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Supplementary appendix

This appendix formed part of the original submission and has been peer reviewed. We post it as supplied by the authors.

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Appendix 1 - Indicators from other Monitoring Programmes Relevant to the Lancet Countdown

Lancet Countdown Thematic Working Group	Lancet Countdown	Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
1. Climate Change Impacts, Exposures and Vulnerabilities	1.1. Health effects of temperature change			Warmer and/or fewer cold days and nights over most land areas. Warmer and/or more frequent hot days and nights over most land areas. Heat-related mortality.	A-1. Number of deaths and missing due to hazardous events per 100,000. A-2. Number of deaths due to hazardous events. A-3. Number of missing due to hazardous events. B-1. Number of affected people per 100,000. B-2. Number of injured or ill people due to hazardous events. B-3. Number of people who left their places of residence due to hazardous events. B-3a. Number of evacuated people due to hazardous events. B-3b. Number of
	1.2. Health effects of heatwaves			Warm spells/heatwaves. Frequency and/or duration increases over most land areas. Heat-related mortality.	
	1.3. Change in labour capacity			Heat stress and work productivity.	

Lancet Countdown Thematic Working Group	Lancet Countdown		Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
						relocated people due to hazardous events. B-4. Number of people whose houses were damaged due to hazardous events. B-5. Number of people whose houses were destroyed due to hazardous events. B-6. Number of people who received food relief aid due to hazardous events.
	1.4. Lethality of weather-related disasters		1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population.			
	1.5. Global health trends in climate-sensitive diseases		3.3.3 Malaria incidence per 1,000 population.			
	1.6. Climate-sensitive infectious diseases		3.3.3 Malaria incidence per 1,000 population.		Populations at risk of infectious and vector-borne diseases for malaria and dengue fever.	
	1.7. Food security and undernutrition	1.7.1. Vulnerability to undernutrition	2.1.1 Prevalence of undernourishment.			C-2. Direct agricultural loss due to hazardous events.

Lancet Countdown Thematic Working Group	Lancet Countdown		Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
		1.7.2. Marine primary production	2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES). 2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age. 2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight). 2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size.			

Lancet Countdown Thematic Working Group	Lancet Countdown		Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
			2.3.2 Average income of small-scale food producers, by sex and indigenous status. 2.4.1 Proportion of agricultural area under productive and sustainable agriculture. 2.a.1 The agriculture orientation index for government expenditures. 2.b.1 Agricultural export subsidies. 2.c.1 Indicator of food price anomalies. 12.3.1 Global food loss index. 14.1.1 Index of coastal eutrophication and floating plastic debris density. 14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations.			

Lancet Countdown Thematic Working Group	Lancet Countdown	Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
		14.4.1 Proportion of fish stocks within biologically sustainable levels.			
	1.8. Migration and population displacement				
2. Adaptation Planning and Resilience for Health	2.1. National adaptation plans for health	1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030. 1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies. 3.d.1 International Health Regulations (IHR) capacity and health emergency preparedness. 13.2.1 Number of countries that have communicated the establishment or operationalization of an		Governance and policy. Vulnerability, impact and adaptation (health) assessments. Health adaptation strategies and action plans. Preparedness, risk management and integrated risk monitoring. Awareness raising and capacity building.	E-3. Number of countries that integrate climate and disaster risk into development planning.
	2.2. City-level climate change risk assessments				
	2.3. Detection, preparedness, and response to health emergencies				
	2.4. Climate information services for health				
	2.5. National assessment of vulnerability, impacts and adaptation for health				
	2.6. Climate-resilient health infrastructure				

Lancet Countdown Thematic Working Group	Lancet Countdown	Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
		integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change. 13.3.2 Number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions.			
3. Mitigation Actions and Health Co-Benefits	3.1. Carbon intensity of the energy system				
	3.2. Coal phase-out		Share amount of coal in total final energy consumption—that is, the share of an economy's energy derived from coal. Share of electricity from coal generation.		
	3.3. Zero-carbon emission electricity	7.1.2 Proportion of population with primary reliance on clean fuels and technology.	Share amount of renewable energy in total final energy consumption—that is, an economy's share of		

Lancet Countdown Thematic Working Group	Lancet Countdown		Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
			7.2.1 Renewable energy share in the total final energy consumption. 7.3.1 Energy intensity measured in terms of primary energy and GDP.	energy derived from renewable sources. Share of electricity from renewable energy generation.		
	3.4. Access to clean energy		1.4.1 Proportion of population living in households with access to basic services. 7.1.1 Proportion of population with access to electricity.			
	3.5. Exposure to ambient air pollution	3.5.1. Exposure to air pollution in cities	3.9.1 Mortality rate attributed to household and ambient air pollution. 11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities population weighted).		Current exposures and health risks due to air pollution, including outdoor air pollution exposure, short-lived climate pollutants, and household air pollution.	
		3.5.2. Sectoral contributions to air pollution				
		3.5.3. Premature mortality from ambient air pollution by sector				
	3.6. Clean fuel use for transport			Share of new vehicles in a particular geography that are electric drive rather than internal combustion engine		

Lancet Countdown Thematic Working Group	Lancet Countdown	Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
			vehicles. Share of electric drive vehicles for the light-duty fleet in a particular year.		
	3.7. Sustainable travel infrastructure and uptake		Total terrestrial passenger km, meaning the total number of km that a population travels, including on private, public, and passenger rail. Number of km travelled in terrestrial modes—private, public, and rail—on a per capita basis. Total number of km travelled in private modes—light-duty vehicles, two-wheelers, and three-wheelers. Total number of km travelled in 6 private modes—light-duty vehicles, two-wheelers, and three-wheelers—on a per capita basis. Total number of km		

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			travelled in public modes—bus and rail. Total number of km travelled in public modes—bus and rail—on a per capita basis. Total number of vehicle km travelled in private modes—light-duty vehicles, two-wheelers, and three-wheelers. Share of passenger km associated with public transport—bus and rail. Total share of electricity in the energy mix for all terrestrial transport—private, public, and freight modes. Share of km associated with private modes of transport—light-duty, two-wheelers, and three-wheelers.		

Lancet Countdown Thematic Working Group	Lancet Countdown	Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
	3.8. Ruminant meat for human consumption		Total amount of greenhouse gas emissions associated with the Agriculture Sector. Total amount of greenhouse gas emissions associated with the Agriculture Sector from direct sources in production and onsite energy use. Total amount of greenhouse gas emissions associated with the Agriculture Sector from electricity. Size of a herd of cattle in a given geography and year on a per capita basis. This metric does not include dairy cattle. Share of agricultural emissions associated with non-dairy cattle. Share of agricultural emissions associated with fertilizers. Greenhouse gas emissions intensity associated with agriculture on a per		

Lancet Countdown Thematic Working Group	Lancet Countdown	Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
	3.9. Healthcare sector emissions				
4. Economics and Finance	4.1. Investments in zero-carbon energy and energy efficiency				
	4.2. Investment in coal capacity				
	4.3. Funds divested from fossil fuels				
	4.4. Economic losses due to climate-related extreme events	1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP). 11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters.			
	4.5. Employment in low-carbon and high-carbon industries				
	4.6. Fossil fuel subsidies	12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels.			
	4.7. Coverage and strength of carbon pricing				
	4.8. Use of carbon pricing revenues				

Lancet Countdown Thematic Working Group	Lancet Countdown		Sustainable Development Goals	Carbon Transparency Initiative	WHO Climate and Health Country Profiles	Sendai Framework for Disaster Risk Reduction
	4.9. Spending on adaptation for health and health-related activities		3.b.2 Total net official development assistance to medical research and basic health sectors. 13.a.1 Mobilized amount of United States dollars per year between 2020 and 2025 accountable towards the $100 billion commitment. 13.b.1 Number of least developed countries and small island developing States that are receiving specialized support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change-related planning and management, including focusing on women, youth and local and marginalized communities.		Financing	
	4.10. Health adaptation funding from global climate financing mechanisms					
5. Public and Political Engagement	5.1. Media coverage of health and climate change	5.1.1. Global newspaper reporting on health and				

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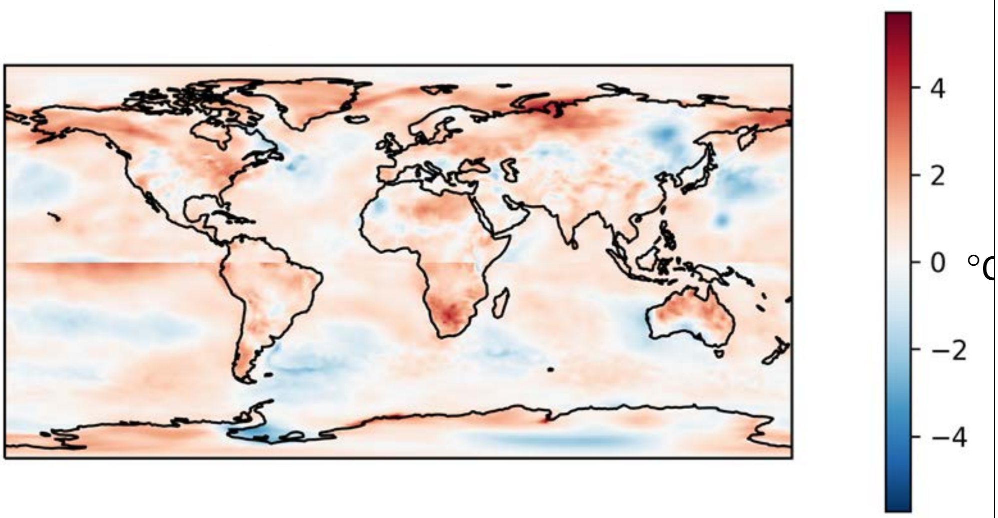
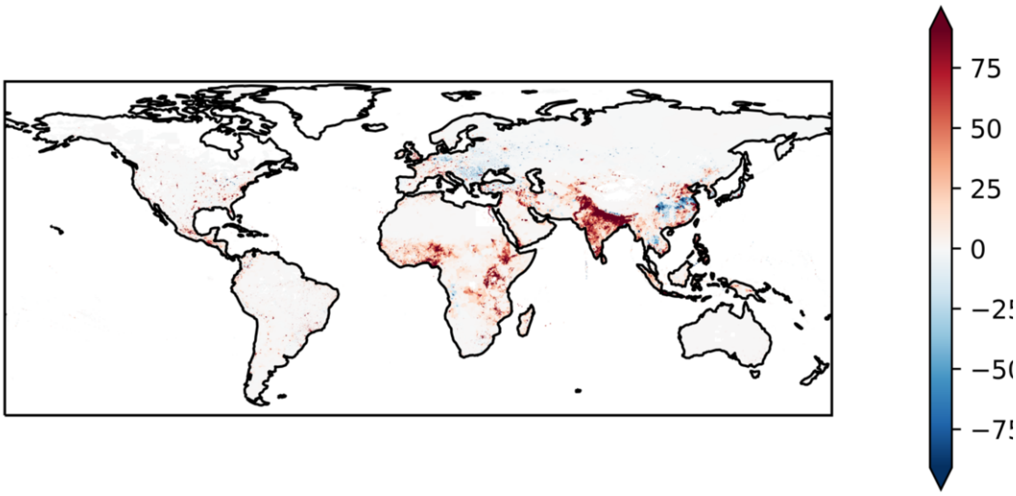
		climate change				
		5.1.2. In-depth analysis of newspaper coverage on health and climate change				
	5.2. Health and climate change in scientific journals					
	5.3. Health and climate change in the United Nations General Assembly				Governance and policy.	

Appendix 2 – Climate Change Impacts, Exposures and Vulnerability

A number of challenges associated with choosing indicators to track the health impacts of climate change are recognised, specifically: dealing with signal-to-noise ratios; attribution to climate change; and the role of institutions and policies in determining the impact of a climate hazard on labour productivity, food security, nutrition, and migration. Signal-to-noise ratios are of particular concern here for two reasons. First, with respect to climate warming and climate hazards, annual natural climate variability introduces noise into the system, whereas an important signal is the long-term climate trend.[17] Attribution, "the process of establishing the most likely causes for a detected change with some level of confidence"[18], thus becomes important when selecting indicators. Second, with respect to identifying the impact of a climate hazard on human wellbeing and health, as reflected in disease, nutrition, and migration, the ultimate impacts on health are heavily mediated by institutions and policies, such that the signal-to-noise ratio between climate hazard and health impact decreases.

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.1.1.1 Health effects of temperature change
Methods	Firstly, temperature change relative to 1986-2008 mean was calculated for 2000-2016. The summer months for each hemisphere were selected (June-July-August for northern hemisphere, December, January, February for southern). Maps of temperature change were plotted and an area-weighted mean was calculated for the temperature change grid. The area weighting was calculated by multiplying the value for each grid location by the cosine of the location latitude, to account for the projection of the rectangular grid onto the spherical globe. Area-weighting is the normal way to define global warming, and is relevant to the 2oC and 1.5oC limits discussed in the Paris Agreement (note however that Figure 1.1 shows changes relative to 1986-2008 rather than relative to pre-industrial). The concept of weighting by exposure was introduced in the 2015 Lancet Commission report, to better represent the exposure of vulnerable parts of the population to changes in mean climate and in climate extremes.4 Exposure-weighting can be seen as a mean of 'vulnerable heads', while area-weighting is a mean over areas of the Earth's surface. Secondly, temperature changes were projected onto a world population grid and the population-weighted mean for each year was calculated to produce a time series. Note that since the weighting for each year was performed using the population for that year, this cancels out population growth effects. This is true for indicators 1.1-1.3.

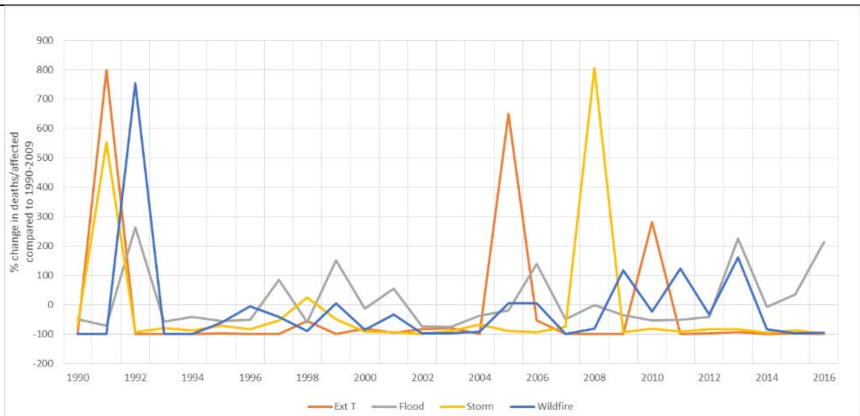
Data	The European Centre for Medium-Range Weather Forecasts (ECMWF) provided weather data for this indicator. ERA-Interim climate reanalysis data was used, as well as a 1986-2008 climatology derived from ERA. (https://www.ecmwf.int/en/research/climate-reanalysis/era-interim) Population gridded data was obtained from the NASA Gridded Population of the World (GPW) v4 using UN-adjusted population grid data (http://sedac.ciesin.columbia.edu/data/collection/gpw-v4) at 5-year intervals from 2000-2020, with yearly population interpolated from these values. 2005 was used as a mid-point for the time series.
Future Form of Indicator	This indicator may readily be updated with new data each year. Additionally, it would be interesting to project it further into the past to obtain a longer term overview of the progression of this indicator.
Additional Information	a)  b)  Map showing a) the trend in mean summer temperatures between 2000 and 2016 and b) population density change from 2000 to 2016, relative to the 1986-2008 recent past average.

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.2. Health effects of heatwaves
Methods	A heatwave was defined as a period of 4 or more days at a given location where the minimum daily temperature was greater than the 99th percentile of the distribution of minimum daily temperature at that location over the 1986-2008 reference period, for the summer months. The number and length of heatwaves was calculated for 1986-2016 over the weather grid. The mean number and length was calculated for 1986-2008. The summer months for each hemisphere were selected as in 1.1. The change in number and length of heatwaves was then calculated for each year from 2000 to 2016 for each location and the global area weighted means calculated for each year. Yearly population grids were used as described in 1.1 The population over 65 count was calculated by matching demographic data the fraction of people over 65 for each year from the UN WPP with country area definitions, and projecting this onto the population grid. This effectively assumed that over 65 fraction is constant across a given country's area. The number and length of heatwaves grid was projected onto the population over 65. A population weighted mean length was calculated and a number of exposures (heatwaves x persons) were calculated for each year.
Data	For weather and population data, see 1.1 Demographic data was obtained from the UN World Population Prospects (WPP) project (https://esa.un.org/unpd/wpp/Download/Standard/ASCII/) Country borders and identifiers (GIS shapefiles) were obtained from the Natural Earth Data repository (http://www.naturalearthdata.com/)
Caveats	Heatwave length was calculated as the total period above the threshold, for periods of 4 or more days, the minimum heatwave length is therefore 4 days.
Future Form of Indicator	As for 1.1, this indicator may be updated every year with new climate data

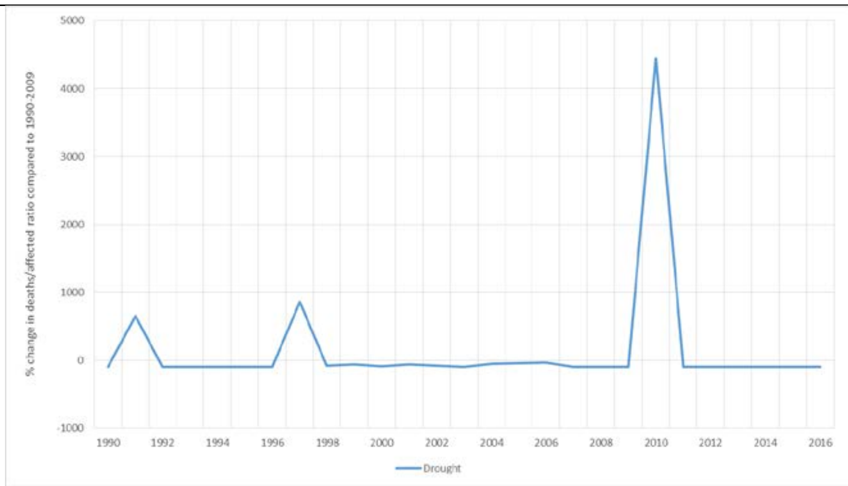
Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.3. Labour productivity loss
Methods	The labour capacity was defined as $$\text{labour capacity} = 100 - 25 * \max(0, \text{WBGT} - 25)^{2/3}$$ where WBGT is the Wet Bulb Globe Temperature, which is a

	function of the dew point temperature (see Dunne et al. 2013). WBGT and labour capacity were calculated for 1986-2016. The difference for each year between labour capacity and the mean labour capacity for 1986-2008 was then calculated. Yearly population grids were used as described in 1.1 Using a method similar to 1.2, the fraction of the population living in rural areas from WPP was associated with each country and projected onto the population grid. This was used to calculate the population weighted change in labour capacity for each year to produce the labour capacity time series.
Data	For weather and population data, see 1.1 For demographic and country border data, see 1.2
Caveats	The rural population was defined as a simple fraction of the population for each country, rather than identifying whether a given population grid location was within an urban or rural area.
Future Form of Indicator	As for 1.1, this indicator may be updated every year with new climate data

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.4. Lethality of weather-related disasters
Methods	This indicator is based on the generic formulation from a climate change perspective of disasters as a function of hazard, exposure and vulnerability. Year to year variation was measured, showing the number of people killed as a proportion of those affected by different hazard type, normalised by the strength of the individual hazards as a measure of adaptive (or maladaptive) changes in national health care services and the associated disaster preparedness and response. Here, deaths are defined as the number of people who lost their life because the disaster happened, and people affected as those requiring immediate assistance during a period of emergency; hence requiring basic survival needs such as food, water, shelter, sanitation and immediate medical assistance.
Data	EM-DAT at the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain, Belgium (http://www.emdat.be/).
Caveats	One underlying assumption is that the normalised number of people killed by climate related disasters is an accurate proxy for measuring health impacts of the climate. Clearly this measure ignores the longer causal chains involving the interaction of climate and health. Finally, a further limitation is that this measure ignores the longer causal chains involving the interactions of weather, climate, disasters, health and health services. To date, there is no international consensus regarding best practices for collecting disaster impact data. However, EM-DAT represents one of the most

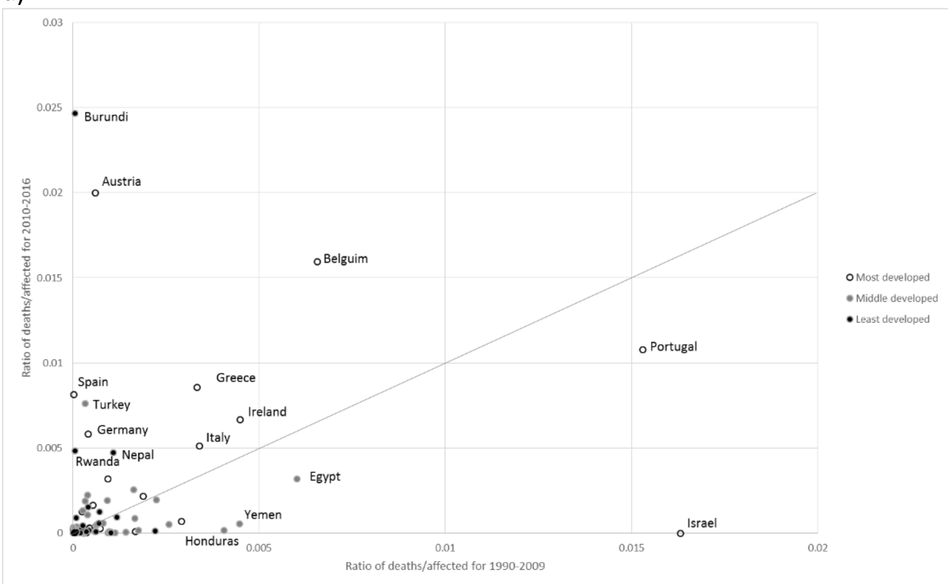
	widely used datasets in this area and is used here for a number of reasons: it is updated on a daily basis; includes information from over 21,000 disasters since 1900; the data entries are reviewed and validated for completeness and consistency; and the data comes from a wide range of sources including UN organisations, local NGOs, insurance companies, research institutes and media/press. The validity of the deaths-to-affected ratio as an indicator rests on the assumption that it reflects disaster management and health system capacity. A key challenge for this indicator is in estimating those affected and those exposed, and distinguishing the two; a difficult task in the context of disasters. An important caveat is that while the number of people affected in a disaster is often reported, the operational definition of who is "affected" varies across countries, as do the methods of estimation. Additionally, some of the most severe droughts are related to water management issues, not to weather, and yet the cause of the drought is not differentiated here. Similarly, the cause of landslides is often difficult to determine, and so these events are not included in the data here.
Future Form of Indicator	Future efforts will include a comparison of estimates of those exposed with those affected. Additionally, the impact of replacing the number of people killed with the number requiring assistance will also be explored. A subsidiary indicator will come from the online Sendai Framework Monitor. Here countries will start reporting against the Sendai Framework indicators and the DRR related indicators of the SDGs. The first Sendai Framework and SDG progress report will be released in 2019[1]. This indicator therefore aims to expand to include country specific progress in vulnerability levels of health service systems to climate risks in relation to this monitoring data.
Additional Information	 Yearly change over time in the percentage of people killed, as a proportion of those affected globally by different climate- and weather-related disasters, as compared to the average for 1990-2010.

[1] http://www.preventionweb.net/drr-framework/sendai-framework-monitor/

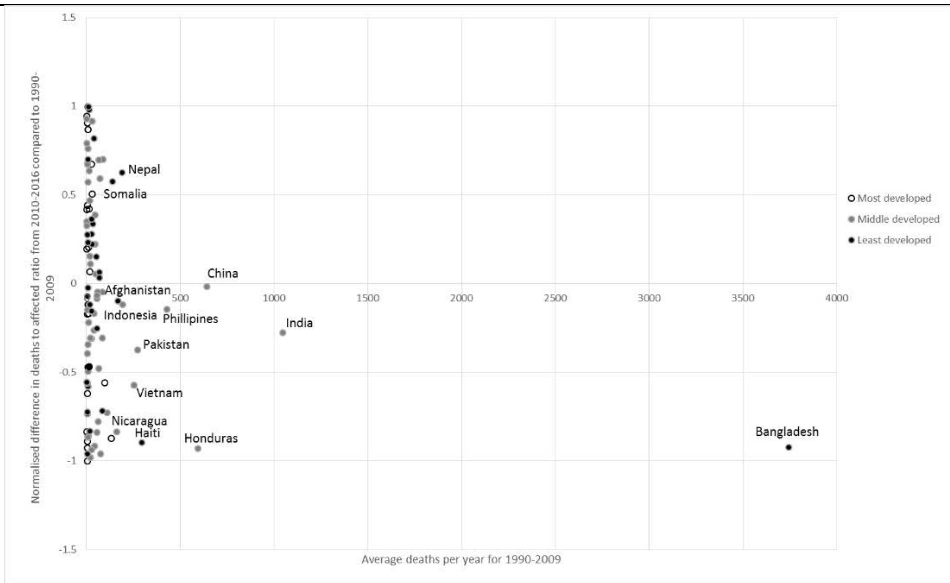


Yearly change over time in the percentage of people killed as a proportion of those affected globally by drought related disasters, as compared to the average for 1990-2010

a)



b)



a) Nationally disaggregated ratio of the average number of deaths: to numbers affected for drought, flood and storm related disasters for the period 2010-2016 compared to 1990-2009. b) The normalised difference in the ratio of the average deaths to numbers affected for 2010-2016 compared to 1990-2009 against the average number of deaths per climate and weather related disaster for 2009-2010. The normalised difference comprise the difference of the deaths: affected ratio between 2010-2016 and 1990-2009 normalised by the sum of these ratios. Positive values indicate and increase in the numbers of deaths per affected.

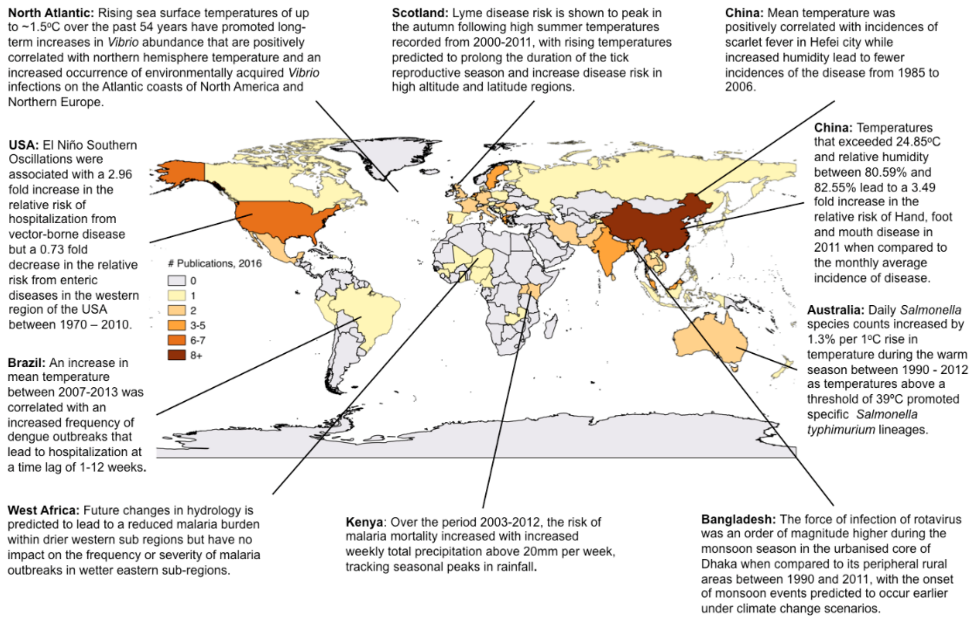
Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.5 Global health trends in climate-sensitive diseases
Methods	This indicator displays generally unprocessed descriptive trends for selected diseases retrieved from The Global Burden of Disease (GBD) project database (1) over the period 1990-2015. The derivation of estimates within the GBD study relies on modelling, rather than analysing direct observations, and the GBD methodology has already been described (1). The trends are aggregated and presented by WHO region as mortality rates per 100,000 individuals per year over the period. We provide also annual estimates by country in the supplement. As far as we can ascertain from the GBD documentation, climate change and weather are not part of the covariates included in the estimates, making it valid to examine GBD outputs in the light of climate and weather data to formulate coherent inter-country comparisons. Trends are described for: all causes of death, malaria, dengue, diarrhoeal diseases, protein-energy malnutrition, heat and cold exposure, malignant melanoma and forces of nature. Deaths directly related to forces of nature have been adjusted for the effects of the most severe seismic events. Of the ten highest country-year mortality estimates due to forces of nature, seven were directly due to specific seismic activity, and these have been discounted by replacing with the same countries' force of nature mortality for the following year.
Data	1. Global Burden of Disease Study 2015. Global Burden of Disease Study 2015 (GBD 2015) Results. Seattle, United States: Institute for

	Health Metrics and Evaluation (IHME), 2016. Available from http://ghdx.healthdata.org/gbd-results- tool.
Caveats	This is not a direct measure of the impact of climate change on death and disease. Rather, it presents mortality figures for those diseases which are none to be influenced by climate. The trends presented therefore do not show detection and attribution of climate change to death. They do show the impact of climate relevant and climate sensitive diseases on mortality rates globally since 1990.
Future Form of Indicator	GBD estimates are now revised annually. Future versions of this indicator may include additional health conditions, may include morbidity as well as mortality, and may extend to national and subnational scales. Increased interest in geo-spatial disease analyses is likely to lead to additional information, such as fringe zone trends and outbreaks, and associate patterns of diseases to climate anomalies, such as those driven by the ENSO circulation. Future disease trends in the GBD estimates will be linked to direct measurements in resource poor areas in Africa and Asia, for example using longitudinal mortality registers from the INDEPTH network.[15]

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.6 Climate-sensitive infectious diseases
Methods	Methods for the analysis on publication on climate-sensitive infectious diseases follow Liang and Gong (2017), updated to the most recent complete year for which data were available (2016). Briefly, we conducted a systematic review of the literature using bibliographic databases including the ISI Web of Science, Scopus, ScienceDirect, and PubMed. We used a multi-step approach, first searching abstract/title/keywords using strings of [(‘climate change’ or ‘climate’) and ‘infectious disease’], followed by retention of articles focussing on disease in humans, then a second round of searching using further keywords describing more specific climate-disease elements, and finally a manual screen according to specific rules (namely, we removed duplicated, non-English, non-peer reviewed, non-human related articles and those that did not report a health outcome related to climate change, such as review, editorial, or commentary articles). Essential article information was extracted from each paper for the summary, including: 1) direct information including the title, journal, publishing year, authors; 2) place name and spatial scale of the study area; 3) study period; 4) research methods used; 5) types of infectious disease studied; 6) types of climatic variable studied; and 7) the conclusions made about the impacts of climate change on human infectious disease. The final dataset included 339 papers. Methods for calculating Vectorial Capacity (VC) follow Liu-Helmersson et al. (2016) and Liu-Helmersson et al. (2014). VC refers to a vector's ability to transmit disease to humans. It incorporates interactions between host, virus, and vector, assuming that all three of these elements are present. Specifically, VC represents the average daily number of secondary cases generated by one primary case introduced into a fully susceptible population, and is expressed as:

	$$VC = \frac{ma^2 b_h b_m e^{-\mu_m n}}{\mu_m}.$$ Where a is the average vector biting rate, bh is the probability of vector to human transmission per bite, bm is the probability of human to vector infection per bite, n is the duration of the extrinsic incubation period – EIP, µm is the vector mortality rate, and m is the female vector-to-human population ratio. In our application, the time unit is one day and each of the vector parameters depends on temperature, with parameter values derived from the literature, typically from experimental data, as described in Liu-Helmersson et al., (2014). Diurnal temperature range (DTR) was reconstructed using a representative daily temperature through a piece-wise sinusoidal function based on the monthly average of daily minimum, maximum, and mean observations. We extracted the annual average VC values per grid cell to Aedes aegypti presence points provided in Kraemer et al., (2015) and averaged these values by country to get country specific trends in VC at a yearly time step from 1950-2015.
Data	Climate data were taken from the Climate Research Unit Time Series (CRU-TS 3.22) online database of gridded (0.5 × 0.5 degrees) monthly averages of daily temperature observations (minimums, maximum, and mean) for the period January 1, 1950 to December 31, 2015 (the latest year available).
Caveats	Key caveats and limitations of the model and its parameterisation are described in Liu-Helmersson et al., (2014, 2016).
Future Form of Indicator	It is difficult to extrapolate the trend in publication effort and trends to 2030 given the very recent near exponential increase in publications meeting the systematic search criteria and the dynamic nature of representativeness of both disease types and geographical spread through time. However, in the near term, we can expect an ongoing increase in the volume of publications exploring climate change – infectious disease associations, covering increasingly more dynamic and complex disease systems with increasing taxonomic and geographic representativeness. We might expect an ongoing decline or flattening off in the proportion of publications reporting positive associations (i.e., increases in risk) as more and increasingly complex systems are addressed more robustly with increasing potential to address confounding and interacting factors. Climate change is not expected to be a universal driver of increasing disease risk and many disease systems may exhibit overall declines in risk as changes in climatic factors could similarly drive components of disease transmission systems beyond environmental optima (Lafferty and Mordecai, 2016). Understanding this broader range of responses is critical to tailor research and management efforts on disease systems and populations. There has been a clear and consistent increase in globally averaged VC since the late 1970s. For *Aedes aegypti*, VC was an average of 9.4% higher in 2015 relative to a 1950 baseline. Extrapolating the strong linear increase in VC for *Aedes aegypti* since 1950 (R^2 = 0.784) suggests that VC could increase by a further 1.6% by 2030 (i.e., ~11% overall increase relative to the 1950 baseline). This extrapolation is based only on the observed increase in VC to date and does not take into account actual projections of climate change from global circulation models.

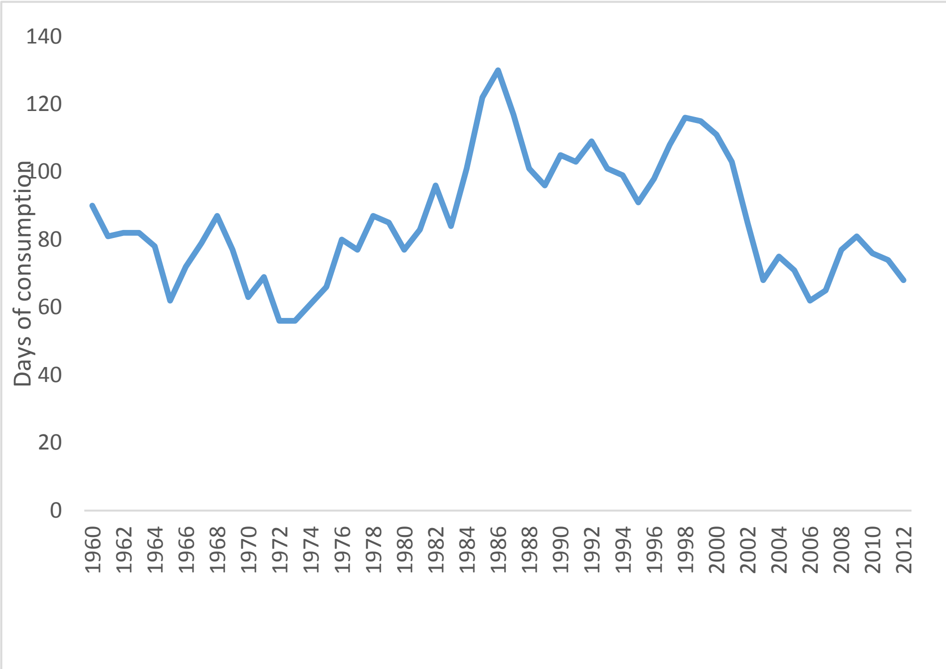
Additional Information



Number of infectious disease and climate change publications in 2016 by country, with select case studies shown in boxes around edge illustrating the diversity of study systems and direction of responses detected.[45-53]

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.7. Food security and undernutrition
Sub-Indicator	1.7.1. Vulnerability to undernutrition
Methods	In an increasingly connected world, food security is equally a globalised concern. The link between agricultural production, health and nutrition, and climate is complex. Thus identifying a single climate and under-nutrition indicator to track, requires compromises and an understanding that only certain aspects of this relationship can be addressed. This methods section explores the logic and rationale behind the specific indicator selected to track climate, food insecurity, and health. In doing so, a number of additional potential indicators are discussed, to contextualise the chosen indicator. First a rapid review of the literature was undertaken to explore indicators of food security, under-nutrition, and climate, and the pathways under which climate change affects under-nutrition. This creates the narrative behind the chosen indicator and its evolution, and is used to identify the critical parameters that need to be taken account of when choosing how to construct the indicator. Second, informed by this review, relevant country-level data were collected that address food production-related vulnerability and exposure to global warming. Third, an indicator was constructed. Fourth, looking forward, a more nuanced indicator is considered that will build on real time data that incorporates temperature in addition to vulnerability and exposure. Whilst the indicator explored here focuses on climate and under-nutrition, it is recognised that food insecurity has long been closely linked to poverty (for example, Reutlinger, 1985; Maxwell, 1996), whether low yields for farmers, low purchasing power for consumers, or a high proportion of income spent on food.

	Thus, irrespective of climate, there are many approaches to enhancing food security and nutrition. *Literature and narrative* Food security has been defined by the FAO as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO. 2002. The State of Food Insecurity in the World 2001. Rome). Thus food security requires there to be enough food, in the right place, and for people to be able afford to purchase it. If an individual is not food secure, implicitly they are at risk of under-nourishment and ill-health. Most of the world's food insecure are located in African countries by proportion (27% under-nourished) and South Asian countries by absolute numbers (300m under-nourished) (www.fao.org). At a global level, total food availability in any one year depends on stocks and current year harvest. Governments and individuals hold grain reserves. Whereas public storage has stabilising impact on food price volatility and therefore a positive impact on food security, grain held by private sector corporations tends to be for speculation (d'Amour, 2016) and thus plays a much smaller role with respect to food security. Carry-over stocks of grain have been described by Lester Brown, president of the Earth Policy Institute, as the most basic indicator of food security. Thus the number of days' worth of grain held in storage can be considered to provide one real time indicator of global food security. Globally, over the past three decades, stocks have been falling, due variously to liberalization of grain markets, the high costs of storage, and governments being increasingly willing to rely on markets rather than storage in times of localized shortages (Figure 1). Whilst this could suggest a reduction in global food security, the accompanying increased trade in grains can substitute for storage, mitigating the impacts of idiosyncratic food production stocks across space, whereas storage mitigates across time.



Grain in storage, expressed as the length of time in days that time the world's food reserves would feed the global population (source: Compiled by Earth Policy Institute from United States Department of Agriculture, Production, Supply & Distribution)

Lower-income countries are vulnerable to climate change, whether they highly dependent on grain imports, or on domestic production, but in different ways. The food system is increasingly globalised, and countries that are highly dependent on food imports are particularly vulnerable to non-localised agricultural productivity shocks that originate in other countries and are propagated through international food markets (Ahmed et al., 2009; d'Amour et al., 2016), suggesting that increased trade may not be able to fully substitute for reduced food stocks. This was clearly demonstrated in the 2008 food crisis. Droughts in Australia affecting the wheat harvest triggered speculation, hording, and several countries introducing export restrictions, which all combined to drive up the price of staples and increase food insecurity (Headey and Fan, 2008), resulting in an extreme spike in the price of rice, and even triggering food riots in Haiti. Indeed, "cereals imports dependency ratio" is a key FAO food security indicator, reflecting the importance of the global food system to individual country food security. Such systemic crises, in which shocks that originate in one country affecting one specific crop trigger instability and crisis in other countries, crops, or sectors, occur with low probability but have a high impact on food security and under-nutrition. They are not the focus here, in part because the pathway from initial climate hazard in one location to undernutrition in another is complex, tricky to predict, and highly mediated by human systems, thus diluting the climate signal considerably.

In part in reaction to the 2008 food crisis, countries may increase their efforts to be food self-sufficient. Yet perhaps paradoxically, some countries that increase their dependence on domestic production rather than imports (i.e. an emphasis on food security through self-sufficiency rather than increased ability to purchase

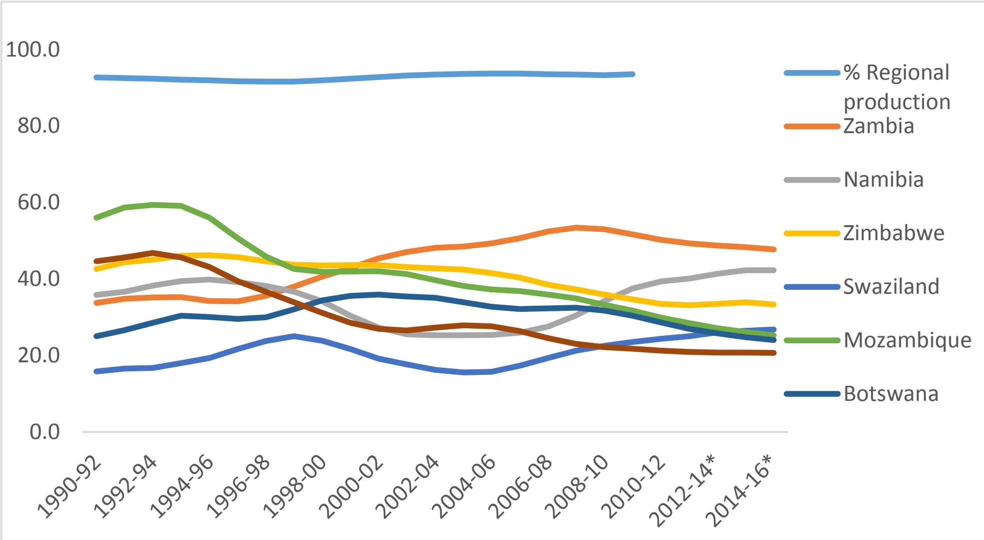
	imported foods) will remain vulnerable to climate change, though under different conditions. This is particularly so for countries located in latitudes where greater temperature increases are predicted, and where yields of key staples have been found to be particularly sensitive to temperature increases. Greater variability in climate in regions where there are already high levels of under-nourishment has been recognized as a consequence of global warming and a key issue for under-nourishment (Schmidhuber and Tubiello, 2007) due to instability in food production (Bruinsma, 2003). Disentangling the impact of climate can be tricky as farming practices and technologies are also changing over time. *Candidates for indicator selection* Given the complex links between climate, food production, food security and under-nutrition, several options for a suitable indicator were considered. For each of these potential options commonalities exist. The first is a focus on countries and regions where there are already high levels of under-nutrition, thus their populations are particularly vulnerable to negative food shocks. The second is a focus on those countries that are most reliant on domestic production, and thus most likely to be directly harmed by location-specific climate hazards. Though yields will be affected differentially depending on the particular crop and location, there is clear evidence from global studies covering over 20 years of research, that crop yields are more negatively affected across most tropical areas than at higher latitudes, and typically countries with a current high hunger levels will experience the highest yield declines due to climate change (Wheeler and von Braun, 2013). The third focus is on locations where climate change is predicted to have a particularly negative impact on yields. The IPCC reports with medium to high confidence that increasing global temperatures will have an overall negative impact on key staple yields, particularly for wheat and maize, whilst the impacts on rice and soybean are smaller. The impacts are not evenly spread across the globe. Higher latitude countries typically are currently benefiting from increasing temperatures, with yields in some more temperate countries predicted to increase in response to climate change. At lower temperature increases, positive feedbacks have been identified for spring wheat and soybean, which have been predicted to improve globally due to CO2 fertilisation effects. Increasing CO2 concentrations enhance water use efficiency and yields but can be accompanied by elevated levels of O3 that can harm yields. Overall, increases in temperature up to 3 degrees Celsius may enhance average global crop yields (Deryng et al., 2014). Thus globally, shifts north and CO2 fertilisation may increase food security in higher latitudes, and mitigate against loss of yield elsewhere at the level of the global food system. Given the decision to focus on countries that are currently experiencing high levels of under-nutrition, that are particularly dependent on domestic production of staple foods, and that are in locations where global warming will have a negative impact on yields, several potential indicators were considered that link to temperature, drought, and vulnerability. *Temperature, climate, and under-nutrition*

	Overall crop yields for staples (excluding rice for which no overall change is predicted) are predicted to decline on average by 8% by the 2050s in South Asia (-16% maize, -11% sorghum) and Africa (-17% wheat, -5% maize, -15% sorghum, -10% millet), currently the most food insecure regions (Wheeler and von Braun, 2013), as a result of increasing temperatures. Recognising the well documented linkages between temperature and yield loss, one option considered was to monitor temperature. Such a temperature-oriented indicator would provide a strong climate signal, but weaker food availability and nutrition signal; is highly data intensive, with the required data being time, location, and crop and variety specific; and with important interactions between temperature and precipitation (Jones and Thornton, 2003). For example, the effects of extreme temperature or precipitation events within any particular growing season can have disproportionately large impacts on final yields. Daytime warming has been found particularly harmful to maize in African countries whereas night time warming is particularly harmful for rice (Lobell et al., 2011). *Drought, climate, and under-nutrition* The second option considered was to monitor the number of households affected by droughts, particularly those in countries already experiencing under-nutrition. Climatic hazards, in the form of droughts, and to a lesser extent floods, have been identified as causing localised and relatively sudden onset of extreme food insecurity (Devereux, 2007) and accompanying health problems in vulnerable communities that are highly dependent on agriculture. Such climate hazards are predicted to increase as a consequence of global warming (Easterling et al., 2000), and are particularly tricky to adapt to in the shorter and longer term. One of the most comprehensive databases of negative harvest shocks caused by drought can be found on reliefweb.org. Reliefweb tracks “disasters” that can be categorized using various search terms. Searching for “drought” within the database allows one to count the number of “drought” events that have resulted in a sufficiently severe localised weather-induced harvest failure to cause significant increases in hunger in the country where the drought occurred. For example, in 2016, Sri Lanka drought led to the loss of two consecutive harvest losses that resulted in 900,000 people being severely food insecure and requiring immediate support to mitigate the impact (Reliefweb.org). However, isolating the climate warming signal from cyclical processes such as El Nino events, given the relatively short time series for which data are available, is not possible and so this option is not pursued. *Yield, climate, and under-nutrition* There is considerable evidence that climate change will have a negative impact on yields in lower latitudes, suggesting the possibility of an indicator that links to realised yields in countries already experiencing high levels of under-nutrition. Average yield data can be obtained from FAOSTAT for the key staple grains for each country, and divergences from regional and global trends calculated. However, even measuring yield differentials rather than absolute yields, given the myriad of adaptation opportunities in the short to medium term that can be adopted to prevent yields from falling, the climate-yield reduction signal is

	weakened and thus too the climate health signal. Thus this option is therefore not pursued. *Vulnerability, climate, and under-nutrition* The fourth option is to focus on vulnerability and exposure of populations in locations where the literature is confident that temperature increases will affect yields negatively. Two key dimensions are considered: reliance on domestic production in lower-latitude countries most likely to be affected negatively by climate change; and existing prevalence of under-nourishment. Countries with low cereal import dependence ratios (high domestic production dependence) are countries most vulnerable to localised weather shocks. This is the option that is followed, and detailed in the section below, though it is recognized that as presented, the climate-health signal remains weak. The indicator currently combines data on vulnerability, as proxied by current levels of under-nutrition, with exposure, as proxied by dependence of the population on locally produced climate-sensitive crops.
Data	The FAO dataset reveals 5 countries with "very high" (>35%) levels of under-nourishment; 15 countries with "high" (>25%) levels; and 18 countries with "moderately high" (>15%) levels (http://www.fao.org/hunger/en/). Details are provided in Table 1 for current under-nourishment prevalence. These countries were then categorised according to the extent to which they are dependent on domestic production, the key cause of their levels of under-nourishment, and their vulnerability to climate-related falls in yield, based on location. At a more aggregated level, five regions with under-nourishment prevalence rates of over 15% stand out. These are Southern Africa (excluding South Africa), Middle Africa, Eastern Africa, Southern Asia, and Western Africa. *Regional details* Countries in southern Africa are highly dependent on food production in the region. Therefore, though individually some countries have a low "domestic production" indicator (for example, Swaziland, 26.8%), the regional "domestic production" indictor is 91%, implying that the region only imports 9% of its food requirements. Thus any localised drought or general fall in production affects the region broadly, though these countries are less vulnerable to the low-probability high-impact systemic crises precipitated by harvest shocks in different parts of the globe. Reflecting the risk of high dependence on local food production, in 2003, 14.5 million people were reported to be at risk of starving in Malawi, Mozambique, Lesotho, Swaziland, Zambia and Zimbabwe, precipitated by a two-year drought in the region. Compounding this high dependence on domestic production is a high dependence on individual crops. For example, Zambia has an 88% maize dependency, and Mozambique 64%. Crop simulations moreover suggest maize yields in this region are highly sensitive to climate change. South African maize yields are predicted to fall between -8%, -25%, and -42% for high, medium, and low-productivity outcomes; with equivalent numbers for Malawi, Mozambique, and Zambia of 2%, -10%, and -22% (Hertel et al., 2010; Schlenker

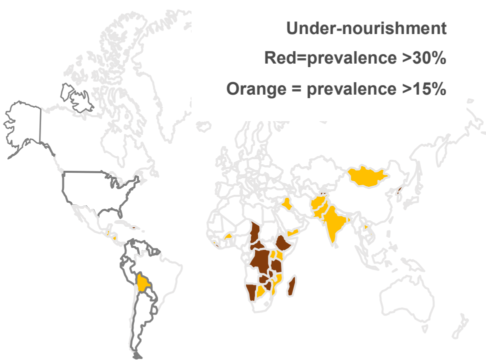
and Lovell, 2010).

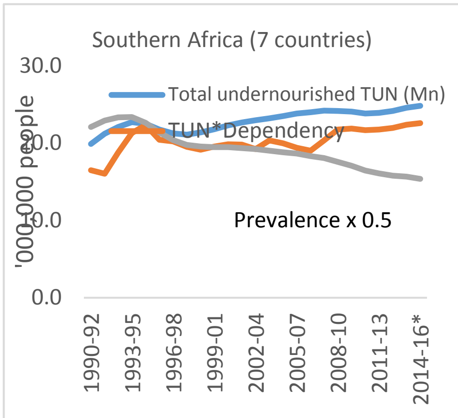
Given these data, southern Africa is a key region to monitor exposure and vulnerability as reflected in current undernutrition and reliance on domestic production. Figure 1 demonstrates clearly that countries in southern Africa remain persistently food insecure, and vulnerable to localised climate hazards.



Under-nutrition in key southern African countries, and % regional production (source: FAOSTAT)

In the following figure, which provides additional detail for the indicator presented in the main text, the first panel in Figure 1.11 shows where countries with the highest prevalence of under-nourishment are located. The following five panels present average prevalence of under-nutrition for the thirty countries, which has been falling in each region; the total number under-nourished (TUN), which is stable or increasing in each region; and the TUN weighted by dependence on regional production of grains, which gives a measure of how exposed already under-nourished populations are to localized climate hazards.





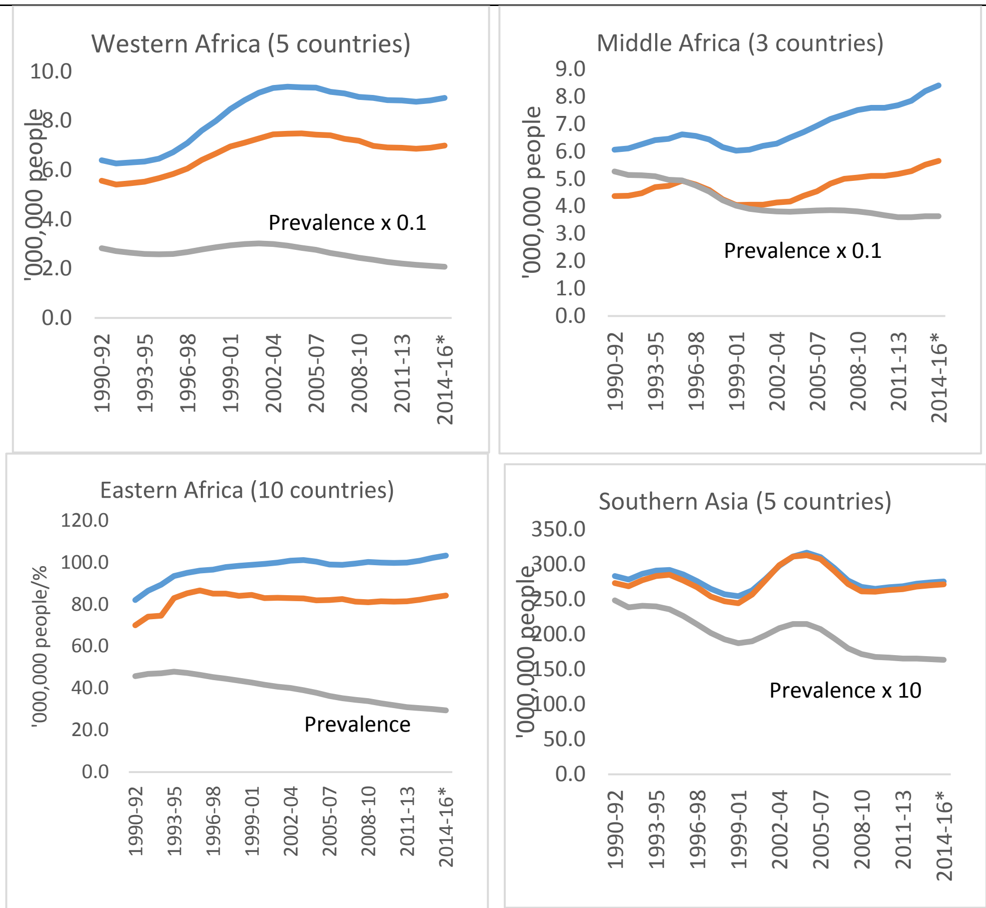


Figure: (a) Food under-nourishment prevalence by country (red>30%, orange >15%); and (b-f) vulnerability-exposure indicator for five regions
Source: FAOSTAT

Caveats

The chosen indicator focuses on the extent to which populations already experiencing moderate to high levels of under-nutrition are vulnerable to localized climate shocks that will compromise their health further. At present, the climate hazard itself has not been incorporated directly, though it is indirectly acknowledged through the choice of locations where climate change is predicted, with confidence, to have a large and negative impact on yields, and where populations are highly dependent on local production.

Ultimately this indicator will aim to combine critical temperatures that are known to reduce maize yields in lower latitudes, with vulnerability as measured by existing levels of under-nutrition, and local exposure as manifested in regional dependence on maize. The data will be initially collected for the particular case of southern Africa. This exercise will be repeated for the other key regions, and the total population-vulnerability-exposure-weighted indicator presented.

The next iteration aims to produce the full suite of indicators addressed above. Our selection of indicator is designed to address food insecurity in the context of the direct impact of climate change on crop production. We do however recognise that this is one element of food security and under-nutrition, and that poverty and conflict have been found to be the key drivers of hunger (Misselhorn, 2005; Margulis, 2013).

Countries	% Under-nourished 2014-16	Cereal domestic dependency ratio 2009-11
Haiti	53.4	46.1
Zambia	47.8	108.2
Central African Republic	47.7	78.6
Namibia	42.3	44.1
DPR Korea	41.6	87.8
Chad	34.4	90.4
Zimbabwe	33.4	51.4
Tajikistan	33.2	56.3
Madagascar	33.0	91.3
UR of Tanzania	32.1	86.8
Ethiopia	32.0	89.3
Liberia	31.9	38.9
Rwanda	31.6	76.3
Congo	30.5	7.1
Timor-Leste	26.9	89.4
Swaziland	26.8	27.1
Afghanistan	26.8	76.4
Yemen	26.1	18.8
Uganda	25.5	90.9
Mozambique	25.3	72.7
Botswana	24.1	19.2
Iraq	22.8	43.2
Sierra Leone	22.3	80.3
Sri Lanka	22.0	74.6
Pakistan	22.0	112.2
Kenya	21.2	63.6
Guinea-Bissau	20.7	68.6
Burkina Faso	20.7	90.2
Malawi	20.7	98.4
Mongolia	20.5	64.9
Lao PDR	18.5	105.1
Nicaragua	16.6	68.5
Guinea	16.4	86.2
Bangladesh	16.4	89.2
Djibouti	15.9	0.0
Bolivia (Plurinational State of)	15.9	81.3
Guatemala	15.6	57.0

	<table><tr><td>India</td><td>15.2</td><td>103.1</td></tr></table>Undernourishment prevalence and cereal domestic production dependency (higher number equals greater reliance on domestic production) (source: FAO)
Future Form of Indicator	Given the importance of temperature, the aim is to incorporate temperature into the indicator from next year, with the focus on lower-latitude areas which are highly dependent on maize. This approach will be piloted using data for southern Africa, for which maize is the dominant staple, the region is highly dependent on local production, and climate change is predicted to result in high crop losses. Key climate-oriented parameters for yield include heat stress at anthesis, and accumulated thermal time over the growing season. For example, in African countries, each degree day spent above 30 °C during the growing season has been shown to reduce final yield by 1% under optimal rain-fed conditions, and by 1.7% under drought conditions (Lobell et al., 2011). These findings emphasise the importance also of precipitation. For example, water deficits during the two critical days of tasselling or pollination have been found to result in yield losses of up to 22% (Hall et al., 1971). Exactly which temperatures should be tracked, and where, will be addressed in detail during the following year.

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.7. Vulnerability of food systems and under-nutrition
Sub-Indicator	1.7.2. Marine primary productivity
Methods	Eleven marine fishery locations which are important in terms of projected impacts and vulnerabilities associated with climate change were selected as determined by FAO (10) (Fig. S1). Moreover, since a mini case study on the impact of changing marine primary productivity on commercial fish catch and human health in the Persian Gulf is presented herein, therefore, Persian Gulf (i.e., location 12) was also included among the locations under investigation. February and August, representing cold and warm periods, were considered for data acquisition. The databanks used for extracting the data related to the A-biotic and Biotic indexes are tabulated in Table S1.

Data

Table S1. Databanks to acquire the required data on the indexes of Marine Primary Production indicator globally

No.	Databank	Index Group	Spatial Coverage
1	*http://oceanservice.noaa.gov/hazards/hab/*	*1.1. Diversity & Density of Phytoplankton Community*	6–11–13-15
2	*http://oceanservice.noaa.gov/news/may17/data-standards.html*		15-17-19
3	*https://catalog.data.gov/dataset/productivity-chlorophyll-a-photosynthetically*		15-17-19
4	*https://www.nodc.noaa.gov/General/plankton.html*		Global
5	*https://www.nodc.noaa.gov/access/cdrom.html#bioatlas*		Global
6	*https://www.nodc.noaa.gov/General/plankton.html*		Global
7	*http://www.st.nmfs.noaa.gov/copepod/*	*1.1. Diversity & Density of Phytoplankton Community* *1.2. Diversity & Abundance of Ichthyoplankton Community*	Global
8	*http://www.st.nmfs.noaa.gov/plankton/atlas/data_src/copepod*		Global
9	*http://oceanservice.noaa.gov/facts/phyto.html*		Global
10	*http://ifl.ifro.ir*	*1.2. Diversity & Abundance of Ichthyoplankton Community*	2
11	*http://www.larvalbase.org*		Global
12	*http://www.fishbase.org*	*1.2. Diversity & Abundance of Ichthyoplankton Community* *1.3. Biomass of Commercial Fish Stocks*	Global
13	*http://www.fao.org/economic/ess/ess-publications/ess-yearbook/en/#. WSar-JKGP1Q*	*1.3. Biomass of Commercial Fish Stocks*	Global
14	*http://www.iucnredlist.org/search*		Global
15	*http://www.fao.org/statistics/en/*		Global
16	*http://irimo.ir/far/*	*2. A-biotic Index (Sub-indexes included)*	2
17	*https://www.bodc.ac.uk/*		Global
18	*https://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/*	*2.1. Sea Surface Temperature (SST)*	Global
19	*https://www.class.ngdc.noaa.gov/saa/products/catSearch?keyword=coastwatch*		Global
20	*http://www.ospo.noaa.gov/Products/ocean/sst.html*		Global
21	*https://www.climate.gov/maps-data*		Global
22	*http://www.earthobservatory.nasa.gov/globalmaps/view.php*	*2.1. Sea Surface Temperature (SST)* *2.2. Sea Surface Salinity (SSS)* *1.1. Diversity & Density of Phytoplankton Community*	Global
23	*https://www.cmecscatalog.org*	*2.3. Coral Reefs Ecosystems*	6-13
24	*http://www.inio.ac.ir/Default.aspx?alias=www.inio.ac.ir/english*		2
25	*https://www.iucn.org/commissions/commission-ecosystem-management/publications*		Global
26	*https://coralreefwatch.noaa.gov/satellite/index.php*		Global
27	*http://www.eosnap.com/page*		Global
28	*http://www.eumetsat.int/website/home/Sentinel3/OceanColour/index.html*		Global
29	*http://www.gebco.net/regional_mapping/mapping_projects/*		6-7-8-10-13
30	*http://www.reefbase.org*	*2.3. Coral Reefs Ecosystems* *1.2. Diversity & Abundance of Ichthyoplankton Community*	Global

[a] Numbers refer to locations of the reference basins (Fig. S2)

[b] NCT: No Certain Trend

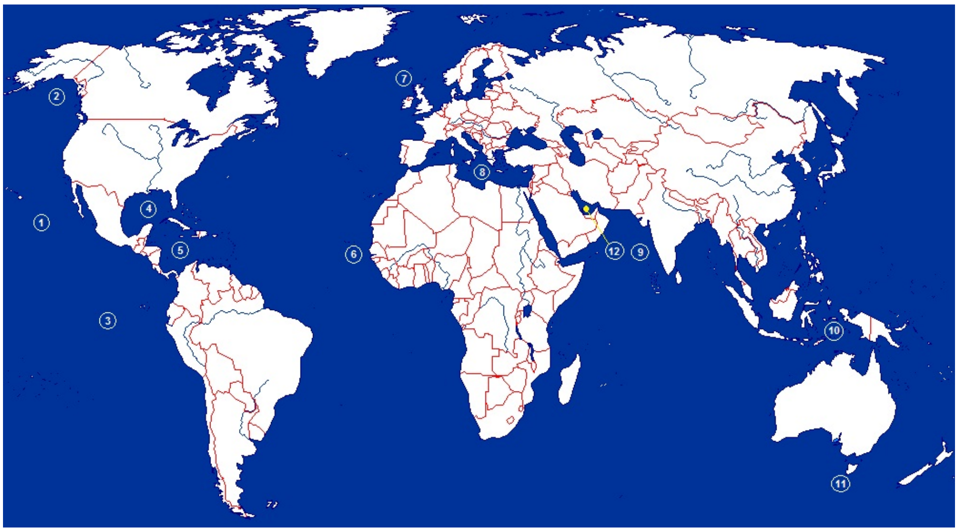
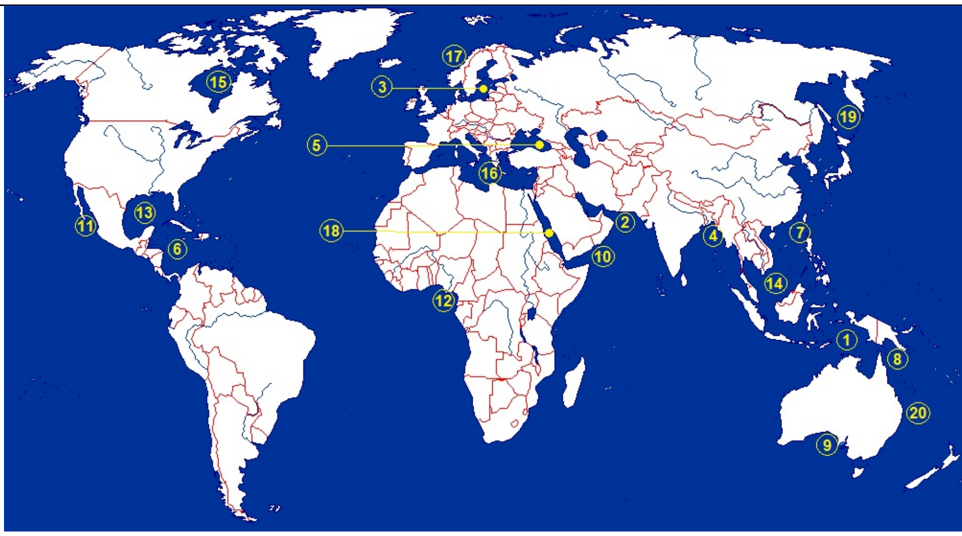


Fig. S1. Important Marine fishery locations in terms of projected impacts and vulnerabilities associated with climate change as determined by FAO. Persian Gulf (i.e., location 12) has also been included as it was considered for the case study presented in this report.

	 Fig. S2. Location of the Reference Basins.
Caveats	As presented in Table S1, there exist some spatial and temporal limitations. More specifically, some of the databases do not present a clear data trend while some other databases only include recently-collected data and there is a lack of log-term data required to interpret the variations in some index groups.
Future Form of Indicator	It would be ideal to observe and monitor the A-biotic index group defined under the Marine Primary Productivity for a period of 3-5 years at the locations of important fishing sites and sensitive marine costal ecosystems especially coral reefs (Fig. S1). These could be found in the databases introduced herein (Table S1). Simultaneously, Biotic index group parameters including density and abundance of important commercial fish stocks (i.e., biomass of commercial fish stocks) and their respective ichthyoplankton community shall also be assessed during the same time period and at the same locations. It is also suggested to investigate the diversity and density of phytoplankton community at the same locations and over similar time frame too. Such findings could assist in assessing the human health-related unfavourable consequences of climate change through jeopardizing marine primary production or in another word, marine-based food security and nutrition. Moreover, the resultant implications could serve as guidelines for the policy makers and the authorities of the marine environment departments to strive to engage NGOs and local communities to contribute to conservation, management, and sustainable utilization of the marine resources and ecosystems. Finally, in locations where commercial fish catch has been negatively affected leading to decreased fish consumption, necessary measures should be taken in order to induce public awareness regarding the associated negative health impacts while trying to change the pattern of consumption in favour of other available marine products.
Additional Information	Analysing the sea surface temperature (SST) data for twelve marine fishery locations revealed approximately 1oC increase from 1985 (22.74^{o}C) to 2016 (22.73^{o}C) (11). Analysing sea surface salinity (SSS) data for the twelve marine fishery locations obtained from the NASA Earth Observatory databank (Table above) revealed 0.43 PSU increase from 1985 (34.98 PSU) to 2014 (35.41 PSU). Coral reed ecosystems are seen to have deteriorated between 2009 and 2016 (12), and the occurrence of Alert 2 has significantly increased. For instance, in February 2016, the incidence of Alert 1 in the Great Barrier Reef compared with February 2009 confirms the severity of its bleaching status (Figure S3).

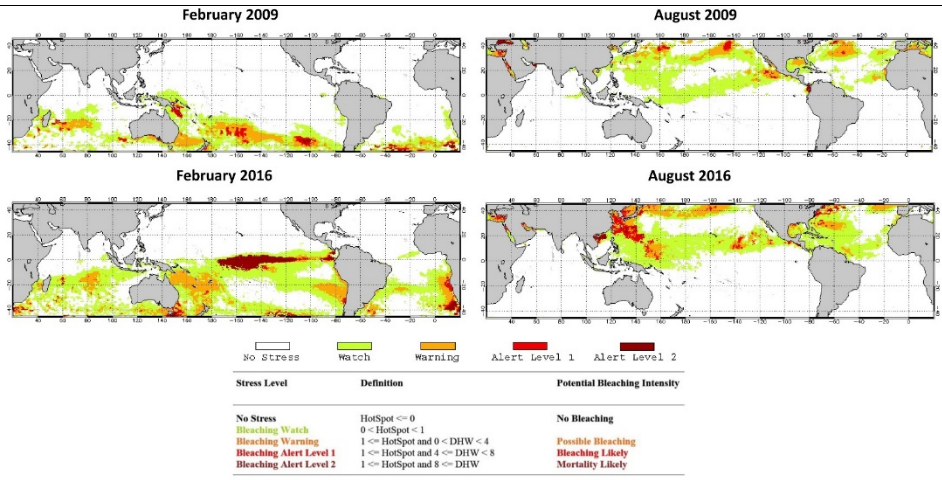
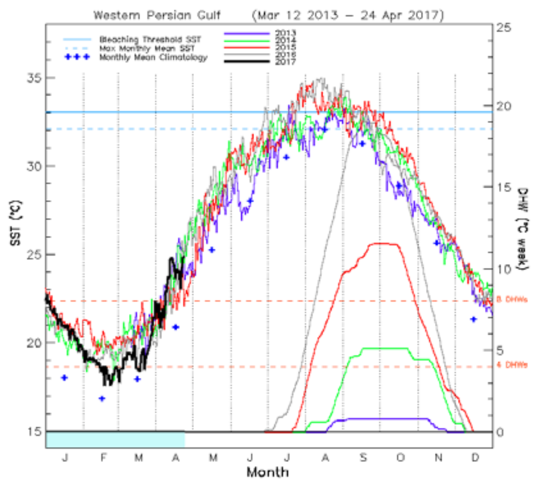


Fig. S3. Coral bleaching thermal stress levels based on the NOAA CRW operational 50-km Coral Bleaching HotSpot and Degree Heating Week (DHW) products, from 2009 to 2016 (Source: NOAA Coral Reef Watch).

Note: As quoted from the NOAA Coral Reef Watch Operational Near-real-time Twice-weekly Global 50 km Satellite Coral Bleaching Thermal Stress Monitoring Product Suite, “Bleaching Degree Heating Weeks (DHW) is the 12-week accumulation of HotSpot values that are at least 1°C. A DHW value of one is equivalent to one week of HotSpot at 1°C and a DHW of two is equivalent to two weeks of HotSpot at 1°C or one week of HotSpot at 2°C. The Bleaching HotSpot is a special type of SST anomaly showing the difference between the nighttime SST and the maximum monthly mean (MMM) SST climatology. The HotSpot data contain only the positive values for identifying potential thermal stress conducive to coral bleaching.”



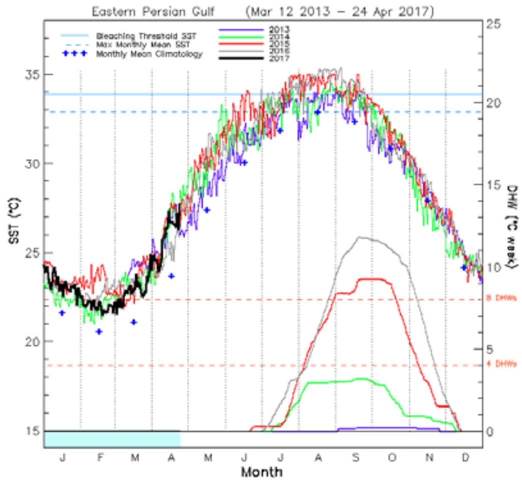


Fig. S4. Changes in SST in the western (top) and eastern (bottom) regions of the Persian Gulf (2014-2017) *vs.* the coral reefs bleaching threshold of 35oC.43 (Source: NOAA Coral Reef Watch - Heron, SF, Liu, G, Rauenzahn, JL, Christensen, TRL, Skirving, WJ, Burgess, TFR, Eakin, CM, Morgan, JA. Improvements to and Continuity of Operational Global Thermal Stress Monitoring for Coral Bleaching. *Journal of Operational Oceanography* 2014; **7**(2): 3-11.).

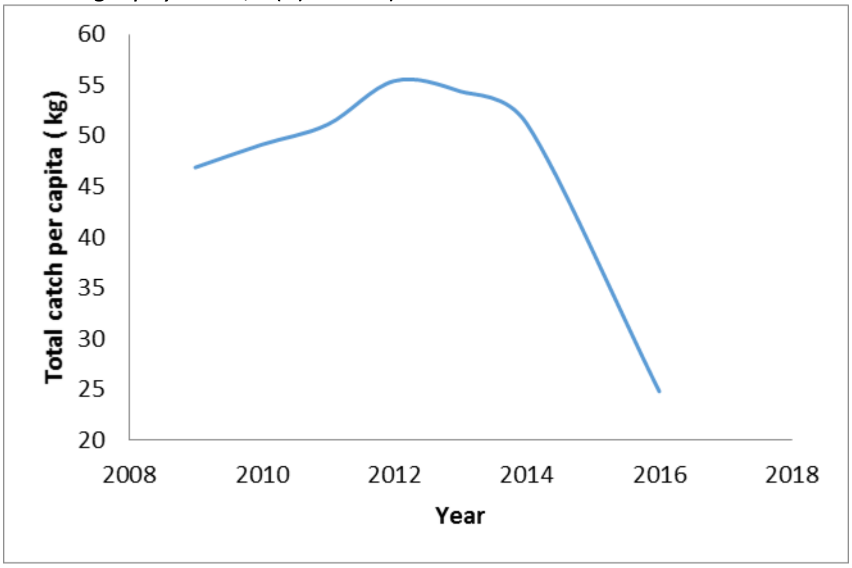


Fig. S5. Annual fish consumption per capita in Bushehr Province (main Iranian fishing site) from 2009-2016 (Source: Iranian Fisheries Organization (IFO), 2014. IFO 1994-2014 Statistical Report)

Food Security and Fish Stocks in the Persian Gulf

One basin in which fish stocks are an important source of food is the Persian Gulf. Fish stocks have been declining in the Persian Gulf since the 1970s, with food security concerns arising for the populations here dependent on fish for food.86 Human activities, including industrial activity (including petroleum production that exacerbates climate change when later burned), dredging and land reclamation are influencing fish stocks here.87 Furthermore, recent studies of fishing show that actual fish catch quantities in this region are up to six times higher than the reported quantities given to the UN, and therefore likely to be at unsustainable levels.88 These factors are compounding to increase the pressure on fish stocks and reduce marine populations, which many people in the area are dependent on as a primary source of food.

For fish populations already under pressure from human activities, climate change

	presents a further challenge to fish stocks in this region by altering the ecosystems in which they live. Thus, the ability of fish populations to withstand and recover from direct human impacts is compromised and threatens the future maintenance and even survival of fish populations in the Persian Gulf. This in turn has implications for human health. Food security in the southern Persian Gulf is already a concern and fish consumption is an important source of protein, accounting for up to 10% of the population's protein consumption. Although innovations in aquaculture have helped address some food security concerns inland, marine fish populations are still declining and so food insecurity is still problematic for coastal communities in the Persian Gulf.89 Considering existing declines in marine fish populations and food security concerns in the Persian Gulf, it is important to understand the implications of climate change in this region, for these current risks could be further exacerbated by ecosystem changes associated with a changing climate. Changes to SST and SSS, key proxies for measuring the influence of climate change on fish stocks, have been found to have been negatively impacting the coral reefs in the Persian Gulf, which fish populations are dependent upon for their survival; for example, there were mass coral bleaching events in the Persian Gulf in 1996 and 1998, which caused a decline in fish.87 SST has risen since 2013, but also exceeded the coral bleaching threshold of 33°C in the summer months across both regions throughout the period 2013 to 2017 (see Appendix 2 Figure S4).90 Rising SST and associated coral stress is likely to have contributed to lower fish populations and associated decreases in the total catch of major commercial fish species in the Iranian waters in the Persian Gulf, including tiger tooth croaker (Otolithes ruber), threadfin (Polynemus spp.), and silver pomfret (Pampus argenteus). Bushehr Province, the main Iranian fish catching site, has experienced a decrease in the total catch of the major commercial fish species, leading to a sharp decline in annual fish consumption per capita, from 46.8 kg in 2009 to 24.7 kg in 2016 (see Appendix 2 Figure S5).91 This decline is most likely a combination of human stressores, including climate change and overfishing, but nonetheless the consequences for human health are clear – reduced fish stocks increases food insecurity and risks undernutrition in the region, as protein from fish becomes increasingly unavailable.

Working Group	1. Climate Change Impacts, Exposures and Vulnerability
Indicator	1.8. Migration and population displacement
Methods	The presumed link between climate change and migration is now firmly embedded in academic and public consciences. Yet critical voices continue to highlight both the lack of evidence linking climate change directly to migration through linear causality and the multitude of factors which influence any connections between the two. These criticisms do not deny interactions between climate change and migration, nor the possibility of future occurrences of large-scale migration linked to climate change. They simply point out the truisms from migration research which are often bypassed that: 1. Migration is and always has been part of humanity. 2. Many factors, including climate-related, influence and have always influenced human migration and non-migration decisions. 3. Where people are forced to migrate or not to migrate when they would prefer otherwise, in many circumstances, it is lack of support mechanisms to deal with environmental changes, rather than the environmental changes themselves, which are the root cause of the migration.

Point 3 is not about removing environmental influences. When houses fall off eroding cliffs in California or lava starts flowing through settlements, little option exists but to migrate, since few support mechanisms exist which would prevent the environmental changes. The key for this indicator is determining when climate change is the only environmental change for which support mechanisms might be needed. For instance, the Californian cliffs have always been prone to erosion, even if climate change influences the rates. Similarly, any influences which climate change is having or might have on volcanic activity (McGuire, 2010) do not change the fact that the settlements were vulnerable to lava flows anyway.

Nonetheless, Table 1 provides key ways which are not covered in this indicator in which climate change might be a factor in people being forced to migrate. Each factor in Table 1 has listed a root cause and a possible intervention mechanism which has the potential for precluding the forced migration or making the migration somewhat forced and somewhat not forced. As such, being a factor does not mean being the cause (and an intervention might also cause further problems). Consequently, this indicator highlights the phrasing 'due to climate change only' to understand where forced migration is truly occurring due to climate change with no other possibilities—and to avoid climate change being used as a scapegoat because it is easier to blame climate change than to tackle the real causes of the migration.

Table 1: How climate change might be a factor in forced migration.

Factor	Root cause	Possible intervention mechanism
Extreme weather including floods, droughts, and storms.	Vulnerability, not hazard.	Reduce root causes of vulnerability to extreme weather.
Increased air temperatures (averages and peaks, especially over extended periods of time) making it dangerous to work outdoors.	Climate change.	Invest resources to mechanise the outdoor labour and train workers with the skills needed, rather than relying on poor people to provide cheap work in challenging circumstances without training.
Limited food or freshwater.	Climate change can be a root cause, such as salination from sea-level rise, but more typically it is human mismanagement and overconsumption.	Improved resource management.

In terms of migration due to only climate change impacts, where intervention mechanisms still exist but the success possibility is low, the main factors are likely to be:

1. Sea-level rise, with three sources (Table 2): (i) slow melting of ice (glaciers, ice sheets, and permafrost) leading to centimetres of sea-level rise over years and undermining of traditional ice-based livelihoods; (ii) thermal expansion of water bodies leading to metres of sea-level rise over decades, and (iii) ice sheet collapse (Greenland and Antarctica) possibly leading to tens of metres of sea-level rise but likely over centuries.
2. Changing Arctic ice conditions which cause coastal erosion—sometimes metres per year—because lack of sea ice leads to wave, storm, and current action on coastlines.
3. Ocean acidification which could lead to shingle beach erosion or, coupled with elevated sea-surface temperatures, could lead to major coral mortality through bleaching which would expose coastlines to the full oceanic power of waves, storms, and currents without a protective reef.

It is important to be cautious regarding attribution of witnessed changes and attribution of migration to climate change. Yet what is observed now does not necessarily indicate the only future possibilities. People might later need to migrate due to climate change only, such as if accelerated sea-level rise occurs or if places around the Arctic Ocean become ice free. Therefore, a hierarchy evolves:

1. People in locations migrating now due to climate change only.
2. People in locations which might possibly need to migrate due to climate change only, most likely due to thermal expansion, lack of sea ice, or ocean acidification (possibly coupled with other climate change impacts), because these factors tend to be localised (thermal expansion is global, but as noted in the caveats, displays regional and local variations). Melting land ice might contribute to this category through additions to sea-level rise and destabilisation of land and infrastructure as permafrost melts.
3. People in locations which might possibly to need to migrate due to climate change only, if ice sheet collapse occurs, because this factor would be a major step change in global conditions, with regional and local variations, but with a global baseline.

The people in these three sets of locations can be quantified by the population in them, leading to the indicator being the number of migrants and the number of communities (as distinct values) migrating only due to climate change according to the three categories. Only material from peer-reviewed literature is considered.

The robustness of each category is:

1. **The number of people in locations migrating now due to climate change only has high robustness.** Nonetheless, new evidence could remove locations from this category. Around 2010, it became evident that the sea was encroaching so extensively onto the atoll of Takuu, PNG that migration would likely be inevitable. While some coastal management had exacerbated the situation, the main explanation based on available data—although not published in peer-reviewed literature—appeared to be sea-level rise associated with climate change. Mann et al.'s (2016) analysis agreed that sea-level rise is measurable around the atoll, but not that the shoreline changes are due to sea-level rise. Consequently, had this indicator been developed in 2015 including Takuu, then Takuu would have been removed in 2016. This situation is a further argument for focusing on peer-reviewed literature rather than on non-peer reviewed reports of local observations.
2. **The number of people in locations who might possibly need to migrate due to climate change only has medium robustness.** Due to lead-time available for this indicator, strong possibilities exist for taking measures to prevent inevitable

migration. In most locations, the need for such measures has been known over the past few decades with little action resulting. The current political climate is also not amenable to large-scale action for some time. Consequently, action is feasible to prevent migration, but does not seem likely before thermal expansion's impacts become apparent.

3. **The number of people in locations who might possibly need to migrate due to ice sheet collapse has low robustness**. Uncertainties are high while manifestation of ice sheet collapse on the century scale means that numerous other factors could influence possibilities for, preparation for, and reactions to migration related to ice sheet collapse.

Data

Table 2. Quantification of sea-level rise

Citation	Sea-level rise component	Amount of sea-level rise	Notes
Brown et al. (2016)	All.	0.29-0.53 m over 1961-1990 levels by the 2090s (the mean is 0.36 m).	Nine different models used.
Clarke et al. (2016)	All	25-52 m over the next 10,000 years	Reported by time period, component, and emissions scenario.
DeConto et al. (2016)	Antarctica ice melt	1 m by 2100 > 15 m by 2500	Based on a current emissions rate.
Dieng et al. (2017)	All.	3.00 ± 0.19 mm/yr 1993-2015	Reported by time period and component.
Jevrejeva et al. (2014)	All.	The maximum possible sea-level rise over 2000 by 2100 is 1.90 m with a more realistic upper limit being 1.80 m.	
Jevrejeva et al. (2016)	All.	0.9 m median projected rise by 2100	Based on current emissions rate.
Mengel et al. (2016)	All.	0.28–0.56 m 0.37–0.77 m 0.57–1.31 m by 2100 compared to 1986–2005.	Depends on emissions scenario. Reported by component.
van den Broeke et al. (2016)	Greenland ice melt	~0.47±0.23 mm/yr on average from 1991–2015; max. 1.2 mm in 2012	

Table 3. Locations potentially seeing forced migration due to climate change (Kelman,

I., 2018, Islandness within climate change narratives of small island developing states (SIDS), Island Studies Journal, 13, 1 (publication approved))

Reference	Locations studied	Results
Albert et al. (2016)	33 reef islands of the Solomon Islands.	Island responses range from entire disappearance to minor accretion.
Auerbach et al., 2015	An island in southwestern Bangladesh.	Worsening flooding from the ocean was attributed more to human deforestation and use of structural defences than to sea-level changes.
Ballu et al. (2011)	Torres Islands, Vanuatu.	Tectonic subsidence is dominating sea-level rise as the reason for ocean encroachment.
Biribo et al. (2013)	Reef islands of Tarawa Atoll, Kiribati.	Significant erosion and accretion are observed, but mainly due to local human activities.
Ford (2012)	Majuro, Marshall Islands	Sea-level rise is measurable, but atoll changes are mainly from local human activities. Where human activities are less noticeable, some shorelines are eroding and some are accreting.
Ford and Kench (2015)	Eight islands of the Marshall Islands.	Sea-level rise is measurable, but all the islands show net accretion.
Kench et al. (2015)	29 islands of Funafuti Atoll, Tuvalu.	Sea-level rise is measurable, with island responses ranging from severe erosion to significant land gain.
Mann et al. (2016)	Takú Atoll, Papua New Guinea.	Sea-level rise is measurable, but is not dominating natural shoreline dynamics.
McLean and Kench (2015)	Over 200 Pacific islands.	Despite measurable sea-level rise, little evidence exists of island sizes being reduced, with both local human activities and wider environmental cycles dominating sea-level rise.
Rankey (2011)	17 atolls across Kiribati.	Increased rates of change for both erosion and accretion.
Webb and Kench (2010)	27 atoll islands across the Federated States of Micronesia, Kiribati, and Tuvalu.	Sea-level rise is measurable, but the islands showed a mixture of erosion, accretion, and stability, with only a few islands losing area overall.
Yates et al. (2013)	47 atolls of Manihi and Manuae, French Polynesia.	Despite measurable sea-level rise, most island areas are expanding or remaining stable, although major localised changes are seen. Two atolls showed local human activities influencing the changes.

Caveats

Caveats from the literature regarding sea-level rise estimates:

(a) Sea-level rise will not be the same everywhere, with significant regional variations from the global mean (Carson et al. 2016; Clarke et al. 2016).

(b) The rate of sea-level rise is expected to accelerate in coming years (Fasllo et al. 2016; Watson 2016).

	(c) Sea-level rise is 0.71 ± 0.20 mm/y slower than expected because the climate is driving increasing water storage on land (Reager et al., 2016). (d) Sea level might have natural, multi-decadal oscillations (Serazin et al., 2016). People from many locations are assumed to be migrating due to the possibilities given as being climate change only, but analysis shows that the assumptions are not always supported (Table 3). In fact, no outcome is certain. Even for coral reefs, Perry et al. (2015) postulate that coral growth under some scenarios could keep up with sea-level rise and other ecosystem changes. Corals' ability to flourish under rapid sea-level changes was demonstrated empirically in the Solomon Islands by Saunders et al. (2016) after sudden tectonic subsidence. Similarly, mangroves so far are demonstrating robustness to sea-level changes while nevertheless being damaged by human activity (Woodroffe et al. 2010). In summary, a linear cause-effect assumption is made of: climate change (impacts) → migration → health impacts Each step has nuances, subtleties, and provisos. For the first step, migration due to climate change (impacts) only is hard to discern because migration has always happened throughout human history for multiple reasons, some climate- and environment- related; some not linked at all to climate or environmental factors; and most often due to a combination of factors. Many assumptions behind migration potentially linked to climate change are hard to prove as being climate change only or are challenging to differentiate from many other environmental factors, such as specific natural hazards or changes to food, water, and/or livelihood conditions which manifest for multiple reasons. For the second step, migration itself, no matter how or why migration occurs, does not necessarily induce specific health outcomes. Migrant and host health could be improved, worsened, or not affected, depending on how the migration is handled. Consequently, the main caveats for this indicator is that no linear cause-effect sequence happens, mainly because the outcomes from a situation depends much more on how a situation is dealt with than on climate change or migration per se.
Future Form of Indicator	Two main prospects exist for this indicator's future. The first is observational. As estimates and observations of sea-level rise, ocean acidification, sea ice, and coastal erosion continue, the indicator's thresholds might change. The second is how the indicator is constructed. Consideration could be given to how managing migration affects health in order to overcome a principal caveat. Irrespective, this caveat can never be fully overcome because health impacts can be managed, if we choose to do so, irrespective of climate change or migration scenarios or realities. In later iterations of this indicator, descriptions can be provided of locations which have switched categories, been removed entirely, or been added as new. As these iterations approach 2030, the tables given for each indicator are likely to expand substantially because the number of studies is expanding immensely on (i) observed climate change impacts with confirmed attribution, (ii) projecting such impacts into the future; and (iii) migration linked to climate change. Consequently, the potential impacts of climate change on migration are likely to become much clearer towards 2030, including possible case studies where such migration has occurred. Caution is still needed regarding numerous cases where attribution is stated with confidence, but the link upon closer examination is not robust. While the indicator here is presented in

	a highly focused and rigid manner, in order to keep it scientifically precise and robust, expanding knowledge and observations might permit the indicator in 2030 to be much more comprehensive and less narrow without losing robustness. Given the complexity of the observational science and the challenges articulated by the caveats, the ideal form of this indicator given adequate time and resource would be a map of all potential migration location origins under different climate change scenarios, animated over time to 2100. Although climate change projections are published for the next 10,000 years (Clarke et al., 2016), social and technological changes will be immense over such time scales, making it difficult to provide any confidence for suggestions regarding how and where people will live and be responding to environmental stimuli long into the future. If people choose to settle other planets, solar systems, or galaxies over the next several millennia in order to escape a dying Earth—as much science fiction (not peer reviewed) has postulated—would they be climate (change) migrants? Such questions are beyond the scope of Lancet Countdown. Consequently, to achieve this proposed map with scientific value, it should not go beyond 2100 and at least one dedicated post-doctoral researcher would be needed, preferably with a GIS and migration specialty because the number of caveats, provisos, uncertainties, and attribution challenges would lead to multiple layers and indicators on a map.
Supplementary Information	<u>Locations possibly needing to migrate due to climate change only</u> The proviso 'possibly' in this title refers to technical solutions being developed to help the people stay in or near their current locations, irrespective of the climate change factors mentioned. These schemes include artificial settlements floating above or built directly on the current locations (Yamamoto et al., 2014), whether above an island being submerged, an eroding coastline, or destabilised permafrost. Financing for these technical proposals has so far been absent and does not seem likely in the near future, plus technical challenges remain. Nonetheless, they are possibilities and it is difficult to project the social and political make-up of the world over the coming decades. The range of possibilities covers shifting the trillions of dollars per year in military spending and fossil fuel subsidies to tackling climate change all the way through to abandoning anyone affected by climate change through refusing to permit them entry into other countries. The most likely outcomes are somewhere in between such extremes. Consequently, the migration of these territories remains 'possibly' rather than 'definitely'. Additionally, defining 'migrating' for this category is not straightforward. Does it mean moving house, street, municipality, island, or country? Would it include moving 5 m, 50 m, 500 m, or 5 km? For example Pingelap atoll in the Federated States of Micronesia has significant area above 15 m above sea level but all land is within 300 m of the coast. If the people of Pingelap move their houses or move to different houses due to sea-level rise, is that migration, because they are still living in effectively the same location? If so, then a street-by-street census would be needed of Pingelap and every other coastline in the world to determine exactly who would need to migrate, due to regional and local variations in how sea-level rise manifests. Consequently, a country rather than community level is presented (Table 4), identifying the countries which might (not definitely) not be able to remain as countries under thermal expansion. Apart from those people already migrating due to

climate change, this indicator yields four countries totalling a population of 584,000 people possibly needing to migrate due to thermal expansion. All four are small island developing states (SIDS), but this is coincidental; all countries have been considered.

Table 4. Locations possibly needing to migrate due to thermal expansion

Location	Population	Notes
Kiribati	106,925	Has plenty of high ground above 10 m above sea level, but little is habitable or viable for large populations.
Maldives	392,960	Highest point is 2.4 m above sea level.
Marshall Islands	73,376	Highest point is 10 m above sea level.
Tuvalu	10,959	Highest point is 5 m above sea level.

As a guess, the countries in Table 4 would need to migrate between 2040 and 2050. This statement is a guess, because the decision to migrate will most likely be political strongly influenced by specific extreme events rather than a strategic analysis of possible futures and outcomes from those futures. This statement is made on the basis of history and how societies have typically dealt with disasters and creeping environmental changes.

As well, other countries could rapidly be added to Table 4. If coral reefs around Fiji or Seychelles experience high mortality, then near-coastal areas could potentially experience rapid erosion. Two provisos preclude large numbers of people in each country, or significant parts thereof, from being forced to migrate. First, while far from an ideal approach, extensive coastal engineering (which both countries already implement) could forestay major coastal erosion. Second, plenty of land is available in those countries which could theoretically take migrants—although with practical problems regarding access, ownership, and heritage protection—and few people would necessarily need to migrate far in theory, leading to the problem of defining 'migration' mentioned above. If land tenure or ecosystem protection precludes settling in areas, is the root cause of migration farther afield climate change or local human decisions regarding land?

All these factors emphasise the 'possibly' word in this indicator's title. They also highlight that this indicator's value is a minimum, but many more possibilities for migrants exist under this category—most notably erosion linked to sea ice disappearance.

<u>Locations which might possibly need to migrate only due to climate change, if ice sheet collapse occurs</u>

In the coming decades, the numbers of people migrating due to ice sheet collapse is likely to be near zero. The reason is that the collapse process itself followed by ice melt and sea-level rise takes a minimum of decades and possibly up to centuries. As we move from the decade scale to the century scale, it is impossible to project social and technological developments. It is too simplistic and it would be indefensible to just calculate the number of people living within a certain elevation above sea level—especially since over the coming decades, these population numbers will change.

Nonetheless, some websites host data on population in coastal zones such as Columbia University http://sedac.ciesin.columbia.edu and the World Bank http://data.worldbank.org/indicator/EN.POP.EL5M.ZS but these are not part of the peer-reviewed literature. The UN has also developed the indicator 'Percentage of Total Population Living in Coastal Areas' http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/oceans_seas_coasts/pop_coastal_areas.pdf into which the World Bank and Columbia University data input, but again, it is not published in the peer-reviewed literature. Instead, peer-reviewed publications provide the following analyses:

- In 1990, 450 million people lived within 20 km coast and below 20 m above sea level (Small and Nicholls, 2003). The provided plots permit higher resolution estimates to be obtained with reasonable precision, but accuracy is questionable.
- In 1994, 1.88 billion people (33.5% of the global population) lived below 100 m above sea level (Cohen and Small, 1998), which was the highest vertical resolution investigated.
- In 2000, 634 million (10% of the global population), of whom 360 million are urban, lived below 10 m above sea level (McGranahan et al., 2007), which was the highest vertical resolution investigated.
- With 2000 as a baseline, the population living below 10 m above sea level and connected to the ocean will change from 638 million to, depending on the societal scenario chosen, 1,005-1,091 million by 2050 and 830-1,184 million by 2100 (Merkins et al., 2016).
- With 2000 as a baseline, the population living below 10 m above sea level on contiguous land which borders a major body of water will change from 702.167 million to, depending on the societal scenario chosen, 492.74-1,145.946 million by 2100 (Jones and O'Neill, 2016).
- The number of people living below 5 m above sea level is calculated to be 290 million (5.4%) in 1990, 380 million (5.6%) in 2010, and 460 million (5.5%) in 2030 (Kummu et al. 2016).
- For 2000-2006, 67.1-153.1 million people live below 1 m above sea level; 308.1-391.4 million people live below 5 m above sea level; and 557.1-709.1 million people live below 10 m above sea level (values are also available for below 2, 3, and 4 m above sea level) depending on the models used (Lichter et al. 2011). This paper also provides a review of similar literature to date, which plenty of further estimates of the coastal population.

Consequently, this indicator yields zero extra people migrating due to ice sheet collapse by 2100; that is, no one would need to migrate who is not already migrating. After 2100 and in ensuing centuries—without appropriate action—based on the above literature, as an order of magnitude, perhaps over one billion people +/- 50% might need to migrate due to ice sheet collapse. This estimate is based on ice sheet collapse only; as noted above, has low robustness because it is mainly guesswork with large errors; and has no relation to the estimates of 'climate migrants' and 'climate change refugees' which have been debunked by Gemenne (2011) and Hartmann (2010). Instead, it simply states that if ice sheets collapse and in the absence of major social and technological changes (an unlikely situation by 2100), then in the decades and centuries after 2100, over one billion people +/- 50% might need to migrate due to climate change only.

Appendix 3 – Adaptation Planning and Resilience for Health

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	2.1 National adaptation plans for health
Methods	In May 2008, the 193 Member States of WHO passed a World Health Assembly (WHA) Resolution 61.19, calling for stronger action to address the health risks associated with climate change both through adaptation and mitigation responses. In addition, the WHO work plan on Climate Change and Health EB136/16 calls for promotion and development of tools for more systematic provision of country-specific information and monitoring of progress. As part of the fulfilment of this mandate, WHO is actively engaged in the United Nations framework Convention on Climate Change and together, WHO and the UNFCCC collaborated on the development of climate and health country profiles to provide ministers of health and health decision-makers with national estimates of the climate hazards, health impacts, potential health co-benefits of mitigation actions and status of national policy response in their countries. The collection of data for this exercise includes a biennial national survey, entitled the “WHO Climate and Health Country Survey”, which is sent to all WHO member states and is completed by ministry of health focal points. Results from the country survey together with

	the WHO Climate and Health Country Profiles form the basis of WHO's global monitoring of national progress on climate and health action. The data presented in this report reflect the responses of 40 countries that participated in the 2015 baseline WHO Climate and Health Country Survey. Validation of the 2015 country reported data was undertaken as part of the development and review of the WHO UNFCCC Climate and Health Country Profiles. Key climate and health stakeholders including the ministry of health and other related government bodies were invited to review country specific findings. The validated data presented in this report are for 40 countries, including; Algeria, Bangladesh, Bhutan, Botswana, Brazil, Brunei Darussalam, Cambodia, China, Colombia, Egypt, Ethiopia, Fiji, France, Germany, Ghana, Indonesia, Iran (Islamic Republic of), Jordan, Kenya, Lao People's Democratic Republic, Madagascar, Malaysia, Maldives, Mexico, Morocco, Myanmar, Nepal, Nigeria, Oman, Pakistan, Peru, Philippines, Sri Lanka, Tanzania (United Republic of), Thailand, Timor-Leste, Tunisia, Uganda, the United Kingdom and the United States of America.
Data	WHO Climate and Health Country Survey
Caveats	The survey sample may not be representative of all countries as this survey was voluntary, and the baseline sample tended to include countries that had active climate and health projects or countries that were working directly with WHO on climate and health projects. As such the overall results may tend to be positively biased but still provide valuable insights into the status of national policy response for participating countries from all WHO regions and representing a diverse range of low, middle and high income nations with varying population sizes, climatic and geographic characteristics and different vulnerabilities to the impacts of climate change.
Future Form of Indicator	The WHO Climate and Health Country Survey will be conducted biennially and will aim to gather data from all WHO member States, with the specific goal of doubling the number of survey respondents to 80 participating member states in the next iteration of the survey (2017).

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	2.2 City-level climate change risk assessments
Methods	CDP serves as an official reporting platform for the Compact of Mayors, and administrates, collects and analyses a global survey of city based environmental and climate change data on an annual basis. In 2016, 553 cities participated in the survey, with 449 reporting publically that included questions on emissions, adaptation assessments and plans. Respondents to the surveys to describe the magnitude of the

<table>
<tr><td></td><td>impact of climate based hazards (extremely serious, serious, less serious) and identify three critical assets or services that may be most impacted.

Based on this data two indicators can be developed. The first is a global cities based indicator of government areas that have undertaken a climate change risk or vulnerability assessment. The second is global cities based indicator of the perceived vulnerability of health infrastructure to climate change.</td></tr>
<tr><td>Data</td><td>CDP data cities</td></tr>
<tr><td>Caveats</td><td>This is a sample survey of 449 public results, are self-reported. As such, the results are not representative and are not necessarily reliable, owing to their being based on self-reporting cities.</td></tr>
<tr><td>Future Form of Indicator</td><td>In future, this indicator will aim to expand the number of cities included in the survey and to have a more regionally representative sample. Also, the quality of the climate change risk assessments and implementation rate of any associated plans would be important to analyse.</td></tr>
<tr><td>Supplementary Information</td><td>Cities that noted that Health & Community are threatened by Climate change
<table>
<tr><th></th><th>Number</th><th>Percentage</th></tr>
<tr><td>Yes</td><td>220</td><td>49%</td></tr>
<tr><td>No</td><td>229</td><td>50%</td></tr>
</table>

Cities by WB Country Income Category that noted that their Health & Community Assets are threatened by Climate change
<table>
<tr><th>World Bank income Category</th><th colspan="2">High Income</th><th colspan="2">Upper Middle Income</th><th colspan="2">Lower Middle Income</th><th colspan="2">Low Income</th></tr>
<tr><th></th><th>Freq.</th><th>%</th><th>Freq.</th><th>%</th><th>Freq.</th><th>%</th><th>Freq.</th><th>%</th></tr>
<tr><td>Yes</td><td>119</td><td>50%</td><td>61</td><td>48%</td><td>11</td><td>46%</td><td>29</td><td>48%</td></tr>
<tr><td>No</td><td>117</td><td>50%</td><td>67</td><td>52%</td><td>13</td><td>54%</td><td>32</td><td>52%</td></tr>
<tr><td>Total Cities</td><td>236</td><td></td><td>128</td><td></td><td>24</td><td></td><td>61</td><td></td></tr>
</table>
</td></tr>
</table>

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	2.3 Detection, preparedness, and response to health emergencies
Methods	Under the International Health Regulations (IHR (2005)) all States Parties are required to have or to develop minimum core public health capacities to implement the IHR (2005) effectively. IHR (2005) also states that all States Parties should report

	to the World Health Assembly annually on the implementation of IHR (2005). In order to facilitate this process, WHO developed an IHR Monitoring questionnaire[2], interpreting the Core Capacity Requirements in Annex 1 of IHR (2005) into 20 indicators for 13 capacities. Since 2010, this self-reporting IHR monitoring questionnaire is sent annually to National IHR Focal Points (NFPs) for data collection. It contains a checklist of 20 indicators specifically developed for monitoring the development and implementation of 13 IHR capacities. The method of estimation calculates the proportion/percentage of attributes (a set of specific elements or functions which reflect the level of performance or achievement of a specific indicator) reported to be in place in a country. The core capacities to implement the International Health Regulations (2005) have been established by a technical group of experts, as those capacities required to detect, assess, notify and report events, and to respond to public health risks and emergencies of national and international concern. To assess the development and strengthening of core capacities, a set of components are measured for each of the core capacities, by considering a set of one to three indicators that measure the status and progress in developing and strengthening the IHR core capacities. Each indicator is assessed by using a group of specific elements referred to as 'attributes' that represents a complex set of activities or elements required to carry out this component. As it is difficult to measure these indicators with a simple question that requires one 'yes' or 'no' answer, one to three questions are derived from each attribute, and these are administered through a questionnaire. The status of performance for an indicator, component and core capacity is determined by the presence of attributes. If a country does not indicate a particular attribute as absent or present, it is counted as absent for scoring purposes. The annual questionnaire has been conducted since 2010 with a response rate of 72% in 2012, 66% in 2016, and 99% of countries reporting at least once since 2010. Annual reporting results are complemented by after action reviews, simulation exercises, and joint external evaluation (JEE).
Data	International Health Regulations (2005) Annual Reporting
Caveats	This indicator does not show the implementation status of IHR core capacities for all countries – it only reports on those countries who reported.
Future Form of Indicator	In future, this indicator would hope to consider additional data sources beyond the IHR Reporting Questionnaires and expand the number of countries included in the results, to strengthen the global picture of the available human resources to prepare, respond and adapt to climate-related health impacts. Closer alignment will be sought with the monitoring of SDG 3D, "Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks". Indicator 3.D.1 is also measured by: "International Health Regulations (IHR) capacity and health emergency preparedness." The indicator may be expanded to include more detailed information provided through the complementary IHR joint external evaluation instruments; or the monitoring systems for the Sendai Framework[3], including data from WHO's reports on country capacities for health emergency and disaster risk management, which may in the future provide a complementary system to track health outcomes, effects on health services and the community and national capacities to manage the health risks of climate related emergencies and disasters. Furthermore, this indicator could

[2] http://www.who.int/ihr/publications/WHO-HSE-GCR-2016.16/en/
[3] http://www.preventionweb.net/files/50683_oiewgreportenglish.pdf

in the future look to include more details of the achieved capacities in relation to health system capacity.
https://sustainabledevelopment.un.org/sdg3, *currently also measured by IHR indicators.*

Supplementary Information

IHR Core Capacity 7: Human Resources. Capacity score (%) of human resources available to implement the IHR (2005), by WHO Region. (IHR Indicator 7.1.1)

WHO region	2010	2011	2012	2013	2014	2015	2016
Africa	24.3	33.11	44.76	48.24	55	63.64	50.83
Americas	43.39	54.31	57.42	68.48	68	67.06	68.39
Eastern Mediterranean	44.76	55.88	62	68.57	67.62	75	76.92
Europe	36.53	36.36	43.87	53.33	53.33	52.94	42.16
South-east Asia	56.2	60	68.89	76	80	72.5	82
Western Pacific	56.5	55	57.78	69.26	70.43	78	85.71

Source: http://www.who.int/gho/ihr/monitoring/human_resources/en/

IHR Core Capacity 3: Surveillance. Combined capacity score for (%) Indicator based, surveillance includes an early warning function for the early detection of a public health event (IHR Indicator 3.1.1); Event-Based Surveillance is established and functioning (IHR Indicator 3.2.1), by WHO Region.

Africa	2010	2011	2012	2013	2014	2015	2016
Americas	61	65	71	69	77	81	83
South-East Asia	59	77	82	87	89	92	90
Europe	65	70	78	77	81	87	92
Eastern Mediterranean	68	82	86	83	87	89	84
Western Pacific	66	80	80	84	83	80	86
Global	61	82	83	85	90	91	92

Source: http://www.who.int/gho/ihr/monitoring/surveillance/en/

IHR Core Capacity 4: Response. Combined capacity score for (%) Public health emergency response mechanisms are established and functioning. (IHR Indicator 4.1.1); and (%) Infection Prevention and Control (IPC) is established and functioning at national and hospital levels (IHR Indicator 4.2.1), by WHO Region.

WHO region	2010	2011	2012	2013	2014	2015	2016
Africa	47	56	62	66	72	79	73
Americas	62	75	78	84	85	85	88
South-East Asia	77	74	77	77	81	86	90
Europe	78	79	84	85	87	88	85
Eastern Mediterranean	76	74	73	78	81	90	87
Western Pacific	78	88	85	88	86	90	91

	Source: http://www.who.int/gho/ihr/monitoring/response/en/ **IHR Core Capacity 5: Preparedness. Combined capacity score for (%)** A Multi-hazard National Public Health Emergency Preparedness and Response Plan is developed and implemented. (IHR Indicator 5.1.1); and **(%) Priority public health risks and resources are mapped and utilized** (IHR Indicator 5.2.1), **by WHO Region.**

WHO region	2010	2011	2012	2013	2014	2015	2016
Africa	25	36	45	40	53	58	55
Americas	40	57	55	67	71	74	76
South-East Asia	42	58	59	69	75	72	82
Europe	60	69	77	73	78	82	82
Eastern Mediterranean	61	61	60	62	65	81	72
Western Pacific	68	72	70	78	78	85	91

Source: http://www.who.int/gho/ihr/monitoring/preparedness/en/

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	2.4 Climate information services for health
Methods	In 2015, the most recent year for which data are available, a total of 104 Members (54%) provided survey results. Response rates were 53% for Africa, 44% for Asia, 75% for South America, 68% North America, Central America and the Caribbean, 29% for the South-West Pacific, and 63% for Europe. This indicator measures the number of members (NHMS) who report to provide targeted/tailored climate information, products, and services to support user requirements in their countries for adaptation and climate risk management in key socio-economic sectors. Data were processed by WHO to focus on the proportion of countries that report providing tailored climate information, products and services to their public health sector.
Data	World Meteorological Organization. WMO (2016). Monitoring and Evaluation Report, January 2012 – December 2015. P 15. www.wmo.int/pages/about/documents/Monitoring_Performance_Evaluation_FinalReport_2012-2015.pdf
Caveats	These are self-reported results, they do not capture the type, source, quality or utility of data provided to the health sector, and nor do they do not capture the use of the data by the health sector. They do not reflect whether data is national or resulting from regional or global products. They do not reflect the potential use of all-sector forecasts or outlooks which are accessed and used by the health sector, nor climate services which may be provided by other sources than the NHMS. Analyses have been structured according to WHO regional definitions and some differences between WHO and WMO member states exist. WMO Members which are not WHO members, or are represented through different classifications were excluded from the analyses and include Macao, Hong Kong, Curaçao and St. Maarten, Dominica and British Caribbean Territories.

Future Form of Indicator	Future WMO surveys are currently being planned which are more specific to evaluate they type of products, user satisfaction, and application. These figures should be complemented by WHO Surveys of countries reporting to partner with their meteorological service and use climate information in routine ways for risk management.

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	2.5 National assessment of vulnerability, impacts and adaptation for health
Methods	See description of methods provided for indicator 2.1 above.
Data	WHO Climate and Health Country Survey
Caveats	See description of caveats provided for indicator 2.1 above.
Future Form of Indicator	The WHO Climate and Health Country Survey will be conducted biennially and will aim to gather data from all WHO member States, with the specific goal of doubling the number of survey respondents to 80 participating member states in the next iteration of the survey (2017). The 2017 country survey will not only gather data on the number of countries that have conducted a national assessment, but also on the use of assessment outcomes to inform policy and the allocation of financial and human resources in the health sector. Furthermore, this indicator could in future look to include more details of these national assessments, including how regularly they are updated; if there has been any action resulting from these assessments to address problems identified; and the involvement of health professionals in developing, undertaking and understanding these assessments.

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	2.6 Climate-resilient health infrastructure
Methods	See description of methods provided for indicator 2.1 above.
Data	WHO Climate and Health Country Survey
Caveats	See description of caveats provided for indicator 2.1 above.
Future Form of Indicator	The WHO Climate and Health Country Survey will be conducted biennially and will aim to gather data from all WHO member States, with the specific goal of doubling the number of survey respondents to 80 participating member states in the next iteration of the survey (2017). Future iterations of the WHO Climate and Health Country Survey will aim to collect data on whether national assessments of the climate resilience of health infrastructure and technology have been conducted and to what extent. Additionally, countries will be asked to report on the specific measures that have been taken to increase climate resilience of health infrastructure including the development of contingency plans to ensure access to and evacuation of hospital sites and the equipment of critical technologies, systems and services to continue functioning despite extreme climate-related events.

Additional Indicators

Working Group	2: Adaptation Planning and Resilience for Health
Indicator	Number of countries using climate information in integrated disease surveillance and response systems
Methods	See description of methods provided for indicator 2.1 above
Data	WHO Climate and Health Country Survey
Caveats	See description of caveats provided for indicator 2.1 above
Future Form of Indicator	The WHO Climate and Health Country Survey will be conducted biennially and will aim to gather data from all WHO member States, with the specific goal of doubling the number of survey respondents to 80 participating member states in the next iteration of the survey (2017). The WHO Climate and Health Country Survey will also aim to investigate more closely the use of climate information in the health sector. Countries will be asked to report whether climate information (short-term, seasonal or long-term data) is currently being used in surveillance, early warning and communication systems for specific climate-sensitive diseases and health outcomes, such as thermal stress, vector-borne diseases and air pollution.

Appendix 4 – Mitigation Actions and Health Co-Benefits

Working Group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.1: Carbon intensity of the energy system
Methods	Technical definition is the tonnes of CO_2 emitted for each unit (TJ) of primary energy supplied. The rationale for the indicator choice is that carbon intensity of the energy system will provide information on the level of fossil fuel use, which have associated air pollution impacts. Higher intensity values indicate a more fossil dominated system, and one that is likely to have a higher coal share. As countries pursue climate mitigation goals, the carbon intensity is likely to reduce with benefits for air pollution. The indicator is calculated based on total CO_2 emissions from fossil fuel combustion divided by Total Primary Energy Supply (TPES). TPES reflects the total amount of primary energy used in a specific country, accounting for the flow of energy imports and exports. The data are available for most countries of the world, for the period 1971-2013.
Data	This indicator is based on based on the energy balances from the International Energy Agency. The source reference is: International Energy Agency (2016): CO2 Emissions From Fuel Combustion: CO2 Indicators (Data downloaded: 10 March 2017). UK Data Service.
Caveats	The indicator does not provide information on the share of different fossil fuels, their use in different sectors, and the absolute levels of usage. These are all important elements in understanding the air pollution emissions,

	and their impacts. Therefore, additional indicators (3.2 & 3.3) provide additional complimentary information.
Future Form of Indicator	This indicator will need to be updated to provide the data for the most recent years, which have seen important shifts in the use of fossil fuels, particularly coal.

Working Group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.2. Coal phase-out.
Methods	Two indicators are used here; i) Total primary coal supply by region / country (in EJ units), and ii) Share of electricity generation from coal (% of total generation from coal). These indicators are important for enable a tracking of change in coal consumption at a regional and country level. Due to the level of coal used for power generation, a second indicator tracks the contribution to electricity generation from coal power plants in selected countries. As countries pursue climate mitigation goals, the use of coal is likely to reduce with benefits for air pollution. The indicator on primary energy coal supply is an aggregation of all coal types used across all sectors (from the IEA energy balances). The indicator on the share of electricity generation from coal is estimated based on electricity generated from coal plant as a percentage of total electricity generated. The data are available for most countries of the world, for the period 1971-2013. Only the period from 1990 has been used, due to data gaps for selected countries prior to 1990. Countries with large levels of coal use (as a share of generation, or in absolute terms), have been selected.
Data	This indicator is based on based on the energy balances from the International Energy Agency. The source reference is: *For total primary coal supply* - International Energy Agency (2015): Coal Information: World Coal Supply, 1960-2013 (Data downloaded: 11 November 2015). UK Data Service. *For data to compile share of electricity from coal generation* - International Energy Agency (2015): World Energy Balances: Extended Energy Balances, 1960-2014 (Data downloaded: 15 October 2015). UK Data Service.
Caveats	These indicators provides a proxy for air quality emissions associated with the combustion of coal. Further work is required to convert coal use by sector and type into emissions of different air quality pollutants.
Future Form of Indicator	In the future, this indicator set could be developed to also estimate the actual air pollutant emissions associated with coal use. This will require sectoral use, coal type (both of which are available) and appropriate emission factors. As per 3.1, this indicator will need to be updated to provide the data for the most recent years, which have seen important shifts in the use of coal.

Working Group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.3. Zero-carbon emission electricity.
Methods	Two indicators are used here, and presented in two ways; i) Total low carbon electricity generation, in absolute terms (TWh) and as a % share of total electricity generated (to include nuclear, and all renewables), and ii) Total renewable generation (excluding hydro), in TWh, and as a % share of total electricity generated. The increase in the use of low carbon and renewable energy for electricity generation will push other fossil fuels, such as coal, out of the mix over time, resulting in an improvement in air quality, with benefits to health. The renewables (excluding hydro) indicator has been used to allow for the tracking of rapidly emergent renewable technologies. For both indicators, generation, rather than capacity, has been chosen as a metric as the electricity generated from these technologies is what actually displaces fossil-based generation. Countries with large levels of low carbon generation (as shares, or in absolute terms), or with higher fossil dependency, have been selected. The data are again taken from the IEA energy balances. The absolute level indicators are total gross electricity generated aggregated from the relevant technology types. The share indicators are estimated as the low carbon or renewable generation as a % of total generation. The data are available for most countries of the world, for the period 1971-2013. Only the period from 1990 has been used, due to data gaps for selected countries prior to 1990.
Data	This indicator is based on based on the energy balances from the International Energy Agency. The source reference is: *For specific renewable and nuclear generation levels* - International Energy Agency (2015): World Energy Balances: Extended Energy Balances, 1960-2014 (Data downloaded: 15 October 2015). UK Data Service, *For total electricity generated* - International Energy Agency (2015): Electricity Information: World Electricity and Heat Supply and Consumption, 1960-2014 (Data downloaded: 11 November 2015).
Caveats	This indicator set does not provide information on the air pollutant emissions displaced due to the increasing share of RE generation.
Future Form of Indicator	This set should be developed to include an indicator to assess the direct impact on air quality emissions from additional low carbon generation, one approach being to compare the emission intensity of the current system with a counterfactual case, which does not have the additional share of RE generation.

Working Group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.4. Access to clean energy
Methods	Definition: "The proportion of population with primary reliance on clean fuels and technology is calculated as the number of people using clean

	fuels and technologies for cooking, heating and lighting divided by total population reporting that any cooking, heating or lighting, expressed as percentage. “Clean” is defined by the emission rate targets and specific fuel recommendations (i.e. against unprocessed coal and kerosene) included in the normative guidance WHO guidelines for indoor air quality: household fuel combustion.” [Above definition from SDG Metadata] The indicator is modelled with household survey data compiled by WHO. Estimates of primary cooking energy for the total, urban and rural population for a given year are obtained separately using a multilevel model (Bonjour et al., 2013)[1]. This is done at the country level.
Data	Estimates of fuel use are derived from WHO household survey data from ~800 nationally representative survey and censuses, including Demographic and Health Surveys (DHS) and Living Standards Measurement Surveys (LSMS), Multi-Indicator Cluster Surveys (MICS), the World Health Survey (WHS), and others. For cooking fuels, coverage of 157 countries is available through the WHO Global Household Energy Database. For lighting fuels, the WHO database includes data for 76 countries. For heating fuels, the WHO database includes data for 16 countries. Time series: From 1980 to 2014
Caveats	The indicator is based on the main type of fuel and technology used for cooking as cooking occupies the largest share of overall household energy needs. However, this will not reflect household fuel use activities when multiple fuels are used through the day or year. There is also a lack of data on the type of fuel and technologies used for home heating and lighting.
Future Form of Indicator	An ideal indicator going forward be further details on the fuel mix used by households for different demands (heating, cooling, cooking, hot water, lighting and other plug loads) for a range of income groupings within the country. The pressures of interest are the GHG and air pollution emissions that contribute to climate change and health outcomes, but also the increased access to energy use, which has broader socio-economic benefits.

Working group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.5 Exposure to ambient air pollution
Sub-Indicator	3.5.1 Exposure to air pollution in cities
Methods	This indicator measures urban background annual average concentration of fine particulate ($PM_{2.5}$) air pollution in selected cities. Measurements are

	from monitoring stations located in urban background, residential, commercial, and mixed areas.
Data	Data on annual average concentration of fine particulate ($PM_{2.5}$) air pollution in urban areas was compiled from the latest version of the WHO's Urban Ambient Air Pollution Database (2016 update). The database assembled air pollution data from public data sources including national/subnational reports and websites, regional networks, agencies (e.g. UN), and academic publications. The database contains estimated annual mean PM_{10} and $PM_{2.5}$ concentrations in almost 3,000 cities in 103 countries covering the period 2008 to 2015. The cities included in this indicator are 143 cities from the Sustainable Healthy Urban Environments (SHUE) database for which there was an air pollution estimate in the WHO data. SHUE is an initiative, funded by the Wellcome Trust, to support policy development in areas relating to environmental and health challenges and opportunities in cities. It aims to test the feasibility and methods of assembling data about the characteristics of a globally distributed sample of cities, and the populations within them, for comparative analyses, and to use such data to assess how policies may contribute to sustainable urban development and human health. Data on city-level GDP for SHUE cities were compiled from various sources, including the Brookings Institute, Organisation for Economic Co-operation and Development (OECD), and World Bank. Where city-level data was unavailable, regional or national data was used.
Caveats	• Data covers urban areas only (cities with >100,000 population). • Variations in the number of monitoring stations used in each city and their locations could influence levels. • There is poor coverage in some regions (esp. Africa). • Updating of the database is sporadic. Data are not specifically a measure of the health co-benefits of climate action (see below).
Future development of indicator	An ideal indicator would provide a marker of benefits for air quality and/or health that are directly attributable to climate change mitigation action (the WHO data represent only the levels of air pollution to which urban populations are currently exposed).

Working group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.5 Exposure to ambient air pollution
Sub-Indicator	3.5.2 Sectoral contributions to air pollution
Methods	This indicator quantifies contributions of each portion of the energy sector to key types of primary air pollution including sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter ($PM_{2.5}$), carbon monoxide (CO), volatile organic compounds (VOCs), and ammonia (NH_3).

Data	Data and figures are from the International Energy Agency (IEA), which used data from the International Institute for Applied Systems Analysis (IIASA) as collected for their Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model.
Caveats	• This indicator focuses specifically on the links between the energy sector and primary air pollution production, with data, analysis and projections in the report including energy production, transformation and use (i.e. the entire energy value chain, from extraction to final use). • This coverage includes both combustion and non-combustion emissions (e.g. process emissions in industry, non-tailpipe emissions in transport) • Data are broadly only specific to countries/regions (United States, Latin America, European Union, Middle East Africa, Russia, China, India, Southeast Asia) • Updating of the data outputs is sporadic – the IEA publication was a "special report" and not a routine publication. Data are not specifically a measure of the health co-benefits of climate action (see below).
Future development of indicator	An ideal indicator would directly map sources of primary air pollution to exposures and attributable health impacts on a country-level or more granularly. Furthermore, it would disaggregate air pollution sources by type (e.g. coal-fired power plant, cars) and include sources outside of the energy sector. In turn, it would be able to quantify the co-impacts on air quality and human health directly resulting from climate change mitigation efforts both in and outside of the energy sector.

Working group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.5 Exposure to ambient air pollution
Sub-Indicator	3.5.3 Premature mortality from ambient air pollution
Methods	This indicator quantifies contributions of individual source sectors to ambient $PM_{2.5}$ exposure and its health impacts.
Data	Estimates of sectoral source contributions to annual mean exposure to ambient $PM_{2.5}$ were calculated using the GAINS model (Amann et al., 2011), which combines bottom-up emission calculations with atmospheric chemistry and dispersion coefficients. Atmospheric transfer coefficients are based on full year simulations with the EMEP Chemistry Transport Model (Simpson et al. 2012) at 0.5°×0.5° resolution using meteorology of 2015 and include a downscaling to capture sub-grid urban concentration gradients. Calculated ambient $PM_{2.5}$ concentrations have been validated against in-situ observations from the latest version of the WHO's Urban Ambient Air Pollution Database (2016 update), and other sources where available (e.g. Chinese statistical yearbook). Premature deaths from total ambient $PM_{2.5}$ are calculated using the methodology of the WHO (2016) assessment on the burden of disease from ambient air pollution, which relies on integrated exposure response relationships (IERs) developed within the Global Burden of Disease 2013

	study (Forouzanfar et al., 2015). Disease and age specific baseline mortality rates are taken from the GBD Results database (http://ghdx.healthdata.org/gbd-results-tool). Attribution of estimated premature deaths from AAP to polluting sectors was done proportional to the contributions of individual sectors to population-weighted mean $PM_{2.5}$ in each country.
Caveats	• The indicator relies on model calculations which are currently available for a limited set of countries (Europe, South Asia, East Asia) • uncertainty in the shape of integrated exposure-response relationships (IERs) make the quantification of health burden inherently uncertain The non-linearity of the IERs used complicates the translation between the mortality burden attributed to an individual source, which is calculated proportional to the source contribution to ambient $PM_{2.5}$, and the effect of mitigating this source. While a reduction of emissions would lead to a (roughly) proportional reduction of ambient $PM_{2.5}$, this would not result in a proportional reduction of the health burden. In highly polluted environments, the health benefits of a marginal reduction of emissions would be disproportionately smaller than the relative change in concentrations.
Future development of indicator	An ideal indicator would provide a marker of benefits for air quality and/or health that are directly attributable to climate change mitigation action, which requires scenario analysis. Going beyond a sectoral split, a more explicit quantification of effects of fossil-fuel versus non-fossil fuel based activities should be undertaken. The spatial coverage should be expanded to global coverage, and other health indicators than premature deaths should be included for a more complete assessment of the health burden, particularly Years of Life Lost (YLLs) and Years Lived with Disability (YLDs).

Working Group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.6. Clean fuel use for transport
Methods	Fuel use data (by fuel type) from the IEA datasets are divided by corresponding population statistics from the World Bank.
Data	International Energy Agency (2015): World Energy Balances: Extended Energy Balances, 1960-2014 (Data downloaded: 15 October 2015). UK Data Service, DOI: http://dx.doi.org/10.5257/iea/web/2015] and World Bank, World Development Indicators, Version: 27 April 2017 http://data.worldbank.org/data-catalog/world-development-indicators The IEA dataset contains annual time series data for over the 30 OECD Member countries and 105 non-OECD countries world-wide. In OECD Member Countries, data are collected by official bodies (most often the national statistics office in each country) from firms, government agencies and industry organisations and are then reported to the IEA using questionnaires to ensure international comparability. In non-OECD countries the data are collected directly from government and industry

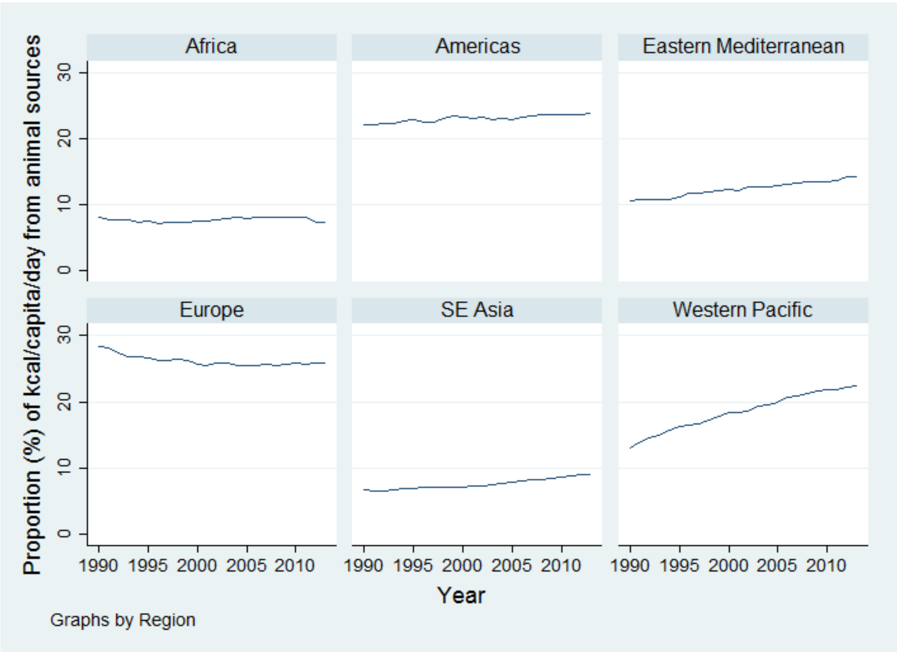
	contacts and from national publications. The World Bank dataset is updated quarterly and contains data compiled from officially-recognized international sources including the (1) United Nations Population Division. World Population Prospects, (2) census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report, (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme. It includes national, regional and global estimates.
Caveats	This indicator does not explicitly quantify the impact associated with transitioning to transport fuels that are less polluting, though it does provide trends that can be used as a proxy. It also cannot, at this time, be disaggregated to the urban level.
Future Form of Indicator	An ideal indicator would capture the direct health impacts of the use of transport fuels, with country- and urban-level specificity within the global coverage. In turn, the co-benefits of transitioning to less-polluting fuels would be quantified directly in terms of reduced exposures to air pollution and their corresponding health impact.

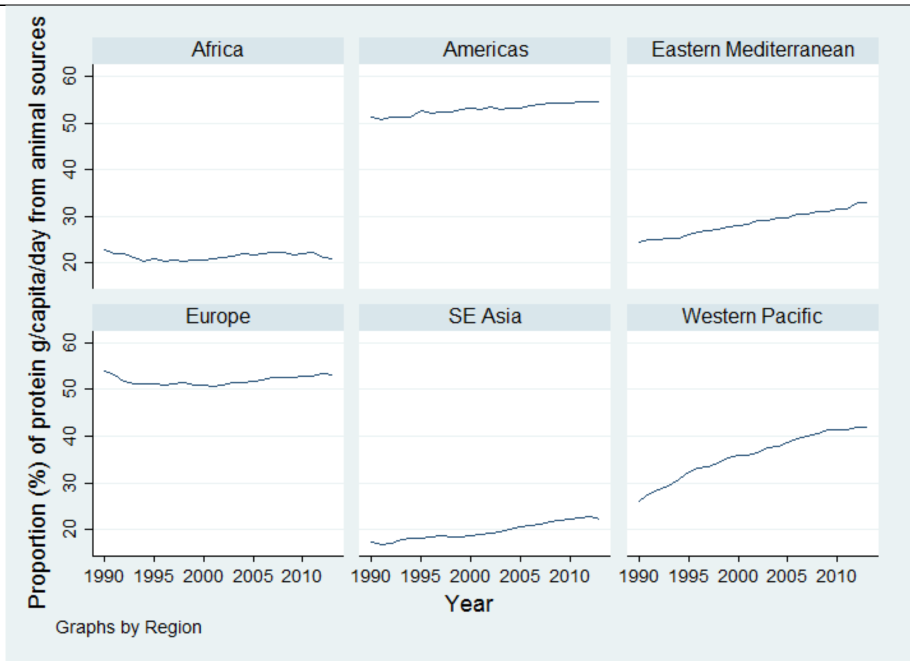
Working group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.7. Sustainable travel infrastructure and uptake
Methods	This indicator measures the proportion of journeys by travel mode (private transport, public transport, walking and cycling) in selected cities. An additional figure examines trends in modal share over time.
Data	T This indicator compiles data from an initial scoping of published proportions from travel surveys and census data. Data on modal share in select cities was collated in LTA Academy (2014) Passenger Transport in World Cities. *Journeys*. Original data sources are: **Tokyo:** Tokyo Metropolitan Area Travel Survey 2008 (in Japanese only, 東京都市圏パーソントリップ調査（交通実態調査）平成20年, Japan) **Osaka**: Osaka 5th Travel Survey Report 2012 (in Japanese, 平成 22年第５回近畿圏パーソントリップ調査集計結果から) **Paris:** Travel survey report (in French, La mobilité des Français, panorama issu de l'enquête nationale transports et déplacements 2008) **Vienna:** Vienna Wiener Linien Facts and Figures 2013 **Dehli:** RITES Transport Demand Forecast Study for Dept. of Transport, GNCTD, 2010 **Shanghai:** Shanghai Construction and Transport Commission 2009 **Sao Paulo:** San Paulo Household Mobility Survey 2012 Main Result (in Portuguese, PESQUISA DE MOBILIDADE DA REGIÃO METROPOLITANA DE SÃO PAULO, PRINCIPAIS RESULTADOS PESQUISA DOMICILIAR, DEZEMBRO

	DE 2013) **Berlin:** Berlin Mobility in the City 2013 **Bogota**: National Administrative Department of Statistics DANE Demand for transportation in Bogota 2010 (in Spanish, Cámara de Comercio de Bogotá Observatorio de Movilidad) **Singapore:** Household Interview Travel Survey 2012 **Prague**: Prague Transportation Yearbook 2013, Prague **London:** London Travel Demand Survey (LTDS) 2013, Transport for London **Bangalore:** Bangalore Mobility Indicators (2010 – 2011) Study – Draft Final Report **New York:** New York State 2009 NHTS Comparison Report **Stockholm:** Facts about SL and the metropolitan area in 2012 **Taipei:** Travel Survey 2013 (in Chinese, 102 年民眾日常使用運具狀況調查) **Ahmedabad:** Indian Cities Transport Indicators **Chicago:** Chicago Regional Household Travel Inventory: Mode Choice and Trip Purpose for the 2008 and 1990 Surveys, Chicago Metropolitan Agency for Planning **Melbourne**: Victorian Integrated Survey of Travel and Activity 2007 Data on trends in modal share comes from: **Berlin**: Institute for Mobility Research (2016) Mobility trends in cutting edge cities **London:** Transport for London (2016) Travel in London Report 9 **Sydney**: NSW Department of Transport (1996) Public transport travel patterns in the greater Sydney Metropolitan area 1981-1991; NSW Department of Transport (2003) Household Travel Survey Summary Report 2002; NSW Department of Transport (2009) Household Travel Survey Summary Report 2007; NSW Department of Transport (2017) Key Transport Indicators- How do people travel **Tokyo:** Institute for Mobility Research (2016) Mobility trends in cutting edge cities **Vancouver:** Translink (2012) 2011 Metro Vancouver Regional Trip Diary Survey Briefing Paper #1 **Santiago**: Institute for Mobility Research (2016) Mobility trends in cutting edge cities; Dictuc S.A. (1992) Estudio Encuesta origen destino de viajes del Gran Santiago, 1991
Caveats	This indicator provides information on sustainable travel uptake using available data on the proportion of all journeys in world cities made by private transport, public transport, walking and cycling. Both single year estimates of modal share and trends in modal share have a number of

	caveats. Data on modal share in cities: • The data presented in this indicator include the most recent data available for a particular city. Transport surveys in different cities and countries have different methods, which may limit comparability. Transport surveys also tend to undercount short trips (particularly those made by foot), with the amount of bias likely to vary between surveys. • Data on modal share classifies journeys by the main mode of travel. The main mode of travel is typically the mode that covers the most distance. This way of classifying journeys misses some sustainable travel that takes place as part of longer journeys with multiple stages. For instance, driving to a public transport station near the edge of the city and continuing the journey by public transport. • Data does not take into account distance travelled Data on trends in modal share has the additional caveat: The methodology of transport surveys changes over time, which may limit comparability even within one city.
Future development of indicator	The data currently included in this indicator come from an initial scoping of available data. An ideal indicator would include data from a systematic search of travel data in all selected cities and countries. This may involve contacting survey teams in different countries to provide estimates or access to the desired data. To more fully capture sustainable uptake a future indicator could collate data on the proportion of total distance travelled made by different modes of transport. Other data on sustainable travel infrastructure, for instance, the presence of cycle schemes would be useful.

Working group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.8. Ruminant meat for human consumption
Methods	Total amount of ruminant meat available for consumption (kg/capita/year) and proportion of energy available from ruminant meat for human consumption (%) compared to all sources of energy, aggregated by WHO region from country-specific data over 1990–2013.
Data	Data comes from UN Food and Agriculture Organization (FAO) Food Balance Sheets. The country-specific data was compiled by the statistics division of the FAO from the national supply and utilization accounts of primary foods and processed commodities, adding food imports, subtracting food exports, food fed to animals, and waste/losses (assumed as 10%), adjusting for changes in food stocks, and dividing country population (mostly mid-year population estimates).
Caveats	All sources of data have some notable limitations. Estimates from each country use different calculation methods and include different elements, limiting comparability. In the UK, there have been changes in the method of

	estimating emissions over time. Although we used the amount and proportion of energy from ruminant meat as a proxy indicator for food groups with some of the highest levels of GHG emissions, it is important to note that emissions are also high for other food groups, especially from other meat and dairy products. The graphs below show the proportion of energy available from animal products and the proportion of protein available from animal products. The proportion of energy available from animal products is highest in the Americas, where trends suggest a slight increase, and Europe, where trends suggest a slight decrease. Proportions are notably low in South East Asia. Trends suggest proportion of energy from animal products is increasing most rapidly in the Western Pacific with slower increases apparent in the Eastern Mediterranean and South East Asia. The proportion of protein avaialbe from animal products follows similar trends to the proportion of energy from animal products: highest in the Americas and Europe, lowest in South East Asia, and growing most rapidly in the Western Pacific. These measures on animal product availability may be useful for tracking progress on shifting away from animal intensive products to more a more plant based diets. However, since the evidence relating consumption of non-red meat and dairy products to adverse health outcomes is currently less clear than for consumption of red meat, we did not include any measure of animal product availability in the core indicators. 

	
Future development of indicator	An ideal method for tracking progress would use a set of indicators reflecting climate and health progress at each level of the DPSEEA framework. For the development of such indicators, considerable effort is required in terms of systematic data collection (e.g. emission and actual food intake data) and methodological developments for context-sensitive data collection, monitoring, and definition of targets for sustainable food production and consumption, particularly in terms of GHG-intensity and health impact.

Working group	3. Mitigation Actions and Health Co-Benefits
Indicator	3.9. Healthcare sector emissions
Methods	This indicator collects data on the $MtCO_2e$ attributable to the health care sector from published reports.
Data source	Data from the UK comes from published reports from the Sustainable Development Unit (NHS). Estimates of GHG emissions include emissions from building energy use, travel to and from sites, and goods and services purchased from the health care sector. Data from the US comes from an article by Eckelman & Sherman (2016) [3]. Estimates are modelled using data on health care expenditures. Data from Australia comes from a published report from the Department of Health in Victoria. Estimates take into account GHG associated with products and food purchased by one municipality (Southern Health), waste, and transportation. To extrapolate to the whole Victorian Health system estimates from Southern Health were scaled up to all of Victoria using separations (as a measure of activity) and floor area.
Caveats	All sources of data have some notable limitations. Estimates from each country use different calculation methods and include different elements, limiting comparability. In the UK, there have been changes in the method of estimating emissions over time. Finally, the indicator does not adjust for

	the size (or changes in the size) of the health care system.
The future (ideal) indicators	A future set of indicators would reflect country-wide GHG emissions of health care systems with denominators of the system size and volume of health care service provision. Indicators should be available at each level of policy and managerial decision-making to inform choices and facilitate selection of policies and organizational operations with lowest GHG emission levels. Additionally, efficiency of health care system performance in relation to climate change can be evaluated by modelling global health risks attributed to the GHG emissions of each health care system as a proportion of their contribution to the health of the population. Mitigation strategies could be designed in collaboration with relevant sectors, such as the insurance sector or health care commissioners and providers.

References

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[2] Hawkesworth S, Dangour AD, Johnston D, Lock K, Poole N, Rushton J, et al. Feeding the world healthily: the challenge of measuring the effects of agriculture on health. Philos Trans R Soc B Biol Sci 2010;365:3083–97. doi:10.1098/rstb.2010.0122.

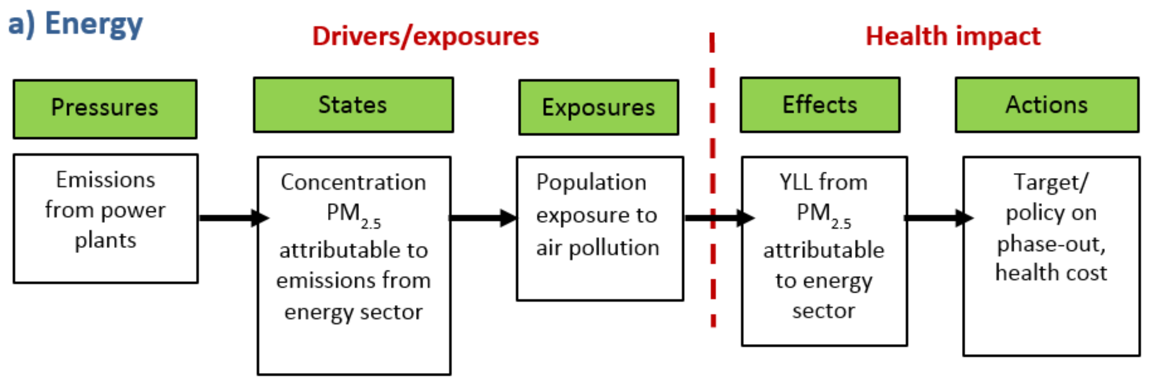
[3] Eckelman MJ, Sherman J. Environmental impacts of the U.S. health care system and effects on public health. PLoS One 2016;11:1–14. doi:10.1371/journal.pone.0157014.

DPSEEA framework - adapted for processes that produce health-co-benefits of climate change mitigation

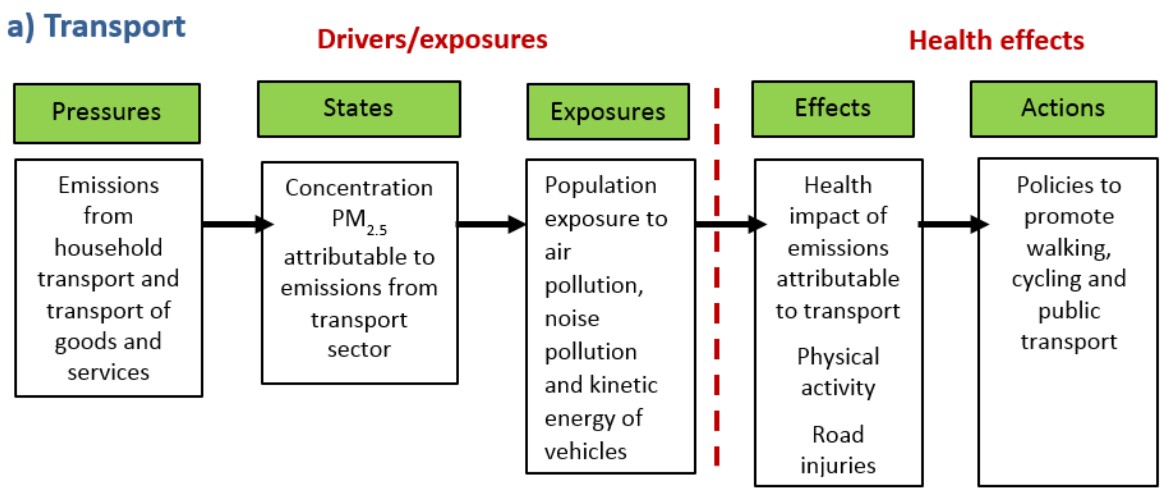
Framework	Explanation	Indicator examples	Indicator	Indicator purpose	A: Level of action

elements			specification			
D: Driving force	Key macro-scale factors driving processes that lead to GHG emissions and consequences for human health, i.e., root causes of the problems	Population growth rate, GDP per capita and growth rate, annual energy consumption levels	Overall	Macro-level progress relevant to climate change and health	Macro-level policies (trade, fiscal, energy, agricultural policy)	**Preventative**
mediators	*Factors determining the extent to which driving forces are translated into pressures*	*Policy context, social attitudes, economic infrastructure*				
P: Pressure	Rate of specific activities (often part of production, consumption), which exert unfavourable pressure on natural social and human environment	Domestic consumption of gas, coal, etc., road traffic volume and density, source-specific GHG emissions, meat production	Sector-specific and overall	Sustainability of human activities	Sector-specific policies regulating relevant activities	
mediators	*Intensity of the pressure exerted by specific activities and permeability of the environmental media to these pressures*	*GHG-intensity of electricity supply, vehicle pollution-intensity, pollution control strategies, resilience of the environment*				
S: State	Extent to which the atmosphere, natural social and human environment (e.g., infrastructure) and behaviour, are changed as a result of the exerted pressures	GHG concentration in the atmosphere, pollution levels, food environments and typical diets	Sector-specific	Early warning with short lead-times	Immediate response-action by local government authorities and individuals	
mediators	*People's activities, behaviour patterns*	*Time spent indoors/outdoors, actual food consumption*				
E: Exposure	The extent of the change in the state of the environment that humans come into with in such manner that it can affect their physiological or mental functioning (health)	External exposure, absorbed dose, target organ dose	Sector-specific	Exposure level assessment	Exposure mitigation, therapeutic treatment provision	**curative**
mediators	*Individual susceptibility*	*Baseline health status, genetic make-up, sex*				
E: Effect	Attributable human health and wellbeing outcomes	Attributable morbidity and mortality	Sector-specific	Impact evaluation	Individual-level medication	

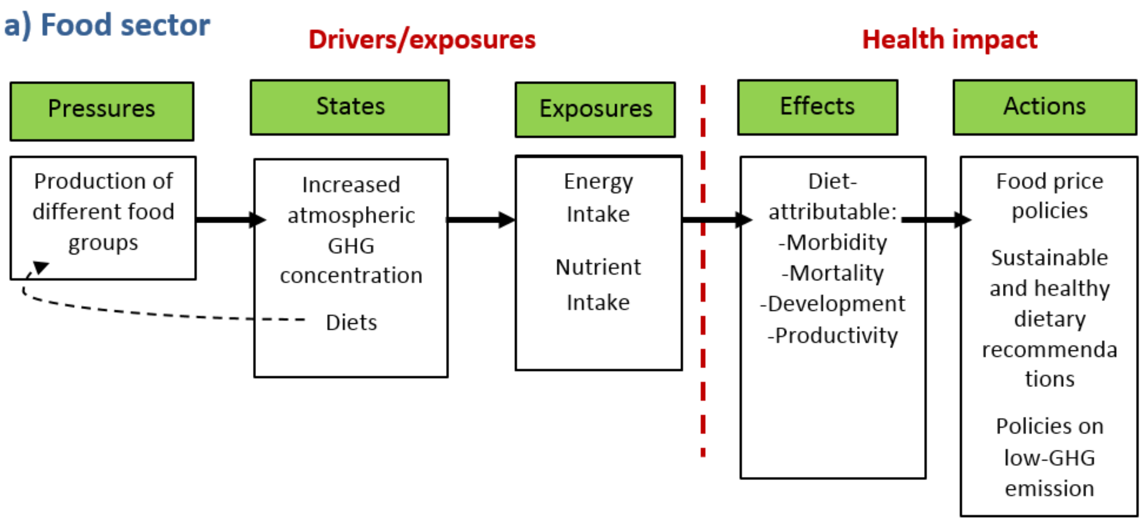
DPSEEA Framework applied to Energy Sector



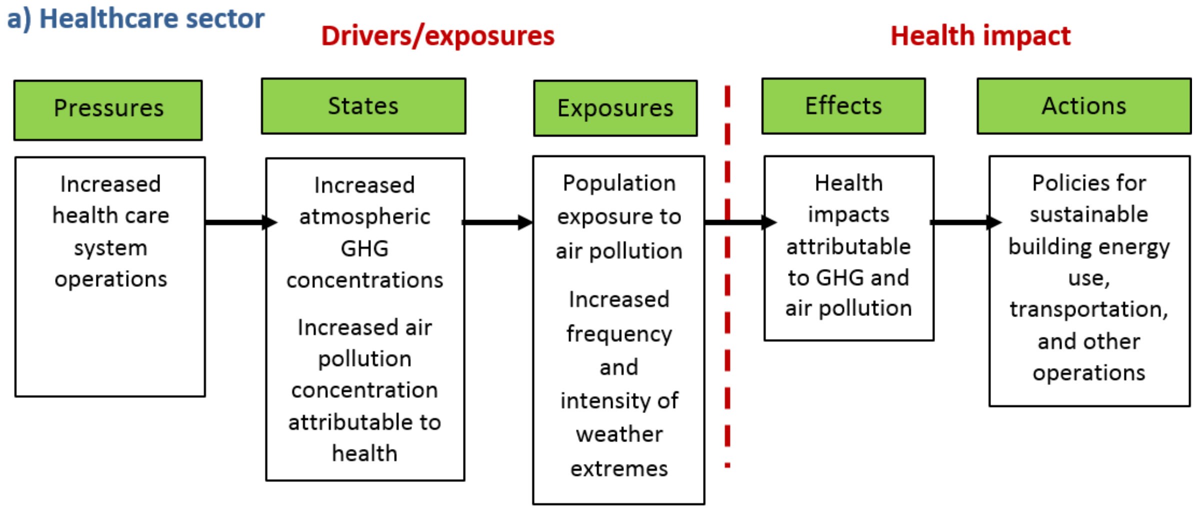
DPSEEA Framework applied to Transport Sector



DPSEEA Framework applied to Food Sector



DPSEEA Framework applied to Health Sector



Appendix 5 – Economics and Finance

Working Group	4. Economics and Finance
Indicator	4.1. Investments in Zero-Carbon Energy and Energy Efficiency
Methods	The data for this indicator are sourced from the annual IEA *World Energy Investment* publication. Four categories of investment are defined: ***Renewables & Nuclear*** – investment in all renewable and nuclear electricity generation, and renewable transport and heating (including biofuels and solar thermal heating) ***Energy Efficiency*** – See below. ***Electricity Networks*** – investment in electricity transmission and distribution infrastructure. ***Fossil Fuels*** – including oil, gas and coal, upstream mining, drilling and pipeline infrastructure, and coal, gas and oil power and other energy generation capacity. For most sectors, 'investment' is defined as overnight capital expenditures on new assets. For some sectors, such as power generation, this investment is attributed to the year in which a new plant or the upgrade of an existing one becomes operational. For other sources, such as upstream oil and gas and LNG projects, where sufficient data are available, investment reflects the capital spending incurred over time as production from a new source ramps up to maintain output from an existing asset. For energy efficiency, 'investment' is defined as incremental spending by companies, governments and individuals to acquire equipment that consumes less energy than that which they would otherwise have bought. Other areas of expenditure, including operation and maintenance, research and development, financing costs, mergers and acquisitions or public markets transactions, are not included. Investment estimates are derived from IEA data for energy demand, supply and trade, and estimates of unit capacity costs, For more information, see IEA (2016[i],2017[ii]). Here, 'renewables and nuclear' includes investment in all renewable and nuclear electricity generation capacity, and renewable transport and heating (including biofuels and solar thermal heating). 'Electricity networks' includes investment in electricity transmission and distribution infrastructure. Investment in fossil fuels includes upstream mining, drilling and pipeline infrastructure for oil, gas and coal, and power and other energy generation capacity for the use of these fuels. For these categories, investment' is defined as overnight capital expenditures on new assets. For energy efficiency, 'investment' is defined as incremental spending by companies, governments and individuals to acquire equipment that consumes less energy than that which they would otherwise have bought.
Data	

	Values presented below are in US$2016, billion. <table><tr><td></td><td>2015</td><td>2016</td></tr><tr><td>Renewables & Nuclear</td><td>$353</td><td>347</td></tr><tr><td>Energy Efficiency</td><td>$223</td><td>234</td></tr><tr><td>Electricity Networks</td><td>$266</td><td>281</td></tr><tr><td>Fossil Fuels</td><td>$984</td><td>837</td></tr><tr><td>Total</td><td>$1,827</td><td>$1,675</td></tr></table>
Caveats	See 'Methods'
Future Form of Indicator	It is not envisaged that the form of this indicator will change over time.

Working Group	4. Economics and Finance
Indicator	4.2. Investments in Coal Capacity
Methods	See indicator 4.1
Data	<table><tr><td rowspan="6">Index (100 = 2006)</td><td>2006</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td></tr><tr><td>100</td><td>109</td><td>106</td><td>106</td><td>122</td></tr><tr><td>2011</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td></tr><tr><td>122</td><td>122</td><td>103</td><td>103</td><td>144</td></tr><tr><td>2016</td><td></td><td></td><td></td><td></td></tr><tr><td>123</td><td></td><td></td><td></td><td></td></tr></table>
Caveats	See indicator 4.1
Future Form of Indicator	It is not envisaged that the form of this indicator will change over time.

Working Group	4. Economics and Finance
Indicator	4.3. Funds Divested from Fossil Fuels
Methods	The data for this indicator are collected and provided by 350.org.[iii] They represent the total assets (or assets under management, AUM) for institutions that have publicly committed to divest in 2016 (for which data is available), with non-US$ values converted using the market exchange rate when the commitment was made, and thus do not directly represent the actual sums divested from fossil fuel companies. A company is committed to 'divestment' if it falls into any of the following five categories: **- 'Fossil Free' -** An institution or corporation that does not have any investments (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) in fossil fuel companies (coal, oil, natural gas) and committed to avoid any fossil fuel investments in the future **- 'Full' - A**n institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing

	shares, corporate bonds) from any fossil fuel company (coal, oil, natural gas). **- 'Partial' -** An institution or corporation that made a binding commitment to divest across asset classes from some fossil fuel companies (coal, oil, natural gas), or to divest from all fossil fuel companies (coal, oil, natural gas), but only in specific asset classes (e.g. direct investments, domestic equity). **- 'Coal and Tar Sands' -** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any coal and tar sands companies. **- 'Coal only' -** An institution or corporation that made a binding commitment to divest (direct ownership, shares, commingled mutual funds containing shares, corporate bonds) from any coal companies.
Data	Due to confidentiality issue, the full dataset is not available for publication. However, interested readers may visit the 350.org website for further information. [i]
Caveats	See 'Methods'.
Future Form of Indicator	The ideal future form of this indicator would have two elements. The first element would track the value of institutional investments in fossil fuels assets, both in absolute terms and as a proportion of their total portfolios. This would also allow for tracking of associated funds that are moved out of fossil fuels, but are not explicitly advertised as 'divesting'. However, such data is unlikely to be available. As such, an indicator that aligns with the data compiled by Bouvet, L and Kirjanas, P. (2017)[iv] will be investigated. The second element of this indicator would more explicitly track the value of funds divested from fossil fuels by healthcare institutions. The data provided for the indicator in this paper may be improved upon through, for example, the issuance of annual surveys either as part of other data collection efforts from healthcare institutions, or independently. The feasibility of each option will be investigated for future publications.
Additional Information	Just 17 organisations recorded as committed to divestment above are 'for-profit' corporations (however, these account for $3.16 trillion (58%) of the total asset value presented above). Pension funds and other institutional investors (for example, insurance companies), which in 2013 held assets under management worth $93 trillion in the OECD alone (larger than the sum of global economic output in that year - $76.8 trillion), also account for a small proportion of the organisations committed to divestment (12% at the end of 2016).[232,233] Institutional investors are substantial investors in fossil fuel companies, due to the historically sizable, yet stable returns generated. Policy makers are increasingly keen to encourage (or require) institutional investors to properly assess and disclose their exposure to climate-related risk. In December 2015, the Financial Stability Board established the 'Task Force on Climate-Related Finance Disclosures', with the aim of developing financial risk assessment and disclosure approaches related to the physical, liability and transition risks associated with climate change. In June 2017, the Task Force published their final report on recommendations to achieve this objective.[234,235] In January 2017, the European Union (EU) introduced

	the recast IORP ('Institutions for occupational retirement provision') Directive, which states that IORPs (pension funds) '…as part of their risk management system… should include…risks related to climate change…[and] to the depreciation of assets due to regulatory change ('stranded assets').[236]

<table>
<tr><td>Working Group</td><td>4. Economics and Finance</td></tr>
<tr><td>Indicator</td><td>4.4. Economic Losses due to Climate-Related Events</td></tr>
<tr><td>Methods</td><td>
Munch Re NatCatSERVICE provided the data for this indicator. The NatCatSERVICE is a global database of natural catastrophe ('nat cat') data. Munich Re has been systematically recording information on natural catastrophe loss events from around the world since 1994. This has developed into one of the world's most comprehensive databases for information on natural catastrophe loss events. Data suitable for systematic and analytical evaluation on a worldwide scale are available from 1980 onwards. For this paper, a base year of 1990 was chosen in order to align with the base year against which GHG emission reduction targets are commonly set.
NatCatSERVICE collect a range of information for around 1,200 events each year. For this paper, aside from descriptive and locational information, only data on direct economic loss (physical/tangible losses, expressed in US$2016), insured losses (all paid-out insured physical/tangible losses) and fatalities are used. Please refer to the online NatCatSERVICE Methodology document, which may be found online (http://natcatservice.munichre.com/assets/pdf/NatCatSERVICE_Methodology.pdf).
The Table below illustrates the 'peril classification' provided by NatCatSERVICE. Perils classified as Meteorological, Hydrological and Climatological have been included in the analysis. Geophysical perils are excluded, due to their general independence from climate change.
<table>
<tr><th>Family</th><th>Main Event</th><th>Sub-Peril</th></tr>
<tr><td>Geophysical</td><td>Earthquake
Volcanic Eruption
Mass Movement (Dry)</td><td>Earthquake (ground shaking)
Fire Following
Tsunami
Volcanic Eruption
Ash Cloud
Subsidence
Rockfall
Landslide (Dry)</td></tr>
<tr><td>Meteorological</td><td>Tropical Storm
Extra-Tropical Storm
Convective Storm
Local Windstorm</td><td>Winter Storm (extra-tropical cyclone)
Hail Storm
Lightning
Tornado
Local Windstorm
Sand/dust storm
Blizzard/Snowstorm
Storm Surge</td></tr>
<tr><td>Hydrological</td><td>Flood
Mass Movement (Wet)</td><td>General Flood
Flash Flood
Glacial Lake Outburst</td></tr>
</table>
</td></tr>
</table>

		Subsidence Avalanche Landslide (Wet)
Climatological	Extreme Temperature Drought Wildfire	Heat Wave Cold Wave/Frost Extreme Winter Conditions Wildfire Drought

Each natural catastrophe event recorded is assigned a direct economic loss, and where applicable, an insured loss, expressed in nominal US$ values. Where these are available, data are taken from official institutions, but where not, estimates are calculated. The process for estimation calculation depends on what data is available. For example, if loss estimates from insurance market data is available, this data may be combined with data on insurance penetration and other event-specific information to estimate total economic losses. If only low-quality information is available, such as a description of the number of homes damaged or destroyed, assumptions on value and costs are made.

Loss values are presented in US$, or if initially expressed in local currency, converted to US$ using the market exchange rates at the end of the month when the event occurred. Values are converted to US$2016 using country-specific Consume Price Indices (CPI).

Once the data was received from the NatCatSERVICE, further analysis was undertaken. Firstly, each country was assigned to its income group as defined by the World Bank. Secondly, to allow 'intensity' calculations as illustrated in Figure 2, economic losses (insured and uninsured) were divided by annual GDP values for each income grouping, sourced from the World Bank Database and deflated to US$2016 using data sourced from the US Department of Commerce Bureau of Economic Analysis.[v] 2016 data for GDP is estimated by multiplying the 2015 value by the average annual the growth rate from the previous 5 years. Fatality data were divided by the relevant annual population of each income grouping, also sourced from the World Bank Database (with 2016 data estimated using same approach as for GDP). Values presented in the paper text are rounded to the nearest 0.05.

Data

		Number of Events	Total Fatalities	Overall Losses US$m (adjusted to 2016 values based on Country CPI)	Insured Losses US$m (adjusted to 2016 values based on Country CPI)	Insured Losses/$1000 GDP (US$2016)	Uninsured Losses/$1000 GDP (US$2016)	Fatalities/Million Population
1990	Low Income	20	444	$219	$0	$0.00	$1.36	1.38
	Lower-Middle	90	5,244	$3,777	$0	$0.00	$2.51	2.75
	Upper-Middle	85	2,064	$8,660	$126	$0.03	$1.92	1.00
	High Income	217	1,013	$52,929	$22,696	$0.72	$0.96	1.01
1991	Low Income	12	1,769	$417	$0	$0.00	$0.26	5.35
	Lower-Middle	75	148,998	$10,652	$357	$0.26	$7.37	76.53
	Upper-Middle	89	3,826	$20,712	$1,005	$0.21	$4.14	1.84

	High Income	158	741	$44,147	$20,693	$0.65	$0.74	0.73
1992	Low Income	8	1,055	$513	$0	$0.00	$3.78	3.10
	Lower-Middle	86	6,438	$6,660	$0	$0.00	$4.63	3.24
	Upper-Middle	109	2,332	$14,769	$37	$0.01	$3.26	1.10
	High Income	187	436	$88,707	$45,412	$1.34	$1.28	0.43
1993	Low Income	24	1,858	$678	$0	$0.00	$5.11	5.31
	Lower-Middle	118	6,040	$20,940	$0	$0.00	$14.71	2.98
	Upper-Middle	151	4,051	$20,813	$163	$0.03	$4.30	1.90
	High Income	203	1,142	$67,250	$17,375	$0.52	$1.49	1.12
1994	Low Income	24	1,933	$221	$0	$0.00	$2.01	5.37
	Lower-Middle	106	5,004	$4,501	$0	$0.00	$2.96	2.42
	Upper-Middle	125	3,385	$23,341	$208	$0.04	$4.52	1.57
	High Income	203	737	$39,474	$10,976	$0.31	$0.81	0.71
1995	Low Income	17	581	$23,702	$0	$0.00	$190.71	1.57
	Lower-Middle	104	5,864	$4,974	$97	$0.06	$2.92	2.78
	Upper-Middle	136	4,044	$19,923	$802	$0.14	$3.42	1.85
	High Income	209	1,349	$42,864	$20,103	$0.53	$0.60	1.30
1996	Low Income	27	767	$3,688	$0	$0.00	$27.29	2.02
	Lower-Middle	99	6,509	$8,211	$73	$0.04	$4.52	3.03
	Upper-Middle	141	4,086	$25,643	$654	$0.11	$4.16	1.85
	High Income	202	914	$47,523	$17,882	$0.47	$0.78	0.87
1997	Low Income	29	2,860	$373	$0	$0.00	$2.69	7.32
	Lower-Middle	83	4,292	$5,162	$13	$0.01	$2.82	1.96
	Upper-Middle	121	3,196	$16,291	$552	$0.09	$2.51	1.43
	High Income	186	967	$36,012	$7,806	$0.21	$0.77	0.92
1998	Low Income	38	885	$517	$0	$0.00	$3.73	2.20
	Lower-Middle	111	29,054	$31,114	$1,073	$0.66	$18.36	13.02
	Upper-Middle	125	9,197	$45,755	$1,263	$0.21	$7.28	4.07
	High Income	227	1,731	$65,158	$24,960	$0.69	$1.11	1.63
1999	Low Income	37	858	$505	$3	$0.02	$3.68	2.08
	Lower-Middle	109	14,148	$6,662	$221	$0.13	$3.68	6.23
	Upper-Middle	133	3,866	$26,725	$772	$0.14	$4.56	1.69
	High Income	212	1,532	$71,883	$37,429	$0.99	$0.92	1.43
2000	Low Income	57	1,546	$1,193	$1	$0.01	$6.59	3.65
	Lower-Middle	122	4,952	$8,896	$49	$0.03	$4.89	2.14
	Upper-Middle	136	1,919	$7,504	$87	$0.01	$1.21	0.83
	High Income	204	833	$42,374	$13,942	$0.37	$0.76	0.77
2001	Low Income	40	1,086	$340	$0	$0.00	$2.51	2.49
	Lower-Middle	116	3,398	$2,518	$0	$0.00	$1.41	1.44
	Upper-	126	3,246	$7,541	$495	$0.08	$1.16	1.40

		Middle							
		High Income	182	761	$29,286	$15,168	$0.42	$0.39	0.70
	2002	Low Income	30	861	$372	$0	$0.00	$2.58	1.92
		Lower-Middle	111	4,118	$4,676	$552	$0.29	$2.19	1.72
		Upper-Middle	130	2,169	$17,996	$583	$0.10	$2.90	0.92
		High Income	180	686	$75,757	$22,684	$0.61	$1.42	0.63
	2003	Low Income	42	827	$324	$0	$0.00	$2.09	1.80
		Lower-Middle	107	7,802	$1,618	$0	$0.00	$0.76	3.22
		Upper-Middle	118	1,987	$22,792	$78	$0.01	$3.43	0.84
		High Income	182	69,038	$59,677	$23,084	$0.56	$0.89	62.93
	2004	Low Income	21	4,000	$1,083	$0	$0.00	$6.28	8.46
		Lower-Middle	84	4,146	$8,673	$0	$0.00	$3.68	1.68
		Upper-Middle	122	2,695	$28,429	$614	$0.08	$3.59	1.13
		High Income	197	927	$105,799	$53,263	$1.20	$1.18	0.84
	2005	Low Income	38	1,193	$985	$0	$0.00	$5.11	2.45
		Lower-Middle	117	5,389	$11,864	$1,242	$0.47	$4.05	2.14
		Upper-Middle	155	2,123	$28,810	$2,327	$0.26	$2.93	0.88
		High Income	197	2,447	$227,268	$114,541	$2.51	$2.47	2.20
	2006	Low Income	53	2,274	$509	$0	$0.00	$2.45	4.55
		Lower-Middle	149	5,701	$14,726	$600	$0.20	$4.69	2.23
		Upper-Middle	139	2,724	$15,925	$443	$0.04	$1.48	1.13
		High Income	265	2,926	$38,246	$18,232	$0.39	$0.43	2.61
	2007	Low Income	72	1,936	$980	$0	$0.00	$4.06	3.77
		Lower-Middle	182	10,134	$16,875	$674	$0.19	$4.55	3.90
		Upper-Middle	199	2,441	$27,932	$2,402	$0.19	$2.02	1.00
		High Income	234	1,388	$49,095	$24,703	$0.50	$0.49	1.23
	2008	Low Income	52	2,145	$647	$0	$0.00	$2.27	4.07
		Lower-Middle	131	144,552	$9,758	$1	$0.00	$2.50	54.82
		Upper-Middle	146	2,011	$46,260	$2,065	$0.14	$2.91	0.82
		High Income	195	595	$89,096	$45,700	$0.88	$0.84	0.52
	2009	Low Income	55	656	$791	$7	$0.02	$2.64	1.21
		Lower-Middle	169	5,495	$10,313	$519	$0.13	$2.46	2.05
		Upper-Middle	146	1,169	$13,054	$368	$0.03	$0.87	0.47
		High Income	218	2,176	$46,221	$23,182	$0.48	$0.48	1.90
	2010	Low Income	65	1,246	$498	$0	$0.00	$1.57	2.24
		Lower-Middle	177	5,917	$17,094	$201	$0.04	$3.38	2.18
		Upper-Middle	149	60,982	$43,587	$1,591	$0.09	$2.42	24.45
		High Income	234	790	$54,515	$29,614	$0.59	$0.50	0.68
	2011	Low Income	60	447	$1,038	$0	$0.00	$2.96	0.78
		Lower-Middle	147	5,097	$8,850	$37	$0.01	$1.59	1.85

	Upper-Middle	141	3,438	$56,665	$15,240	$0.75	$2.03	1.37
	High Income	220	1,227	$95,613	$54,807	$1.04	$0.77	1.06
2012	Low Income	85	1,409	$1,153	$0	$0.00	$3.10	2.39
	Lower-Middle	184	4,596	$7,026	$633	$0.11	$1.13	1.64
	Upper-Middle	198	2,396	$24,690	$1,005	$0.05	$1.11	0.95
	High Income	252	1,097	$128,763	$63,385	$1.23	$1.26	0.94
2013	Low Income	54	1,014	$210	$0	$0.00	$0.53	1.68
	Lower-Middle	159	15,390	$19,442	$1,808	$0.31	$3.03	5.41
	Upper-Middle	188	1,880	$43,806	$2,881	$0.13	$1.83	0.74
	High Income	234	1,346	$63,286	$31,593	$0.61	$0.62	1.15
2014	Low Income	70	1,472	$331	$13	$0.03	$0.76	2.37
	Lower-Middle	176	3,539	$14,986	$772	$0.13	$2.37	1.23
	Upper-Middle	205	1,415	$31,803	$1,672	$0.07	$1.33	0.55
	High Income	275	797	$49,987	$28,698	$0.56	$0.41	0.68
2015	Low Income	80	1,518	$1,473	$7	$0.02	$3.67	2.38
	Lower-Middle	244	7,939	$15,267	$1,649	$0.28	$2.29	2.71
	Upper-Middle	219	1,680	$27,580	$1,083	$0.05	$1.27	0.65
	High Income	288	4,684	$51,650	$29,165	$0.61	$0.47	3.95
2016	Low Income	84	1,864	$2,358	$25	$0.06	$5.56	2.84
	Lower-Middle	221	4,013	$7,552	$370	$0.06	$1.16	1.35
	Upper-Middle	227	1,631	$49,754	$2,628	$0.12	$2.16	0.62
	High Income	265	632	$69,753	$37,193	$0.78	$0.68	0.53

Caveats	See 'Method'.
Future Form of Indicator	An ideal form of this indicator would allow attribution of fatalities and economic losses to events induced by climate change. However, such attribution is unlikely to be feasible over the course of the Lancet Countdown. As such, it is not envisaged that this indicator will significantly alter.

Working Group	4. Economics and Finance
Indicator	4.5. Employment in Low-Carbon and High-Carbon Sectors
Methods	The data for this indicator is sourced from IRENA (2017)[vi] (renewables) and IBISWorld (2016[vii]; 2017[viii]) (fossil fuel extraction). Bioenergy includes liquid biofuels, solid biomass and biogas. 'Other technologies' includes geothermal energy, small hydropower, concentrated solar power, municipal and industrial waste, and ocean energy. Fossil fuel extraction values include direct employment, whereas renewable energy jobs include direct and indirect employment (e.g. equipment manufacturing).

Data	<table><tr><td></td><td colspan="5">**Million Jobs**</td></tr><tr><td></td><td>**2012**</td><td>**2013**</td><td>**2014**</td><td>**2015**</td><td>**2016**</td></tr><tr><td>Large Hydropower</td><td>1.41</td><td>1.74</td><td>1.66</td><td>1.63</td><td>1.52</td></tr><tr><td>Other Technologies</td><td>0.33</td><td>0.38</td><td>0.4</td><td>0.4</td><td>0.45</td></tr><tr><td>Solar Heating/Cooling</td><td>0.89</td><td>0.5</td><td>0.76</td><td>0.94</td><td>0.83</td></tr><tr><td>Wind Energy</td><td>0.75</td><td>0.83</td><td>1.03</td><td>1.08</td><td>1.16</td></tr><tr><td>Bioenergy</td><td>2.4</td><td>2.5</td><td>2.99</td><td>2.88</td><td>2.74</td></tr><tr><td>Solar Photovoltaic</td><td>1.36</td><td>2.27</td><td>2.49</td><td>2.77</td><td>3.09</td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Fossil Fuel Extraction</td><td>8.90</td><td>9.04</td><td>9.11</td><td>8.82</td><td>8.64</td></tr></table> The data for this indictor is sourced from IRENA (renewables) and IBIS World (fossil fuel extraction). 25,26, 27 Bioenergy includes liquid biofuels, soil biomass and biogas. 'Other technologies' includes geothermal energy, small hydropower, concentrated solar power, municipal and industrial waste, and ocean energy. Fossil fuel extraction values include direct employment, whereas renewable energy jobs include direct and indirect employment (e.g. equipment manufacturing).
Caveats	Fossil fuel extraction values include direct employment, whereas renewable energy jobs include direct and indirect employment (e.g. equipment manufacturing).
Future Form of Indicator	An ideal future form of this indicator would track both direct and indirect employment from the renewables and fossil fuel extraction industries, along with the geographical distribution in their change over time. This would allow for an assessment of substitution. However, at present such data is unavailable, and impractical to collect for the purposes of the Lancet Countdown alone.

Working Group	4. Economics and Finance
Indicator	4.6. Fossil Fuel Subsidies
Methods	The data for this indicator are taken from the International Energy Agency (IEA), and is calculated using the price-gap approach, for 42 mostly non-OECD countries (see data below). The 'price-gap' approach is the most commonly applied methodology for quantifying consumption subsidies. It compares average end-user prices paid by consumers with reference prices that correspond to the full cost of supply. The price gap is the amount by which an end-use price falls short of the reference price and its existence indicates the presence of a subsidy. Prices are converted to US2016 using data sourced from the US Department of Commerce Bureau of Economic Analysis.[v] To view the original data, a full description of the price-gap approach and the data employed to calculate it, please see IEA (2017)[ix]
Data	IEA Data (US$2016) <table><tr><td>**Country**</td><td>**Product**</td><td>**2012**</td><td>**2013**</td><td>**2014**</td><td>**2015**</td></tr><tr><td rowspan="3">Algeria</td><td>Oil</td><td>$12,926</td><td>$11,251</td><td>$10,970</td><td>$9,409</td></tr><tr><td>Electricity</td><td>$2,606</td><td>$2,408</td><td>$2,393</td><td>$2,676</td></tr><tr><td>Natural</td><td>$4,274</td><td>$3,017</td><td>$2,549</td><td>$2,326</td></tr></table>

		Gas				
		Coal	$0	$0	$0	$0
		Total	$19,910	$16,676	$15,912	$14,411
	Angola	Oil	$1,772	$1,520	$1,778	$208
		Electricity	$417	$354	$174	$233
		Natural Gas	$0	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$2,189	$1,874	$1,952	$441
	Argentina	Oil	$1,042	$1,308	$2,358	$1,586
		Electricity	$4,795	$6,162	$7,272	$5,494
		Natural Gas	$4,378	$5,415	$5,041	$3,541
		Coal	$0	$0	$0	$0
		Total	$10,215	$12,885	$14,671	$10,621
	Azerbaijan	Oil	$938	$816	$215	$30
		Electricity	$625	$504	$361	$533
		Natural Gas	$938	$705	$478	$495
		Coal	$0	$0	$0	$0
		Total	$2,502	$2,025	$1,054	$1,058
	Bahrain	Oil	$938	$759	$712	$455
		Electricity	$1,564	$1,443	$1,305	$1,238
		Natural Gas	$0	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$2,397	$2,203	$2,016	$1,694
	Bangladesh	Oil	$938	$645	$247	$252
		Electricity	$4,378	$1,909	$961	$587
		Natural Gas	$3,544	$2,692	$2,071	$1,701
		Coal	$0	$0	$0	$0
		Total	$8,965	$5,246	$3,278	$2,541
	Bolivia	Oil	$1,251	$1,637	$1,525	$1,160
		Electricity	$104	$181	$156	$67
		Natural Gas	$208	$230	$175	$118
		Coal	$0	$0	$0	$0
		Total	$1,564	$2,047	$1,856	$1,345
	Brunei	Oil	$417	$255	$236	$165
		Electricity	$104	$40	$21	$16
		Natural Gas	$0	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$521	$296	$257	$181
	China	Oil	$17,199	$12,702	$12,613	$12,354
		Electricity	$13,655	$14,765	$11,357	$7,167
		Natural Gas	$1,251	$2,015	$2,680	$0
		Coal	$0	$0	$0	$0
		Total	$32,001	$29,482	$26,650	$19,521
	Chinese Taipei	Oil	$104	$325	$162	$0
		Electricity	$0	$75	$0	$0
		Natural Gas	$0	$0	$0	$0

		Coal	$0	$106	$0	$0
		Total	$104	$506	$162	$3
	Colombia	Oil	$6,567	$1	$0	$0
		Electricity	$313	$0	$0	$0
		Natural Gas	$0	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$6,880	$1	$0	$0
	Ecuador	Oil	$22,724	$5,739	$5,019	$2,270
		Electricity	$6,776	$577	$541	$0
		Natural Gas	$2,085	$0	$0	$6
		Coal	$0	$0	$0	$0
		Total	$31,480	$6,316	$5,560	$2,276
	Egypt	Oil	$104	$21,061	$17,221	$8,604
		Electricity	$417	$7,109	$5,596	$4,816
		Natural Gas	$0	$2,641	$1,749	$234
		Coal	$0	$0	$0	$0
		Total	$521	$30,811	$24,565	$13,654
	El Salvador	Oil	$0	$1	$2	$4
		Electricity	$0	$526	$457	$238
		Natural Gas	$0	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$0	$528	$459	$242
	Gabon	Oil	$0	$53	$47	$152
		Electricity	$0	$6	$0	$0
		Natural Gas	$0	$0	$1	$1
		Coal	$0	$0	$0	$0
		Total	$0	$59	$47	$153
	Ghana	Oil	$41,070	$56	$40	$16
		Electricity	$3,336	$0	$0	$0
		Natural Gas	$2,814	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$47,220	$56	$40	$16
	India	Oil	$23,975	$36,104	$28,015	$14,699
		Electricity	$5,942	$5,377	$3,432	$2,520
		Natural Gas	$0	$4,257	$4,614	$2,277
		Coal	$0	$0	$0	$0
		Total	$29,917	$45,737	$36,061	$19,496
	Indonesia	Oil	$15,219	$19,986	$19,904	$9,205
		Electricity	$2,085	$8,713	$13,433	$6,335
		Natural Gas	$104	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$17,408	$28,698	$33,337	$15,540
	Iraq	Oil	$24,705	$9,423	$7,815	$3,818
		Electricity	$11,154	$1,730	$1,428	$1,807
		Natural Gas	$20,327	$83	$70	$385
		Coal	$0	$0	$0	$0

		Total	$56,185	$11,235	$9,313	$6,009
	Iran	Oil	$1,668	$30,851	$38,073	$21,217
		Electricity	$2,293	$11,134	$14,766	$13,756
		Natural Gas	$730	$18,565	$21,168	$18,202
		Coal	$2,606	$0	$0	$0
		Total	$7,297	$60,550	$74,008	$53,174
	Kazakhstan	Oil	$0	$1,631	$2,060	$842
		Electricity	$0	$490	$403	$612
		Natural Gas	$0	$508	$406	$676
		Coal	$208	$1,580	$1,371	$1,079
		Total	$208	$4,209	$4,241	$3,209
	Korea	Oil	$4,170	$0	$0	$0
		Electricity	$3,857	$0	$0	$0
		Natural Gas	$1,876	$0	$0	$0
		Coal	$0	$190	$192	$117
		Total	$9,903	$190	$192	$117
	Kuwait	Oil	$5,212	$2,732	$2,496	$1,458
		Electricity	$938	$2,880	$2,793	$3,734
		Natural Gas	$104	$1,120	$931	$919
		Coal	$0	$0	$0	$0
		Total	$6,254	$6,731	$6,221	$6,111
	Libya	Oil	$5,733	$5,994	$6,166	$3,726
		Electricity	$208	$820	$702	$519
		Natural Gas	$1,042	$82	$74	$10
		Coal	$0	$0	$0	$0
		Total	$6,984	$6,896	$6,942	$4,256
	Malaysia	Oil	$17,616	$7,146	$4,460	$1,090
		Electricity	$1,355	$94	$0	$0
		Natural Gas	$1,042	$77	$0	$0
		Coal	$0	$0	$0	$0
		Total	$19,910	$7,317	$4,460	$1,090
	Mexico	Oil	$7,401	$8,088	$2,516	$21
		Electricity	$104	$6,001	$5,358	$5,459
		Natural Gas	$521	$1,429	$582	$581
		Coal	$0	$0	$0	$0
		Total	$8,026	$15,517	$8,457	$6,062
	Nigeria	Oil	$0	$5,059	$4,120	$2,884
		Electricity	$0	$214	$0	$0
		Natural Gas	$0	$398	$97	$49
		Coal	$0	$0	$0	$0
		Total	$0	$5,672	$4,217	$2,933
	Oman	Oil	$730	$0	$2,121	$89
		Electricity	$3,127	$0	$1,132	$0
		Natural Gas	$8,131	$0	$1,856	$0
		Coal	$0	$0	$0	$0
		Total	$11,987	$0	$5,109	$89

	Pakistan	Oil	$2,606	$105	$164	$118
		Electricity	$2,189	$2,679	$2,394	$743
		Natural Gas	$1,668	$6,079	$4,931	$2,630
		Coal	$0	$0	$0	$0
		Total	$6,463	$8,864	$7,489	$3,492
	Qatar	Oil	$0	$2,596	$1,954	$944
		Electricity	$20,327	$1,744	$2,034	$1,506
		Natural Gas	$21,056	$1,373	$1,428	$971
		Coal	$0	$0	$0	$0
		Total	$41,383	$5,713	$5,416	$3,421
	Russia	Oil	$48,158	$0	$0	$0
		Electricity	$15,740	$15,569	$15,388	$15,578
		Natural Gas	$12,717	$15,207	$14,020	$15,202
		Coal	$0	$0	$0	$0
		Total	$76,511	$30,776	$29,408	$30,780
	Saudi Arabia	Oil	$313	$42,070	$41,929	$29,914
		Electricity	$313	$12,278	$11,699	$12,653
		Natural Gas	$0	$8,218	$7,029	$6,794
		Coal	$0	$0	$0	$0
		Total	$625	$62,567	$60,656	$49,361
	South Africa	Oil	$417	$0	$0	$0
		Electricity	$625	$0	$0	$2,628
		Natural Gas	$0	$0	$0	$0
		Coal	$208	$0	$0	$0
		Total	$1,251	$0	$0	$2,628
	Sri Lanka	Oil	$3,023	$208	$199	$58
		Electricity	$3,961	$86	$157	$88
		Natural Gas	$1,564	$0	$0	$0
		Coal	$834	$0	$0	$0
		Total	$9,382	$295	$357	$145
	Thailand	Oil	$313	$2,193	$1,625	$719
		Electricity	$417	$331	$0	$0
		Natural Gas	$0	$637	$369	$191
		Coal	$0	$163	$79	$0
		Total	$730	$3,324	$2,073	$909
	Trinidad and Tobago	Oil	$4,274	$616	$544	$365
		Electricity	$1,251	$496	$414	$321
		Natural Gas	$4,899	$0	$0	$0
		Coal	$0	$0	$0	$0
		Total	$10,424	$1,112	$958	$686
	Turkmenistan	Oil	$0	$2,741	$2,552	$2,204
		Electricity	$4,378	$913	$804	$928
		Natural Gas	$10,424	$3,200	$2,393	$2,439
		Coal	$0	$0	$0	$0
		Total	$14,698	$6,853	$5,750	$5,571
	Ukraine	Oil	$4,795	$0	$0	$0

	Electricity	$6,671	$2,314	$2,956	$3,194
	Natural Gas	$13,655	$4,225	$3,350	$3,120
	Coal	$0	$0	$0	$0
	Total	$25,122	$6,539	$6,305	$6,314
UAE	Oil	$730	$5,180	$3,875	$1,181
	Electricity	$2,606	$3,661	$3,076	$1,993
	Natural Gas	$10,632	$9,208	$7,949	$6,883
	Coal	$0	$0	$0	$0
	Total	$13,968	$18,049	$14,900	$10,057
Uzbekistan	Oil	$18,033	$529	$458	$216
	Electricity	$3,544	$1,955	$1,339	$1,084
	Natural Gas	$2,814	$7,951	$6,983	$5,248
	Coal	$0	$0	$0	$0
	Total	$24,288	$10,435	$8,780	$6,548
Venezuela	Oil	$417	$25,985	$21,632	$14,847
	Electricity	$4,482	$9,567	$7,113	$3,144
	Natural Gas	$730	$4,702	$3,361	$2,230
	Coal	$0	$0	$0	$0
	Total	$5,629	$40,253	$32,107	$20,221
Vietnam	Oil	$0	$17	$0	$0
	Electricity	$0	$1,309	$795	$36
	Natural Gas	$0	$502	$250	$175
	Coal	$0	$6	$3	$3
	Total	$0	$1,834	$1,049	$214

Caveats	The data for this indicator is provided by the IEA, and calculated using the price-gap approach, for 42 mostly non-OECD countries (see Appendix 5 for further details). Fossil fuel production subsidies and consumption subsidies for most OECD countries are not included, due to the lack of consistent data. However, the vast majority of fossil fuel subsidies are consumer subsidies in non-OECD countries. In 2014, consumer subsidies in OECD countries were worth less than 14% of the non-OECD value, with producer subsidies worth around 4%.[248] As such, the indicator presented provides a broad overview of global trends in fossil fuel subsidies.
Future Form of Indicator	An ideal future form of this indicator would have two key elements. The first element would be the consistent inclusion of production and consumption subsidies for all countries, available on an annual basis. The second element would be the use of this data, along with that of carbon pricing data (see Indicator 4.9), to create a since 'net carbon price' indicator. The future practicality of this indicator will depend on the availability of data at the appropriate level of granularity.

Working Group	4. Economics and Finance
Indicator	4.7. Coverage and Strength of Carbon Pricing

Methods	The World Bank provides the data for this indicator, through the interactive 'Carbon Pricing Dashboard'.[x] Prices for 2016 and 2017 are those as of 1st August 2016 and 1st April 2017, respectively. For 2017, the indicator includes only instruments that had been introduced by 1st April 2017. Baseline-and-credit systems are excluded from the analysis. GHG coverage data is presented as a proportion of 2012 global anthropogenic GHG emissions (53, 937 $MTCO_2e$) as calculated by EDGAR (Emissions Database for Global Atmospheric Research)[xi]. Monetary values are presented in US$, in current prices.

Data

	2016			2017		
Instrument	**Emissions Covered ($MtCO_2e$)**	**% Global Emissions Covered**	**Price (1st August 2017)**	**Emissions Covered ($MtCO_2e$)**	**% Global Emissions Covered**	**Price (1st April 2017)**
Alberta SGER	117	0.002169181	15.37529374	117	0.002169181	22.53953576
Alberta carbon tax	-	-	-	117	0.002169181	15.02635717
BC carbon tax	42	0.000779978	23.0629406	42.07	0.000779978	22.53953576
Beijing pilot ETS	85	0.001569319	8.034194853	84.645	0.001569319	7.566369379
California CaT	378	0.007002356	12.8	377.689	0.007002356	13.81
Chile carbon tax	-	-	-	50.9044415	0.000943769	5
Chongqing pilot ETS	97	0.00180283	1.205204553	97.24	0.00180283	0.870698433
Colombia carbon tax	-	-	-	52.26475294	0.000968989	5.207904198
Denmark carbon tax	22	0.000400222	25.61075831	21.58693116	0.000400222	24.7801806
EU ETS	2132	0.03952433	4.87867152	2131.840256	0.03952433	4.992703384
Estonia carbon tax	1	1.41E-05	2.232801611	0.76	1.41E-05	2.138202734
Finland carbon tax	25	0.000465168	64.75124672	25.08995822	0.000465168	66.28428476
France carbon tax	176	0.003256221	24.56081772	175.632171	0.003256221	32.6075917
Fujian pilot ETS	-	-	-	200	0.003708001	5.021027628
Guangdong pilot ETS	366	0.006791204	1.325725008	366.3	0.006791204	2.230439151
Hubei pilot ETS	162	0.003005057	2.118147002	162.085	0.003005057	2.461174236
Iceland carbon tax	3	5.62E-05	9.525006283	3.029756537	5.62E-05	10.52552559
Ireland carbon tax	31	0.000570884	22.32801611	30.792	0.000570884	21.38202734
Japan carbon tax	999	0.018529386	2.821153932	999.4272087	0.018529386	2.579206433
Korea ETS	453	0.00839688	15.14615635	452.9059931	0.00839688	18.45713097
Latvia carbon tax	2	3.81E-05	3.90740282	2.055018436	3.81E-05	4.810956152
Liechtenstein carbon tax	0	1.11E-06	86.18920583	0.059925838	1.11E-06	83.91650714
Mexico carbon tax	307	0.0056979	2.661882377	307.33	0.0056979	2.741612717
New Zealand ETS	40	0.00073876	13.03209949	39.8467998	0.00073876	12.02453564
Norway carbon tax	38	0.000706783	51.53240376	38.122038	0.000706783	51.83839129
Ontario CaT	-	-	-	136.858	0.002537348	13.58382688
Poland carbon tax	16	0.000288055	0.073671375	15.53693138	0.000288055	0.073501755
Portugal carbon tax	21	0.000385663	7.446393373	20.80167748	0.000385663	7.323344364
Quebec CaT	67	0.00123393	12.8	66.555	0.00123393	13.81
RGGI	94	0.001746482	5.237045204	94.20074809	0.001746482	3.450233414

Saitama ETS	7	0.000130403	14.64266747	7.0336	0.000130403	13.3868846
Shanghai pilot ETS	170	0.003146035	1.322711997	169.689	0.003146035	5.66969796
Shenzhen pilot ETS	61	0.001134648	5.644876826	61.2	0.001134648	5.080525354
Slovenia carbon tax	5	9.19E-05	19.31373394	4.958970808	9.19E-05	18.49545365
Sweden carbon tax	26	0.00048471	130.5009117	26.14402793	0.00048471	126.2568512
Switzerland ETS	6	0.000110348	9.234557767	5.951891	0.000110348	6.493539243
Switzerland carbon tax	18	0.000333257	86.18920583	17.97501032	0.000333257	83.91650714
Tianjin pilot ETS	118	0.002192356	2.19949831	118.25	0.002192356	1.966327293
Tokyo CaT	14	0.000258077	14.64266747	13.92	0.000258077	13.3868846
UK carbon price floor	136	0.002529755	23.72570555	136.4484747	0.002529755	22.41451148
Ukraine carbon tax	287	0.005321162	0.013298355	287.0097431	0.005321162	0.013668267

Caveats	Instrument coverage of GHG emissions, in both absolute and proportional term, are based on total anthropogenic GHG emissions in 2012 – the last year in which consistent data was available. 'Baseline and Credit' instruments are not included due to a lack of price data. Some instruments experience an overlap in coverage. For example, the UK Carbon Price Floor applies to the power sector in the UK, which is also subject to carbon pricing under the EU ETS. Other instruments experience only partial overlap. As such, total emissions coverage is likely to be overestimated (*ceteris paribus*), although this effect is likely to be minor. The price used to calculate the weighted average prices are the prevailing prices on a single day. The prices for many instruments (particularly ETS instruments) are likely to alter of the course of a year, however the effect on the final value is likely to be minor. Prices are presented in current values.
Future Form of Indicator	See Indicator 4.7. – Fossil Fuel Subsidies.

Working Group	4. Economics and Finance
Indicator	4.8. Use of Carbon Pricing Revenues
Methods	Data on revenue generated is provided by the World Bank's interactive 'Carbon Pricing Dashboard'.[Error! Bookmark not defined.] Data for the division into the four categories of revenue expenditure are provided largely by Carl and Fedor (2016), supplemented by external sources (as described below). The method of revenue expenditure classification is also adapted from Carl and Fedor (2016)[xii]. Definitions and assumptions regarding the categories as applied in this paper are as follows: **Climate Change Mitigation** – revenues are explicitly allocated to activities or infrastructure that seeks to reduce, or enable the reduction, of greenhouse gas emissions, from any source, within or outside of the sectors or jurisdiction in which the carbon price is applied. **Climate Change Adaptation** – as above, but for adaptation activities or infrastructure. **Environmental Tax Reform (ETR)** – revenues are explicitly returned to some broad

portion of the population through individual or business tax rate cuts, tax eliminations, or rebates in order to achieve broad revenue neutrality. Revenue returned to directly compensate for the cost of GHG emissions (through free permit allocation or targeted assistance for energy-intensive, trade-exposed firms) are not included).

General Funds – revenues are explicitly used for purposes other than those described above, or the use of revenues is unspecified or information is unavailable.

Only revenue that may be considered government income is included. For example, revenue generated by sale of permits issued to utilities under the Californian cap and trade instrument, which much then be used to finance discounts on household energy bills through 'carbon credits', are not considered, as this revenue does not pass through the State government. Instruments for which price data is not available, either due to the type of instrument or simply lack of data, are not included.

Other assumptions as applied to individual instruments are described below.

Data

			Revenue Allocation				
	Revenue (US$2016 million)		Mitigation	Adaptation	Environmental Tax Reform (ETR)	General Funds	Note
Alberta SGER	101.88	%	93.5%	2.0%	0.0%	4.5%	(3)
		$	$95.3	$2.0	$0.0	$4.6	
Quebec CaT	336.06	%	94.4%	0.0%	0.0%	5.6%	(4)
		$	$317.2	$0.0	$0.0	$18.8	
Switzerland ETS	4.01	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$4.0	
Fujian Pilot ETS	0.51	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$0.5	
Guangdong Pilot ETS	1.56	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$1.6	
EU ETS	4,214.61	%	64.8%	21.0%	0.0%	14.2%	(5)
		$	$2,731.1	$885.1	$0.0	$598.5	
New Zealand ETS	0.0005	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$0.0	
RGGI	266.47	%	80.0%	0.0%	15.0%	5.0%	(6)
		$	$213.2	$0.0	$40.0	$13.3	
California CaT	901.10	%	97.8%	1.0%	0.0%	1.2%	(7)
		$	$881.3	$9.0	$0.0	$10.8	
BC Carbon Tax	902.33	%	0.0%	0.0%	100.0%	0.0%	(8)
		$	$0.0	$0.0	$902.3	$0.0	
Switzerland Carbon Tax	1,002.00	%	35.8%	0.0%	64.2%	0.0%	(9)
		$	$359.1	$0.0	$643.0	$0.0	
Denmark Carbon Tax	531.83	%	0.0%	0.0%	50%	50%	(2)
		$	$0.0	$0.0	$265.9	$265.9	
Estonia Carbon Tax	2.68	%	2.68	2.68	2.68	2.68	(1)
		$	$0.0	$0.0	$0.0	$2.7	
Finland Carbon Tax	1,262.21	%	0.0%	0.0%	50.0%	50.0%	(2)
		$	$0.0	$0.0	$631.1	$631.1	
France Carbon Tax	4,062.59	%	38.0%	0.0%	0.0%	62.0%	(2)
		$	$1,543.8	$0.0	$0.0	$2,518.8	
Ireland Carbon Tax	465.06	%	11.9%	0.0%	0.0%	88.1%	(2)
		$	$55.3	$0.0	$0.0	$409.7	
Iceland Carbon Tax	31.56	%	31.56	31.56	31.56	31.56	(2)
		$	$0.0	$0.0	$0.0	$31.6	
Japan Carbon Tax	2,340.92	%	100.0%	0.0%	0.0%	0.0%	(2)
		$	$2,340.9	$0.0	$0.0	$0.0	
Lichtenstein Carbon Tax	4.76	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$4.8	
Latvia Carbon Tax	6.35	%	40.0%	0.0%	0.0%	60.0%	(10)
		$	$2.5	$0.0	$0.0	$3.8	

Mexico Carbon Tax	440.41	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$440.4	
Norway Carbon Tax	1,486.88	%	30.0%	0.0%	30.0%	40.0%	(11)
		$	$446.1	$0.0	$446.1	$594.8	
Poland Carbon Tax	1.14	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$1.1	
Portugal Carbon Tax	133.09	%	0.0%	0.0%	100.0%	0.0%	(12)
		$	$0.0	$0.0	$133.1	$0.0	
Sweden Carbon Tax	2,556.00	%	0.0%	0.0%	50.0%	50.0%	(2)
		$	$0.0	$0.0	$1,278.0	$1,278.0	
Slovenia Carbon Tax	79.06	%	33.3%	0.0%	0.0%	66.7%	(2)
		$	$26.4	$0.0	$0.0	$52.7	
Ukraine Carbon Tax	3.24	%	0.0%	0.0%	0.0%	100.0%	(1)
		$	$0.0	$0.0	$0.0	$3.2	
UK Carbon Price Floor	1,168.88	%	0.0%	0.0%	0.0%	100.0%	(13)
		$	$0.0	$0.0	$0.0	$1,168.9	
Total	**22,307.19**	**%**	**40.4%**	**4.0%**	**19.5%**	**36.1%**	
		$	**$9,012.1**	**$896.1**	**$4,339.4**	**$8,059.6**	

(1) No Data Available
(2) Carl and Fedor (2016)
(3) CAN$312.8 million total revenue allocated so far (excluding admin costs), CAN$7 million (2.2%) to adaptation with remainder to mitigation. Around CAN$6 million operating costs in 2016 (US$ 4.5 million). It is assumed these proportions apply to 2016 revenue allocations. Source: CCEMC (2016)[xiii]
(4) All programs thus far are mitigation-related (despite objective that funds are for both mitigation and adaptation). CAN$25 million operating costs for fund in 2015/2016 (~US$19,000), with this proportion assumed to remain constant. Source: Fondsvert (2016) *Comptes 2016 2016 Du Fonds Vert*, Ministére Du Développement Durable, De L'Environment et de La Lutte Contre Les Changements Climatiques, Québec
(5) Based on Figure 5 in Velten et al (2016)[xiv]. It is assumed that revenue allocation proportions remain constant. It is also assumed that 'cross-cutting action', 'Other' and 'non-specified' funding channels are 50% mitigation, 50% adaptation. All 'non-climate' spending is assumed to go to general funds.
(6) Based on Chart 4 in RGGI (2016)[xv]. It is assumed that revenue allocation proportions remain constant.
(7) All funds listed as allocated to programs listed in Appendix B of CCI (2017)[xvi] are considered to be 'mitigation' allocations, except for the 'Urban Greening Program', for which the value allocated to adaptation is assumed at 10%. Cumulative budget allocations are assumed to remain constant. The cumulative value for program support are allocated as 'general funds' and assumed to be spread equally across years.
(8) BCMOF (2015) *Carbon Tax*, [online] Available at: http://www.fin.gov.bc.ca/tbs/tp/climate/carbon_tax.htm
(9) For 2013-20, two thirds of revenue (to a cap of CHF 300 million) is to be spent on building sector emission reduction efforts. CHF 25 million per year also allocated to loan guarantee 'Technology Fund' (CHF1 roughly equal to US$1). Remainder recycled through various means. Values assumed to remain constant across the period. Source: Carl and Fedor (2016).
(10) 40% for 'climate change measures in 2016', assumed to be mitigation. Remainder unknown. Source: World Bank (2017).
(11) Assumed all 'green subsidies' as allocated in Carl and Fedor (2016) are for climate change mitigation.
(12) Pereira *et al* (2015)[xvii]
(13) Ares and Delebarre (2016)[xviii]

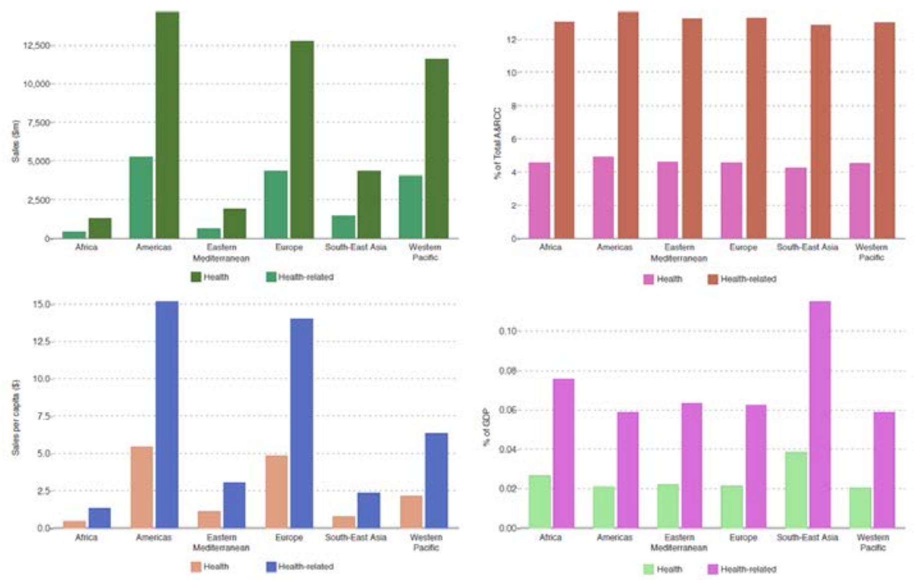
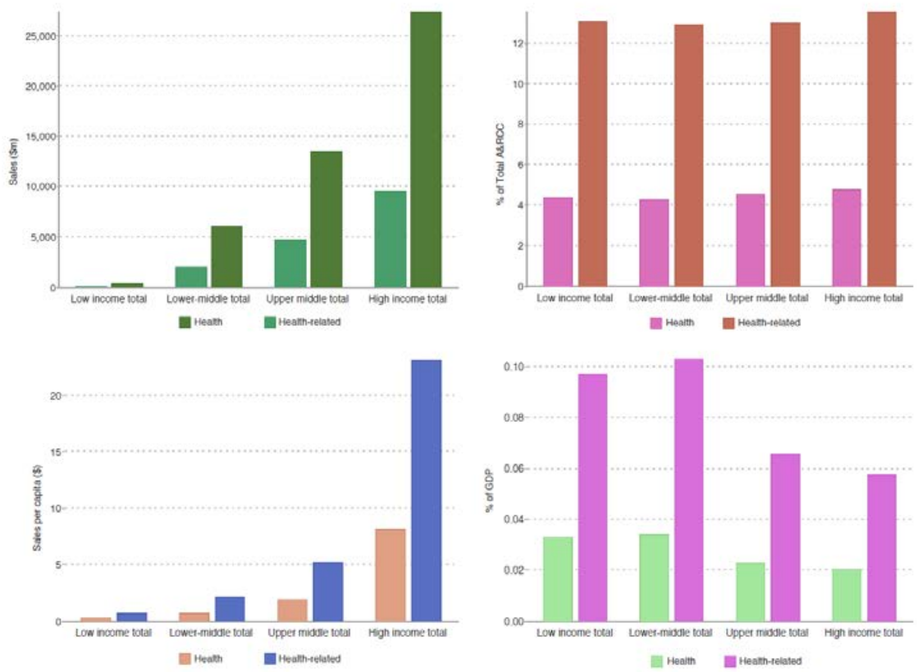
Caveats	See 'Methods' and 'Data' sections
Future Form of Indicator	An ideal form of this indicator would also measure the extent to which revenues are allocated to health-related measures. The availability of such data, or the possibility to collect it, will be investigated for future publications.

Working Group	4. Economics and Finance
Indicator	4.9 Spending on adaptation for health and health-related activities
Methods	The 'Adaptation and Resilience to Climate Change' dataset measures spending on economic activities related to adaptation and resilience to climate change. It was developed by data research firm kMatrix in partnership with numerous stakeholders, and includes the key adaptation measures identified by the IPCC. This classification of adaptation activities was originally developed from attempts by the UK Department for Environment, Food and Rural Affairs to

	measure adaptation in 2009/2010. The definition of adaptation activities was extended through collaboration with the Greater London Authority in 2014. In 2017, the definition of adaptation and resilience activities has been updated through a project with Climate-KIC, which has added several new industrial sectors as well as significantly expanding the activities under health and healthcare. The methodology used for data acquisition and analysis is based on a system called as 'profiling', which was originally developed at Harvard Business School to track and analyse technical and industrial change. This is the basis for building taxonomies of economic activities and value chains, which can then be populated with estimates of key economic metrics like sales value and employment by triangulating transactional and operational business data to estimate economic values. This methodology is particularly valuable in areas where government statistics and standard industry classifications are not available. When measuring an industry or sector, the new taxonomy is populated from the bottom up, searching for evidence for the ideal definition and including only economic activities where sufficient evidence is available. For each transaction listed in the adaptation economy data, a minimum of seven separate sources must independently record the transaction for it to be confirmed and included in our database. Triangulating data from multiple sources permits large volumes of unsorted, fragmented data of different types from different sources to be processed to arrive at more accurate estimates of transactional value that would not be possible using a single source. For the adaptation economy, data are produced to a confidence level of around 80%. Accessing and analysing multiple types of data is also key to identifying the 'purpose' behind an economic activity, which is key for accurately assigning economic activities to the adaptation dataset. Developing the new definition of adaptation and resilience to climate change involved the top-down taxonomy of the entire `make and mend' economy, and then adaptation and resilience in all forms. Then these categories were filtered to isolate economic activities that can be strictly identified as being relevant to adaptation and resilience to climate change. The taxonomy of A&RCC is drawn from 11 sectors of the economy at-large: Agriculture & Forestry, Built Environment, Disaster-Preparedness, Energy, Health, ICT, Natural Environment, Professional Services, Transport, Waste and Water. From across the entire adaptation and resilience to climate change dataset, it was seen that there are a number of activities across different sectors that are 'health-related', outside of the strictly-defined healthcare sector. Part of the design of the indicator therefore required the definition of those activities from the other 10 sectors of the A&RCC data that can be clearly related to health, and thus should be included in a definition of 'health-related' adaptation spending. An initial exploration of the A&RCC dataset had yielded a 'three-tier' approach for the categorization of health-related adaptation activities; 1) adaptation activities with direct, important health impacts, that clearly and directly protect health in substantial ways, or address major contributors to

	burdens of disease 2) those with less direct or more minor health impacts, that indirectly benefit human health, or prevent minor impacts of burdens of disease 3) activities that primarily protect infrastructure and investment, those with no health impact or an impact on human health that is too circuitous or indirect. A robust interim approach was adopted for this year's Lancet Countdown. A 'health-related' definition of activities that would be assigned to 'category 1' of the proposed categorisation was used, consisting the activities of the Healthcare/Health Sector, Disaster Preparedness and Agriculture adaptation activities from the kMatrix dataset. Although these may be revised in future research to define the full health-related adaptation definition, it was determined with a fairly high degree of certainty that there would be very little that is currently measured in these three sectors that would not be included the 'most direct impacts' category of our categorisation. Further detail can be found in 'Future Form of Indicator' on the future development of the indicator. A methodology is already under development to define a full health-related adaptation definition across the entire A&RCC dataset. Researchers from University College London, kMatrix and the University of Washington will collaborate on leading a consultation exercise on the creation of the full health-related adaptation definition in order to provide this as input to the next iteration of the Lancet Countdown. Comparison Data Population and nominal GDP data from 2015 and 2016 from the IMF's World Economic Outlook (April 2017) were used to estimate 2015/2016 Financial Year values for population and nominal GDP. Categorization of countries into the regions defined by the WHO's regional classification was conducted using metadata from the WHO. Geographical Coverage The indicator has global coverage for 226 countries and territories. Data has not been reported for all 226 countries and territories as the accompanying comparison data is not available for all, therefore the data reports a subset of countries for whom adaptation spending data, GDP estimates and population estimates are available, which totals over 180 countries. Spending data was available for 226 countries and territories, but due to missing data (principally population and GDP data) for 46 of these, we report on 180 countries.
Data	Data Sources: Adaptation and Resilience to Climate Change dataset: kMatrix Ltd, in partnership with University College London Population and nominal GDP data: IMF World Economic Outlook Data on national population and GDP for FY 2015-16 were taken from the

	International Monetary Fund's World Economic Outlook (April 2017 update) (www.imf.org/external/pubs/ft/weo/2017/01/weodata/index.aspx). Regional classification: World Health Organization
Caveats	Due to the nature of the methodology, transactions are only measured where there is an economic 'footprint', i.e. where there is transactional/financial data available to be measured. Therefore, public sector spending with economic 'footprint' (government spending on salaries, for example), cannot be measured. It also not possible to directly identify what percentage of measured spending is public versus private. Values are not currently adjusted for inflation. Values of sales generated are not directly comparable with values derived from national statistics. The reference period is financial year 2015/16 (including annual growth in %). Unfortunately, it was not possible to process all of the historical data to provide trend data back to 2010/11 in time for the 2017 report deadline, but it is highly likely that this will be available in the future. This is, however, partly because significant effort was devoted to extended and updating the definitions of adaptation activities, which should make for a more comprehensive dataset (20% of the value in the new dataset represents new activities, so it is a significant step change). The 'health-related adaptation' measure is based on Health, Agriculture and Disaster Preparedness for this year's report, but in future years it will also include health activities from a wider spread of the economy, as well as have another 'tier' of measurement. Given differences in data collection methods between transactional triangulation and GDP, comparisons as a percentage of GDP should be treated as indicative. GDP (nominal) data was used and transactional data, in this case, has not been adjusted for differences in purchasing power parity, and this should be considered when consulting the data.
Future Form of Indicator	There will be three major developments in the future form of the indicator. The first will be the development of the 'three-tier' definition of; 1) adaptation activities with direct, important health impacts 2) those with less direct or more minor health impacts 3) those with no health impact or too tenuous a health impact. Further details of how this will be developed are available in the 'Methods' section of this appendix. Secondly, in the future it will possible to present historical data for the indicator (back to 2010/2011), in order to provide trend data on change in spend over time. It would also be ideal to provide a comparison of health sector and health-related adaptation spend as a percentage of overall transactional spend in the health sector. As noted above, in future reports it should be possible to include historical trend data, along with an annual update to the latest available data. It

	may also be possible within this time frame (2018+), depending on funding, to develop the full health sector model for measurement as previously discussed. Finally, in future iterations, it will be possible to provide an indicator of adaptation spending as a percentage of the overall health sector spend and health-related spend as a percentage of the entire economy (represented by 24 industries), compiled using transactional data. This should be available within the next few years.
Supplementary Information	 Health and health-related adaptation funding classified by WHO region  Health and health-related adaptation funding classified by income grouping

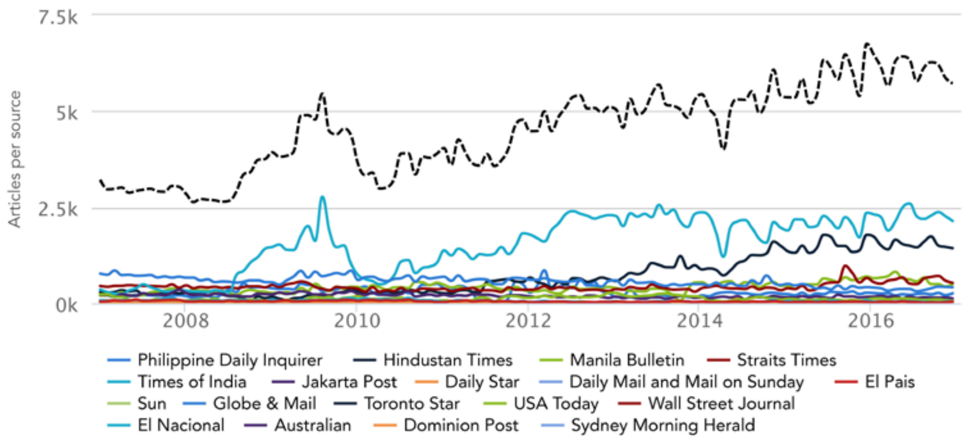
Working Group	4. Economics and Finance
Indicator	4.10 Health adaptation funding from global climate financing mechanisms
Methods	This indicator used the Climate Funds Update (CFU http://www.climatefundsupdate.org) [20]data on total gross flows of all multilaterally governed funds focused on climate change since 2003. The data also includes funds from bilateral organisations, but excludes funding from bilateral to multinational organisations, to avoid double counting of funds. For this indicator, the CFU data selected was for adaptation only and the "approved funding" figure was used to calculate adaptation funding. To calculate the adaptation funding that has been allocated to health, the following sectors were selected: "basic health", "health" and "health, general". Although it is recognised that other adaptation measures can have important health co-benefits, drawing out how effectively adaptation projects benefitted and accounted for health is complex and developing a consistent methodology for doing so would require more resource. Therefore, only those projects earmarked specifically as health were included in the analysis here.
Data	Climate Funds Update
Caveats	Some of the data was incomplete and so those adaptation projects that did not have the year noted could not be included, as it would then not be possible to accurately show the annual funding for adaptation and health adaptation, or changes in funding over time. To counter this, project documents were searched for and, where available, the project approval date updated in the CFU data. However, this was not possible for all projects. Furthermore, these results show funding through global climate financing mechanisms only and do not show the additional funding support given to these adaptation projects (for example, from UN agencies or national governments). The funding mechanisms included in the CFU data are shown in Web Table 1. Climate funding from Canada, the US, Japan and Denmark is not included in the CFU data; as such the figures presented here are likely to be underestimates. Additionally, the data presented in Figure 1 is not cumulative. Although most projects run for more than one year, there was insufficient information in the CFU data detailing the allocated spending for each project year and so only the total approved adaptation funding in each given year was shown.
Future Form of Indicator	In future, this indicator could show all funding streams that fund adaptation generally and health adaptation specifically. The contributions of different funding streams could then be analysed and new funding streams (such as national governments) shown.

Appendix 6 – Public and Political Engagement

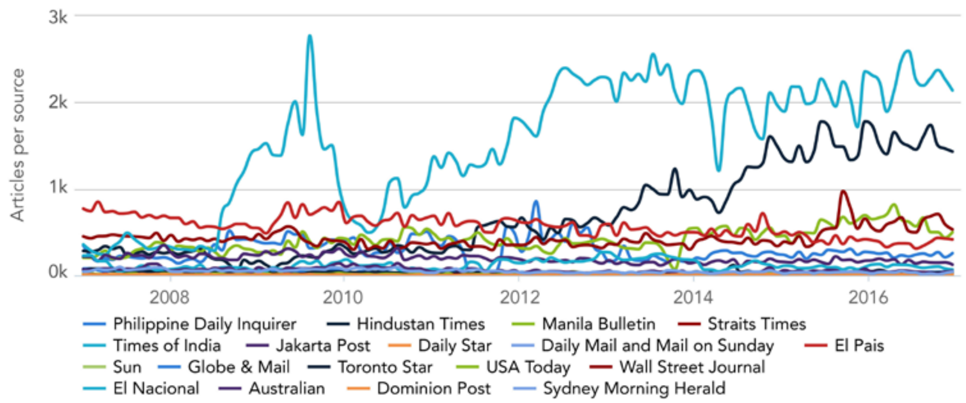
Working Group	5. Public and Political Engagement
Indicator	5.1. Media coverage of health and climate change
Sub-Indicator	5.1.1. Global newspaper reporting on health and climate change
Methods	In this portion of the project, we identify intersecting trends in coverage in eighteen selected sources across six regions – Asia, Oceania, North America, South America, Middle East, and Europe – between climate change and health from January 2007 through December 2016. We assemble the data by accessing archives through the Lexis Nexis, Proquest and Factiva databases via the University of Colorado libraries. These sources are selected through a decision processes involving weighting of four main factors: (1) geographical diversity (favouring a greater geographical range), (2) circulation (favouring higher circulating publications), (3) national sources (rather than local/regional), and (4) reliable access to archives over time (favouring those accessible consistently for longer periods). The following Boolean searches in English and Spanish, respectively, were used: • malaria or diarrhoea or infection or disease or sars or measles or

	pneumonia or epidemic or pandemic or public health or healthcare or epidemiology or health care or health or mortality or morbidity or nutrition or illness or infectious or NCD or non-communicable disease or communicable disease or air pollution or nutrition or malnutrition or mental disorder or stunting AND climate change or global warming or green house or temperature or extreme weather or global environmental change or climate variability or greenhouse or low carbon or ghge or renewable energy or carbon emissions or co2 emissions or climate pollutants • malaria or diarrea or infección or enfermedad or sars or sarampión or neumonía or epidemia or pandemia or salud pública or salud or epidemiología or salud or salud or mortalidad or morbilidad or nutrición or enfermedad or enfermedad infecciosa or NCD or no transmisible or enfermedad contagiosa or transmisible or contaminación del aire or nutrición or desnutrición or trastorno mental or retraso del crecimiento AND cambio climático or calentamiento global or temperatura or clima extremo or cambio ambiental global or variabilidad climática or invernadero or bajo carbono or ghge or energía renovable or emisiones de carbono or emisiones de CO2 or contaminantes climáticos
Data	• ASIA: Times of India (India), Hindustan Times (India), Jakarta Post (Indonesia), Manila Bulletin (Philippines), Philippine Daily Inquirer (Philippines), Straits Times (Malaysia) • MIDDLE EAST: Daily Star (Lebanon) • EUROPE: El País (Spain), Daily Mail/Mail on Sunday (UK), The Sun (UK) • SOUTH AMERICA: El Nacional (Venezuela) • NORTH AMERICA: Toronto Star (Canada), Globe and Mail (Canada), USA Today (USA), Wall Street Journal (USA) • OCEANIA: The Australian (Australia), Dominion Post (New Zealand), Sydney Morning Herald (Australia)
Caveats	There are some cautions with these findings. With this extensive Boolean string, there may be some returns that do not centrally address climate change and health together. For example, the search term "temperature" often generates a hit, but articles may be addressing a fever related to some illness, rather than climate change or global warming. As another example, there may be some overlap between articles discussing climate change legislation and health care legislation without meaningfully linking climate change and health. Also, in working with newspapers, rather than, for example, UN communications/documents, a narrower or more tailored approach might more effectively reduce the possibilities for false positives in the dataset. However, for consistency with the other groups and collaborators in the Lancet Countdown project, we have agreed to carry out the searches with the established terms above and we therefore are committed to the search results and trends generated.
Future Form of Indicator	In future, more newspaper will be included in the analysis, with improved representation of different regions. Further details on how health and climate change is reported on will also be sought, including the demonstration of how marginal health is to the wider coverage of/debates about climate change. There will also be an effort to match the newspaper included in 1.5.1 and 1.5.2 to allow for better comparison and analysis of newspaper reporting on health and climate change.

<table>
<tr><td>Additional Information</td><td>



Number of articles reporting on health and climate change in the 18 newspapers analysed, including the global total (2007 to 2016).



Number of articles reporting on health and climate change in the 18 newspapers analysed (2007-2016).

</td></tr>
</table>

Working Group	5. Public and Political Engagement
Indicator	5.1. Media coverage of health and climate change
Sub-Indicator	5.1.2. In-depth analysis of newspaper coverage on health and climate change
Methods	The analysis used online databases, holding both printed and online versions of Le Monde and FAZ, and was conducted in two stages. Potential articles related to health and climate change were captured through an initial search, a more detailed keyword search within each text then identified articles linking health and climate change. This second stage also collected information on the framing of health and climate change (for instance, as an environmental or economic issue), potential policy responses and co-benefits. The tracking analysis relied on a consistent set of search terms for the two newspapers, but this may have introduced a linguistic bias. Furthermore, only two newspapers were analysed, so the findings cannot be used to indicate the broader nature of newspaper coverage on health and climate change. The methodology of our analysis is based on and has been developed by the 4C-Health research group, set up by the Centre Virchow-Villermé in Paris and Berlin, to analyse how the health-climate nexus was addressed in the media. We used a

detailed strategy to search the online database of the French newspaper *Le Monde* and the German newspaper *Frankfurter Allgemeine Zeitung (FAZ)*. Specific inclusion and exclusion criteria were applied in order to capture the most relevant literature in the timeframe chosen.

The search was conducted in two stages, the first one with broad term aiming to capture most articles on the subject. The second stage consisted in a keyword search within text to collect only the articles linking climate change and health.

To filter the valuable articles in the online data bases we have a two-stage-process. In the first step, we have applied a quantitative approach by choosing keywords which would specify the topic "climate change and health" in order to exclude the unrelated articles. Therefore we looked for the most obvious keywords "climate change" and "health" and climate-change-related as well as health-related keywords. These keywords have been deductively defined, meaning, while reading the articles we have noticed the reoccurrence of particular climate-change-related or health-related terms, which have then been added to our keyword group. In practice we have searched for the following keywords in *Le Monde and the FAZ (see Table 1).*

German		**English**	**French**
Keywords stage 1 climate			
Klimaerwärmung		climate warming	réchauffement climatique
Klimaveränderun g		climate change	changement climatique
klimawandel		climate change	changement climatique
		climate disruptions/ climate disturbances	dérèglement climatique
erderwärmung		global warming/ climate warming	réchauffement climatique
Boolean operator	AND		
Keywords stage 1 health			
gesundheit		health	santé
krankheit		disease	maladie
Erkrankung		disease	maladie

gesundheitsschäden		health damages	atteintes à la santé
Boolean Operator	AND /OR		
Keywords stage 2			
infektionskrankheit		infectious disease	maladie infectieuse
atemwegserkrankung		respiratory disease	maladie respiratoire
herz-Kreislauf-Erkrankung		cardivascular disease	maldie cardiovaculaire
herzerkrankung		cardivascular disease	maldie cardiovaculaire
psychische Erkrankung		mental illness	maladie mentale
Vorteile		co benefits	co-bénéfices
Todesfall		case of death	décès
unterernährung		malnutrition	malnutrition
hungerkatastrophe		famine	famine
hungersnot		famine	famine
zugang zu Wasser		acces to water	accès à l'eau
wassermangel		lack of water	
verfügbarkeit von wasser		availability of water	disponibilite en eau
konflikt		conflict	conflit
wetterextrem		weather extreme	évènement climatique extrême
überschwemmung		flooding	inondation
Überflutung		flooding	inondation

Flut		flooding	inondation
hochwasser		high water	inondation
hitzewelle		heat wave	vague de chaleur
Dürre		drought	sécheresse
luftverschmutzun g		air pollution	pollution de l'air
temperaturanstie g		temperature rise	augmentation de la température
Meeresspiegelans tieg		sea level rise	élèvation du niveau de la mer

Table 1 : Keywords and Boolean operator ; stage 1 ; stage 2

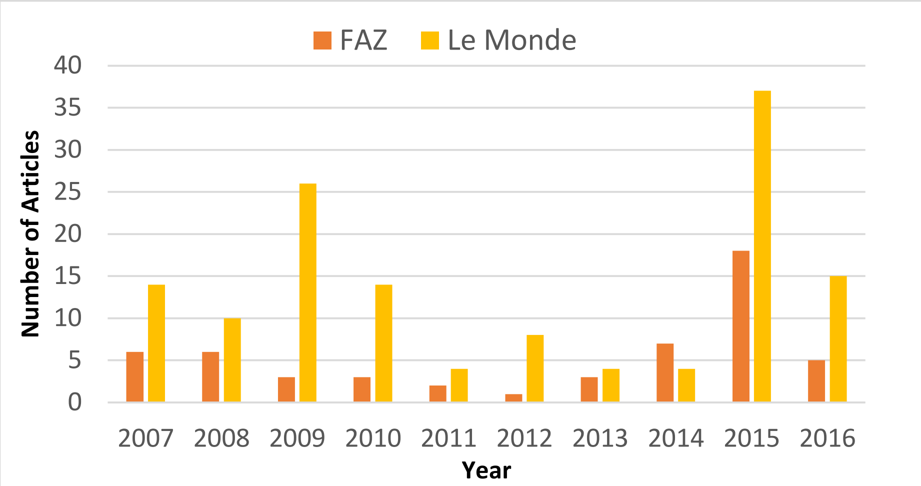
As the Table indicates, the first stage keyword search for the FAZ was more elaborated than the one for *Le Monde*. This was due to the fact that the online data base of the FAZ showed only a small number of articles that included "health" as a health-related term. By adding more health-related keywords to the list, it allowed us to have a greater total number of relevant articles to progress to the second-stage-process. Articles were only accepted for the second-stage-process if they included a health-related **and** a climate-change-related term.

For the second stage of the analysis, a qualitative screening of the articles was undertaken to categorize them according to a predefined grid.

- Context: This category distinguishes whether the article was about an international summit (COP, G8, etc.), the publication of a study/scientific report (IPCC, lancet commission) or an extreme weather event (flooding, heat waves).
- Recommendations: we identified whether the dominant recommendation (if there was one) was about mitigation, adaptation, or co-benefits.
- Tone: we have categorized the tone of the article into four classes: neutral, positive, mixed and negative.

Tone	**Definition**
Negativ e	Urgent matter, something must be done immediately, pessimism about the future, description of a dramatic situation
Neutral	Plain facts and numbers without any specific comment

Mixed	Worrisome situation with a remaining chance for it to get better or still acceptable situation but progressively degrading
Positive	There is still time to counter climate change, there is hope but we have to start now



Newspaper articles on health and climate change in Le Monde and FAZ (2007-2016).

Context and content of publications addressing the climate-health nexus

The context was often related to international events such as climate conferences or scientific discoveries (see table below). Health crises seldom led to articles pointing out the role of climate change.

	Le Monde	FAZ
International event	43 %	31%
Scientific announcement	15%	21%
Health crisis	12%	7%
Extreme climate event	5%	7%
Media event	2%	-
Agricultural crisis	1%	-
Undefined	22%	28%

Articles mentioning health impacts were a small proportion of the total of articles about climate change: out of 4031 articles about climate change in *Le Monde*, only 168 mentioned a link between climate change and health. The share was even smaller in *FAZ*: 67 articles mention the linkages between climate change and health of 5757.

The climate-health nexus is addressed purely as an environmental issue in France, while it is more likely to be treated as an economic and/or social issue in Germany (see box below).

<table>
<tr><td></td><td>Le Monde : Planète (Earth) (70%), Idées (Ideas) (16%), Economie (Economy) (6,5%), A la Une (Front-page news) (2,5%), Vous (« Opinion ») (1,5) International (International), Santé (Health), Science (Science), Société (Society), Culture (Culture), Sport (Sport), Techno (Innovation) (0,5%).

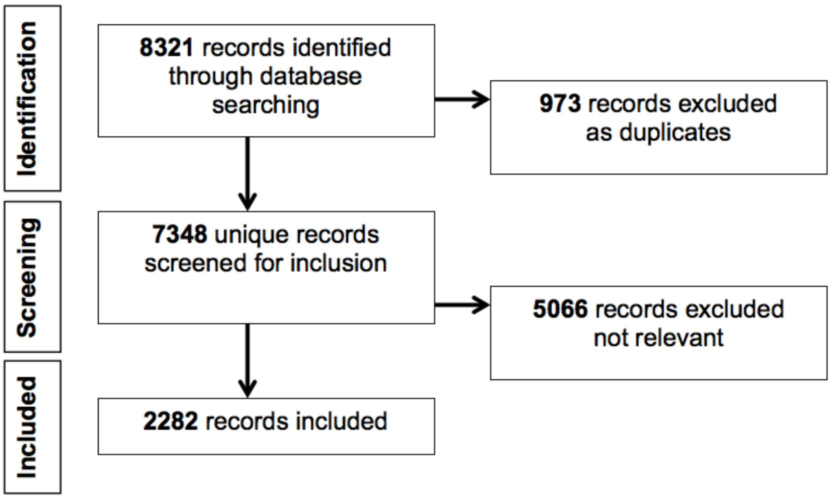
FAZ. : Wirtschaft (Economy) (23%), Rhein-Main Zeitung (Local news) (20 %), Politik (Politics) (17%), Natur-und-Wissenshaft (Natural sciences) (15%), FAZ.net (Online news) (15%), Feuilleton (Culture) (6%), Verlagsbeilage (Print Supplement), Sonntagszeitung (Week end edition) (4%).

Another difference between Le Monde and FAZ was the solutions that were recommended to address the health impacts of climate change: while Le Monde focused on the adaptation strategies to deploy, FAZ put more emphasis on the mitigation of greenhouse gas emissions. The co-benefits that public health policies can represent for mitigation, however, are barely mentioned in either of the papers. The table below summarises the share of articles where the dominant recommendation was about mitigation, adaptation, or co-benefits.

<table>
<tr><th></th><th>Le Monde</th><th>FAZ</th></tr>
<tr><td>Mitigation dominant</td><td>12%</td><td>40%</td></tr>
<tr><td>Adaptation dominant</td><td>41%</td><td>21%</td></tr>
<tr><td>Co-benefits dominant</td><td>17%</td><td>9%</td></tr>
<tr><td>No recommendation</td><td>30%</td><td>30%</td></tr>
</table>
Comparison of the dominant recommendation in the articles considered.

<table>
<tr><th></th><th>Le Monde</th><th>FAZ</th></tr>
<tr><td>Neutral</td><td>44 %</td><td>49 %</td></tr>
<tr><td>Positive</td><td>4 %</td><td>16 %</td></tr>
<tr><td>Negative</td><td>32 %</td><td>19 %</td></tr>
<tr><td>Mixed</td><td>20 %</td><td>16 %</td></tr>
</table>
The tone of the articles.</td></tr>
<tr><td>Data</td><td>The databases are online databases from Le Monde and the Frankfurter Allgemeine Zeitung. We used a combination of quantitative and qualitative methods (see methods above). Articles were searched in the online search databases using specific search syntax. Articles were then screened, identified and categorised according to specified criteria (type of article, studied health impact, geographical focus, etc).</td></tr>
<tr><td>Caveats</td><td>This analysis considers only a narrow range of search terms, which can induce a strong linguistic bias. French articles addressing health will almost always mention the term ‘santé’ (‘health’ in French), whereas the German equivalent ‘Gesundheit’ is less often mentioned in articles addressing public health. In order to provide a similar basis for comparison, we had to use the same protocol to analyse articles in both Le Monde and FAZ, but we need to be aware that some terms (‘health’ in particular) were more frequently used in a language than in the other.</td></tr>
<tr><td>Future Form of Indicator</td><td>In the future, we aim to compare and contrast our analysis of coverage in Le Monde and FAZ with other newspapers, such as The Guardian or The New York Times, in order to account for perspectives of other older industrialised countries, and with newspapers from developing countries, where the health impacts of climate change are most marked. Our longer- term goal is a series of international newspapers analyses. The analysis will include both the global North and the global South.</td></tr>
</table>

<table>
<tr><td>Working Group</td><td>5. Public and Political Engagement</td></tr>
<tr><td>Indicator</td><td>5.2. Health and climate change in scientific journals</td></tr>
<tr><td>Methods</td><td>We tracked the use of climate-related terms and their co-occurrence with health terms using a bibliometric search in both PubMed and Web of Science databases.
The search terms were the following and adapted according to the database:
<table>
<tr><th>Climate change related terms</th><th>Health related terms</th></tr>
<tr><td>Climate Change
Global warming
Climate variability
Greenhouse effect
GHGE</td><td>Health
Disease
- Non-Communicable
- NCD
- Communicable
Epidemiology
Lifestyle
Co-Benefits
Mortality
Morbidity
Nutrition
Malnutrition
Dehydration
Migration
Mental disorders</td></tr>
</table>
This list of search terms were found to be exhaustive and appropriate for scientific databases. A more detailed search syntax, including the diseases of poverty used by indicator 5.3 was not necessary as with the use of medical subject headings (MeSH-Terms) for instance in PubMed those diseases are covered through the MeSH Term “Communicable diseases”. Different search syntaxes were applied and the final number of overall publications did not show to vary significantly underlining that the search strategy was robust and able to capture most relevant articles.
Titles and abstracts of identified papers for relevance to the topic were screened three times. The results were then merged using the Endnote reference manager software and duplicates removed. Conflicts were resolved within the research team and a final selection of articles was prepared for analysis. The stepwise process of the selection of articles is presented in the flow chart below.</td></tr>
</table>

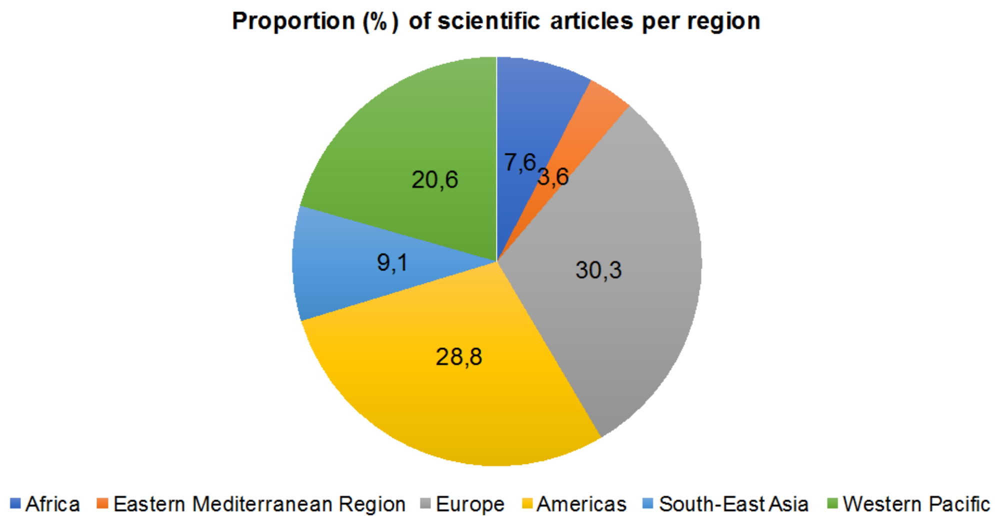


Numbers indicate the article count retained at each step of the process. With the applied search terms more than 8000 scientific articles on climate change and health were identified for the period of 2007-2016. After the screening process only 4% (27 of 2282) were retained and found to be relevant. Indeed, a majority just mentioned climate change in the abstract and did not focus on the link between climate change and health. Other articles explored ecological health or animal health but not human health and were therefore excluded. A minority of papers were excluded as these were book chapters or conference proceedings referenced in both databases.

After the screening process, data were extracted, categorized and coded to allow for statistical analysis of the results.

Geographically, the majority of publications address the impact of climate change and health in Europe and the Americas (Figure S5.1 below). This is particularly concerning given that countries in the Global South will bear the greatest health burden.

Figure S5.1

	 Figure S5.2 shows the proportion of scientific papers published between 2007 and 2016 per world region. The distribution varied significantly; from 84 for the Eastern Mediterranean Region to almost 700 articles with a European focus. Indeed, more than half of identified papers focused on Europe and the Americas. The Eastern Mediterranean Region was less represented followed by papers focussing on the African continent.

<table>
<tr>
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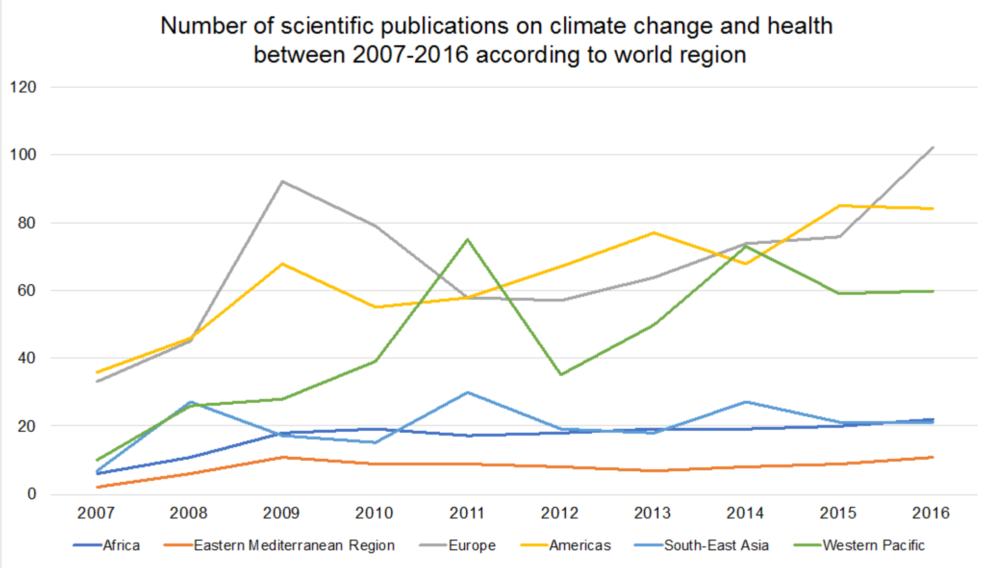
<td>


Figure S5.2 shows the distribution of publications on health and climate change by the location of the study (using WHO world regions). For almost all regions, a first peak of scientific publications is observed in 2008-2009. While some regions showed a subsequent decline in publications (in 2010-2011), this was not a global trend (the number of studies focussed on South-East Asia as well as on the Western Pacific Region was on the rise). Big trends or peaks for regions such as Africa or Eastern Mediterranean region could not be observed due to their low publication volume.
</td>
</tr>
<tr>
<td>Data</td>
<td>Specific inclusion and exclusion criteria were applied in order to capture the most relevant literature. Only peer-reviewed scientific articles on climate change and population health in English were included. This means that all articles including original quantitative and qualitative studies, reviews, editorials, viewpoints or comments are covered in this indicator. Also, no restriction with respect to country or population was applied. Through the screening process, articles that mentioned climate-related or health-related terms in titles or abstracts but did not have a specific focus on, or direct link between, climate change and health were excluded.</td>
</tr>
<tr>
<td>Caveats</td>
<td>This indicator only used two databases, which may be a limitation. However, both databases are complementary and cover together the majority of the scientific publications in the area of climate change and human health. Grey literature is not captured in the indicator and may bias the results. Also the restriction to publications in English language only may be a caveat. Finally, the quality of identified scientific publications was not assessed, and analysis was conducted using the title and abstract of articles due to the restrictions in locating full texts for the large volume of articles included.
With respect to caveats, the trends identified in scientific engagement (Figure 5.2) may be influenced by the search terms used in the review. As far as possible, used common search terms were used across the three indicators in this chapter, enabling comparisons to be drawn across engagement in health and climate change in the media, the scientific community and in the political sphere. Furthermore, the review was restricted to English-language journals.
Other caveats for this indicator include the narrow range of search terms, which excludes reference to many of indirect links between health and climate change. Several</td>
</tr>
</table>

	UNGD statements in the dataset refer to such indirect connections, such as effects of climate change on water and agriculture, but these are not included. Therefore, the results present a conservative estimate of high-level political engagement with the intersecting issues of health and climate change. Future Lancet Countdown reports will consider political engagement with these indirect links, as well as providing additional forms of analysis. For the regional analysis (Figure 5.4), note should be taken of variation in the number of countries per region.
Future Form of Indicator	The indicator aims to provide an overview of existing scientific publications in the area of climate change and health. For the 2017 report, it provides an overview of trends across the last decade. Going forward, it will monitor future trends. The search syntax can be used each year to track the number of scientific articles on climate change and health. In the future, each identified scientific publication will be categorized according to different criteria (geographical focus, type of article, health outcome, type of climate change measurement, etc.) in order to provide a more in depth analysis of research trends and foci. Other dimensions, such as the country location and institutional affiliation of authors, cross-country collaboration and citations could also be analysed.

Working Group	5. Public and Political Engagement
Indicator	5.3. Health and climate change in the United Nations General Assembly
Methods	The dataset on UNGD statements used contains all country speeches made in the UNGD between 1970 and 2016. Here, the frequency of references to health and climate change in annual UNGD statements was considered between 2007 and 2016. Overall, 1,928 high level statements were examined. The keywords used are based on a) health-related terms and b) climate change-related terms. The search terms for (a) heath are: "malaria", "diarrhoea", "infection", "disease", "pneumonia", "epidemic", "pandemic", "public_health", "health_care", "epidemiology", "healthcare", "health", "mortality", "morbidity", "nutrition", "illness", "infectious", "ncd", "non-communicable_disease", "noncommunicable_disease", "communicable_disease", "air_pollution", "nutrition", "malnutrition", "mental_disorder", "stunting". The search terms for (b) climate change are: "climate_change", "global_warming", "green_house", "temperature", "extreme_weather", "global_environmental_change", "climate_variability", "greenhouse", "low_carbon", "ghge", "renewable_energy", "carbon_emission", "co2_emission", "climate_pollutant". In order to produce an indicator of engagement with the intersection of climate

	change and health, we focused on whether any of the health related terms appeared immediately before or after any climate change terms in the GD statements. This was based on a search of the 10 words before and after a reference to a climate change related term.
Data	To produce this indicator, we draw on a new dataset of GD statements: *the United Nations General Debate corpus*, in which the annual GD statements have been pre-processed and prepared for use in quantitative text analysis.[4] The dataset contains all of the country speeches made in the UN General Debate between 1970 and 2016.
Caveats	This analysis here is based on a narrow range of search terms, which excludes reference to many of indirect links between climate change and health. A number of GD statements in this time period refer to such indirect connections, such as the effects of climate change on water and agriculture – however, these are not included here. Therefore, the results present a somewhat conservative estimate of high level political engagement with the intersection of climate change and health. Future work in this area will consider engagement with these indirect links, as well as providing additional forms of analysis.
Future Form of Indicator	In the future, we plan on looking more closely at the references to indirect links between climate change and health. For example, what are the main ways in which governments view climate change impacting on health? We will consider whether this changes over time based on awareness of the multiple ways in which climate change and health are connected. We will also look to expand this indicator by considering private sector engagement with climate change and health. Specifically, for next iteration of the indicator we will examine annual corporate social responsibility and sustainability reports ("Triple Bottom Line Reports") of major international corporations. Using these report, we will perform similar searches (engagement with health, climate change, and intersection of the two) based on these reports.
Additional Results	We present some additional findings and breakdowns in this section. Figure S5.3 below shows the level of political engagement with climate change and health separately, rather than engagement with the intersection of climate change and health. Again, this is measured by the references to the key search terms associated with climate change and health in General Debate speeches. The figure shows that in general there is a higher level of engagement with climate change than health. It also shows a decline in engagement with climate change in the General Debate following COP 15 in Copenhagen in 2009. However, in recent years this has increased around the Paris Agreement. Engagement with health has generally been quite low in the General Debate. However, there is a large increase in the salience of global health from 2012 onwards, which coincides with the transition from the Millennium Development Goals (MDGs) to the Sustainable

[4] Baturo, A., Dasandi, N., and Mikhaylov, S. (2017) 'Understanding State Preferences with Text As Data: Introducing the UN General Debate Corpus', Research and Politics, 4(2): 2053168017712821

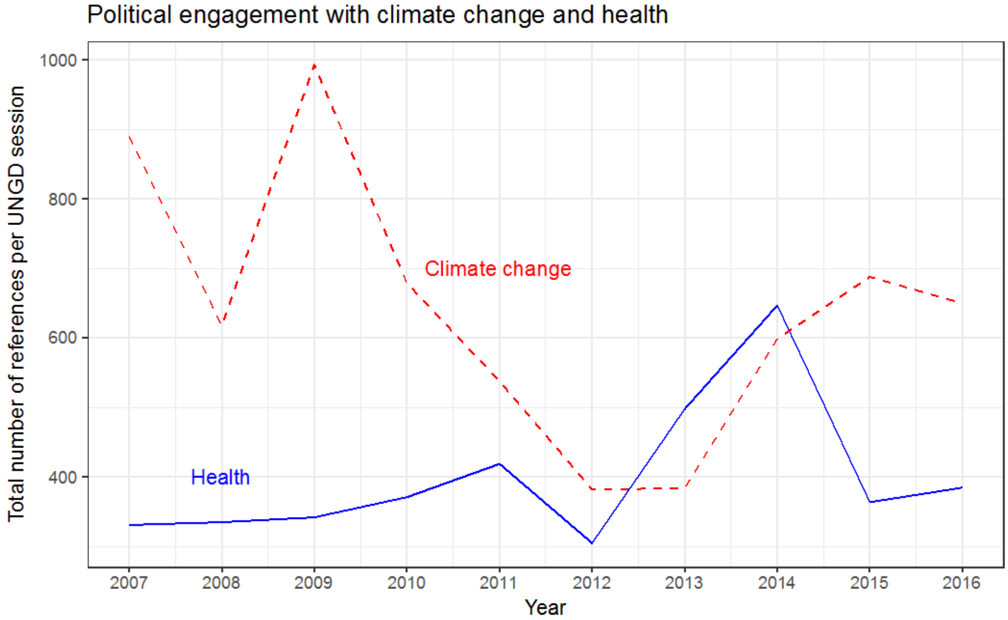
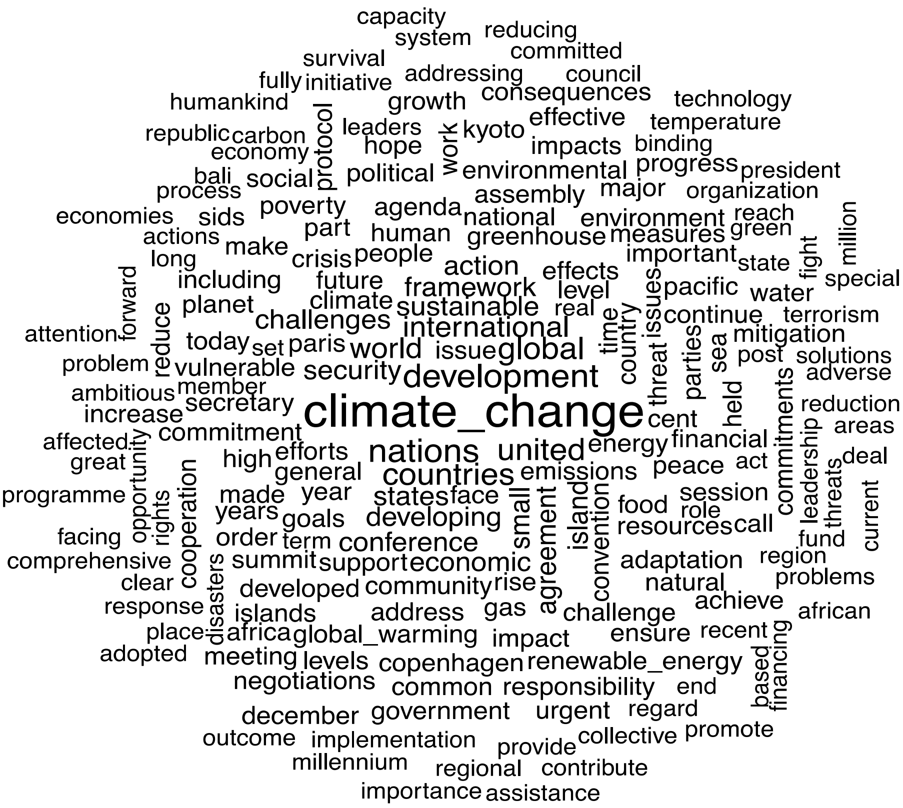
	Development Goals (SDGs). **<u>Figure S5.3</u>**  **<u>Figure S5.4</u>**

Figure S5.4 above displays a word cloud of terms linked to the intersection of climate change and health. In other words, it shows the main topics that are raised in GD statements (2007-2016) when governments discuss the linkages between climate change and health. The figure shows that in addition to topics that are directly linked to climate change and health, issues such as food, global disasters, poverty, and security are also referred to. The word cloud also shows that Copenhagen and Paris were key issues raised in the discussions of the intersection of climate change and health between 2007 and 2016.

Figure S5.5 below displays a word cloud for health. In other words, it shows the topics that governments refer to in General Debate statements when discussing health. It is important to note that climate change features as a prominent topic. Therefore, this suggests that when discussing health in the General Debate, governments tend to emphasise the role of climate change.

Figure S5.5

	 Figure S5.6 below shows a word cloud for climate change. It is worth noting that ‘health’ does not feature, suggesting that when governments discuss climate change in the General Debate, they tend to emphasize other issues, such as security and development, much more than specifically referring to the health implications of climate change. **<u>Figure S5.6</u>**



There references to the linkages between climate change and health in the GD statements tend to vary considerably. For example, Denmark's address in 2014 made a more general reference to "…climate change causing great risks to human health, global food security and economic development…" Other statements focus on more specific linkages. For example, Angola's statement in 2016 highlights the importance of the 2015 Paris Agreement on Climate Change, and links greenhouse gas emissions and climate change to "…the deterioration and shortening of cycles of drought and heavy rainfall, which pose a risk to agriculture…", and goes on to state that "…such effects also increase the incidence of various epidemic diseases".

Proposed additional indicators for future Countdown reports

Working Group	Public and political engagement
Proposed indicator	Engagement with health and climate change in corporate social responsibility and sustainability reports
Methods	In order to produce a measure of corporate engagement with the intersection of climate change and health using corporate social responsibility (CSR) and sustainability reports of major public international companies. We will focus on whether any key health related terms appeared immediately before or after any key climate change terms in the CSR and sustainability reports. This is based on a search of the 10 words before and after a reference to a climate change related term.
Data	To produce this indicator, we will collect the CSR and sustainability reports that cover economic, environmental, social, and governance performance of major public international companies. These reports are designed to show internal and external stakeholders organisational commitment to sustainable development. As a primary data source we will focus on the collection of reports available through the United Nations Global Compact.[5] Corporations that sign up to the UN Global Compact have to report annually on their progress on the various principles of the Global Compact, which include a strong focus on environmental and social responsibility. The aim of these reports is to create greater accountability by enabling stakeholders to judge the performance of corporations that have signed up. Therefore, these reports provide an important source of information on how corporations on the extent to which corporations engage with the linkages between climate change and health. Furthermore, these reports are comparable across corporations from a wide range of developed and developing countries, as well as from different sectors.[6]
Caveats	The degree of data coverage is unclear and likely to be slightly uneven given voluntary nature of producing such reports and making them publicly available.

Working Group	Public and political engagement
Proposed indicator	Inclusion of health and climate change within medical and public health curricula
Background	Health professionals have a key role in promoting climate change and health to the public and politics. As a trusted and respected knowledge source, health professionals can advocate these issues to their patients and help building community resilience (1, 2). They can use their unique health expertise and community understanding to effectively influence environmental policy (1, 3, 4). The WHO Second Global Conference Health & Climate thus called for health professionals to take on a role of leadership and advocacy on these

[5] Information regarding the UN Global Compact together with the CSR and sustainability reports are available here: https://www.unglobalcompact.org/ [accessed 2 June 2017].

[6] Rasche, A. (2009) 'Toward a Model to Compare and Analyze Accountability Standards – the Case of the UN Global Compact', *Corporate Social Responsibility and Environmental Management*, 16(4): 192-205.

	issues (4). Yet, several studies report that they are impeded by a lack of education on these topics (5, 6). The inclusion of health & climate change in health professionals training is therefore essential. This proposed indicator will aim at describing the state of health & climate change education within medical and public health curricula.
Methods	The scope of the proposed indicator is limited to medical education before specialization, and to master degree programs of public, global, or international health. The data are collected through a survey questionnaire, informed by a literature review and advice from selected experts. The questions concern the inclusion of courses on climate change, their design and their integration in the curriculum. The results are analysed using descriptive statistics. The analysis will include a regional comparison using the WHO region grouping.
Data	The survey used to collect data was sent to the member institutions of three international networks: the M8 alliance, the World Federation of Academic Institutions for Global Health (WFAIGH) and the World Federation for Medical Education (WFME). Responses from 11 public health master degree programs and 25 medical schools are already available.
Caveats	• The already available responses may not be representative of the global state of climate change and health education worldwide: they represent a small number of programs, from 4 of the 6 WHO regions, and several from the same country. • The proposed indicator is limited to medical schools and public / global / international health masters. Ideally, it should reflect the climate change & health education of all health professionals. • Given the slow rate to which curricula change, it may not be relevant to update this proposed indicator each year.
References	1. Gomez A, Balsari S, Nusbaum J, Heerboth A, Lemery J. Perspective: Environment, biodiversity, and the education of the physician of the future. Academic medicine : journal of the Association of American Medical Colleges. 2013;88(2):168-72. 2. Green EI, Blashki G, Berry HL, Harley D, Horton G, Hall G. Preparing Australian medical students for climate change. Australian family physician. 2009;38(9):726-9. 3. Ramanathan V, Haines A. Healthcare professionals must lead on climate change. BMJ. 2016;355. 4. WHO, editor Conference conclusions and Action Agenda. Second Global Conference Health & Climate; 2016; Paris. 5. Majra JP, Acharya D. Protecting Health from Climate Change: Preparedness of Medical Interns. Indian Journal of Community Medicine : Official Publication of Indian Association of Preventive & Social Medicine. 2009;34(4):317-20. 6. Nigatu AS, Asamoah BO, Kloos H. Knowledge and perceptions about the health impact of climate change among health sciences students in Ethiopia: a cross-sectional study. BMC Public Health. 2014;14:587-.

[i] International Energy Agency. World Energy Investment 2016, Paris, 2016. (***Also in main document)***

[ii] International Energy Agency. World Energy Investment 2016, Paris, 2017. (***Also in main document)***

[iii] 350.org (2017) *Divestment* Commitments, [Online] Available at: https://gofossilfree.org/commitments/

[iv] Bouvet, L and Kirjanas, P. (2017) *Global Climate Index 2017: Rating the World's Investors on Climate Related Financial Risk*, Asset Owners Disclosure Project (***Also in main document)***

[v] BEA (2017) *Implicit Price Deflators for Gross Domestic Product*, [Online] Available at: https://www.bea.gov/iTable/iTable.cfm?reqid=9&step=3&isuri=1&903=13#reqid=9&step=3&isuri=1&904=1990&903=13&906=a&905=20

[vi] IRENA (2017) *Renewable Energy and Jobs: Annual Review 2017,* International Renewable Energy Agency, Abu Dhabi (***Also in main document)***

[vii] IBISWorld (2016) *Global Coal Mining*, IBISWorld Inc. (***Also in main document)***

[viii] IBISWorld (2017) *Global Oil & Gas Exploration & Production,* IBISWorld Inc. (***Also in main document)***

[ix] IEA (2017) *Fossil-fuel subsidies – methodology and assumptions*, [Online} Available at: http://www.worldenergyoutlook.org/resources/energysubsidies/methodology/

[x] World Bank (2017) *Carbon Pricing Dashboard*, [Online] Available at: http://carbonpricingdashboard.worldbank.org/map_data (***Also in main document)***

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