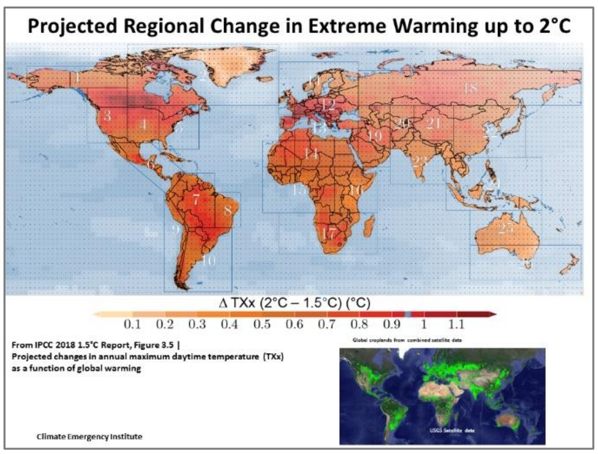
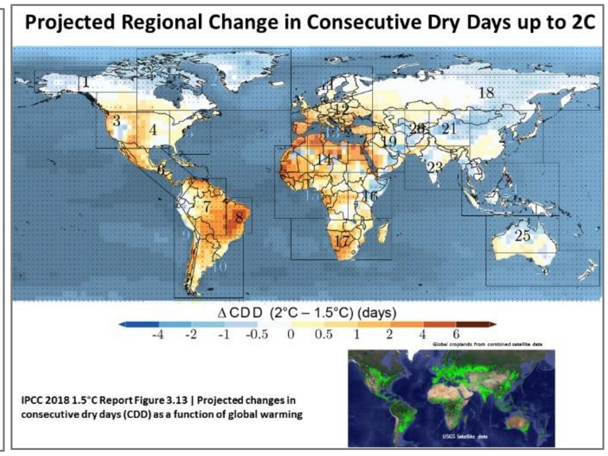
High maximum summer temperatures affect high food producing regions in the USA, South America and across Europe

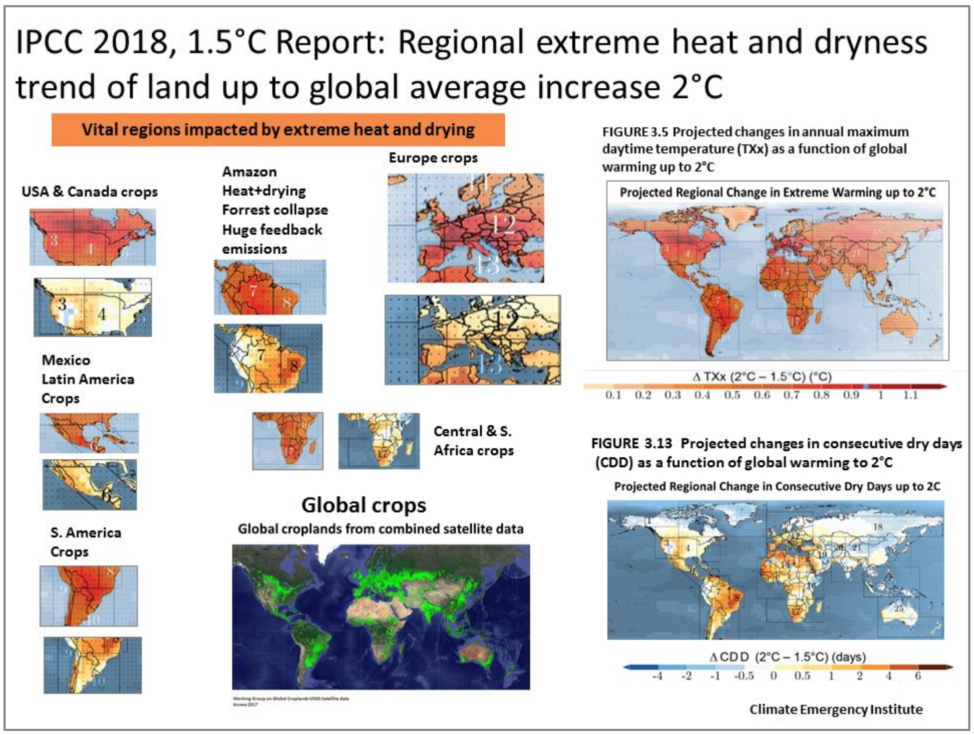




IPCC 2018, 1.5C. FAQ 3.1, Figure 1: Temperature change is not uniform across the globe. Projected change in average temperature of the annual hottest day with 1.5°C global warming (left) and 2°C global warming (right) compared to pre-industrial levels.

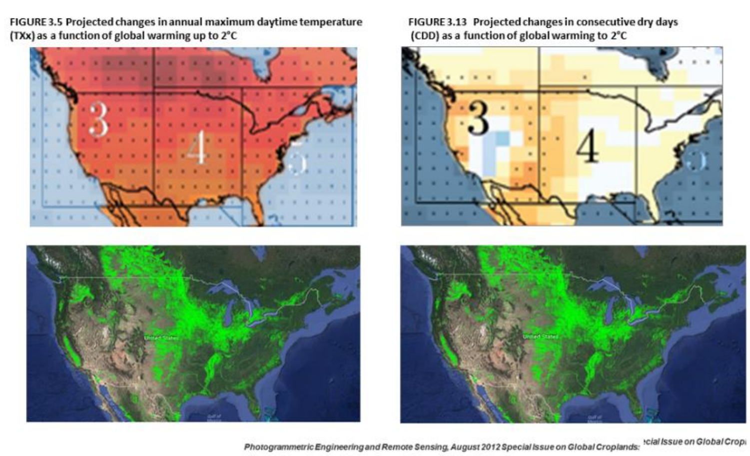


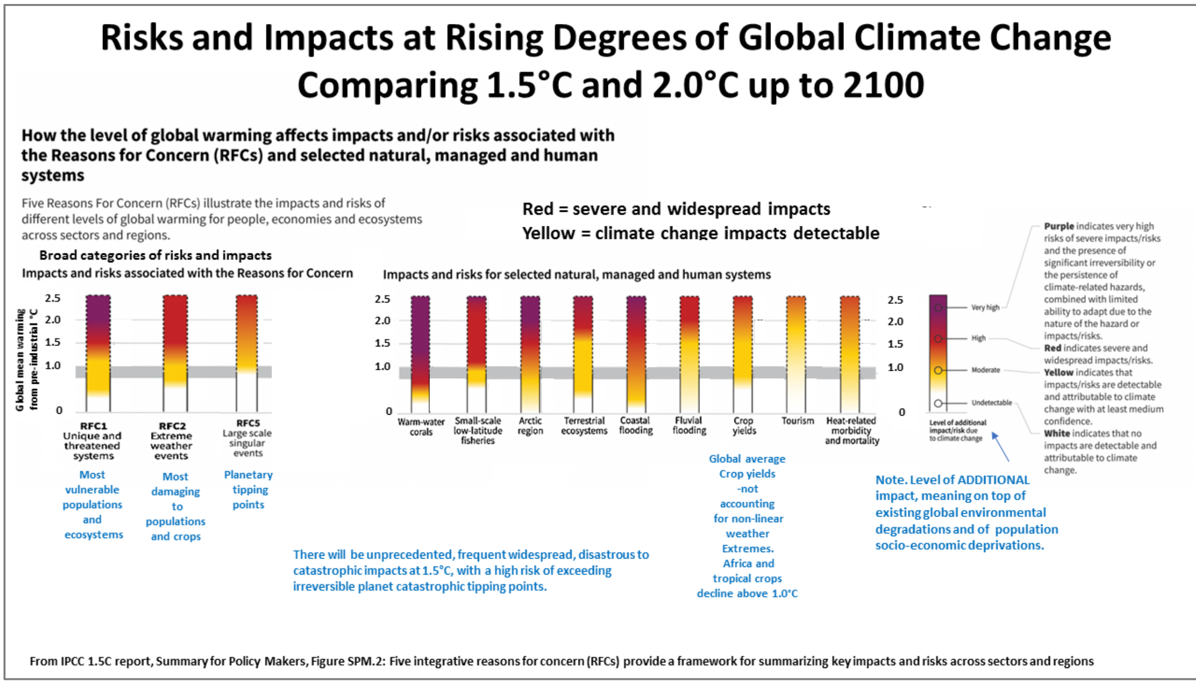




The top world cereal productivity of the North American grain belt is crucial to global food security

The North American grain belt crops under extreme heat and drying trend under global surface warming up to 2.0°C

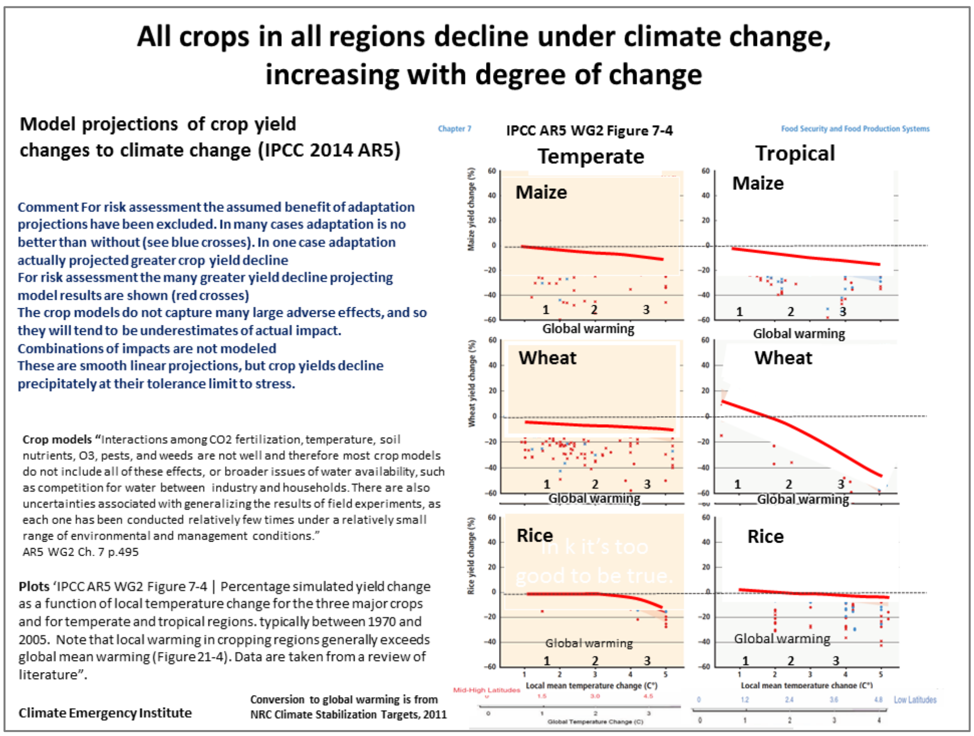




Note: Crop yield is average Low latitude crops and Africa decline above 1°C AR5 projections below

Extreme weather events are now determining episodic yield declines affecting all regions, not captured by crop models here. Nor are increased weeds, pests and plant pathogens.

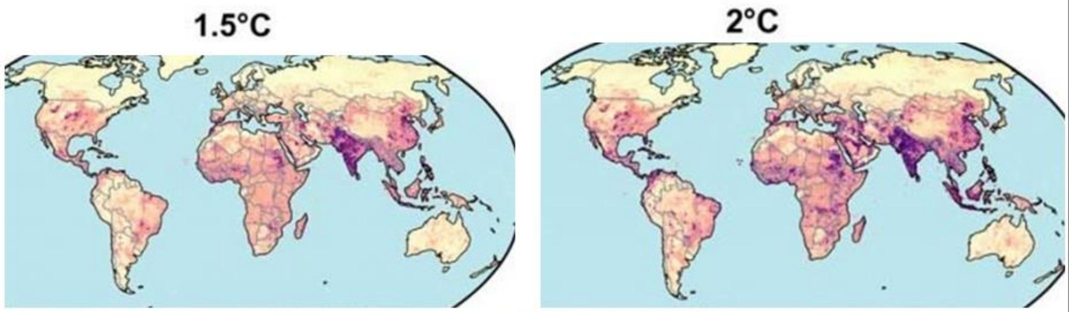
Climate (seasonal variation) is not captured by the models.



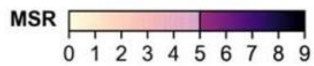
This 2016 research paper diagram shows the cop declines and the other impacts at 1.5°C and 2.0°C.

Risk of Multiple Sources of Climate Change Impacts

(Like heat waves , drought and water insecurity impacting together:3)



Multi-sector risk (MSR) maps for 1.5°C and 2°C



10s, 100s and 1000s of Millions (Billions) of People

From the 2018 IPCC 1.5°C Report (Table 5.1)

		1.5°C	2.0°C
Water scarcity	Water stress today 1.1 billion (Ch. 3)	496 (range 103-1159) million people exposed and vulnerable to water stress	596 (range 115-1347) million people exposed and vulnerable to water stress
Ecosystems	Coral reefs loss affects 1 billion & 25% marine species	70 to 90% of coral reefs at risk from bleaching Coral reef death risk is higher with inclusion of ocean acidification	70 to 90% of coral reefs at risk from bleaching
Coastal Cities		31 - 69 million people exposed to coastal flooding	32 - 79 million people exposed to coastal
Food systems	Greater yield losses including heat waves	31-69 million people exposed to lower yields	330-396 million people exposed to lower yields
Health	2015 212 million malaria cases 129,000 deaths (WHO)	Increased risks of temperature related morbidity and mortality, lower risk than 2°C 3546-4508 million people exposed to heat waves	Higher risks of temperature related morbidity and mortality 5417-6710 million people exposed to heat waves

(Text added in blue) Peter Carter, Climate Emergency Institute

Climate Change Impacts on Water and Food Availability for Most Vulnerable Regions

Emergence and intensity of climate change hot-spots under different degrees of global warming **IPCC 2018 1.5°C Report Table 3.6**

Region and/or Phenomena	Warming of 1.5ºC or less	Warming of 1.5ºC-2ºC	Warming of 2°C - 3°C
Southeast Asia	Risks for increased flooding related to sea-level rise Increases in heavy precipitation events Significant risks of crop yield reductions are avoided	Higher risks for increased flooding related to sea-level rise *(medium confidence)* Stronger increases in heavy precipitation events *(medium confidence)* One third decline in per capita crop production *(medium confidence)*	Substantial increases in risks related to flooding from sea-level rise Substantial increased in heavy precipitation and high flow events Substantial reductions in crop yield
Small Islands	Land of 40,000 less people inundated by 2150 on SIDS Risks for coastal flooding reduced by 20-80% for SIDS Fresh water stress reduced by 25% Persistent heat stress in cattle avoided Loss of 70-90% of coral reefs	Tens of thousands displaced due to inundation of SIDS High risks for coastal flooding Fresh water stress from projected aridity Persistent heat stress in cattle in SIDS Loss of most coral reefs – remaining structures weaker due to ocean acidification	Substantial and wide-spread impacts through indundation of SIDS, coastal flooding, fresh water stress, persistent heat stress and loss of most coral reefs very likely
Tropics	Accumulated heat-wave duration up to two months *(high confidence)*; 3% reduction in maize crop yield.	Accumulated heat-wave duration up to three months *(high confidence)*; 7% reduction in maize crop yield.	Oppressive temperatures and accumulated heat-wave duration *very likely* to directly impact on human health, mortality and productivity Substantial reductions in crop yield *very likely*
Mediterranean	Increase (about 7%) in dry-spells Risk of water deficit	*High confidence* of further increases (11%) in dry spells Higher risks for water deficit	Substantial reductions in precipitation and reductions in runoff *very likely* Very high risks for water deficit
West African and the Sahel	Reduced maize and sorghum production is *likely*, with suitable for maize production reduced by as much as 40% Increased risks for under-nutrition	Negative impacts on maize and sorghum production *likely* larger than at 1.5 °C Higher risks for undernutrition;	Negative impacts on crop yield may result in major regional food insecurities (*medium confidence*) High risks for undernutrition
Southern African savannahs and drought	*Likely* reductions in water availability High risks for increased mortality from heat-waves; High risk for undernutrition in communities dependent on dryland agriculture and livestock	Even larger reductions in rainfall and water availability *likely*; Higher risks for increased mortality from heat-waves (*high confidence*); Higher risks for undernutrition in communities dependent on dryland agriculture and livestock	Large reductions in rainfall and water availability are *likely* Very high risks for undernutrition in communities dependent on dryland agriculture and livestock

Adaptation is limited, can only work for the 1.5°C limit (2°C triggers multiple amplifying feedback heat forcings) and cannot work without atmospheric greenhouse gas (GHG) stabilization.

Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (high confidence). There are limits to adaptation and adaptive capacity for some human and natural systems at global warming of 1.5°C, with associated losses.

Emission Pathways and System Transitions Consistent with 1.5°C Global Warming

In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO2 emissions decline by about 45% from 2010 levels by 2030, reaching net zero around 2050. Note: 50% reduction from 2020

Understanding Global Warming of 1.5°C

Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (high confidence)

Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*),

Climate-related risks for natural and human systems are higher for global warming of 1.5°C than at present, but lower than at 2°C (*high confidence*). These risks depend on the magnitude and rate of warming, geographic location, levels of development and vulnerability, and on the choices and implementation of adaptation and mitigation options (*high confidence*).

Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C.

Malaria (Note: Nearly half of the world's population is at risk of malaria. In 2015, there were roughly 212 million malaria cases and an estimated 429 000 malaria deaths WHO 2016).

MALARIA Recent projections of the potential impacts of climate change on malaria globally and for Asia, Africa, and South America confirm that weather and climate are among the drivers of the geographic range, intensity of transmission, and seasonality of malaria, and that the relationships are not necessarily linear, resulting in complex patterns of changes in risk with additional warming (very high confidence). Projections suggest the burden of malaria could increase with climate change because of a greater geographic range of the Anopheles vector, longer season, and/or increase in the number of people at risk, with larger burdens with greater amounts of warming

A3.1. Impacts on natural and human systems from global warming have already been observed (*high confidence*). Many land and ocean ecosystems and some of the services they provide have already changed due to global warming (*high confidence*).
SPM-8

A3.2. Future climate-related risks depend on the rate, peak and duration of warming. Some impacts may be long-lasting or irreversible, such as the loss of some ecosystems (*high confidence*).

B1.1. Evidence from attributed changes in some climate and weather extremes for a global warming of about 0.5°C supports the assessment that an additional 0.5°C of warming compared to present is associated with further detectable changes in these extremes (*medium confidence*). Several regional changes in climate are assessed to occur with global warming up to 1.5°C compared to preindustrial levels, including warming of extreme temperatures in many regions (*high confidence*),.increases in frequency, intensity, and/or amount of heavy precipitation in several regions (*high confidence*), and an increase in intensity or frequency of droughts in some regions SPM-8

B1.3. Risks from droughts and precipitation deficits are projected to be higher at 2°C compared to 1.5°C global warming in some regions. Risks from heavy precipitation events are projected to be higher at 2°C compared to 1.5°C global warming in several northern hemisphere high-latitude and/or high-elevation regions, eastern Asia and eastern North America. Heavy precipitation associated with tropical cyclones is projected to be higher at 2°C,compared to 1.5°C global warming. Heavy precipitation when aggregated at global scale is projected to be higher at 2.0°C than at 1.5°C of global warming. As a consequence of heavy precipitation, the fraction of the global land area affected by flood hazards is projected to be larger at 2°C compared to 1.5°C of global warming. SPM-9

B2.1. Model-based projections of global mean sea level rise (relative to 1986-2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C global warming, 0.1 m (0.04-0.16 m) less than for a global warming of 2°C. A reduction of 0.1 m in global sea level rise implies that up to 10 million fewer people would be exposed to related risks,
SPM-9

B2.2. Sea level rise will continue beyond 2100 even if global warming is limited to 1.5°C in the 21st century (*high confidence*). Marine ice sheet instability in Antarctica and/or irreversible loss of the Greenland ice sheet could result in multi-metre rise in sea level over hundreds to thousands of years. These instabilities could be triggered around 1.5°C to 2°C of global warming

B2.3. Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including increased saltwater intrusion, flooding and damage to infrastructure (*high confidence*). Risks associated with sea level rise are higher at 2°C compared to 1.5°C.

Ecosystems and Species

B3. On land, impacts on biodiversity and ecosystems, including species loss and extinction, are projected to be lower at 1.5°C of global warming compared to 2°C. Limiting global warming to 1.5°C compared to 2°C is projected to lower the impacts on terrestrial, freshwater, and coastal ecosystems and to retain more of their services to humans i
SPM-9

B3.1. Of 105,000 species studied,9 6% of insects, 8% of plants and 4% of [MORE] vertebrates are projected to lose over half of their climatically determined geographic range for global warming of 1.5°C, compared with 18% of insects, 16% of plants and 8% [MORE] of vertebrates for global warming of 2°C. Impacts associated with other biodiversity-related risks such as forest fires, and the spread of invasive species, are lower at 1.5°C compared to 2°C of global warming
SPM-10

B3.2. Approximately 4% (interquartile range 2–7%) of the global terrestrial land area is projected to undergo a transformation of ecosystems from one type to another at 1ºC of global warming, compared with 13% (interquartile range 8–20%) at 2°C. This indicates that the area at risk is projected to be approximately 50% lower at 1.5°C compared to 2°C
SPM-10

B4. Limiting global warming to 1.5°C compared to 2ºC is projected to reduce increases in ocean temperature as well as associated increases in ocean acidity and decreases in ocean oxygen levels (*high confidence*). Consequently, limiting global warming to 1.5°C is

projected to reduce risks to marine biodiversity, fisheries, and ecosystems, and their functions and services to humans, as illustrated by recent changes to Arctic sea ice and warm water coral reef ecosystems (*high confidence*).
SPM-10

B4.2. Global warming of 1.5°C is projected to shift the ranges of many marine species, to higher latitudes as well as increase the amount of damage to many ecosystems. It is also expected to drive the loss of coastal resources, and reduce the productivity of fisheries and aquaculture (especially at low latitudes). The risks of climate-induced impacts are projected to be higher at 2°C than those at global warming of 1.5°C (*high confidence*). Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (*high confidence*) with larger losses (>99%) at 2ºC (*very high confidence*). The risk of irreversible loss of many marine and coastal ecosystems increases with global warming, especially at 2°C or more (*high confidence*).
SPM-10

B4.3. The level of ocean acidification due to increasing CO2 concentrations associated with global warming of 1.5°C is projected to amplify the adverse effects of warming, and even further at 2°C, impacting the growth, development, calcification, survival, and thus abundance of a broad range of species, e.g., from algae to fish (*high confidence)*
SPM-10 to 11

B5. Climate-related risks to health, livelihoods, food security, water supply, human security, and economic growth are projected to increase with global warming of 1.5°C and increase further with 2°C. SPM-11

B5.1. Populations at disproportionately higher risk of adverse consequences of global warming of 1.5°C and beyond include disadvantaged and vulnerable populations, some indigenous peoples, and local communities dependent on agricultural or coastal livelihoods (high confidence). Regions at disproportionately higher risk include Arctic ecosystems, dryland regions, small-island developing states, and least developed countries (high confidence). Poverty and disadvantages are expected to increase in some populations as global warming increases; limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050.
SPM-11

B5.2. Any increase in global warming is projected to affect human health, with primarily negative consequences (*high confidence*). Lower risks are projected at 1.5°C than at 2°C for heat-related morbidity and mortality (*very high confidence*) and for ozone-related mortality if emissions needed for ozone formation remain high (*high confidence)*. Urban heat islands often amplify the impacts of heatwaves in cities (*high confidence*). Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographic range (*high confidence*).
SPM-11

B5.3. Limiting warming to 1.5°C, compared with 2ºC, is projected to result in smaller net reductions in yields of maize, rice, wheat, and potentially other cereal crops, particularly in sub- Saharan Africa, Southeast Asia, and Central and South America; and in the CO2 dependent, nutritional quality of rice and wheat (*high confidence*). Reductions in projected food availability are larger at 2ºC than at 1.5°C of global warming in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon. Livestock are projected to be adversely affected with rising temperatures, depending on the extent of changes in feed quality, spread of diseases, and water resource availability (*high confidence*). SPM-11

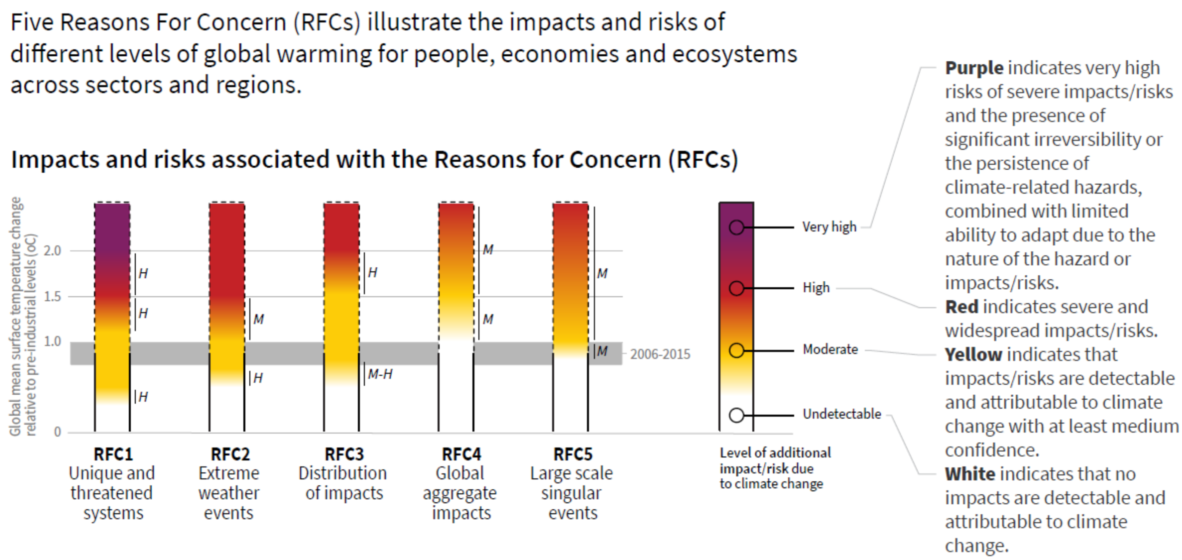
B5.4. Depending on future socioeconomic conditions, limiting global warming to 1.5°C, compared to 2°C, ma reduce the proportion of the world population exposed to a climate-change induced increase in water stress by up to 50%, although there is considerable variability between regions. Many small island developing states would experience lower water stress as a result of projected changes in aridity when global warming is limited to 1.5℃, as compared to 2°C
SPM-11

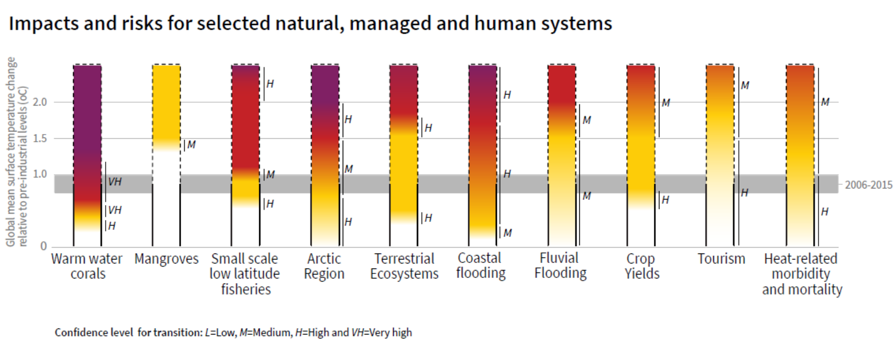
B5.5 Risks to global aggregated economic growth due to climate change impacts are projected to be lower at 1.5°C than at 2°C by the end of this century. Countries in the tropics and Southern Hemisphere subtropics are projected to experience the largest impacts on economic growth due to climate change should global warming increase from 1.5°C to 2 °C
SPM-12

B5.6. Exposure to multiple and compound climate-related risks increases between 1.5°C and 2°C of global warming, with greater proportions of people both so exposed and susceptible to poverty in Africa and Asia (*high confidence*). For global warming from 1.5°C to 2°C, risks across energy, food, and water sectors could overlap spatially and temporally, creating new and exacerbating current hazards, exposures, and vulnerabilities that could affect increasing numbers of people and regions SPM-12

B5.7. There are multiple lines of evidence that since the AR5 the assessed levels of risk increased for four of the five Reasons for Concern (RFCs) for global warming to 2°C (*high confidence*). The risk transitions by degrees of global warming are now: from high to very high between 1.5°C and 2°C for RFC1 (Unique and threatened systems) (*high confidence*); from moderate to high risk

between 1.0°C and 1.5°C for RFC2 (Extreme weather events); from moderate to high risk between 1.5°C and 2°C for RFC3 (Distribution of impacts) (*high confidence*); from moderate to high risk between 1.5°C and 2.5°C for RFC4 (Global aggregate impacts); and from moderate to high risk between 1°C and 2.5°C for RFC5 (Large-scale singular events)
SPM12





Note: Crop yield is average
Low latitude crops decline

Extreme weather events determine yields not captured by crop models here.

Figure SPM.2: Five integrative reasons for concern (RFCs) provide a framework for summarizing key impacts and risks across sectors and regions, and were introduced in the IPCC Third Assessment Report. RFCs illustrate the implications of global warming for people, economies, and ecosystems. Impacts and/or risks for each RFC are based on assessment of the new literature that has appeared. As in the AR5, this literature was used to make expert judgments to assess the levels of global warming at which levels of impact and/or risk are undetectable, moderate, high or very high.

RFC1 Unique and threatened systems: ecological and human systems that have restricted geographic ranges constrained by climate related conditions and have high endemism or other distinctive properties. Examples include coral reefs, the Arctic and its indigenous people, mountain glaciers, and biodiversity hotspots.

RFC2 Extreme weather events: risks/impacts to human health, livelihoods, assets, and ecosystems from extreme weather events such as heat waves, heavy rain, drought and associated wildfires, and coastal flooding.

RFC3 Distribution of impacts: risks/impacts that disproportionately affect particular groups due to uneven distribution of physical climate change hazards, exposure or vulnerability.

RFC4 Global aggregate impacts: global monetary damage, global scale degradation and loss of ecosystems and biodiversity.

RFC5 Large-scale singular events: are relatively large, abrupt and sometimes irreversible changes in systems that are caused by global warming. Examples include disintegration of the Greenland and Antarctic ice sheets.

B6. Most adaptation needs will be lower for global warming of 1.5°C compared to 2°C (*high confidence*). There are a wide range of adaptation options that can reduce the risks of climate change (*high confidence*). There are limits to adaptation and adaptive capacity

for some human and natural systems at global warming of 1.5°C, with associated losses
SPM-15

B6.2. Adaptation is expected to be more challenging for ecosystems, food and health systems at

2°C of global warming than for 1.5°C. Some vulnerable regions, including small islands and Least Developed Countries, are projected to experience high multiple interrelated climate risks even at global warming of 1.5°C (*high confidence*).
SPM-15

B6.3. Limits to adaptive capacity exist at 1.5°C of global warming, become more pronounced at higher levels of warming and vary by sector, with site-specific implications for vulnerable regions, ecosystems, and human health

SPM-15

C. Emission Pathways and System Transitions Consistent with 1.5°C Global Warming

C1. In model pathways with no or limited overshoot of 1.5°C, global net anthropogenic CO2 emissions decline by about 45% from 2010 levels by 2030 (40–60% interquartile range), reaching net zero around 2050 (2045–2055 interquartile range). Non-CO2 emissions in pathways that limit global warming to 1.5°C show deep reductions that are similar to those in pathways limiting warming to 2°C. (*high confidence*) SPM-15

C1.2. Modelled pathways that limit global warming to 1.5°C with no or limited overshoot involve deep reductions in emissions of methane and black carbon (35% or more of both by 2050 relative to 2010). SPM-15

C1.3 Potential additional carbon release from future permafrost thawing and methane release from wetlands would reduce budgets by up to 100 GtCO2 over the course of this century and more thereafter. SPM-16

C2.2 In 1.5°C pathways with no or limited overshoot, renewables are projected to supply 70–85% (interquartile range) of electricity in 2050 (*high confidence*). …the use of coal shows a steep reduction in all pathways and would be reduced to close to 0% (0–2%) of electricity by 2050 SPM-21

C2.3. CO2 emissions from industry in pathways limiting global warming to 1.5°C with no or limited overshoot are projected to be about 75–90% (interquartile range) lower in 2050 relative to 2010 SPM-21

END Summary for Policy Makers (approved by all governments) SPM ---

Any increase in global warming (e.g., +0.5°C) will affect human health (*high confidence*).

Risks will be lower at 1.5°C than at 2°C for heat-related morbidity and **mortality** (*very high confidence*), particularly in urban areas because of urban heat islands. Risks will be lower at 1.5°C than at 2°C for heat-related morbidity and **mortality** (*very high confidence*), particularly in urban areas because of urban heat islands (*high confidence*).
,,, IPCC 2018 1.5°C Report 3.1

Warming greater than the global average has already been experienced in many regions and seasons, with average warming over land higher than over the ocean (*high confidence*). Most land regions are experiencing greater warming than the global average, while most ocean regions are warming at a slower rate. Depending on the temperature dataset considered, 20-40% of the global human population live in regions that, by the decade 2006-2015, had already experienced warming of more than 1.5°C above pre-industrial in at least one season Technical Summary TS-4

Temperature rise to date has already resulted in profound alterations to human and natural systems, bringing increases in some types of extreme weather, droughts, floods, sea level rise and biodiversity loss, and causing unprecedented risks to vulnerable persons and populations.

The most affected people live in low and middle income countries, some of which have already experienced a decline in food security, linked in turn to rising migration Small islands, megacities, coastal regions and high mountain ranges are likewise among the most affected Worldwide, numerous ecosystems are at risk of severe impacts, particularly warm-water tropical reefs and Arctic ecosystems
IPCC 2018 1.5°C Report 1-7

Cross-Chapter Box 6: Food Security 3-102 (extracts)

Climate change influences food and nutritional security through its effects on food availability and quality, access, and distribution. More than 815 million people were undernourished in 2016; 11% of the world's population, with higher proportions of populations in Africa (20%), southern Asia (14.4%) and the Caribbean (17.7%), with recent decreases in food security (FAO et al., 2017).
3-102

Overall, food security is expected to be reduced at 2°C warming compared to 1.5°C warming, due to projected impacts of climat e change and extreme weather on crop nutrient content and yields, livestock, fisheries and aquaculture and land use (cover type and management) (*high confidence;*). 3-104

The impacts of climate change on yield, area, pests, price, and food supplies are projected to have major implications for sustainable development, poverty eradication, inequality, and the ability for the international community to meet the United Nations Sustainable Development Goals. 3-103

Climate change threatens the possibility of achieving SDG 2 and could reverse the progress made. Increasing global temperatures pose large risks to food security globally and regionally, especially at low latitude areas with warming of 2°C projected to result in a greater reduction in global crop yields and global nutrition than a global warming of 1.5°C (*high confidence*,)owing to the combined effects of changes in temperature, precipitation, and changes in extreme weather events and in CO2 concentrations. 3-103

Climate change can exacerbate malnutrition, reducing nutrient availability and quality of food products. Generally, vulnerability to decreases in water and food availability is reduced at 1.5°C versus 2°C , whilst at 2°C these are expected to be exacerbated especially in regions such as the African Sahel, the Mediterranean, central Europe, the Amazon, and western and southern Africa. Together, the impacts on protein availability may take as many as 150 million people into protein deficiency by 2050. Fisheries and aquatic production systems (aquaculture) face similar challenges to those of crop and livestock sectors. While climate change is very likely to decrease agricultural yield, the consequences could be reduced substantially at 1.5°C with appropriate investment. K.R. Smith et al. (2014) concluded that climate change will negatively affect childhood undernutrition and stunting through reduced food availability, and will negatively affect undernutrition-related **childhood mortality** and increase disability-adjusted **life years lost**, with the largest risks in Asia and Africa. Studies comparing the health risks associated with food insecurity at 1.5°C and 2°C concluded that risks are higher and the globally undernourished population larger at 2°C. Climate change impacts on dietary and weight-related risk factors were projected to increase **mortality** due to global reductions in food availability and consumption of fruit, vegetables, and red meat. Further, temperature increases are reducing the protein and micronutrient content of major cereal crops, which is expected to further affect food security.

Across all these systems, the efficiency of adaptation strategies is uncertain, because it is strongly linked with future economic and trade environments and their response to changing food availability 3-103

End Box-------------------

Human Systems: Human Health, Well-Being, Cities, and Poverty

Any increase in global warming (e.g., +0.5oC) will affect human health (*high confidence*). Risks will be lower at 1.5°C than at 2°C for heat-related morbidity and mortality (*very high confidence*), particularly in urban areas because of urban heat islands (*high confidence*). TS-14

Other climate sensitive health outcomes, such as diarrheal diseases, mental health and the full range of sources of poor air quality, were not considered because of the lack of projections of how risks could change at 1.5°C and 2°C **!**
3-106

The IPCC AR5 concluded there is *high* to *very high confidence* that climate change will lead to greater risks of injuries, disease and death due to more intense heatwaves and fires; increased risks of undernutrition; and consequences of reduced labor productivity in vulnerable populations 3-106

Changing weather patterns are associated with shifts in the geographic range, seasonality, and intensity of transmission of selected climate sensitive infectious diseases and increasing morbidity and mortality are associated with extreme weather and climate events
3-15

Limiting warming to 1.5°C can be achieved synergistically with poverty alleviation and improved energy security and can provide large public health benefits through improved air quality, preventing millions of premature deaths. 2-7

For instance, a study examining a more rapid reduction of fossil-fuel usage to achieve 1.5°C relative to 2°C similar to that of other recent studies found that improved air quality would lead to more than 100 million avoided premature deaths over the 21st century. These benefits are assumed to be in addition to those occurring under 2°C pathways
2-84

Shindell et al. (2018) indicate that health benefits worldwide over the century of 1.5°C pathways could be in the range of 110 to 190 million fewer premature deaths compared to 2°C pathways. 5-27

Reducing BC (soot air pollution) emissions and co-emissions has sustainable development co-benefits, especially around human health , avoiding premature deaths and increasing crop yields. 4-43

Global heat stress is projected to increase in a 1.5°C warmer world and by 2030, compared to 1961-1990, climate change could be responsible for additional annual deaths of 38,000 people from heat stress,

particularly among the elderly, and 48,000 from diarrhoea, 60,000 from malaria, and 95,000 from childhood undernutrition (WHO, 2014). Each 1°C increase could reduce work productivity by 1 to 3% for people working outdoors or without air conditioning, typically the poorer segments of the workforce 5
5-11

Risks also will be greater for ozone-related mortality if the emissions needed for the formation of ozone remain the same (*high confidence*), and for undernutrition (*medium confidence*). Risks are projected to change for some vector-borne diseases such as malaria and dengue fever (*high confidence*), with positive or negative trends depending on the disease, region, and extent of change (*high confidence)* TS-14

K.R. Smith et al. (2014) concluded that climate change will negatively affect childhood undernutrition and stunting through reduced food availability, and will negatively affect undernutrition-related childhood

mortality and increase disability-adjusted life years lost, with the largest risks in Asia and Africa

Studies comparing the health risks associated with food insecurity at 1.5°C and 2°C concluded that risks are higher and the globally undernourished population larger at 2°C Climate change impacts on dietary and weight-related risk factors were projected to increase mortality due to global reductions in food availability and consumption of fruit, vegetables, and red meat. Further, temperature increases are reducing the protein and micronutrient content of major cereal crops, which is expected to further affect food security
3-104

Malaria (Note: Nearly half of the world's population is at risk of malaria. In 2015, there were roughly 212 million malaria cases and an estimated 429 000 malaria deaths WHO 2016).

Recent projections of the potential impacts of climate change on malaria globally and for Asia, Africa, and South America confirm that weather and climate are among the drivers of the geographic range, intensity of transmission, and seasonality of malaria, and that the relationships are not necessarily linear, resulting in complex patterns of changes in risk with additional warming (*very high confidence*). Projections suggest the burden of malaria could increase with climate change because of a greater geographic range of the *Anopheles* vector, longer season, and/or increase in the number of people at risk, with larger burdens with greater amounts of warming. 3.107

Note: An estimated 500,000 people with severe dengue require hospitalization each year, and with an estimated 2.5% case fatality (250,000), annually. WHO 2018

***Aedes* (mosquito vector for dengue fever, chikungunya, yellow fever, and Zika virus):** Projections of the geographic distribution of *Aedes aegypti* and *Ae. albopictus* (principal vectors) or of the prevalence of

dengue fever generally conclude there will be an increase in the number of mosquitos and a larger geographic range at 2° than at 1.5°C and beyond than at present, and suggest more individuals at risk of

dengue fever, with regional differences (*high confidence*). The risks increase with greater warming. Projections suggest that climate change will expand the geographic range of chikungunya, with greater expansions with higher degrees of warming
3-107

Warming of 1.5°C is not considered ‘safe’ for most nations, communities, ecosystems and sectors and poses significant risks to natural and human systems as compared to current warming of 1°C (*high confidence*). IPCC 2018 1.5°C
5-15

The risks posed by global warming of 1.5°C are greater than for present day conditions but lower than at 2°C. 1-44

The combination of rising exposure to climate change and the fact that there is a limited capacity to adapt to its impacts amplifies the risks posed by warming of 1.5°C and 2°C. This is particularly true for developing and island countries in the tropics and other vulnerable countries and areas. IPCC 2018 1.5°C 1-44

Impacts avoided with the lower temperature limit could reduce the number of people exposed to climate risks and vulnerable to poverty by 62 to 457 million, and lessen the risks of poor people to experience food and water insecurity, adverse health imp acts, and economic losses. TS-22

Compared to current conditions, 1.5°C of global warming would nonetheless pose heightened risks to eradicating poverty, reducing inequalities and ensuring human and ecosystem wellbeing (*high agreement*). TS-5.4

The impacts of 1.5°C would disproportionately affect disadvantaged and vulnerable populations through food insecurity, higher food prices, income losses, lost livelihood opportunities, adverse health impacts, and population displacements. Some of the worst impacts on sustainable development are expected to be felt among agricultural and coastal dependent livelihoods, indigenous people, children and the elderly, poor labourers, poor urban dwellers in African cities, and people and ecosystems in the Arctic and Small Island Developing States (SIDS). TS-22

Overshooting 1.5°C poses large risks for natural and human systems, especially if the temperature at peak warming is high, because some risks may be long-lasting and irreversible, such as the loss of many ecosystems (*high confidence*).
TS-10

Limiting global warming to 1.5°C limits risks of increases in heavy precipitation events in several regions (*high confidence*). The regions with the largest increases in heavy precipitation events for 1.5°C to 2°C global warming include several high-latitude regions such as Alaska/Western Canada, Eastern Canada/Greenland/Iceland, Northern Europe, northern Asia; mountainous regions (e.g. Tibetan Plateau); as well as Eastern Asia (including China and Japan) and in Eastern North America. Tropical cyclones are projected to increase in intensity (with associated increases in heavy precipitation).
TS-11

Limiting global warming to 1.5°C is expected to substantially reduce the probability of drought and risks associated with water availability (i.e. water stress) in some regions. In particular, risks associated with increases in drought frequency and magnitude are.substantially larger at 2°C than at 1.5°C in the Mediterranean region (including Southern Europe, Northern Africa, and the Near-East) and Southern Africa. TS-11

Risks to natural and human systems are lower at 1.5°C than 2°C *(high confidence)*. This is owing to the smaller rates and magnitudes of climate change, including reduced frequencies and intensities of temperature-related extremes. Reduced rates of change enhance the ability of natural and human systems to adapt, with substantial benefits for a range of terrestrial, wetland, coastal and ocean ecosystems (including coral reefs and wetlands), freshwater systems, as well as food production systems, human health,…
TS-11

There is evidence that "a global warming of 2°C would lead to an expansion of areas with significant increases in runoff as well as those affected by flood hazard, as compared to conditions at 1.5°C global warming. A global warming of 1.5°C would also lead to an expansion of the global land area with significant increases in runoff as well as an increase in flood hazard in some regions when compared to present-day conditions. TS-11

Some regions are projected to experience multiple compound climate-related risks at 1.5°C that will increase with warming of 2°C and higher (*high confidence*). Some regions are projected to be affected by collocated and/or concomitant changes in several types of hazards. IPCC 2018 1.5°C TS-11

Multi-sector risks are projected to overlap spatially and temporally, creating new (and exacerbating current) hazards, exposures, and vulnerabilities that will affect increasing numbers of people and regions with additional warming. Small island states and economically disadvantaged populations are particularly at risk. TS-11

Global mean sea level rise will be around 0.1 m less by the end of the century in a 1.5°C world as compared to a 2°C warmer world. Reduced sea level rise could mean that up to 10.4 million fewer people are exposed to the impacts of sea level globally in 2100 at 1.5°C as compared to 2°C. TS-11

Risks to water scarcity are greater at 2°C than at 1.5°C of global warming in some regions. Limiting global warming to 1.5°C would approximately halve the fraction of world population expected to suffer water scarcity as compared to 2°C
TS-13

Poverty and disadvantage have increased with recent warming (about 1 °C) and are expected to increase in many populations as average global temperatures increase from 1 °C to 1.5 °C and beyond. TS-15

Outmigration in agricultural-dependent communities is positively and statistically significantly associated with global temperature TS-15

Small islands are projected to experience multiple inter-related risks at 1.5 °C that will increase with warming of 2ºC and higher (*high confidence)* TS-15

Impacts associated with sea level rise and changes to the salinity of coastal groundwater, increased flooding and damage to infrastructure, are critically important in sensitive environments such as small islands, low lying coasts and deltas at global warming of 1.5ºC and 2ºC TS-15

Globally, the projected impacts on economic growth in a 1.5 °C warmer world are larger than those of the present-day (about 1 °C), with the largest impacts expected in the tropics and the Southern Hemisphere subtropics. At 2 °C substantially lower economic growth is projected for many developed and developing countries, with the potential to also limit economic damages at 1.5ºC of globa l warming TS-15

There is *high confidence* that the probability of a sea-ice-free Arctic Ocean during summer is substantially higher at 2 °C when compared to 1.5ºC TS-11

Note: a summer ice free Arctic ocean is a large temperature amplifying feedback with a high risk of cascading Arctic and global amplifying feedback greenhouse gas emissions and runaway.

The ocean has absorbed about 30% of the anthropogenic carbon dioxide, resulting in ocean acidification and changes to carbonate chemistry that are unprecedented in 65 million years at least. Risks have been identified for the survival, calcification, growth, development, and abundance of a broad range of taxonomic groups (i.e. from algae to fish) Multiple lines of evidence reveal that ocean warming and acidification (corresponding to global warming of 1.5 °C of global warming) is expected to impact a wide ran ge of marine organisms, ecosystems, as well as sectors such as aquaculture and fisheries (*high confidence*)
TS-12

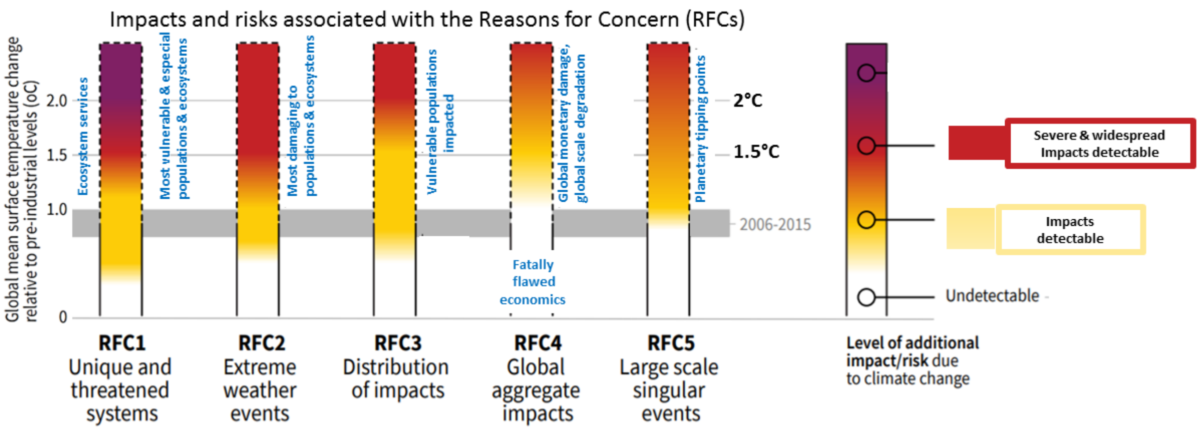
Global warming of 1.5 °C (as opposed to 2ºC) is projected to reduce climate induced impacts on crop yield and nutritional content in some regions (*high confidence*). Affected areas include Sub-Saharan Africa (West Africa, Southern Africa), South-East Asia, and Central and South America TS-13

Risks of food shortages are lower in the Sahel, southern Africa, the Mediterranean, central Europe, and the Amazon at 1.5 °C of global warming when compared to 2 °C**.** This suggests a transition from medium to high risk of regionally differentiated impacts between 1.5 and 2 °C for food security. International food trade is *likely* to be a potential adaptation response for alleviating hunger in low- and middle-income countries potential adaptation response for alleviating hunger in low- and middle-income countries
TS-13

RESEARCH IN IPCC 1.5C SHOWS THAT RISKS AND IMPACTS OCCUR AT LOWER DEGREES OF GLOBAL CLIMATE CHAGE THAN PREVIOUSLY ESTIMATED

There are multiple lines of evidence that there has been a substantial increase since AR5 in the levels of risk associated with four of the five Reasons for Concern (RFCs) for global warminglevels of up to 2 °C (high confidence).
TS-16

Constraining warming to 1.5ºC rather than 2ºC avoids risk reaching a ‘very high’ level in RFC1 (Unique and Threatened Systems) (high confidence), and avoids risk reaching a ‘high’ level in RFC3 (Distribution of Impacts) (high confidence) and RFC4 (Global Aggregate Impacts) (medium confidence). It also reduces risks associated with RFC2 (Extreme Weather Events) and RFC5 (Large scale singular events). TS-16



More detailed explanation of Reasons for Concern (RFCs) from IPCC 2014 AR5 WG2

Unique and threatened systems: Some unique and threatened systems, including ecosystems and cultures, are already at risk from climate change (high confidence). Many species and systems with limited adaptive capacity are subject to very high risks with additional warming, particularly Arctic-sea-ice and coral-reef systems.

Extreme weather events: Climate-change-related risks from extreme events, such as heat waves, extreme precipitation, and coastal flooding, are already moderate. Risks associated with some types of extreme events (e.g., extreme heat) increase further at h igher temperatures

Global aggregate impacts: Risks of global aggregate impacts are moderate for additional warming reflecting impacts to both Earth's biodiversity and the overall global economy

Large-scale singular events: With increasing warming, some physical systems or ecosystems may be at risk of abrupt and irreversible changes. Risks associated with such tipping points become moderate between 0–1°C additional warming, due to early warning signs that both warm-water coral reef and Arctic ecosystems are already experiencing irreversible regime shifts (medium confidence). Risks increase disproportionately as temperature increases between 1–2°C additional warming and become high above 3°C, due to the potential for a large and irreversible sea level rise from ice sheet loss. For sustained warming greater than some threshold, near-complete loss of the Greenland ice sheet would occur over a millennium or more, contributing up to 7 m of global mean sea level rise.

In "Unique and Threatened Systems" (RFC1) the transition from high to very high risk is located between 1.5ºC and 2ºC global warming TS-16

In "Extreme Weather Events" (RFC2) the transition from moderate to high risk is located between 1.0°C and 1.5°C global warming, which is very similar to the AR5 assessment but there is greater confidence in the assessment. The impact literature contains little information about the potential for human society to adapt to extreme weather events
TS-16

In "Distribution of impacts" (RFC3) a transition from moderate to high risk is now located between 1.5ºC and 2ºC global warming as compared with between 1.6ºC and 2.6ºC global warming in AR5, due to new evidence about regionally differentiated risks to food security, water resources, drought, heat exposure, and coastal submergence.
TS-16

In "Global aggregate impacts" (RFC4) a transition from moderate to high levels of risk now occurs between 1.5ºC and 2.5ºC global warming as opposed to at 3ºC warming in AR5, owing to new evidence about global aggregate economic impacts and risks to the earth's biodiversity. TS-16

In "Large scale singular events" (RFC5), moderate risk is located at 1ºC global warming and high risks are located at 2.5ºC global warming, as opposed to 1.9°C. TS-16