# 10 New Insights in Climate Science 2018

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# Content

# Introduction

From fires in North America to floods across Asia, many societies have in the last 12 months begun to experience more severe impacts attributable to human-induced climate change. Although predicted by scientists, some of these impacts have come earlier than expected. Published in October, the Intergovernmental Panel on Climate Change's (IPCC) landmark special report provided an unequivocal warning of the negative impacts of allowing global average temperature increase to go beyond 1.5°C (2.7°F).

Humanity is experiencing the warmest average temperature on Earth since the end of the last Ice Age, 12,000 years ago, an increase by 1°C since the start of the industrial revolution[1]. In 2018, global carbon dioxide emissions from human activities are projected to reach a new record high of about 41.5 billion tons per year[2]. Rising levels of greenhouse gases in the atmosphere are increasing the global average temperature, causing ocean acidification, and perturbing the climate system through, for instance, changed rainfall patterns[1]. Climate change is leading to observed increases in economic losses and human suffering, by displacing vulnerable populations and deepening existing inequalities[3].

In an effort to mitigate climate change and limit warming to well below 2°C (3.6°F), each country party to the UNFCCC has set a Nationally Determined Contribution (NDC), or national greenhouse gas reduction target. However, the emission reductions pledged under the NDCs are insufficient for the world to limit warming to well below 2°C, let alone 1.5°C[4]. More ambitious NDCs and stronger mitigation action until 2030 is needed to keep the 1.5°C target in reach.

Limiting the temperature increase to less than 1.5°C will require greenhouse gas emissions to approximately halve by 2030, according to the IPCC - a Herculean task. The world is far from this trajectory. However, this trajectory is still achievable: solutions exist to halve emissions globally. Furthermore, limiting emissions will also benefit other areas of society, by creating new employment opportunities, improving health, and increasing energy and food security. As nations meet in Poland for the 24th UNFCCC Conference of the Parties, this report synthesizes recent key insights from science with focus on those published in 2017-2018. The report emphasizes the urgency to act now and summarizes what we need to know to navigate the transformation to low-carbon societies.

# 1. Extreme weather events are now clearly attributable to climate change

**Key facts:**

- Increasing frequency and intensity of extreme events can, with higher precision, be linked to climate change
- 2018 has been a year of record-breaking extremes in the Northern Hemisphere with flooding and locally unprecedented heat waves and wildfires

The frequency and intensity of extreme events, including flooding, heat waves, and drought conditions has been increasing[1,2,3,4]. Until recently, it was difficult to clearly attribute these events to climate change. Now, more accurate observations and progress in modelling has made the link clear[5].

Storms are becoming wetter and slower[6,7]. Being slower means that the storm as a whole is likely to spend more time over any single location. This combined with being wetter, increases the risk of flooding events, such as when Hurricane Harvey stalled over Texas in August 2017[8]. The level of precipitation released by Hurricane Harvey is statistically extremely rare, with a once per 9,000 years probability[8]. Similar record-breaking storms were seen in 2018 such as Hurricane Florence[9,10] and Typhoon Mangkhut, in Asia, which killed at least 70 people as massive mudslides, strong winds, and storm tides battered the region[9].

Storms are also more frequently occurring outside the traditional storm season. For example, after the extremely active 2017 Atlantic hurricane season, the third most active on record[11], NOAA predicted 2018 to be below average, in part because of developing El Niño conditions[12]. However, by mid-September the Atlantic hurricane season had already exceeded the predicted[13] named storms[13] - with two and a half months left in the season.

Rainfall patterns are not only getting more intense with climate change but are also swinging from wet to dry more erratically[10]. If carbon dioxide emissions continue to increase, half of all the additional rainfall driven by climate change is likely to occur within the wettest six days of the year[10]. The consequences of such changes could be seen in Kerala, India, this year. After 20 days of 164% more rain than usual[10], the ground collapsed, causing landslides throughout the state and driving more than 1 million people out of their homes.

Record-breaking heat waves also characterised the 2018 northern hemisphere summer, with models suggesting that climate change made the heat waves up to twice as likely to occur in many places[5]. Japan declared a national disaster in July as a heat wave swept across the country, killing at least 80 people[14]. A new record high, 41.1°C, was recorded in Japanese Kumagaya[14]. In the Arctic Circle, temperatures above 30°C and wildfires were recorded[15]. Lake and sea waters were 5-6°C warmer than normal in Finland, which led to severe algae blooming and toxic water[15]. The highest temperature to ever be reliably measured in Africa, 51.3°C, was recorded in Algeria's Sahara Desert in July and the highest overnight temperature known to have been measured in the world, 42.6°C at the coolest part of the night, was recorded in Oman[15].

The heat wave in northern Europe exacerbated an existing drought, brought on by exceptionally dry and warm May and June. Sweden suffered some of its worst recorded outbreaks of forest fires, leading to the biggest ever coordinated EU fire emergency response[16]. The drought also had large implications for agriculture, with 30-50% of crop yield expected to be lost[15]. At 1.5°C and 2°C global warming, heat wave events could be amplified by humidity in the Eastern US and China, leading to peak apparent temperatures greater than 55°C, and likely high mortality rates[17].

# 2. Growing climate impacts show risks of critical tipping points

**Key facts:**

- Changes have been observed in major Earth systems: a weakening of the Atlantic overturning circulation, mass mortality of the world's coral reefs, and ice loss from the West Antarctic ice sheet has tripled in 25 years
- With continued warming, these and other systems can reach points where they rapidly collapse or a major, largely unstoppable transformation is initiated
- The world at 2°C warming and beyond is unsafe territory with a risk of crossing a planetary threshold towards a "Hothouse Earth"

Tipping points in the Earth System refer to thresholds that, if crossed, lead to far-reaching, in some cases abrupt and/or irreversible changes. In recent years, the risks associated with single, in principle well-known climate processes and their interaction have been corrected upwards as science makes new data or methodologies available. Some tipping elements are currently approaching a critical threshold or have already crossed it.

For example, a weakening of the Atlantic overturning circulation, often referred to as the Gulf stream system, has been expected from model simulations. Recent studies confirm that it has slowed down by 15% since the middle of the 20th century and is at its weakest in over a thousand years[1,2]. This is already having observed effects, such as extreme weather in Europe[3], and further weakening is expected to strongly affect European weather as well as exacerbating sea-level rise at the east coast of North America[4,5].

Corals are already experiencing mass mortality. In 2015-2016, record temperatures triggered pan-tropical bleaching of corals, affecting 91% of the Great Barrier Reef in Australia[6]. The recurrence of severe bleaching has become so frequent that reefs have difficulties recovering[7]. If warming would be limited to 1.5°C, 10-30% of the world's coral reefs might be saved, while at 2°C virtually all will probably be lost[8]. Coral ecosystem collapse is a matter of utmost concern as an estimated 500 million people depend on these for food, income, coastal protection, and more[9].

Another example of a biological system prone to tipping behaviour is the Amazon rainforest. Under climate change, there is the risk of conversion into dry forest or savannah ecosystems. Rainfall reduction, arising from climate feedbacks due to deforestation, further enhances forest degradation. A significant decrease in rainfall might occur in the future at 30-50% deforestation (or even lower)[10,11,12].

A collapse of the West Antarctic ice sheet is now a significant risk that would result in about 3 meters of sea-level rise. Ice losses there have tripled over the last 25 years[13]. Episodes of ocean melting increase the risk of ice sheet collapse[14], there is strong evidence for this having already begun in the Amundsen Sea sector[15,16,17].

Emerging scientific evidence shows how much tipping elements are linked to each other. For example, freshwater input into the North Atlantic from Greenland ice sheet melting can affect the ocean circulation and cause changes in rainfall from the West African monsoon, with substantial consequences for livelihoods[18]. Interacting tipping elements in the Earth System could potentially lead to tipping cascades and catapult the planet into a new state[19].

There might be a planetary threshold, beyond which no intermediate warming levels can be stabilized. While its exact location is uncertain, it can be as low as 2°C of warming. Beyond this threshold, temperatures could rise as high as 4-5°C, with 10-60 meters of long-term sea-level rise, and various other hazards to humanity and nature, locking Earth into a "Hothouse" state for tens to hundreds of millennia[19]. This is a state that best corresponds to the Earth as it was 15-17 million years ago when no human roamed this planet.

# 3. Every half degree matters: Large difference in impacts between 1.5°C and 2°C degrees of warming

**Key facts:**

- Significantly lower impacts on human health and living conditions and natural ecosystems, when limiting global warming to 1.5°C instead of 2°C
- 1.5°C can now be considered a strongly preferable target for the planetary climate boundary

The Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5°C that was released this year has shown that the magnitude and risk of a range of climate change impacts increase significantly between 1.5°C and 2°C. Every half degree matters.

For oceans, the risk of the Arctic Sea being ice-free during the summer increases from one very likely occurrence every century at 1.5°C, to one every decade at 2°C[1]. Furthermore, 2°C warming would mean an additional sea level rise of 0.1m in 2100 relative to 1.5°C[1,2], flooding lands currently home to 5 million people[3]. Overall, at least an additional 10 million people would be affected by sea level rise at 2°C[1,2].

For land, limiting the temperature increase to 1.5°C would not only avoid aridification in two thirds of the area where it would otherwise occur under 2°C[4], but also reduce the risk of both heavy flooding and droughts[1]. These risks are greatest in the northern hemisphere, particularly in the high latitudes and high altitudes[1].

The impact of greater warming on land affects food security, with a higher reduction in global crop yield at 2°C compared with 1.5°C[1]. The risk of food shortages is particularly more pronounced at 2°C in southern Africa, the Sahel, the Mediterranean, central Europe and the Amazon[1]. At 1.5°C, half the proportion of people will suffer from water stress as compared with 2°C[1]. In the Hindu Kush Himalaya region, the source of 10 large Asian rivers and providing water for a fifth of the world population, a warming of just 1.5°C means losses of more than one third of glacier volume and substantive changes in the timing and magnitude of stream flows - and at further warming the glacier loss will be significantly worse[5].

Finally, the positive impacts of keeping warming below 1.5°C are not limited to the human realm. Biodiversity is less threatened at 1.5°C, with half as many land species affected as compared with at 2°C[1]. Aiming for 1.5°C as a climate target will avoid a range of serious climate impacts.

| Differences in ***impact*** between... <br> Impact of 1.5°C and 2°C, respectively (IPCC 2018) | 1.5°C | 2°C |
|---|---|---|
| Additional increase in temperature for extremely warm days on land at mid-latitudes (deg C) | 3°C | 4°C |
| Billion persons exposed to severe heat waves at least once per 5 years | 1 billion | 2.7 billion |
| Billion persons exposed to water stress | 3.3 billion | 3.7 billion |
| Land area projected to undergo a transformation of ecosystems from one type to another (million km²) | 9 million km² | 17 million km² |
| Species projected to lose over half of their range (%) | | |
| Vertebrate | 4% | 8% |
| Plant | 8% | 16% |
| Insect | 6% | 18% |
| Coral reefs experiencing long-term degradation (%) | 70-90% | >99% |
| Differences in ***mitigation*** <br> Emissions reductions by 2030 (compared to 2010) | -45% | -20% |
| Year of ***zero net emissions*** | **2050** | **2075** |

# 4. New understanding of the acceleration of sea level rise and its future

**Key facts:**

- The rate of ice loss from Antarctica is increasing, now almost twice as high as projected by the latest IPCC assessment (2014)
- Satellite data confirms that the rate of sea level rise is accelerating
- Limiting warming to 1.5°C instead of 2°C can avoid the inundation of lands currently home to about 5 million people.

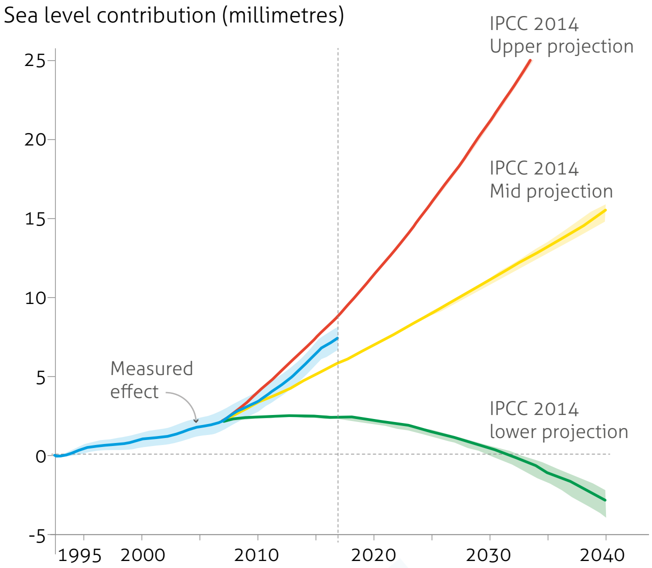
Sea-level rise is an important indicator of climate change as it integrates many factors of climate change. Improvements in the calculation of these contributing factors to sea level rise (ocean thermal expansion, ice sheet mass loss, glaciers, and changes in land water storage) are providing important constraints on areas we know less about, such as changes in the deep ocean[1]. The current rate of sea level rise now exceeds 3 mm/yr and recent research confirms that this rate is accelerating[2].

The sea-level response times to warming from climate change are slow; they range from 10–100 years for glacier contributions, to thousands of years for contributions from deep-ocean warming and ice-sheet melting. Global sea level rise from these combined contributions will thus continue for many millennia, even if temperatures are stabilised[3]. New research calculates that even if the world manages to meet the 2°C target, for every 5 years we delay the peak in CO2 emissions this commits us to 20 cm additional sea-level rise in 2300[4].

The rate of ice loss from Antarctica is increasing and is now 80% higher than the central projections made by the IPCC in 2014[5]. Continuing this trajectory would mean an additional 10 to 15 cm to global sea level rise by 2100. However, the IPCC's 2014 projections did not consider the full dynamic responses of the ice sheet and their potential tipping points, this number could increase considerably[5]. Further ice loss from West Antarctica and Greenland could occur because of marine ice sheet instabilities and increased melting, respectively[6]. This could cause a multi-metre rise in sea level in the coming centuries or millennia, and these tipping points could be crossed around 1.5°C to 2°C of global warming[7].

### Antarctic sea-level contribution

Antarctic contribution to sea-level rise following high prediction




Adapted from Slater and Shepherd, Nature Climate Change, 2018

The sea-level contribution from Antarctica is increasing, with observations following most closely to the upper projections from the latest IPCC assessment report (AR5) in 2014.

Even without these tipping points being triggered, the difference between 1.5°C and 2.0°C warming on sea level rise is estimated to be 14-21 cm by the year 2150[8]. Limiting warming to 1.5°C relative to 2°C (based on median sea level projections) can avoid the inundation of lands currently home to about 5 million people, including 60,000 people currently residing in Small Island Developing States[9].

# 5. Managing plants and soil: a prerequisite for meeting the Paris Agreement

**Key facts:**

- Between 2007 and 2016, land use change was responsible for annual global emissions of, on average, 4.7 billion tons of CO2, which is around 12% of CO2 emissions
- Natural climate solutions could potentially provide over one-third of the cost-effective climate mitigation needed between now and 2030 to stabilize warming to below 2°C

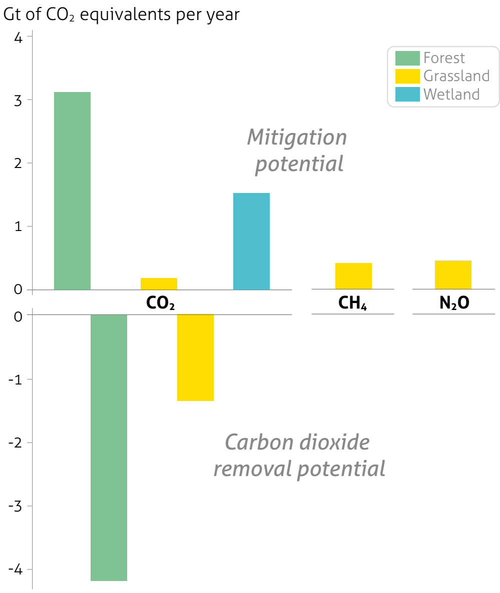
If the vegetation on this planet is viewed purely in terms of carbon, it holds around 450 billion tons, corresponding to 1650 billion tons of $CO_2$[1,2]. If the landscape had been left unchanged by humans, the potential vegetation would store over 900 billion tons of carbon, corresponding to 3360 billion tons of $CO_2$, under current climate conditions. This difference highlights the massive effect of human land use on biomass stocks[2].

Land degradation is a global problem that threatens the state of these carbon stores. In the first global-scale assessment of land degradation, it is reported that climate change, and the expansion and unsustainable management of croplands and grazing lands, are the most extensive global drivers of land degradation, with climate becoming increasingly important[3]. But the relationship goes two ways, and the impacts of land use change, including degradation, on the climate are clear; between 2007 and 2016, land use change, was responsible for annual global emissions of 4.7 (±2.6) billion tons of $CO_2$[4]. However, the impacts of land degradation are much wider ranging than climate and cover biodiversity loss, loss of ecosystem services, and negative impacts on well-being[3].

The potential for climate change mitigation through land management has been gaining increasing attention. It is recognised that we need measures that both increase carbon sinks via improved land stewardship and also reduce emissions from land use activities. Recent research shows that better land management, particularly reforestation and avoided forest conversion, can be a stronger solution to mitigate climate change

**Forests dominate green solutions**

Potential mitigation and carbon uptake of natural climate solutions




Source: Griscom et al, PNAS 114, 2017

Better land management is important for emissions reductions, but could also serve as a mechanism to remove carbon dioxide already in the atmosphere. The potential mainly lies in avoided deforestation and re-/afforestation, but managing grasslands and wetlands is also of importance. Graph adapted from Griscom[5].

than previously thought. Natural climate solutions, which include conservation, restoration, and improved land management actions, could potentially provide over one-third of the cost-effective climate mitigation needed between now and 2030 to stabilize warming to below 2°C[5].

As these land systems have been managed by humans for many generations, there is a wealth of knowledge that can be readily applied today with confidence. There is also the added benefit that these approaches present opportunities to meet other global sustainability goals, such as improved water quality, ecosystem restoration, biodiversity preservation, food and nutrition security, job creation and improved crop yields[6]. Delaying action increases both the difficulties and costs to society for both mitigation and adaptation.

# 6. Options to remove $CO_2$ from the atmosphere are limited

**Key facts:**

- Scenarios that have recently been assessed by the IPCC show that the world will need to draw ca 100-1000 billion tons of $CO_2$ out of the air, so-called Carbon Dioxide Removal (CDR), during this century to achieve the 1.5°C target
- Some CDR options can have co-benefits at small scales but all options run into major scalability and sustainability limitations at large scales
- This calls for both stronger emissions reductions to minimize the need for CDR, and more stringent sustainability criteria for the rapid deployment of CDR techniques

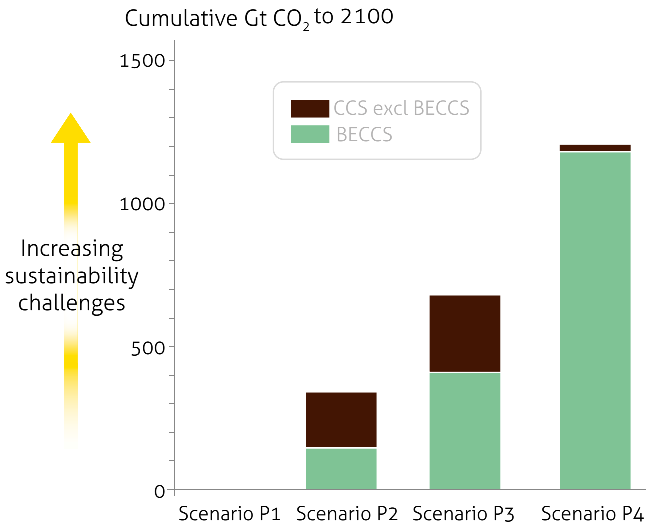
Every emissions pathway achieving 1.5°C global warming in 2100 assessed by the Intergovernmental Panel on Climate Change (IPCC) relies on some level of Carbon Dioxide Removal (CDR)[1]. CDR means removing $CO_2$ that has been emitted to the atmosphere and includes a wide range of natural and technological options, from re- and afforestation to bioenergy with carbon capture and storage (BECCS) or direct air capture of $CO_2$.

Depending on how large and how fast emissions reductions will be in the short term, CDR in the range of 100-1000 billion tons of $CO_2$ is expected to be needed over the rest of the century to follow 1.5°C pathways with limited or no overshoot[1]. Pathways assuming high amounts of CDR rely on afforestation and large-scale deployment of BECCS, which is unproven at global scale and also poses critical tradeoffs with sustainability objectives largely related to land-use, such as food production, cultural landscapes, and biodiversity[2,3,4,5]. There are multiple feasibility and sustainability constraints already at CDR deployment of several hundred billion tons[1]. Extensive use of BECCS to reach the 1.5°C target could even lead to greenhouse gas emissions if it means expanding bioenergy crops on forest land or on other lands that hold much carbon[6].

With the imposed limits to carbon dioxide reduction, emissions need to decrease rapidly if we are to stay “well below” 2°C. Recent research shows possible pathways to meeting Paris targets with no or limited CDR and these require strong efforts to reduce emissions, focused particularly on limiting rising levels of energy demand[7,8]. Still, some level of CDR is likely to be needed. A wider set of CDR methods exists, such as enhanced weathering, biochar, and soil carbon sequestration. A portfolio of combined CDR options at significant scales but still at the low end, from 0.5 up to a few billion tons per year each, would reduce risks for other sustainability goals while preserving the ability to remove $CO_2$ and keep 1.5°C within reach[4]. Properly managed and at moderate scales, some CDR techniques such as enhanced weathering and soil carbon management could even yield co-benefits, like increased soil quality[4].

**From challenging to unsustainable**

Carbon Dioxide Removal under scenarios assessed by IPCC 2018




The recent IPCC report on 1.5 degrees assesses four scenarios with varying levels of mitigation, where scenario P1 has the most rapid emissions reductions and scenario P4 the slowest. This results in significant differences in the amount of carbon dioxide removal (CDR) required to keep temperatures as 1.5°C.

# 7. Major socio-technical transformations needed to meet the 1.5°C target

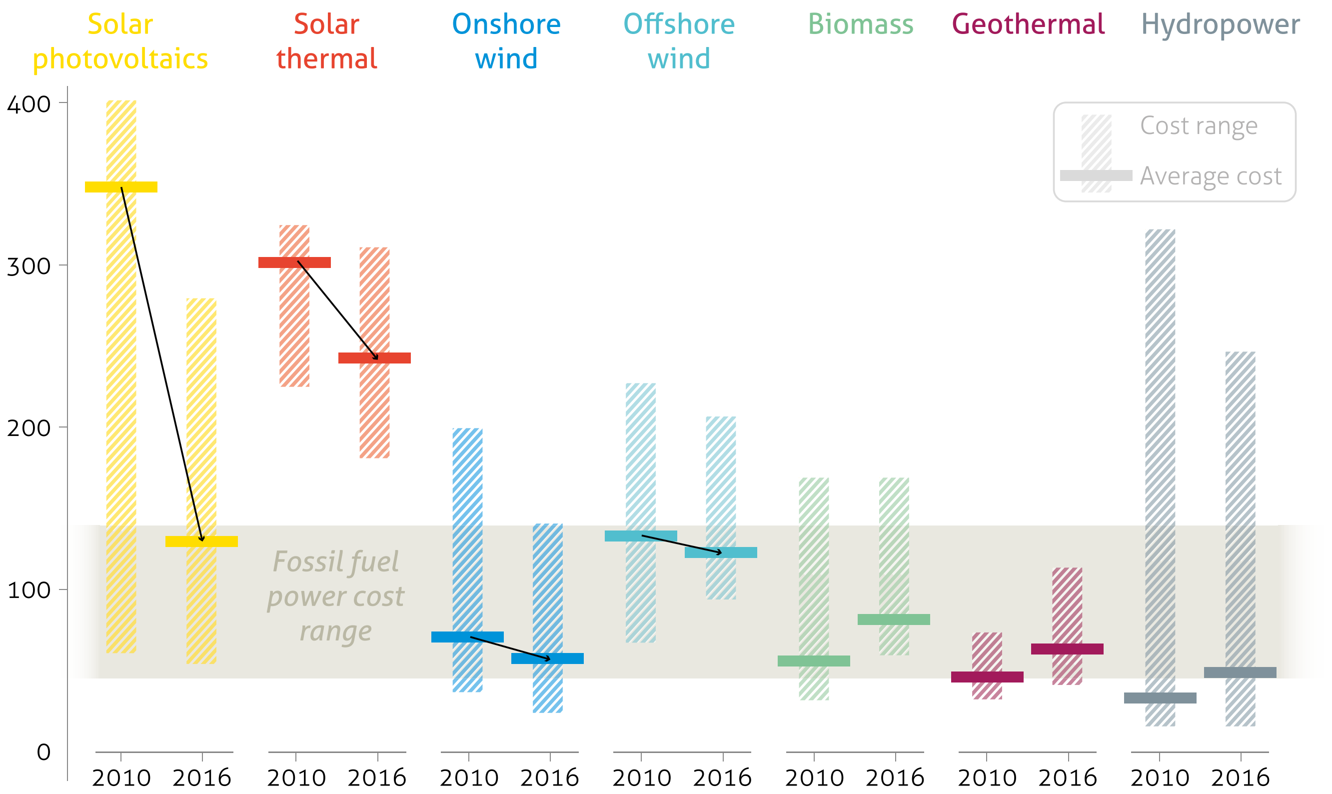
**Key facts:**

- Pathways to limit warming to 1.5°C require at least a halving of emissions to 2030
- Such rapid reductions require transformations of full sociotechnical systems, across all sectors and scales
- Cities and energy systems are pivotal and there is already considerable momentum in the energy sector that it could see major shifts towards very low emissions, with the right support

The path to limiting warming to 1.5°C, with no or limited overshoot, requires the world to follow pathways with at least a halving of current emissions to 2030 (40-60% reduction of emissions by 2030 compared to 2010)[1]. We need to stay within a carbon budget, a total net amount of $CO_2$ emitted to the atmosphere, of 420-570 billion tons for a 66% likelihood of limiting warming to 1.5°C[1]. It also requires significant reductions of other drivers such as methane and black carbon[1]. A simple, approximate rule of thumb for emission reduction is the Global Carbon Law of halving every decade from 2020, which is consistent with the Paris Agreement target of "well below" 2°C and aiming at 1.5°C[2].

## Price drop in solar and wind power since 2010

Cost of electricity, USD/kWh




Estimated global levelized cost of electricity in 2016 USD. Adapted from: IRENA 2018

Such rapid and deep decarbonization requires transformation not just of single technologies but of socio-technical systems - the interlinked mix of technologies, infrastructures, organizations, markets, regulations, and user practices [3]. Socio-technical transformations are inherently complex and can be disruptive, contested, and non-linear [4]. Major possible impediments that need to be overcome include lack of global cooperation, high inequality, high population growth, and/or rapidly growing resource-intensive consumption [5].

The cities of the world are key players as they are dominant drivers of carbon dioxide emissions related to energy use and infrastructure[6]. If cities in developing countries follow the path taken by cities in developed countries, in term of equal per capita emissions embedded in infrastructure, these countries would use up to half of the total $CO_2$ budget for 1.5°C just to meet future housing demands[7]. New models of transformative infrastructure development, therefore, are urgently needed. Cities need to better understand climate change on both the local and global level, to reduce emissions and adapt to impacts such as heat stress and flooding[8].

The energy system is, likewise, pivotal as three-quarters of global greenhouse gas emissions are related to energy use[9]. While many scenarios in the past have assumed increasing energy usage, recent assessments, including some analysed by the IPCC[1], are based on decreasing world primary energy demand. Social, organisational and technological innovations coupled with strong efficiency standards can potentially reduce the energy demand without compromising global living standards[10]. In addition, readily-available technological substitutions already exist for ~73% of today's emissions[11].

The speed of energy supply transformation will in the coming years be a battle between the growing political and economic momentum of renewable energy[12] and the residual momentum of fossil fuels. Between 2006 and 2016, solar and wind power have gone from a combined 0.7% to 5% share of global electricity production, doubling their output every 3 years[13,14]. Solar power, in particular, has grown faster than what has been expected by models[15]. The global average prices of solar photovoltaic and wind power installations have fallen and are in many regions of the world now within or even below the cost range of new fossil generation[16]. However, while global coal use peaked in 2013, global coal capacity is currently growing, particularly in countries with fast-growing electricity demand in South or South-East Asia[17,18]. If all coal power plants currently in the pipeline were built and ran until the end of their lifetime they would – in combination with the existing stock of power plants – produce 300 billion tons of $CO_2$, about half of the available carbon budget to 1.5°C[1,17,19].

Many actors are stepping up climate action, not least on the sub-governmental level. Commitments have been made by more than 9000 cities from 128 countries, around 240 states and regions from more than 40 countries, and more than 6000 businesses in 120 countries representing 36 trillion USD[20]. Financial institutions are increasingly mainstreaming climate change into their operations and investment decisions. The green bond market, issued to fund environmental projects ranging from wind farms to water purification facilities, has been growing rapidly and in 2018 the total value of climate-aligned bonds reached 1.45 trillion USD[21]. Renewable energy targets have been spreading, with 79% of the global greenhouse gas emissions covered in 2017 compared to 45% in 2007, with a steep increase in developing countries[22]. While emissions continue growing, so do the foundations for transformative change to low-carbon societies.

# 8. Stronger policy measures would reduce climate risks

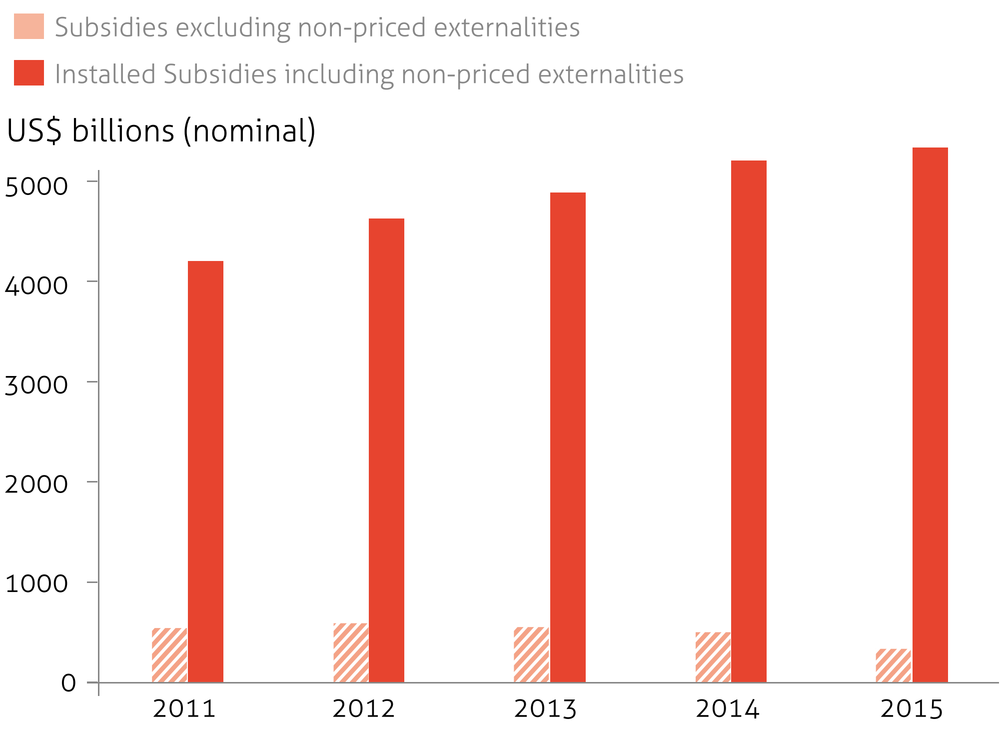
**Key facts:**

- Climate action to limit warming to 1.5°C could save the world in the order of 20 trillion USD and likely benefit a vast majority of the global population
- Phasing out fossil fuel subsidies would reduce global carbon emissions and strengthen public budgets, but reforms should consider acceptance, effects on poverty, and possible adverse effects such as shifts from gas to coal
- A comprehensive and dynamic portfolio of policies including standards, regulations, incentives, and carbon pricing would effectively support and accelerate a low-carbon transition

There is more than a 60% chance that limiting warming to 1.5°C would save the world over 20 trillion USD (2010 USD)[1]. 71% of countries— representing 90% of the global population—have more than a 75% chance of benefiting from these relative economic advantages, with poorer countries benefiting the most[1].

While almost every government on Earth has signed the Paris agreement, many still subsidize carbon-emitting fossil fuels. The government consumption-based subsidies to fossil fuels were more than 300 billion USD/year (in 2017)[2], or 5300 billion USD/year when including non-priced externalities (in 2015)[3]. Policy reforms to phase out government subsidies can reduce global carbon emissions up to 10%[4] and increase public budgets by almost 0.5% of global GDP[4]. The effects of reforms will depend on how well they are designed to avoid unwanted side-effects, such as shifts from oil and gas to more carbon-intensive coal[5]. Dedicated and carefully timed measures are also required as subsidy reforms are difficult to implement, due to their political nature, special interest groups, and low public awareness of the existence and consequences of the subsidies[6,7].

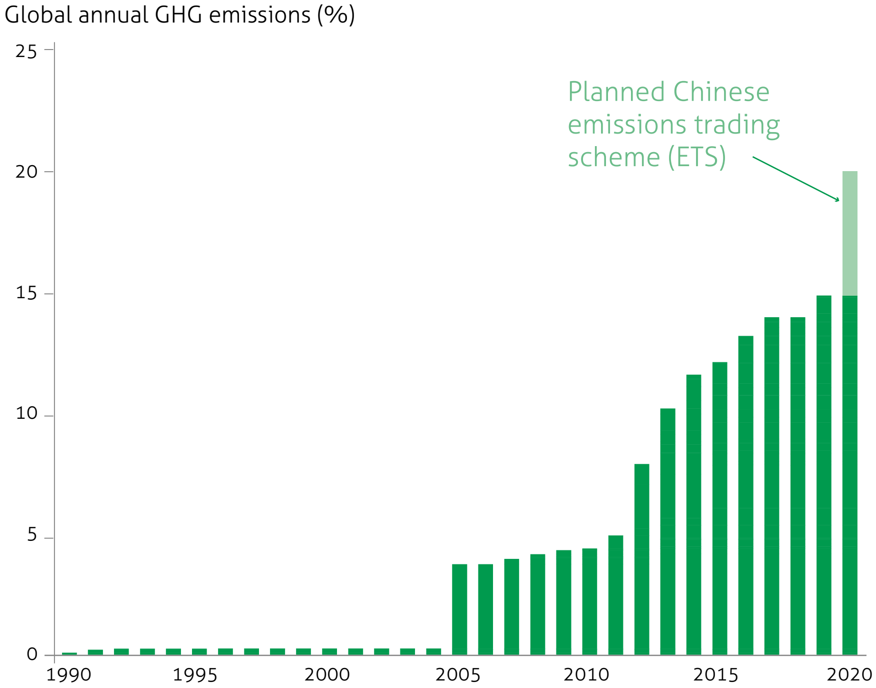
## Global fossil fuel subsidies




Adapted from Coady et al, World Development, 2017

Implementing a price on carbon corresponding to its costs to society would help address the non-priced externalities of fossil fuels. Roughly half of the carbon emissions from fossil energy are subject to carbon pricing or other fiscal policies related to energy and excise taxes, but almost 90% of emissions are priced at rates below 30

## Increasing share of emissions covered by carbon pricing




The amount of global emissions currently under specific carbon tax or trading schemes are growing, with a step up expected when the Chinese emissions trading scheme starts in 2020. The amount of emissions under any kind of fiscal policy that can be translated to a carbon price is more than twice as high. (This is an adaptation of an original work by The World Bank. Views and opinions expressed in the adaptation are the sole responsibility of the authors of the adaptation and are not endorsed by The World Bank.)

Adapted from World Bank, 2018

EUR (34 USD)[8]. From 2003 to 2015 the global mean gasoline tax even fell by 13%[9]. If energy prices had fully accounted for production costs, global and domestic environmental impacts and general taxes in 2013, global $CO_2$ emissions would have been 21% lower, air-pollution deaths associated with fossil fuels would have been 55% lower, and government revenues as a percentage of GDP would have been 4% higher[3]. If revenues are used to cut pre-existing taxes, e.g. on labour or income, the costs of climate policy can be reduced substantially.

To be effective, carbon pricing needs to be part of a dynamic policy mix including other instruments such as performance and efficiency standards, regulatory measures, feebates (self-financing systems of fees and rebates), and moratorium on coal power[10,11]. Policies should also support emerging alternatives, with market support for energy-efficient and low-carbon technology, innovation policies, and investments in infrastructure that supports energy system transformation[10,11]. In Europe, the use of public money to subsidize renewable energy has significant support, while more are against (44%) than in favour (30%) of increasing fossil fuel taxes[12]. Government policies have, to date, mainly addressed fossil fuel consumption, but to limit global average temperature increases to below 2°C, they also need to address the production of fossil fuels[13,14].

Certain mitigation policies may increase the price of energy-intensive goods and services and yield significant real income losses for poor households[15]. Tax reductions, transfers or pro-poor public spending can avoid increases in inequality and poverty due to climate policy[16].

# 9. Transformation of food systems needed for global health and reduced greenhouse gas emissions

**Key facts:**

- Decarbonizing and building resilience in the world food system is a prerequisite to succeed with the Paris Agreement
- Dietary shifts away from unhealthy “Western diets” towards reduced meat and dairy consumption are a significant way to reduce greenhouse gas emissions and improve health.
- 29% of farms worldwide, or 163 million farms, practice forms of sustainable agricultural intensification.

The global population is projected to grow from the current 7.6 billion people to about 10 billion by around 2050[1]. The food sector is responsible for up to 29% of global greenhouse gas emissions (and over 50% of non-$CO_2$ emissions)[2]. Furthermore, food systems are a prime driver of deforestation, nitrogen and phosphorus pollution and biodiversity loss.

Many studies highlight that changing diets towards lowered meat and dairy consumption combined with sustainable intensification of agricultural practices can reduce greenhouse gas emissions and enhance carbon stocks on land[3,4]. For example, dietary shifts relating to reduced meat and dairy consumption could theoretically reduce food’s land use by up to 76% and food’s greenhouse gas emissions by up to 49%[5]. Therefore, a transformation to sustainable food systems will be an essential strategy to meet the Paris Agreement.

Early signs indicate that an important transformation of agriculture is already underway. About 29% of farms worldwide, or 163 million farms covering 9% of global agricultural land, practice forms of sustainable intensification[6]. Key tools to accelerate this shift towards sustainable food systems are changes in demand, efficiency improvements, and policies[3].

Diets with low meat and dairy consumption are most consistent with pathways to meet the 1.5°C target. Such diets also show multiple synergies with other Sustainable Development Goals and produce the lowest number of trade-offs[3]. However, most national dietary guidelines are not consistent with meeting the Paris Agreement[6].

# 10. Benefits for global health by addressing climate change

**Key facts:**

- Climate change is increasing the numbers of injuries, illnesses, and deaths from, for example, extreme weather and climate events, infectious diseases, poor air quality, and undernutrition
- Health systems are beginning to track and manage the risks posed by climate change
- Most mitigation policies have significant health co-benefits, with the magnitude of the co-benefits about the same as the cost of mitigation

Climate change is amplifying risks from climate-related hazards and leading to increases in injuries, illnesses, and deaths across the globe. Between 2030 and 2050, if current trends continue, climate change is expected to cause approximately 250 000 additional deaths per year, from malnutrition, malaria, diarrhoea, and heat stress[1]. Without rapid investment in mitigation and adaptation, any increase in global temperature is likely to further increase morbidity and mortality. Directly, climate change affects health through changes in the frequency and intensity of extreme weather events such as heat, drought and heavy rain. Climate change also affects health through climate-related changes in the natural systems that affect disease vectors, air pollution, and undernutrition, and through mental stress[2].

The risk of adverse health consequences associated with exposure to high ambient temperatures, ground-level ozone, and undernutrition, is higher at 2°C warming as compared with 1.5°C, with regional variation[3]. For vector-borne diseases, such as malaria and dengue fever, climate change is projected to globally increase their geographic range along the edges of their current distribution and/or a longer season of disease transmission. At regional scales, climate change could affect the disease frequency, range and season to either increase or decrease health risk, depending on regional climate responses and disease ecology[3].

To promote resilience, health professionals need to understand, track, and manage current and future health risks posed by climate change[4]. Particular focus should be on monitoring and evaluating vulnerability and exposure to climate-related hazards; current impacts and projected risks; and adaptation processes and health system resilience. Health systems are beginning to incorporate this information[4].

Mitigating climate change is projected to improve health outcomes later in the century[2]. Shifts to cleaner fuels and electricity create strong co-benefits for health due to reduced air pollution[5]. Indoor air pollution currently claims an estimated 2.9-4.3 million lives per year and outdoor air pollution 3.0-4.3 million lives per year, in both cases strongly linked to the combustion of fossil fuels[6]. Policies are needed to address the upstream drivers of pollution and dietary choices. Examples include promoting cleaner and more sustainable electricity generation systems, designing urban and transport policies that facilitate walking and cycling and updating national dietary guidelines to reflect the 1.5°C target[7,8]. Such actions not only promote health in the short and longer term, but would also reduce carbon dioxide emissions.

A lack of progress in reducing emissions and building adaptive capacity threatens both human lives and the viability of the national health systems they depend on, with the potential to disrupt core public health infrastructure and overwhelm health services[9]. Ultimately, the extent and effectiveness of adaptation and vulnerability reduction measures will determine the magnitude and pattern of climate impacts on health in the future.

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