1.5°C risks and feasibility

This document provides key points on

1. Risks associated with 1.5°C warming
2. Responses to arguments commonly made against 1.5°C, specifically
   a. "1.5°C goal is not feasible"
   b. "1.5°C is too expensive"
   c. "1.5°C is a risk to food security"

Scientific sources are listed in the left column, talking points derived from those sources in the right column.

November 5, 2015.

1. Risks associated with 1.5°C warming

The 2°C goal is not safe and 1.5°C has many benefits	
Source	**Key Points**
"The 'guardrail' concept, in which up to 2 °C of warming is considered safe, is inadequate and would therefore be better seen as an **upper limit**, a defence line that needs to be stringently defended, while less warming would be preferable." (SED Message #5)	• The SED has shown that limiting warming to 2°C does not prevent dangerous climate change. • Indeed, this has led the SED to state that efforts should be made to push the warming limit as low as possible. • Clearly, the long-term global goal of holding warming below 1.5°C is much more in line with the key Messages from the SED than an "unsafe" limit of 2°C.
"While science on the 1.5 °C warming limit is less robust**, efforts should be made to push the defence line as low as possible**" (SED Message # 10)	
"Some experts warned that current levels of warming are already causing impacts beyond the current adaptive capacity of many people, and that there would be **significant residual impacts even with 1.5 °C of warming** (e.g. for sub-Saharan farmers)" (SED para 113)	• The SED clearly states that already now, at 0.8°C warming, climate change poses severe challenges to populations, beyond the current adaptive capacity of many people. • The SED stresses that holding warming below 1.5°C has large benefits over a 2°C limit.
"Experts emphasized the **high likelihood of meaningful differences between 1.5 °C and**	

2 °C of warming regarding the level of risk from **ocean acidification** and of **extreme events or tipping points**, because impacts are already occurring at the current levels of warming; risks will increase with further temperature rise" (SED para 108)	• However, even at 1.5°C, residual impacts would still be significant, for example for sub-Saharan farmers, while we know that even today the rural population here amounts to over 600 million people. • On the positive side, the SED has also shown that many severe climate risks can be avoided by limiting warming to 1.5°C, including those to ecosystems and food security, which are of direct relevance to the Objective of the Convention.
"[R]egional **food security risks** are significantly different between 1.5 °C and 2 °C of warming" (SED para 108)	
"[S]ome **benefits of scenarios with 1.5 °C** instead of 2 °C of warming were identified and include the following: most terrestrial and marine species would be able to follow the speed of climate change; up to **half of coral reefs may remain**; **sea level rise may remain below 1 m**; some Arctic sea ice may remain; **ocean acidification impacts would stay at moderate levels**; and **more scope for adaptation** would exist, especially in the agricultural sector" (SED para 110)	

Even at 1.5°C there are risks to sustainable economic development and ecosystems	
Source	**Key Points**
The risks for **unique and threatened** systems are high at 1.5°C (IPCC Working Group 2 – see Annex I)	• Even at 1.5°C, the IPCC clearly identifies high risks of extreme events and high risks for unique and threatened systems worldwide. • Extreme events today regularly set back vulnerable countries in their economic development. • These grave setbacks impede our sustainable economic development, will do more so at 1.5°C, and yet more severely at 2°C, which is in direct conflict with the Objective of the Convention. • The risks for ecosystems also relate directly to the Objective of the Convention.
The risks of **extreme events** are high at 1.5°C (IPCC Working Group 2– see Annex I)	
„In response to further warming by 1°C or more by the mid-21st century and beyond, **ocean-wide changes in ecosystem properties** are projected to continue" (IPCC, Working Group 2, Chapter 6, Executive Summary)	

2. Responses to arguments commonly made against 1.5°C

Background: Calls for 1.5°C are often met with arguments that (a) the goal is no longer feasible, (b) that it is too expensive and (c) scenarios present risks to food security due to land-use change. The following key points drawn from the science for these statements.

2a) "The 1.5°C goal is not feasible"

Reaching the 1.5°C goal requires the same technologies as 2°C	
Source	**Key Points**
"The technologies required for the 1.5 °C scenarios are the same as for the 2°C pathway, but need to be deployed faster, and energy demand needs to be reduced earlier, implying a higher cost than in the 2 °C scenarios." (SED para 114)	• Science tells us that the technologies and knowledge for limiting warming to below 1.5°C are the same as needed for 2°C. • Their implementation is a challenge and they must be deployed faster, but it is clearly technically and economically feasible.
"In general, pathways limiting warming to below 1.5 °C by the end of the century are similar to those limiting warming to 2 °C, but call for more immediate mitigation action and an additional scaling-up of the challenging features of the 2 °C scenarios, such as the scaling-up of CO2 removal technologies and of the full set of low-carbon technologies" (SED para 114)	

2b) "1.5°C is too expensive"

1.5°C only delays growth in global wealth by 4 years and brings many co-benefits	
Source	**Key Points**
"[A]chieving a 1.5 °C-consistent scenario is roughly 1.5–2.1 times more costly than achieving a corresponding likely 2 °C scenario" (Rogelj et al. 2015)	• 1.5°C pathways are more costly than 2°C pathways. • Whilst this sounds like a lot , it is not!

	• The IPCC estimate that the cost of limiting warming below 2°C is a reduction in global GDP growth of about 0.06% of GDP p.a. over the 21st century. This would reduce economic growth from, say, 2.30% to 2.24% per year. Put another way it would lead to only a 2 year delay in reaching the same level of global wealth over the period from 2010 to 2100.
"The window of emissions in 2030 that still keeps the option open to limit warming to below 1.5 °C by 2100 is much lower and substantially smaller than the corresponding window for 2 °C-consistent scenarios. Diverting investments towards low-carbon technologies in the coming decade is therefore critical." (Rogelj et al. 2015)	
"[M]itigation scenarios that reach atmospheric concentrations of about 450 ppm CO2eq by 2100 entail losses in global consumption—not including benefits of reduced climate change as well as co-benefits and adverse side-effects of mitigation—of 1% to 4% (median: 1.7 %) in 2030, 2% to 6% (median: 3.4 %) in 2050, and 3% to 11% (median: 4.8 %) in 2100 relative to consumption in baseline scenarios that grows anywhere from 300% to more than 900% over the century. These numbers correspond to an annualized reduction of consumption growth by 0.04 to 0.14 (median: 0.06) percentage points over the century relative to annualized consumption growth in the baseline that is between 1.6% and 3% per year." (WG3 Summary for Policy Makers)	• Over the 21st century limiting warming below 1.5°C by 2100 is about 50% more, so about 0.1 % of GDP p.a. over the 21st century. This would reduce economic growth from, say, 2.30% to 2.20% per year, resulting in only a 4 year delay in reaching the same level of global wealth over the period from 2010 to 2100. • And, it has to be recalled, that these mitigation costs do not include the co-benefits of mitigation (see below), which are often as large as or greater than the direct costs. • The urgency to act on climate change is high, particularly for 1.5°C. The longer we wait, the more costly mitigation will become. And eventually we lose the opportunity to meet the Objective of the Convention altogether.
„In addition to their implications for climate change, essentially all the important climate-altering pollutants (CAPs) other than carbon dioxide (CO2) have near-term health implications (very high confidence). In 2010, more than 7% of the global burden of disease was due to inhalation of these air pollutants (high confidence)." (IPCC WG2 chapter 11)	• Reduced air pollution provides what is called a large 'co-benefits' for health – lives and costs would be saved, and agriculture in terms of increased food production as air pollution is reduced.

"O3 in the stratosphere provides protection from lethal short-wave solar ultraviolet radiation, but in the troposphere it is a phytotoxic air pollutant...Being a powerful oxidant, O3 and its secondary by-products damage vegetation by reducing photosynthesis and other important physiological functions... The literature published since AR4 further corroborates the negative impacts of increasing concentrations of surface O3 on yield at global (...) and regional scales " (IPCC WG2 chapter 7)	

1.5°C has many benefits in terms of avoided impacts	
Source	**Key Points**
Highly unusual heat extremes would affect around 20-25% of land area in Sub-Saharan Africa under 1.5°C and around 45% of land area under 2°C warming. (Turn Down the Heat 2) Highly unusual heat extremes would affect around 15% of land area in South Asia under 1.5°C and around 20% of land area under 2°C warming. (Turn Down the Heat 2)	• The benefits of limiting warming to 1.5°C, in terms of reduced damages, adaptations and risks are large. These benefits are not included in cost calculations for mitigation. And many of the avoided damages cannot be monetized. • Compared to a 2°C pathway: ○ There is a large reduction in exposure to the extremes in many regions. For example heat extremes would affect 5-20% less land area in Sub-Saharan Africa,
Highly unusual heat extremes would affect around 30% of land area in Latin America and the Caribbean under 1.5°C and around 30-40% of land area under 2°C warming. (Turn Down the Heat 3)	

"[S]ome benefits of scenarios with 1.5 °C instead of 2 °C of warming were identified and include the following: most terrestrial and marine species would be able to follow the speed of climate change; up to half of coral reefs may remain; sea level rise may remain below 1 m; some Arctic sea ice may remain; ocean acidification impacts would stay at moderate levels; and more scope for adaptation would exist, especially in the agricultural sector" (SED para 110)	South Asia and Latin America and the Caribbean than under a 2°C goal. o Sea level rise may remain below 1 meter in the 21st century and the risk of long term, multi-metre sea level rise from ice sheet loss appears significantly reduced o Half of all coral reefs worldwide may survive, whereas under a 2°C warming it has been projected all may be lost o There will be more scope for adaptation and a reduction in loss and damage.
The 2003 heat wave was one such record event; therefore, the probability that particular heat wave can be attributed to climate change is 75% or more, and on this basis it is likely the excess mortality attributed to the heat wave (about 15,000 deaths in France alone (Fouillet et al., 2008)) was caused by anthropogenic climate change.	• And this does not only apply to the most vulnerable countries. In France the heat wave 2003 alone caused 15.000 deaths, with a high probability due to climate change!

The level of future energy demand has a larger effect on mitigation costs than the whole difference between 1.5°C and 2°C	
Source	**Key Points**
Costs increase by a factor of 1.5-2 moving from likely 2°C to 1.5°C pathways. Costs increase by a factor of 2 if future energy demand is medium, instead of low, and a factor of 5 if future energy demand is high (Rogelj et al. 2015 Figure 4 see Annex II)	• The level of future energy demand has a larger effect on mitigation costs than the whole difference between 1.5°C and 2°C, while the benefits of 1.5°C over 2°C would remain. • High Energy efficiency to reduce energy demands is good for all, no matter what fuels are used to make energy and the benefits of this are often overlooked in the discussion about costs. • If future energy demand were on the high, rather than on the low side of assumptions in the scientific literature, the costs would rise over twice as fast as the total cost difference between 1.5°C and 2°C

2c) "1.5°C poses risks to food security"

Background: Sometimes the worry is voiced that the relatively high reliance on negative emission technologies (carbon dioxide removal and storage) will create land-use conflicts and endangers food security. This is often cited as a distinctive feature of 1.5°C scenarios, compared to limiting warming to 2°C.

Mitigation for 1.5°C does not pose larger risks to food security than mitigation for 2°C would. Limiting warming below 2°C and 1.5°C avoids large risks to food security.	
Statement and Source	**Key Points**
"We estimate the sustainable technical potential [of bioenergy] as up to 100 EJ: high agreement; 100–300 EJ: medium agreement; above 300 EJ" (Creutzig et al. 2014) (Scenario analysis shows that 1.5°C is achieved with the potential constrained at 300 EJ)	• Science shows no indications that the risk of landuse conflicts is larger for 2°C than for 1.5°C. Because of the delay in substantial global reductions to date, both limits now rely on negative emissions. For 1.5°C there is a greater urgency to scale them up earlier by a decade or so. • Risks to food security emerge for high reliance on "first generation" bioenergy,
According to the IPCC's 2012 *Special Report*	

on Renewable Energy Sources and Climate Change Mitigation (SSREN) around 100 EJ/yr can be extracted from agricultural and forestry residues, dung and organic waste alone (SRREN Table 2.2, see Annex III)	derived from food crops. Fortunately, such risks are eliminated by using "second generation" bioenergy, derived from agricultural and forestry residues, dung and organic waste.
A model comparison study with five global economic models shows that the aggregate food price effect of large-scale lignocellulosic bioenergy deployment (i.e., 100 EJ globally by the year 2050) is significantly lower (+5 % on average across models) than the potential price effects induced by climate impacts on crop yields (+25 % on average across models (Lotze-Campen et al., 2013). Possibly hence, ambitious climate change mitigation need not drive up global food prices much, if the extra land required for bioenergy production is accessible or if the feedstock, e. g., from forests, does not directly compete for agricultural land." (IPCC Working Group 3, chapter 11)	• Comprehensive policies can safeguard against any remaining risks to food security. • However, in any such considerations, it must never be ignored that even present-day climate extremes pose very large risks to food security in many of our countries, due to crop losses and spikes in food prices, and that these risks are set to increase under 1.5 and more rapidly on our way to 2°C or higher.

Sources

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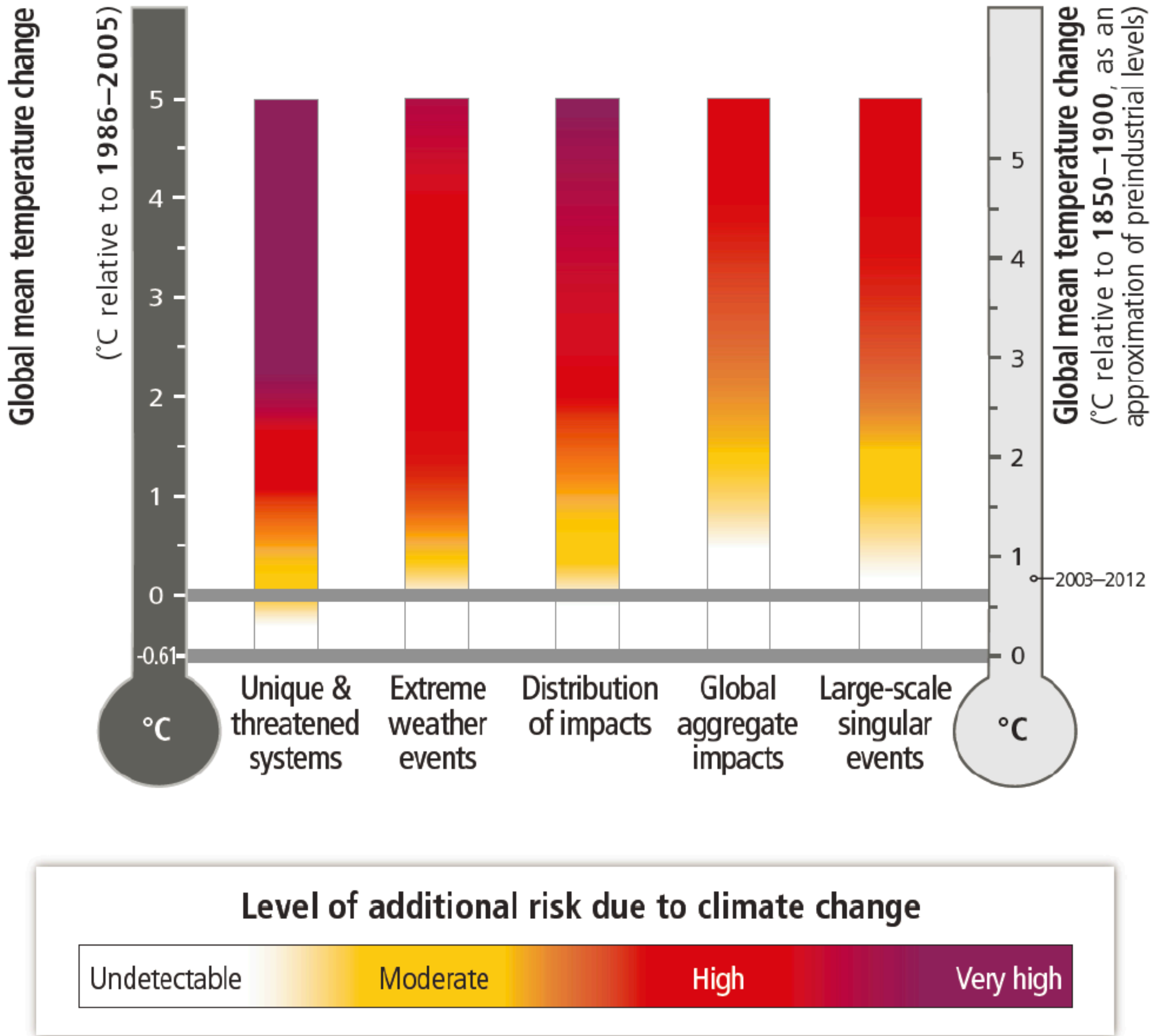
Annex I

"Reasons for Concern" Figure IPCC (2014), Working Group 2 Summary for Policy Makers Assessment Box SPM.1 Figure 1



Annex III - Rogelj et al (2015)
Mitigation costs for 1.5°C and 2°C scenarios

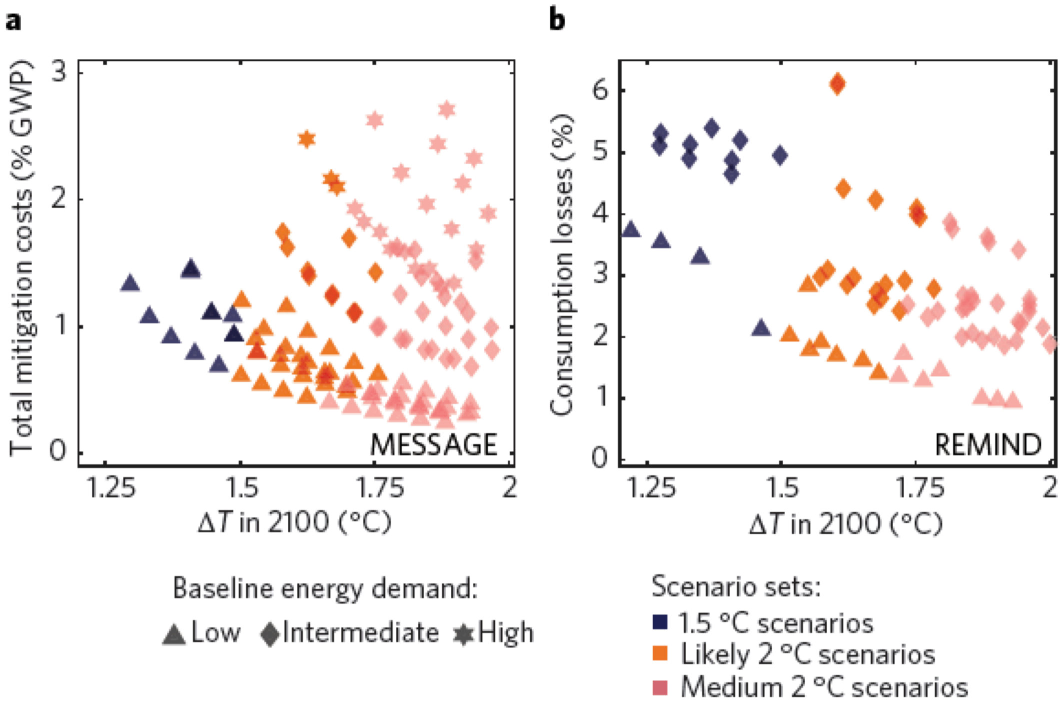


Figure 4 | Mitigation costs for 1.5 °C and 2 °C scenarios. Aggregated, discounted mitigation costs from 2010 to 2100 (discount rate 5%) as a function of median temperature (*T*) increase above pre-industrial in 2100. Scenarios are coded as a function of the underlying baseline energy-demand evolution (low, intermediate and high represented by triangles, diamonds and stars, respectively; actual demand numbers are provided in Supplementary Fig. S8) and their probability of limiting warming to particular temperature levels (pink, orange and blue). **a,** Total mitigation costs for the scenarios of the MESSAGE model; **b,** consumption losses for the scenarios from the REMIND model. The mitigation costs methodology is described in the Methods section.

Annex III

Global technical potential overview for a number of categories of land-based biomass supply for energy production (primary energy numbers have been rounded). . IPCC SRREN Report, Chapter 2. Table 2.2.

Table 2.2 | Global technical potential overview for a number of categories of land-based biomass supply for energy production (primary energy numbers have been rounded). The total assessed technical potential can be lower than the present biomass use of about 50 EJ/yr in the case of high future food and fibre demand in combination with slow productivity development in land use, leading to strong declines in biomass availability for energetic purposes.

Biomass category	Comment	2050 Technical potential (EJ/yr)
Category 1. **Residues from agriculture**	By-products associated with food/fodder production and processing, both primary (e.g., cereal straw from harvesting) and secondary (e.g., rice husks from rice milling) residues.	15 – 70
Category 2. **Dedicated biomass production on surplus agricultural land**	Includes both conventional agriculture crops and dedicated bioenergy plants including oil crops, lignocellulosic grasses, short-rotation coppice and tree plantations. Only land not required for food, fodder or other agricultural commodities production is assumed to be available for bioenergy. However, surplus agriculture land (or abandoned land) need not imply that its development is such that less total land is needed for agriculture: the lands may become excluded from agriculture use in modelling runs due to land degradation processes or climate change (see also 'marginal lands' below). Large technical potential requires global development towards high-yielding agricultural production and low demand for grazing land. Zero technical potential reflects that studies report that food sector development can be such that no surplus agricultural land will be available.	0 – 700
Category 3. **Dedicated biomass production on marginal lands**	Refers to biomass production on deforested or otherwise degraded or marginal land that is judged unsuitable for conventional agriculture but suitable for some bioenergy schemes (e.g., via reforestation). There is no globally established definition of degraded/marginal land and not all studies make a distinction between such land and other land judged as suitable for bioenergy. Adding categories 2 and 3 can therefore lead to double counting if numbers come from different studies. High technical potential numbers for categories 2 and 3 assume biomass production on an area exceeding the present global cropland area (ca. 1.5 billion ha or 15 million km^2). Zero technical potential reflects low potential for this category due to land requirements for, for example, extensive grazing management and/or subsistence agriculture or poor economic performance if using the marginal lands for bioenergy.	0 – 110
Category 4. **Forest biomass**	Forest sector by-products including both primary residues from silvicultural thinning and logging, and secondary residues such as sawdust and bark from wood processing. Dead wood from natural disturbances, such as fires and insect outbreaks, represents a second category. Biomass growth in natural/semi-natural forests that is not required for industrial roundwood production to meet projected biomaterials demand (e.g., sawn wood, paper and board) represents a third category. By-products provide up to about 20 EJ/yr implying that high forest biomass technical potentials correspond to a much larger forest biomass extraction for energy than what is presently achieved in industrial wood production. Zero technical potential indicates that studies report that demand from sectors other than the energy sector can become larger than the estimated forest supply capacity.	0 – 110
Category 5. **Dung**	Animal manure. Population development, diets and character of animal production systems are critical determinants.	5 – 50
Category 6. **Organic wastes**	Biomass associated with materials use, for example, organic waste from households and restaurants and discarded wood products including paper, construction and demolition wood; availability depends on competing uses and implementation of collection systems.	5 – >50
Total		**<50 – >1000**

Notes: Based on Fischer and Schrattenholzer (2001); Hoogwijk et al. (2003, 2005, 2009); Smeets and Faaij (2007); Dornburg et al. (2008, 2010); Field et al. (2008); Hakala et al. (2009); IEA Bioenergy (2009); Metzger and Huttermann (2009); van Vuuren et al. (2009); Haberl et al. (2010); Wirsenius et al. (2010); Beringer et al. (2011).