

The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate

Article

Accepted Version

Watts, N., Amann, M., Arnell, N. ORCID: <https://orcid.org/0000-0003-2691-4436>, Ayeb-Karlsson, S., Belesova, K., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D., Capstick, S., Chambers, J., Dalin, C., Daly, M., Dasandi, N., Davies, M., Drummond, P., Dubrow, R., Ebi, K. L., Eckelman, M., Ekins, P., Escobar, L. E., Fernandez Montoya, L., Georgeson, L., Graham, H., Hagggar, P., Hamilton, I., Hartinger, S., Hess, J., Kelman, I., Kiesewetter, G., Kjellstrom, T., Kniveton, D., Lemke, B., Liu, Y., Lott, M., Lowe, R., Sewe, M. O., Martinez-Urtaza, J., Maslin, M., McAllister, L., McGushin, A., Jankin Mikhaylov, S., Milner, J., Moradi-Lakeh, M., Morrissey, K., Murray, K., Munzert, S., Nilsson, M., Neville, T., Oreszczyn, T., Owfi, F., Pearman, O., Pencheon, D., Phung, D., Pye, S., Quinn, R., Rabbaniha, M., Robinson, E. ORCID: <https://orcid.org/0000-0002-4950-0183>, Rocklöv, J., Semenza, J. C., Sherman, J., Shumake-Guillemot, J., Tabatabaei, M., Taylor, J., Trinanes, J., Wilkinson, P., Costello, A., Gong, P. and Montgomery, H. (2019) The 2019 report of The Lancet Countdown on health and climate change: ensuring that the health of a child born today is not defined by a changing climate. *The Lancet*, 394 (10211). pp. 1836-1878. ISSN 0140-

6736 doi: [https://doi.org/10.1016/S0140-6736\(19\)32596-6](https://doi.org/10.1016/S0140-6736(19)32596-6)
Available at <https://centaur.reading.ac.uk/87309/>

It is advisable to refer to the publisher's version if you intend to cite from the work. See [Guidance on citing](#).

To link to this article DOI: [http://dx.doi.org/10.1016/S0140-6736\(19\)32596-6](http://dx.doi.org/10.1016/S0140-6736(19)32596-6)

Publisher: Elsevier

All outputs in CentAUR are protected by Intellectual Property Rights law, including copyright law. Copyright and IPR is retained by the creators or other copyright holders. Terms and conditions for use of this material are defined in the [End User Agreement](#).

www.reading.ac.uk/centaur

CentAUR

Central Archive at the University of Reading

Reading's research outputs online

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34

The 2019 Report of The Lancet Countdown on Health and Climate Change

Nick Watts, Markus Amann, Nigel Arnell, Sonja Ayeb-Karlsson, Kristine Belesova, Maxwell Boykoff, Peter Byass, Wenjia Cai, Diarmid Campbell-Lendrum, Stuart Capstick, Jonathan Chambers, Carole Dalin, Meaghan Daly, Niheer Dasandi, Michael Davies, Paul Drummond, Robert Dubrow, Kristie L Ebi, Matthew Eckelman, Paul Ekins, Luis E Escobar, Lucia Fernandez Montoya, Lucien Georgeson, Hilary Graham, Paul Haggar, Ian Hamilton, Stella Hartinger, Jeremy Hess, Ilan Kelman, Gregor Kiesewetter, Tord Kjellstrom, Dominic Kniveton, Bruno Lemke, Yang Liu, Melissa Lott, Rachel Lowe, Maquins Odhiambo Sewe, Jaime Martinez-Urtaza, Mark Maslin, Lucy McAllister, Alice McGushin, Slava Jankin Mikhaylov, James Milner, Maziar Moradi-Lakeh, Karyn Morrissey, Kris Murray, Simon Munzert, Maria Nilsson, Tara Neville, Tadj Oreszczyn, Fereidoon Owfi, Olivia Pearman, David Pencheon, Dung Phung, Steve Pye, Ruth Quinn, Mahnaz Rabbaniha, Elizabeth Robinson, Joacim Rocklöv, Jan C Semenza, Jodi Sherman, Joy Shumake-Guillemot, Meisam Tabatabaei, Jonathon Taylor, Joaquin Trinanes, Paul Wilkinson, Anthony Costello*, Peng Gong*, Hugh Montgomery*

* Denotes Co-Chair
[Insert institutional logos for inside cover]

Word Count: 17,540

35 Table of Contents

36 Table of Contents2

37 List of Figures, Tables and Panels4

38 List of Figures4

39 List of Tables6

40 List of Panels6

41 List of Abbreviations6

42 Executive Summary.....9

43 Introduction13

44 Strengthening a global monitoring system for health and climate change15

45 The year in health and climate change.....16

46 Section 1: Climate Change Impacts, Exposures, and Vulnerabilities.....18

47 Indicator 1.1: Health and heat19

48 *Indicator 1.1.1: Vulnerability to extremes of heat*19

49 *Indicator 1.1.2: Health and exposure to warming*20

50 *Indicator 1.1.3: Exposure of vulnerable populations to heatwaves*20

51 *Indicator 1.1.4: Change in labour capacity*21

52 Indicator 1.2: Health and extreme weather events24

53 *Indicator 1.2.1: Wildfires*.....24

54 *Indicator 1.2.3: Lethality of weather-related disasters*26

55 Indicator 1.3: Global health trends in climate-sensitive diseases27

56 Indicator 1.4: Climate-sensitive infectious diseases.....28

57 *Indicator 1.4.1: Climate suitability for infectious disease transmission*28

58 *Indicator 1.4.2: Vulnerability to mosquito-borne diseases*30

59 Indicator 1.5: Food security and undernutrition31

60 *Indicator 1.5.1: Terrestrial food security and undernutrition*31

61 *Indicator 1.5.2: Marine food security and undernutrition*33

62 Conclusion.....33

63 Section 2: Adaptation, Planning, and Resilience for Health34

64 Indicator 2.1: Adaptation planning and assessment35

65 *Indicator 2.1.1: National adaptation plans for health*35

66 *Indicator 2.1.2: National assessments of climate change impacts, vulnerability, and*
67 *adaptation for health*.....36

68 *Indicator 2.1.3: City-level climate change risk assessments*37

69 Indicator 2.2: Climate information services for health.....37

70 Indicator 2.3: Adaptation delivery and implementation38

71 *Indicator 2.3.1: Detection, preparedness and response to health emergencies*38

72 Indicator 2.4: Spending on adaptation for health and health-related activities.....41

73 Conclusion.....42

74 Section 3: Mitigation Actions and Health Co-Benefits43

75 Indicator 3.1: Emissions from the energy system44

76 *Indicator 3.1.1: Carbon intensity of the energy system*44

77 *Indicator 3.1.2: Coal phase-out*.....46

78 *Indicator 3.1.3: Zero-carbon emission electricity*.....47

79 Indicator 3.2: Access and use of clean energy49

80 Indicator 3.3: Air pollution, transport, and energy.....52

81 *Indicator 3.3.1: Exposure to air pollution in cities*52

82 *Indicator 3.3.2: Premature mortality from ambient air pollution by sector*.....53

83 Indicator 3.4: Sustainable and healthy transport54

84 Indicator 3.5: Emissions from livestock and crop production55

85 Indicator 3.6: Mitigation in the healthcare sector.....57

86 Conclusion.....60

87 Section 4: Economics and Finance60

88 Indicator 4.1: Economic losses due to climate-related extreme events61

89 Indicator 4.2: Economic costs of air pollution62

90 Indicator 4.3: Investing in a low-carbon economy63

91 *Indicator 4.3.1: Investment in new coal capacity*63

92 *Indicator 4.3.2: Investments in zero-carbon energy and energy efficiency*.....65

93 *Indicator 4.3.3: Employment in renewable and fossil fuel energy industries*66

94 *Indicator 4.3.4: Funds divested from fossil fuels*.....67

95 Indicator 4.4: Pricing greenhouse gas emissions from fossil fuels68

96 *Indicator 4.4.1: Fossil fuel subsidies*.....68

97	<i>Indicator 4.4.3: Use of carbon pricing revenues</i>	72
98	Conclusion.....	73
99	Section 5: Public and Political Engagement	73
100	Indicator 5.1 Media coverage of health and climate change	74
101	Indicator 5.2 Individual engagement in health and climate change	78
102	Indicator 5.3 Government engagement in health and climate change.....	79
103	Indicator 5.4 Corporate sector engagement in health and climate change.....	81
104	Conclusion.....	82
105	Conclusion: The 2019 Report of the Lancet Countdown.....	83
106	References	85
107		
108		
109	List of Figures, Tables and Panels	
110	List of Figures	
111	Figure 1: Change in the number of heatwave exposure events in the over 65 population	
112	compared with the historical average number of events	21
113	Figure 2: Potential global work hours lost by sector 2000-2018.....	22
114	Figure 3: Potential full-time work lost in the sun or in the shade.....	23
115	Figure 4: Person days exposed to fire in 2018.....	25
116	Figure 5: Mean change in number of extreme rainfall events per year over the 2000-2018	
117	period	26
118	Figure 6: Global trends in all-cause mortality and mortality from selected causes.....	28
119	Figure 7: Changes in global vectorial capacity for the dengue virus vectors <i>Aedes aegypti</i> and	
120	<i>Aedes albopictus</i> 1950-2017.....	30
121	Figure 8: Change in suitability for pathogenic <i>Vibrio</i> outbreaks as a result of changing sea	
122	surface temperatures	30
123	Figure 9: Change in crop growth duration (days) for five crops.....	32
124	Figure 10: Number of countries with a national health and climate change plan or strategy	
125	36

126	Figure 11: Global proportion of households with air conditioning (orange line), prevented	
127	fraction of heatwave-related mortality due to air conditioning (blue line), and CO ₂ emissions	
128	from air conditioning (green line) 2000-2016.	41
129	Figure 12: Adaptation Spending for Financial Years 2015/16 to 2017/18	42
130	Figure 13: Carbon intensity of Total Primary Energy Supply (TPES) for selected regions and	
131	countries, and global CO ₂ emissions from energy combustion by fuel type, 1972-2018	45
132	Figure 14: Total Primary Energy Supply (TPES) coal use in selected countries and regions,	
133	and global TPES coal, 1978-2018	47
134	Figure 15: Renewable and zero-carbon emission electricity generation (excluding	
135	bioenergy), 1990-2016.....	48
136	Figure 16: Proportion of clean fuel use for cooking 1995-2017 by World Bank income group.	
137	50
138	Figure 17: Premature deaths attributable to ambient PM _{2.5} in 2015 (upper bars) and 2016	
139	(lower bars), by economic source sectors of pollutant emissions, for the 2015 population..	54
140	Figure 18: Per capita fuel use by type (TJ/person) for road transport with all fuels (left) and	
141	non-fossil fuels only (right).	55
142	Figure 19: Global livestock (a) and crop (b) GHG emissions annually from 2000-2016, by	
143	process.	56
144	Figure 20: Per capita healthcare GHG emissions by country	58
145	Figure 21: Insured and uninsured Economic Losses from Climate-Related Events Relative to	
146	GDP by World Bank income group.	62
147	Figure 22: Annual global investment in coal-fired capacity 2006-2018	64
148	Figure 23: Annual Investment in the Global Energy System.	65
149	Figure 24: Employment in Renewable Energy and Fossil Fuel Extraction Sectors	66
150	Figure 25: Global Fossil Fuel Consumption Subsidies 2008-2018.	69
151	Figure 26: Carbon pricing instruments implemented, scheduled for implementation, and	
152	under consideration.....	71
153	Figure 27: Number of articles reporting on climate change and on both health and climate	
154	change in the People's Daily 2008-2018.....	75
155	Figure 28: Connectivity graph of Wikipedia articles on health (blue) and climate change (red)	
156	visited in 2018.....	79

157	Figure 29: Proportion of countries referring to climate change, health, and the intersection	
158	between the two in their UNGD statements, 1970-2018.	81

159

160 [List of Tables](#)

161

162	Table 1: Carbon Pricing – Global Coverage and Weighted Average Prices per tCO ₂ e.....	70
-----	---	----

163	Table 2: Carbon pricing revenues and allocation in 2018.	72
-----	---	----

164

165 [List of Panels](#)

166

167	Panel 1: The 2019 Lancet Countdown Indicators.....	14
-----	--	----

168	Panel 2: Household air pollution conditions in Nairobi, Kenya.....	51
-----	--	----

169	Panel 3: Healthcare sector response to climate change.....	59
-----	--	----

170	Panel 4: Dominant themes in elite newspaper coverage of health and climate change in	
-----	--	--

171	India and the USA.....	77
-----	------------------------	----

172

173 [List of Abbreviations](#)

174 A&RCC – Adaptation & Resilience to Climate Change

175 AAP – Ambient Air Pollution

176 AUM – Assets Under Management

177 BEV – Battery Electric Vehicle

178 CDP – Carbon Disclosure Project

179 CFU – Climate Funds Update

180 CO₂ – Carbon Dioxide

181 COP – Conference of the Parties

182 COPD – Chronic Obstructive Pulmonary Disease

183 CPI – Consumer Price Indices

184 CSD – Climate Sensitive Disease

185 DALYs – Disability Adjusted Life Years

186 DPSEEA – Driving Force-Pressure-State-Exposure-Effect-Action

187 ECMWF – European Centre for Medium-Range Weather Forecasts

188 EEIO – Environmentally-Extended Input-Output

189 EEZ – Exclusive Economic Zone

190 EJ – Exajoule (10¹⁸ joules)

191 EM-DAT – Emergency Events Database

192 ERA – European Research Area

193 ETR – Environmental Tax Reform

194 ETS – Emissions Trading System

195	EU – European Union
196	EU28 – 28 European Union Member States
197	EV – Electric Vehicle
198	FAO – Food and Agriculture Organization of the United Nations
199	FAZ – Frankfurter Allgemeine Zeitung
200	FISE – Social Inclusion Energy Fund
201	GBD – Global Burden of Disease
202	GDP – Gross Domestic Product
203	GHG – Greenhouse Gas
204	GtCO ₂ – Gigatons of Carbon Dioxide
205	GW – Gigawatt
206	GWP – Gross World Product
207	HAB – Harmful Algal Blooms
208	HFC - Hydrofluorocarbon
209	HIC – High Income Countries
210	HNAP – Health component of National Adaptation Plan
211	HT – Hindustan Times
212	ICS – Improved Cook Stove
213	IEA – International Energy Agency
214	IHR – International Health Regulations
215	IPC – Infection Prevention and Control
216	IPCC - Intergovernmental Panel on Climate Change
217	IRENA - International Renewable Energy Agency
218	KP – Kaiser Permanente
219	LMICs – Low- and Middle-Income Countries
220	LPG – Liquefied Petroleum Gas
221	Mt – Megaton
222	MtCO _{2e} – Metric Tons of Carbon Dioxide Equivalent
223	MODIS – Moderate Resolution Imaging Spectroradiometer
224	MRIO – Multi-Region Input-Output
225	NAP – National Adaptation Plan
226	NASA – National Aeronautics and Space Administration
227	NDCs - Nationally Determined Contributions
228	NHMSs – National Meteorological and Hydrological Services
229	NHS – National Health Service
230	NO _x – Nitrogen Oxides
231	NYT – New York Times
232	OECD – Organization for Economic Cooperation and Development
233	PHEV – Plug-in Hybrid Electric Vehicle
234	PM _{2.5} – Fine Particulate Matter
235	PV – Photovoltaic
236	SDG – Sustainable Development Goal
237	SDU – Sustainable Development Unit
238	SHUE – Sustainable Healthy Urban Environments
239	SO ₂ – Sulphur Dioxide
240	SSS – Sea Surface Salinity

241	SST – Sea Surface Temperature
242	tCO ₂ – Tons of Carbon Dioxide
243	tCO ₂ /TJ – Total Carbon Dioxide per Terajoule
244	TJ – Terajoule (10 ¹² joules)
245	ToI – Times of India
246	TPES – Total Primary Energy Supply
247	TWh – Terawatt Hours
248	UHC – Universal Health Coverage
249	UK – United Kingdom
250	UN – United Nations
251	UNFCCC – United Nations Framework Convention on Climate Change
252	UNGA – United Nations General Assembly
253	UNGD – United Nations General Debate
254	USA – United States of America
255	V&A – Vulnerability and Adaptation
256	VC – Vectorial Capacity
257	VLV – Value of a Life Year
258	WHL – Work Hours Lost
259	WHO – World Health Organization
260	WMO – World Meteorological Organization
261	WP – Washington Post
262	YLL – Years of Life Lost

263 Executive Summary

264 The Lancet Countdown is an international, multi-disciplinary collaboration, dedicated to
265 monitoring the evolving health profile of climate change, and providing an independent
266 assessment of governments' delivery of their commitments under the Paris Agreement.

267 The 2019 report presents an annual update of 41 indicators across five key domains: climate
268 change impacts, exposures, and vulnerability; adaptation, planning, and resilience for
269 health; mitigation actions and health co-benefits; economics and finance; and public and
270 political engagement. It represents the findings and consensus of 27 leading academic
271 institutions and UN agencies from every continent. Each year, the methods and data that
272 underpin the Lancet Countdown's indicators are further developed and improved, with
273 updates described at each stage of this report. In order to generate the quality and diversity
274 of data required, the collaboration draws on the world-class expertise of climate scientists,
275 ecologists, mathematicians, engineers, energy, food, and transport experts, economists,
276 social and political scientists, public health professionals, and doctors.

277 The science of climate change describes a range of possible futures, which are largely
278 dependent on the degree of action or inaction in the face of a warming world. To this end,
279 the policies implemented now will have far-reaching effects in determining these
280 eventualities, with the indicators tracked here monitoring both the present-day effects of
281 climate change, as well as the world's response. Understanding these decisions as a choice
282 between one of two pathways – one that continues with “business as usual” and one that
283 redirects to a future that remains “well below 2°C” – helps to bring the importance of
284 today's decisions, into sharp focus.

285 Evidence provided by the Intergovernmental Panel on Climate Change, the International
286 Energy Agency, and the US National Aeronautics and Space Administration is helpful in
287 understanding the degree of climate change experienced today and in contextualising these
288 two pathways.

289

290 **The Impacts of Climate Change on Human Health**

291 The world has so-far observed a 1°C temperature rise above pre-industrial levels, with
292 feedback cycles and polar amplification seeing a rise as high as 3°C in North Western
293 Canada.^{1,2} Indeed, eight of the ten hottest years on record have occurred in the last
294 decade.³ Such rapid change is primarily driven by the combustion of fossil fuels, consumed
295 at a rate of 171,000 kg of coal, 11,600,000 litres of gas, and 186,000 litres of oil per second.⁴⁻
296 ⁶ Progress in mitigating this threat is intermittent at best, with CO₂ emissions continuing to
297 rise in 2018.⁷ Importantly, many of the indicators contained in this report suggest the world
298 is following this “business as usual” pathway.

299 The carbon intensity of the energy system has remained unchanged since 1990 (Indicator
300 3.1.1), and from 2016 to 2018, total primary energy supply from coal increased by 1.7%,
301 reversing a previous downwards trend (Indicator 3.1.2). Correspondingly, the healthcare
302 sector is responsible for some 4.6% of global emissions, steadily rising across most major
303 economies (Indicator 3.6). Global fossil fuel consumption subsidies increased by 50% over
304 the last three years, reaching a high of almost US\$430 billion in 2018 (Indicator 4.4.1).

305 Here, a child born today will experience a world that is over four degrees warmer than the
306 pre-industrial average, with climate change impacting human health from infancy and
307 adolescence to adulthood and old age. Across the world, children are among the worst
308 affected by climate change. Downward trends in global yield potential for all major crops
309 tracked since 1960 threatens food production and food security, with infants often worst
310 affected by the potentially permanent effects of undernutrition (Indicator 1.5.1). Children
311 are among the most susceptible to diarrhoeal disease and experience the most severe
312 effects of dengue fever. Trends in climate suitability for disease transmission are hence
313 particularly concerning, with nine of the ten most suitable years for the transmission of
314 dengue fever on record occurring since 2000 (Indicator 1.4.1). Similarly, since an early 1980s
315 baseline, the number of days suitable for Vibrio (a pathogen responsible for part of the
316 burden of diarrhoeal disease) has doubled, and global suitability for coastal Vibrio cholerae
317 has increased by 9.9% (Indicator 1.4.1).

318 Through adolescence and beyond, air pollution – principally driven by fossil fuels, and
319 exacerbated by climate change – damages the heart, lungs, and every other vital organ.
320 These effects accumulate over time, and into adulthood, with global deaths attributable to
321 ambient PM_{2.5} remaining at 2.9 million in 2016 (Indicator 3.3.2) and total global air pollution
322 deaths reaching 7 million.⁸

323 Later in life, families and livelihoods are put at risk from increases in the frequency and
324 severity of extremes of weather, with women often among the most vulnerable. At the
325 global level, 77% of countries experienced an increase in daily population exposure to
326 wildfires from 2001-2014 to 2015-2018 (Indicator 1.2.1). Perhaps unsurprisingly, India and
327 China sustained the largest increases, with an increase of over 15 million and 10.5 million
328 exposures over this time period. In low-income countries, almost all economic losses from
329 extreme weather events are uninsured, placing a particularly high burden on individuals and
330 households (Indicator 4.1). Temperature rises and heatwaves are limiting the labour
331 capacity of populations at increasing rates. In 2018, 45 billion potential work hours were lost
332 globally compared to a 2000 baseline, and Southern parts of the United States of America
333 lost as much as 15-20% of potential daylight work hours during the hottest month of 2018
334 (Indicator 1.1.4).

335 Populations aged over 65 years are particularly vulnerable to the health effects of climate
336 change, and especially to extremes of heat. From 1990 to 2018, populations in every region
337 have become more vulnerable to heat and heatwave, with Europe and the Eastern
338 Mediterranean remaining the most vulnerable (Indicator 1.1.1). In 2018, these vulnerable
339 populations experienced 220 million heatwave exposures globally, breaking the previous

340 record of 209 million set in 2015 (Indicator 1.1.3). Already faced with the challenge of an
341 ageing population, Japan had 32 million heatwave exposures affecting people aged over 65
342 in 2018, the equivalent of almost every person in this age group experiencing a heatwave.
343 Finally, whilst they are difficult to quantify, the down-stream risks of climate change, such as
344 those seen in migration, poverty exacerbation, violent conflict, and mental illness affect
345 people of all ages and all nationalities.

346 A business as usual trajectory will result in a fundamentally altered world, with the
347 indicators described above providing a glimpse of the implications of this pathway. Here,
348 the life of every child born today will be profoundly affected by climate change. Without
349 significant intervention, this new era will come to define the health of people at every stage
350 of their lives.

351

352 **Responding to Climate Change for Health**

353 The Paris Agreement lays out a target of “holding the increase in the global average
354 temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the
355 temperature increase to 1.5°C”. In a world that matches this ambition, a child born today
356 would see the phase-out of all coal in the UK and Canada by their 6th and 11th birthday; they
357 would see France ban the sale of petrol and diesel cars by their 21st birthday, and they
358 would be 31 years old by the time the world reaches net zero in 2050, with the UK’s recent
359 commitment one of many to come. The changes seen in this alternate pathway could result
360 in cleaner air, safer cities, and more nutritious food, coupled with renewed investment in
361 health systems and vital infrastructure. It is clear that this second path, which limits global
362 average temperature rise to “well below 2°C” is possible, and would transform the health of
363 a child born today for the better, right the way through their life.

364 Considering the evidence available in the 2019 indicators, there are signs that the beginning
365 of such a transition may be unfolding. Despite a small increase in coal use in 2018, in key
366 countries such as China, it continued to fall as a share of electricity generation (Indicator
367 3.1.2). Correspondingly, renewables accounted for 45% of global growth in power
368 generation capacity that year, and low-carbon electricity reached a high of 32% of global
369 electricity in 2016 (Indicator 3.1.3). Global per capita use of electric vehicles grew by an
370 enormous 20.6% between 2015 and 2016, and now represents 1.8% of China’s total
371 transportation fuel use (Indicator 3.4). Improvements in air pollution seen in Europe from
372 2015 to 2016 could result in a reduction of Years of Life Lost worth €5.2 billion annually if
373 this reduction remained constant across a lifetime (Indicator 4.2). In a number of cases, the
374 savings from a healthier and more productive workforce, with fewer healthcare expenses,
375 will cover the initial investment costs of these interventions. Similarly, more resilient cities
376 and health systems are beginning to emerge. Almost 50% of countries and 69% of cities
377 surveyed reported efforts to conduct national health adaptation plans or climate change
378 risk assessments (Indicators 2.1.1, 2.1.2 and 2.1.3). These plans are now being implemented,
379 with the number of countries providing climate services to the health sector rising from 55

380 in 2018 to 70 in 2019 (Indicator 2.2) and 109 countries reporting medium to high
381 implementation of a national health emergency framework (Indicator 2.3.1). Growing
382 demand is coupled with a steady increase in health adaptation spending, which represents
383 5% (£13 billion) of total adaptation funding in 2018 and has increased by 11.8% over the
384 past 12 months (Indicator 2.4). This is in part funded by growing revenues from carbon
385 pricing mechanisms, which saw a 30% increase in funds raised between 2017 and 2018, up
386 to US\$43 billion (Indicator 4.4.3).

387 However, current progress is inadequate, and despite the beginnings of a transition
388 described above, the indicators published in the Lancet Countdown's 2019 report are
389 suggestive of a world struggling to cope with warming that is occurring faster than
390 governments are able, or willing to respond. There are too many missed opportunities to
391 improve public health, and leadership in recognising these links at the UN General Assembly
392 is too often left to Small Island Developing States (Indicator 5.3). Indeed, it is the generation
393 that has led the wave of school climate strikes across the world that will be affected most by
394 climate change.

395 Meeting this unprecedented challenge will require an unprecedented global response, with
396 bold, new approaches to policymaking, research, and business. It will take the work of the
397 7.5 billion people currently alive, to ensure that the health of a child born today isn't
398 defined by a changing climate.

399

400

401

402

403 Introduction

404 Human wellbeing, and the stability of local communities, health systems, and governments
405 all depend on how they interface with the changing global climate.^{9,10} Across the world, an
406 average temperature rise of 1°C since a pre-industrial baseline^{1,2} has already revealed
407 profound impacts, with more severe storms and floods, prolonged heatwaves and droughts,
408 new and emerging infectious diseases,¹¹⁻¹³ and compounding threats to food security. Left
409 unabated, climate change will define the health profile of current and future generations,
410 will challenge already overwhelmed health systems, and undermine progress towards the
411 United Nations (UN) Sustainable Development Goals (SDGs) and universal health coverage
412 (UHC).^{14,15}

413 The Intergovernmental Panel on Climate Change (IPCC)'s recent Special Report on Global
414 Warming of 1.5°C makes the scale of the response required clear: global annual emissions
415 must halve by 2030 and reach net-zero by 2050 in order to limit warming to 1.5°C, whilst
416 recognising that no amount of climate change is considered "safe".² Placing health at the
417 centre of this transition will yield enormous dividends for the public and the economy, with
418 cleaner air, safer cities, and healthier diets. Analysis focused on one of these pathways –
419 cleaner air through more sustainable transport and power generation systems – suggests
420 that the economic gains from the health benefits of meeting the Paris Agreement
421 substantially outweigh the cost of any intervention by a ratio of 1.45 to 2.45, resulting in
422 trillions of dollars of savings world-wide.¹⁶ When the health benefits of any increase in
423 physical activity that results from modal shift are taken into account, the economic gains
424 increase significantly.¹⁷ These analyses complement a recent assessment from outside the
425 health sector, which estimates that a robust response to climate change could yield over
426 US\$26 trillion and 65 million new low-carbon jobs by 2030, compared to a business-as-usual
427 scenario.¹⁸

428 Monitoring this transition from threat to opportunity and demonstrating the benefits of
429 realising the Paris Agreement is precisely why *the Lancet Countdown: Tracking Progress on*
430 *Health and Climate Change* was formed. As an international, independent research
431 collaboration, the partnership brings together some 27 academic institutions and UN
432 agencies from every continent. The indicators and report presented here represent the
433 work and consensus of climate scientists, geographers, engineers, energy, food and
434 transport experts, economists, social and political scientists, public health professionals, and
435 doctors.

436 The 41 indicators of the 2019 report span five domains: climate change impacts, exposures,
437 and vulnerability; adaptation planning and resilience for health; mitigation actions and their
438 health co-benefits; economics and finance; and public and political engagement (Panel 1).
439

Working Group	Indicator	
Climate Change Impacts, Exposures and Vulnerability	1.1: Health and heat	1.1.1: Vulnerability to extremes of heat
		1.1.2: Health and exposure to warming
		1.1.3: Exposure of vulnerable populations to heatwaves
		1.1.4: Change in labour capacity
	1.2: Health and extreme weather events	1.2.1: Wildfires
		1.2.2: Flood and drought
		1.2.3: Lethality of weather-related disasters
	1.3: Global health trends in climate-sensitive diseases	
	1.4: Climate-sensitive infectious diseases	1.4.1: Climate suitability for infectious disease transmission
		1.4.2: Vulnerability to mosquito-borne diseases
	1.5: Food security and under-nutrition	1.5.1: Terrestrial food security and under-nutrition
		1.5.2: Marine food security and under-nutrition
Adaptation, Planning, and Resilience for Health	2.1: Adaptation planning and assessment	2.1.1: National adaptation plans for health
		2.1.2: National assessments of climate change impacts, vulnerability, and adaptation for health
		2.1.3: City-level climate change risk assessments
	2.2: Climate information services for health	
	2.3: Adaptation delivery and implementation	2.3.1: Detection, preparedness and response to health emergencies
		2.3.2: Air conditioning – benefits and harms
2.4: Spending on adaptation for health and health-related activities		
Mitigation Actions and Health Co-Benefits	3.1 Energy system and Health	3.1.1: Carbon intensity of the energy system
		3.1.2: Coal phase-out
		3.1.3: Zero-carbon emission electricity
	3.2: Access and use of clean energy	
	3.3: Air pollution, energy, and transport	3.3.1: Exposure to air pollution in cities
		3.3.2: Premature mortality from ambient air pollution by sector
	3.4: Sustainable and healthy transport	
	3.5: Food, agriculture, and health	
3.6: Mitigation in the healthcare sector		
Economics and Finance	4.1: Economic losses due to climate-related extreme events	
	4.2: Economic costs of air pollution	
	4.3: Investing in a low-carbon economy	4.3.1: Investment in new coal capacity
		4.3.2: Investments in zero-carbon energy and energy efficiency
		4.3.3: Employment in low-carbon and high-carbon industries
		4.3.4: Funds divested from fossil fuels
	4.4: Pricing greenhouse gas emissions from fossil fuels	4.4.1: Fossil fuel subsidies
4.4.2: Coverage and strength of carbon pricing		
4.4.3: Use of carbon pricing revenues		
Public and Political Engagement	5.1: Media coverage of health and climate change	
	5.2: Individual engagement in health and climate change	
	5.3: Engagement in health and climate change in the United Nations General Assembly	
	5.4: Engagement in health and climate change in the corporate sector	

440 *Panel 1: The Lancet Countdown Indicators*

441

442 Strengthening a global monitoring system for health and climate change

443 This collaboration builds on three decades of work around the world, which has sought to
444 understand and assess the scientific pathways linking climate change to public health.¹³ In
445 2016, the Lancet Countdown launched a global consultation process, actively seeking input
446 from experts and policymakers on which aspects of these pathways could and should be
447 tracked as part of a global monitoring process. A large number of indicators were initially
448 considered, and then narrowed down into the five indicator domains and published, along
449 with a request for further input.¹⁹ The final set of indicators were selected, based on: the
450 presence of credible scientific links to climate change and to public health; the presence of
451 reliable and regularly updated data, available across temporal and geographic scales; and
452 the importance of this information to policymakers.²⁰

453 Overcoming the data and capacity limitations inherent in this field and remaining adaptable
454 to a rapidly evolving scientific landscape has required a commitment to an open and
455 iterative approach. This has meant that the analysis provided in each subsequent annual
456 report replaces analyses from previous years, with methods and datasets being
457 continuously improved and updated. In every case, a full description of these changes is
458 provided in the appendix, which is intended as an essential companion to the main report,
459 rather than a more traditional addendum.

460 The 2019 report presents 12 months of work refining the metrics and analysis. In addition to
461 updating each indicator by one year, key developments include:

- 462 - The strengthening of methodologies and datasets for indicators that capture: heat
463 and heatwaves; labour capacity loss; the lethality of weather-related disasters;
464 terrestrial food security and undernutrition; health adaptation planning and
465 vulnerability assessments; air pollution mortality in cities; household fuel use for
466 cooking; and qualitative validation of engagement from the media and national
467 governments in health and climate change.
- 468 - The expansion of geographical and temporal coverage for indicators that capture:
469 marine food security; national adaptation planning for health; health vulnerability
470 assessments; climate information services for health; the carbon intensity of the
471 energy system; access to clean energy; and Chinese media engagement in health and
472 climate change.
- 473 - The construction of new indicators that capture: exposure to wildfires; the
474 transmission suitability for cholera; the benefits and harms of air conditioning;
475 emissions from livestock and crop production; global healthcare system emissions;
476 economic cost of air pollution; and individual online engagement in health and
477 climate change.

478 There is also ongoing work to establish indicators for concepts which are inherently difficult
479 to quantify, such as the mental health effects of climate change. In addition, three indicators
480 included in previous years – covering migration, global health adaptation funding, and
481 academic engagement in health and climate change – are not presented in the 2019 report,
482 as further work is being conducted to improve their methods and to ensure that they are

483 able to be sustainably reproduced into the future. These indicators will be re-introduced in
484 subsequent years.

485 For the second consecutive year, these changes represent significant updates to a majority
486 of indicators – a pace which will only accelerate as additional funding and capacity from the
487 Wellcome Trust and the Lancet Countdown’s partners grow. Going forward, the
488 collaboration will seek to further strengthen its scientific processes, continuously review its
489 indicators, and produce internally coherent frameworks to guide the development of new
490 indicators. To this end, the Lancet Countdown remains open to new input and participation
491 from experts and academic institutions willing to build on the analysis published in this
492 report.

493

494 [The year in health and climate change](#)

495 The 2019 report points to a number of worsening human symptoms of climate change. Over
496 220 million additional exposures to heatwaves (with each exposure defined as one person
497 over 65 exposed to one heatwave) occurred in 2018 compared to a climatological baseline,
498 higher than ever previously tracked (Indicator 1.1.3). This occurred at a time when
499 demographic vulnerability to these extremes continued to increase across every region
500 (Indicator 1.1.1), and the warming experienced by human populations reached four times
501 that of the global average temperature rise (Indicator 1.1.2). Around the world, resultant
502 losses in labour capacity were seen, with a number of the Southern states in the USA losing
503 as much as 15-20% of daylight capacity, for workers in construction and agriculture
504 (Indicator 1.1.4). The effects of this warming extended to other extremes, with 106
505 countries experiencing a marked increase in the daily population exposures to wildfires
506 when compared to baseline (Indicator 1.2.1). In the case of infectious disease, 2018 was the
507 second most suitable year on record for the transmission of diarrhoeal disease and wound
508 infections from *Vibrio* bacteria, and nine out of the last ten most suitable years for the
509 transmission of dengue fever have occurred since 2000 (Indicator 1.4.1). The distribution of
510 exposure and impact is not equal, with a number of these indicators reporting greater
511 changes in low-income settings in parts of Africa, South East Asia, and the Western Pacific
512 (Indicator 4.1).

513 Despite this, the carbon intensity of the global energy system has remained flat since 1990
514 (Indicator 3.1.1), and use of clean fuels for household services is stagnating (Indicator 3.2).
515 Perhaps of greatest concern, total primary energy supply from coal increased by 1.7% from
516 2016 to 2018, reversing a previously observed downwards trend (Indicator 3.1.2), and CO₂
517 emissions from the energy sector, far from falling, rose by 2.6% from 2016 to 2018
518 (Indicator 3.1.1). Global fossil fuel subsidies rose to US\$427 billion in 2018, a 33% rise from
519 2017 (Indicator 4.4.1), and healthcare-associated emissions now represent 4.6% of global
520 emissions, rising across most major economies (Indicator 3.6). Fossil fuel use continues to
521 contribute to ambient air pollution, which resulted in 2.9 million deaths in 2016 (Indicator
522 3.3.2).

523 Whilst these emerging health impacts and the lack of a coordinated global response portray
524 a bleak picture, they also mask important trends that lie behind the data. Encouraging
525 reductions in investment in new coal capacity and a fall in coal as a share of total electricity
526 generation continue (Indicators 4.3.1 and 3.1.2). Renewable energy accounted for 45% of
527 total growth in 2018 (Indicator 3.1.3), and low-carbon electricity represented an impressive
528 32% share of total global electricity generation in 2016 (Indicator 3.1.3). The reduction in air
529 pollution seen in Europe from 2015 to 2016, if held constant across a lifetime, could result in
530 annual reduction in Years of Life Lost valued at €5.2 billion (Indicator 4.2). These changes
531 are reinforced by new commitments from the UK²¹ and France²² to reach net zero by 2050,
532 with others soon expected to follow.

533 At the same time, the world is beginning to adapt, with almost 50% of countries, and 69% of
534 cities surveyed, reporting the completion or undertaking of a climate change risk
535 assessment or adaptation plan (Indicators 2.1.2 and 2.1.3). Increasingly, these plans are
536 being implemented, with 70 countries providing meteorological services targeted towards
537 the health sector in 2019 and 109 countries achieving medium to high implementation of a
538 national health emergency framework (Indicators 2.2 and 2.3.1).

539 In the health sector, the UK's Royal College of General Practitioners and Faculty of Public
540 Health divested their fossil fuels investments in 2018, joining a large number of universities,
541 non-governmental organisations and pension funds from across the world (Indicator 4.3.4).
542 Alongside this, new analysis suggests a growing and more sophisticated recognition of the
543 health benefits of the response to climate change in the media (Indicator 5.1).

544 Many of the trends identified in the 2019 Lancet Countdown report are deeply concerning.
545 Greenhouse gas (GHG) emissions continue to rise. Nevertheless, the continued expansion of
546 renewable energy, increased investment in health system adaptation, improvements in
547 sustainable transport, and growth in public engagement suggests ongoing reasons for
548 cautious optimism. At a time when the UN Framework Convention on Climate Change is
549 preparing to review commitments under the Paris Agreement in 2020, greatly accelerated
550 ambition and action is required in order to meet the world's commitment to remaining
551 "well below 2°C."²³
552

553 Section 1: Climate Change Impacts, Exposures, and Vulnerabilities

554 Climate change and human health are interconnected in a myriad of complex ways.¹³
555 Building on the Lancet Countdown's previous work, section 1 of the 2019 report continues
556 to track quantitative metrics along pathways of population vulnerability, exposure, and
557 health outcomes that are indeed indicative of the cost to human health of climate change,
558 and thus the urgent need to reduce GHG emissions. The impacts tracked here in turn
559 motivate and guide climate change adaptation (section 2) and mitigation (section 3)
560 interventions.

561 Changes in warming and weather events are not evenly distributed across the globe, and
562 some populations, including children, the elderly and outdoor workers, are more vulnerable
563 than others. Efforts to track the unequal impacts of climate change are reflected through
564 indicators that, for example, focus on particularly vulnerable populations, and by focusing
565 on low- and middle-income countries experiencing the worst of these effects.

566 Whilst it is certainly true that the effects of climate change vary by geography and that
567 these effects will not always be negative, it is also true that any so-called 'positives' are
568 often short-term in nature, and quickly overwhelmed and outweighed by other exposures.
569 One such example is seen in Australia, where any benefit that may have been gained from
570 CO₂ fertilisation is both small and largely outweighed by greater climate variation, with crop
571 yields now stalling as harvests are increasingly affected by more frequent drought.²⁴ Even
572 disregarding the negative effects of temperature change, any CO₂ fertilisation benefits are
573 likely to be short-lived, as rising CO₂ concentrations will negatively affect grain quality.²⁵⁻²⁸

574 For 2019, a new metric tracking exposure to wildfires has been added (Indicator 1.2.1), as
575 has an expansion of climate suitability of infectious diseases (Indicator 1.4.1), to now
576 include cholera transmission risk. These indicators portray a world which is rapidly warming,
577 where environmental and social systems are already feeling the effects of climate change,
578 and human health is being affected as a result.
579

580 Indicator 1.1: Health and heat

581 The most immediate and direct impact of a changing global climate on human health is seen
582 in the steady increase in global average temperature, and the increased frequency,
583 intensity, and duration of extremes of heat. The pathophysiological consequences of heat
584 exposure in humans are well documented and understood, and include heat stress and heat
585 stroke, acute kidney injury, exacerbation of congestive heart failure,²⁹ and increased risk of
586 interpersonal,³⁰ and collective violence.³¹ In particular, during periods of extreme heat,
587 young children have a greater risk of electrolyte imbalance, fever, respiratory disease and
588 kidney disease.³² Here, four indicators are related to heat, tracking the vulnerabilities,
589 exposures, and labour implications of a warming world.

590

591 *Indicator 1.1.1: Vulnerability to extremes of heat*

592 **Headline finding:** *Vulnerability to extremes of heat continues to rise among older*
593 *populations in every region of the world with the Western Pacific, South East Asia and*
594 *African regions all seeing an increase in vulnerability of over 10% since 1990.*

595 Certain populations are more vulnerable to the health effects of heat than others. Older
596 populations are particularly vulnerable, especially those with pre-existing medical
597 conditions (such as diabetes and cardiovascular, respiratory, and renal disease).³³ Outdoor
598 workers, while younger and healthier overall, are also vulnerable due to heightened
599 exposure. This indicator presents a heat vulnerability index which ranges from 0 to 100 and
600 includes proportion of the population over 65, prevalence of chronic diseases, and
601 proportion of the population living in urban areas, with the data and methods unchanged
602 from previous years, and provided in detail in the appendix.

603

604 Populations over 65, in all regions of the world, are becoming increasingly vulnerable.
605 However, the highest increase from 1990 to 2017 has been seen in the Western Pacific
606 (33.1% to 36.6%) and African (28.4% to 31.2%) regions. Overall, Europe remains the most
607 vulnerable region to heat exposure (followed closely by the Eastern Mediterranean region),
608 due to its ageing population, high rates of urbanisation, and high prevalence of
609 cardiovascular and respiratory disease, and diabetes.

610

611

612 *Indicator 1.1.2: Health and exposure to warming*

613 **Headline finding:** *Human populations are concentrated in the areas most exposed to*
614 *warming, experiencing a mean summer temperature change four times higher than the*
615 *global average.*

616 This indicator compares the population-weighted summer temperature change from a
617 1986-2005 baseline with the global average summer temperature change over the same
618 period, using weather data from the European Centre for Medium-Range Weather
619 Forecasts (ECMWF),³⁴ ERA-Interim project and population data from the NASA
620 Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World
621 (GPWv4).³⁵ Full details are provided in the appendix, along with an explanation of
622 improvements for the 2019 report, which uses higher resolution climate and population
623 data (0.5° grid instead of 0.75° grid).

624 The population-weighted temperatures continue to grow at a significantly faster pace than
625 the global average, increasing the human health risk. The global average population-
626 weighted temperature has risen by 0.8°C from the 1986-2005 baseline to 2018, compared
627 with a global average temperature rise of 0.2°C over the same period.

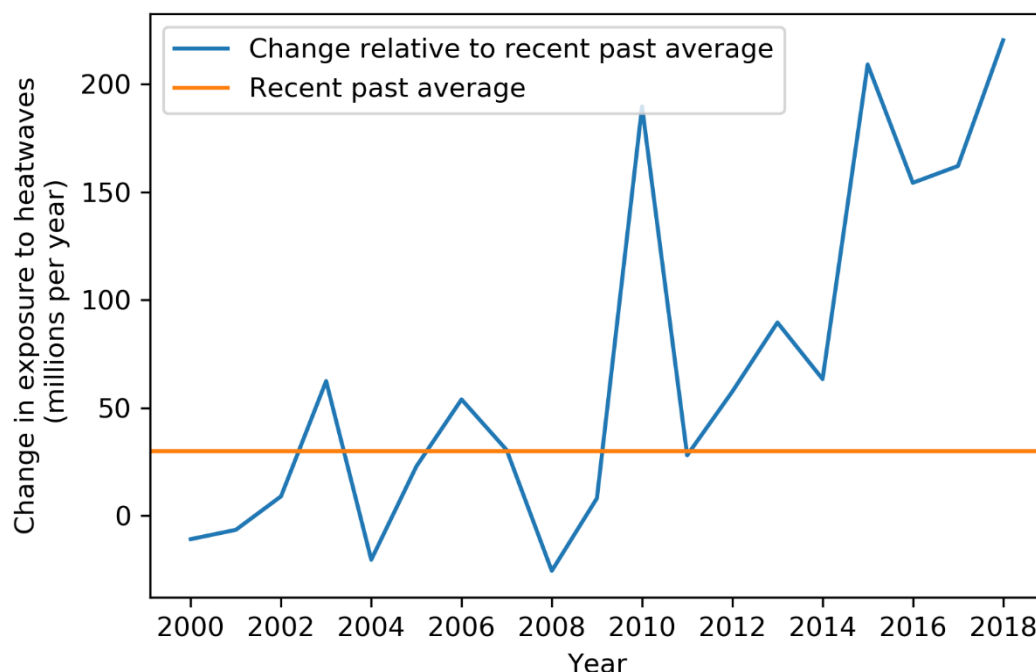
628

629 *Indicator 1.1.3: Exposure of vulnerable populations to heatwaves*

630 **Headline finding:** *In 2018, 220 million more heatwave exposures affecting older populations*
631 *were observed, breaking the previous record set in 2015. Japan alone experienced 32 million*
632 *heatwave exposures, the equivalent of almost every person aged 65 and above experiencing*
633 *a heatwave in 2018.*

634 Heatwaves across all of the Northern Hemisphere made headlines in 2018, reaching new
635 highs for a number of countries.³⁶ The definition of a heatwave, the demographic data³⁵ and
636 methods used here remain unchanged from previous reports (see appendix).⁴⁶ Each
637 heatwave exposure event is defined as one heatwave experienced by one person aged over
638 65. This indicator was also improved with a higher resolution (0.5° grid instead of 0.75°
639 grid).

640 Figure 1 presents the change in heatwave exposure events relative to the recent past
641 average. The increase in heatwave exposure events (220 million, which is 11 million more
642 than the 2015 record) is due to a series of heatwaves across India (45 million additional
643 exposures); in central and northern Europe (31 million additional exposures in the EU); and
644 northeast Asia, where the heatwave affected Japan, the Korean peninsula, and Northern
645 China. There were 32 million exposures affecting people aged over 65 in Japan alone, the
646 equivalent of almost every person in this age group experiencing a heatwave in 2018.³⁷



647
 648 *Figure 1: Change in the number of heatwave exposure events in the over 65 population compared*
 649 *with the historical average number of events (1986–2005 average).*

650

651 *Indicator 1.1.4: Change in labour capacity*

652 **Headline finding:** *higher temperatures continue to affect people’s ability to work. In 2018,*
 653 *due to rising temperatures, there were 45 billion additional potential work hours lost*
 654 *compared with the year 2000.*

655 People’s ability to work is affected by temperature and humidity, which are both captured
 656 in the Wet Bulb Globe Temperature (WBGT) measurement. Labour productivity loss
 657 estimates for every degree increase of WBGT beyond 24°C range from 0.8% to 5%.³⁸
 658 Reduced labour productivity is often the first symptom of the health effects of heat, and, if
 659 not addressed, may lead to more severe health effects, such as heat exhaustion and heat
 660 stroke.

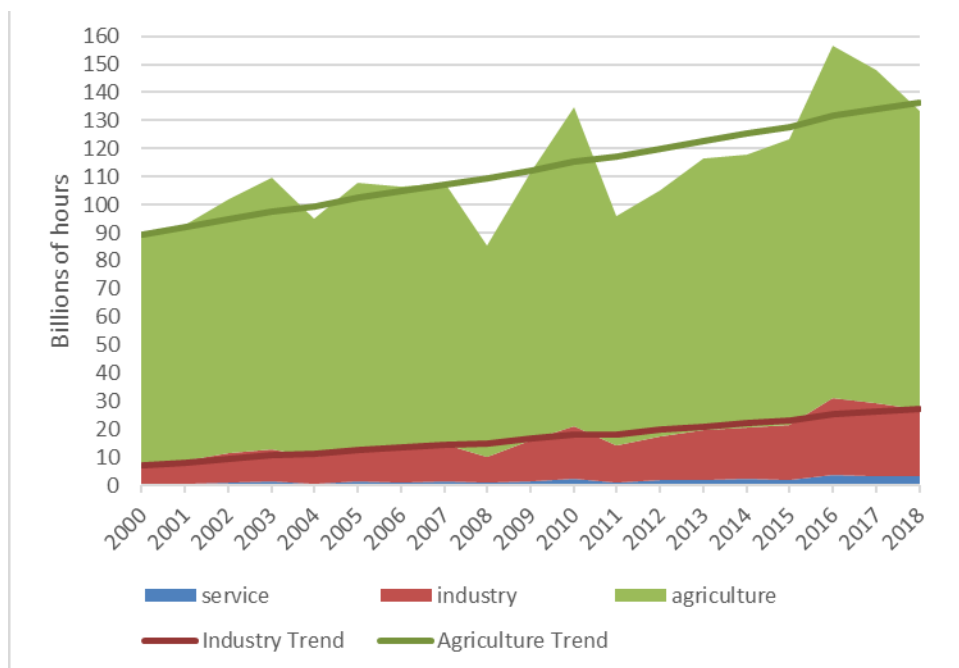
661 This indicator highlights the important impact of climate change on labour capacity in
 662 vulnerable populations.³⁹ It assigns work-fraction loss functions to different activity sectors
 663 (service, manufacturing and agriculture), linking WBGT with the power (metabolic rate)
 664 typically expended by a worker within each of these three sectors. This is then coupled with
 665 the proportion of the population working within each of these three sectors to calculate
 666 potential work hours lost (WHL) by country. This indicator has been improved to include the
 667 impact of sunlight on the potential WHL by calculating the increase in WBGT using solar

668 radiation data available from the ERA database, with full methods described in the
669 appendix.^{35,40,41}

670 The global atmospheric temperature and humidity in 2018 were slightly more favourable for
671 work than in 2017, but the upward trend of potential WHL since 2000 remains clear (Figure
672 2). In 2018, 133.6 billion potential work hours were lost, 45 billion hours more than in 2000.

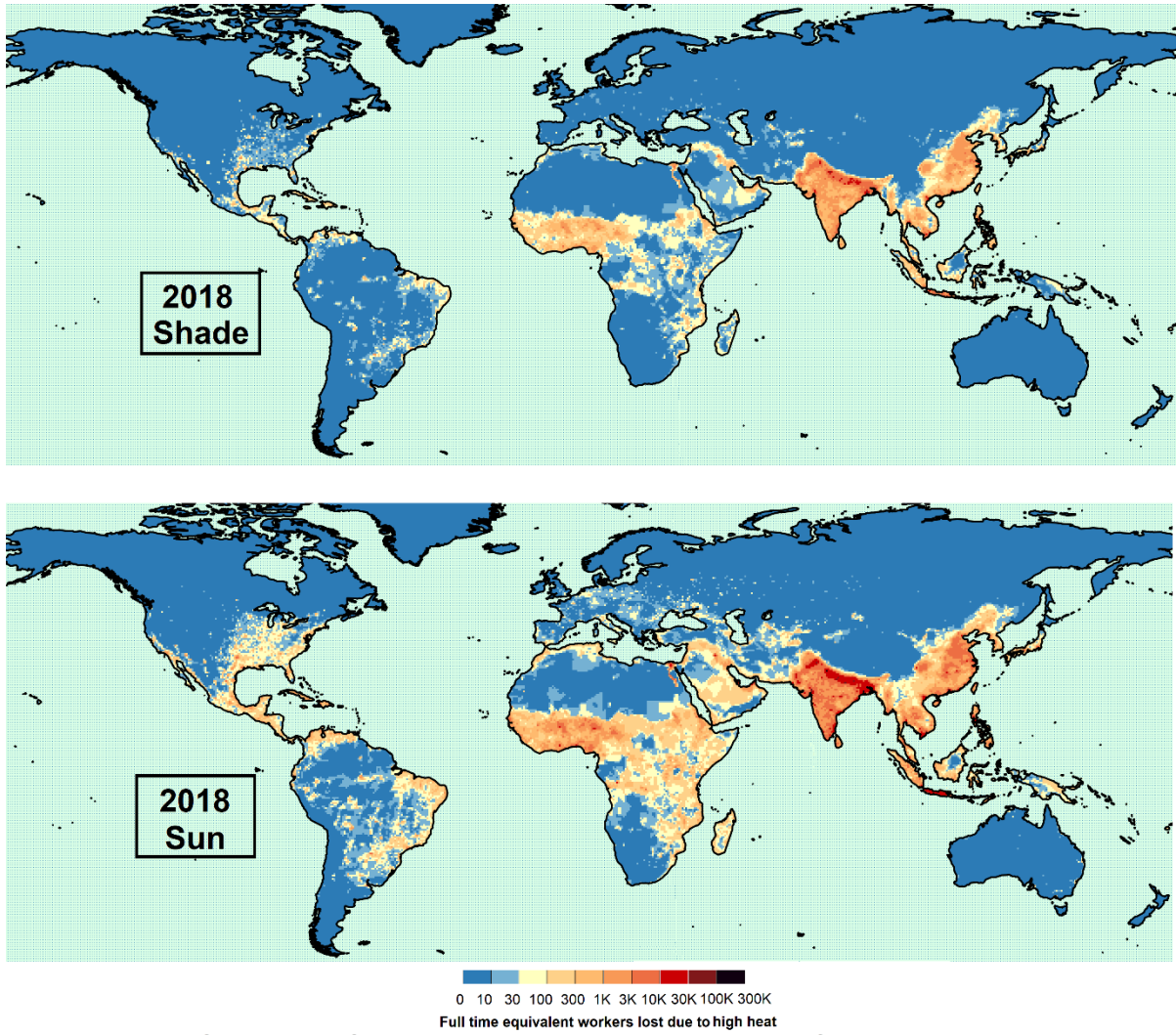
673 Figure 3 presents a map of the equivalent potential full-time work lost in the sun and the
674 shade. Of note, for 300W work in the shade (typical for manufacturing), over 10% potential
675 daily work hours were lost in densely populated regions such as South Asia. For 400W work
676 in the sun (typical for agriculture and construction), even workers in the Southern parts of
677 the USA (below a latitude of 34°N, with Texas, Louisiana, Mississippi, Alabama, Georgia, and
678 Florida particularly affected), lost 15-20% of potential daylight work hours in the hottest
679 month in 2018.

680



681 *Figure 2: Potential global work hours lost by sector 2000-2018.*

682



683
684
685
686

Figure 3: Potential full-time work lost in the sun or in the shade, based on the percent of people working in agriculture (400W), industry (300W) and services (200W) in each grid cell.

687 Indicator 1.2: Health and extreme weather events

688 *Indicator 1.2.1: Wildfires*

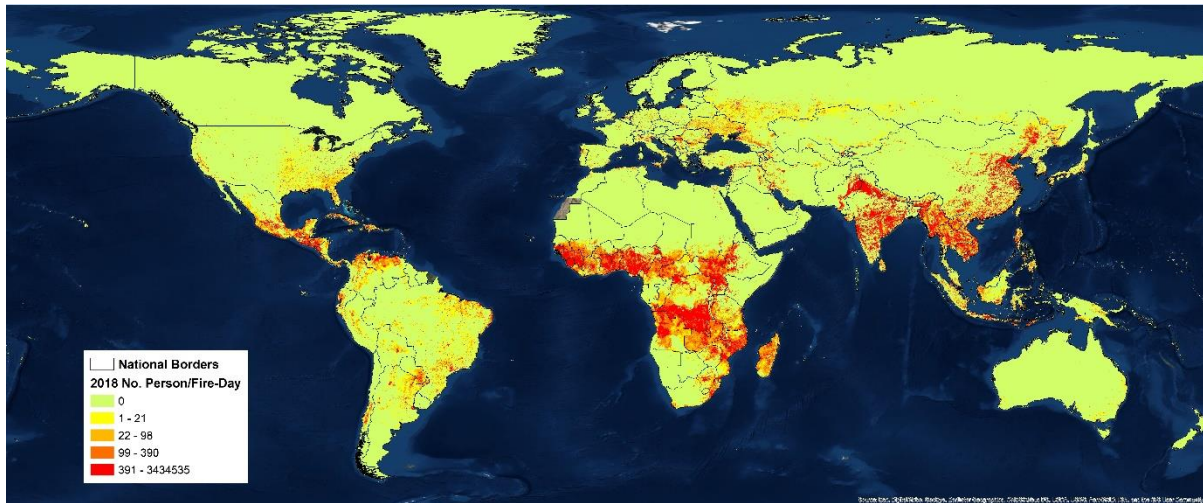
689 **Headline finding:** 152 out of 196 countries saw an increase in annual daily population
690 exposure to wildfires in 2015-2018 compared to 2001-2004, with India alone experiencing an
691 increase of 21 million annual daily exposures. This not only poses a threat to public health,
692 but also results in major economic and social burdens in both higher- and lower-income
693 countries.

694 The health impacts of wildfires range from direct thermal injuries and death, to the
695 exacerbation of acute and chronic respiratory symptoms due exposure to wildfire smoke.⁴²
696 Additionally, the global economic burden per person affected by wildfires is over twice that
697 of earthquakes and over 48 times that of floods, although the global number of events and
698 number of people affected by floods are much higher.⁴³ Furthermore, recent climatic
699 changes, including increasing temperature and earlier snowmelt, contribute to hotter, drier
700 conditions, that increase risk of wildfires. Yet, wildfires remain an important component of
701 many ecosystems, although they can be ecologically harmful through human ignition or
702 where forest management practices do not fully account for periodic, natural burning.

703 This new indicator represents the change in the average annual number of days people
704 were exposed to wildfire in each country. It was developed using Collection 6 active fire
705 product from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the
706 NASA Terra and Aqua satellites.⁴⁴ Fire point locations were matched to a political border
707 shapefile from the Global Burden of Disease (GBD), and consequently joined with
708 population count per square kilometre, taken from NASA SEDAC GPWv4.³⁵ The result is an
709 annual sum of people experiencing a fire event per day. The mean number of person-days
710 exposed to wildfire was taken for years 2001-2004 (the earliest years for which data with
711 adequate coverage and resolution is available) and compared with the mean from 2015-
712 2018.

713 Overall, this indicator reports a mean increase of 464,032 person-days exposed to wildfire
714 per year over the period studied, however the change experienced in some countries is far
715 greater than the global increase. India, China, the Democratic Republic of Congo, Mexico,
716 and Iraq sustained the largest increase in the number of person-days impacted by wildfires,
717 with a maximum difference of nearly 21,807,000 person-days in India followed by
718 17,003,000 person-days in China (Figure 4). Countries including Spain, Russia and Uzbekistan
719 saw significant reductions in the number of people affected.

720 Crucially, this indicator will evolve over time to cover the health risks of wildfire smoke,⁴²
721 which can travel far distances and affect areas that are not directly exposed to fires.⁴⁵



722
723 *Figure 4: Person days exposed to fire in 2018.*

724

725 *Indicator 1.2.2: Flood and drought*

726 **Headline Finding:** *Extremes of precipitation, resulting in flood and drought, have profound*
727 *impacts on human health and wellbeing, with South American and South East Asian*
728 *populations experiencing long-term increases in both phenomena.*

729 This indicator tracks exposure to extremes of precipitation, using weather and population
730 data used in previous reports,^{20,46} and described in full in the appendix. Analysis across time
731 and space reveals regional trends for drought and extreme heavy rain that are more
732 significant than global trends, reflecting the varying nature of climate change depending on
733 the geographical region.

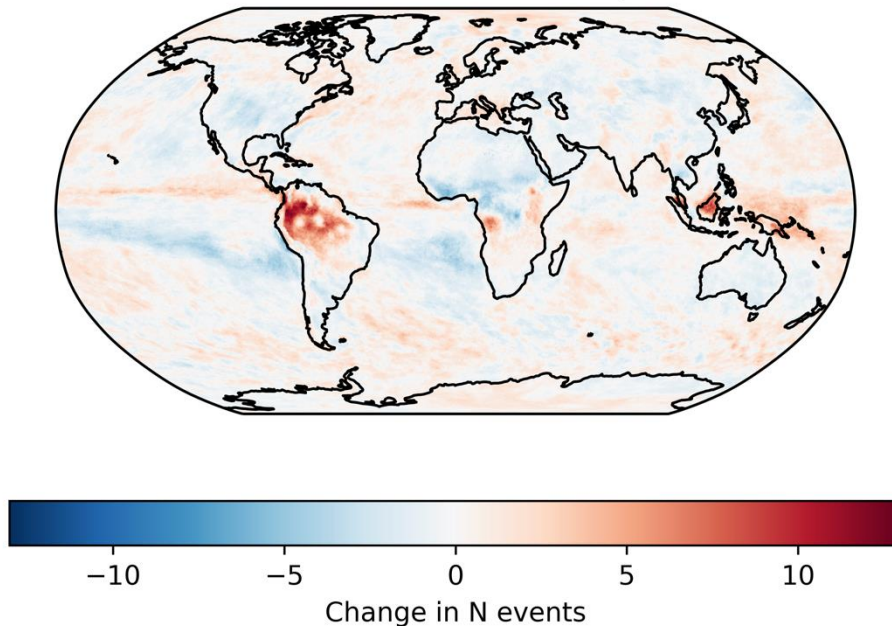
734 Floods are particularly problematic for health, resulting in direct injuries and death, the
735 spread of vector- and water-borne disease, and mental health sequelae.⁴⁷ Figure 5 provides
736 a global map of extremes of rainfall as a proxy for flood, and demonstrates that South
737 America and South East Asia are experiencing the largest increases.

738 Prolonged drought remains one of the most dangerous environmental determinants of
739 premature mortality, affecting hygiene and sanitation, as well as resulting in reduced crop
740 yields, food insecurity, and malnutrition.⁴⁷ The change in the mean number of severe
741 droughts highlights increased exposure in large areas of South America, Northern and
742 Southern Africa, and South East Asia, with many areas experiencing a full 12 months of
743 drought throughout 2018 (see appendix).

744

745

Mean change in number of extreme rainfall events over 2000 to 2018 period



746
747
748

Figure 5: Mean change in number of extreme rainfall events per year over the 2000-2018 period (change calculated relative to mean of 1986-2005).

749

750 *Indicator 1.2.3: Lethality of weather-related disasters*

751 **Headline Finding:** To date, there has been a statistically significant long-term upward trend
752 in the number of flood and storm related disasters in Africa, Asia, Europe, and the Americas
753 since 1990. At the same time, Africa has experienced a statistically significant increase in the
754 number of people affected by these types of disasters.

755 This indicator tracks the number of occurrences of weather-related disasters, the number of
756 people affected, and the lethality. These are formulated as a function of the hazard
757 (magnitude and frequency) and the vulnerability and exposure of populations at risk, using
758 data from the Centre for Research on the Epidemiology of Disasters.⁴⁸ For the 2019 report,
759 disasters have been separated into two groupings: flood and storm related disasters; and
760 heatwave, extreme temperature and drought related disasters. Further detail of these
761 methods and data are presented in the appendix.

762 For the heatwave, extreme temperature, and drought related disasters, no statistically
763 significant global trend was identified. One explanation for this could be the geographically
764 local nature of such events. However, in the case of floods and storms, a statistically
765 significant trend in occurrence was identified individually across Africa, Asia, and the
766 Americas. There has also been a statistically significant increase in the number of people

767 affected by floods and storms in Africa, although there was not a statistically significant
768 increase in the lethality of these events.

769 The relative stability of the lethality and numbers of people affected due to these disasters
770 could be possibly linked to improved disaster preparedness (including improved early
771 warning systems) as well as increased investments in healthcare services, and is discussed
772 further in section 2.⁴⁹⁻⁵¹ Importantly, work from the 2015 Lancet Commission demonstrates
773 that a business-as-usual trajectory is expected to result in an additional 2 billion flood-
774 exposure events per year by 2090, which will likely overwhelm health systems and public
775 infrastructure.¹³

776

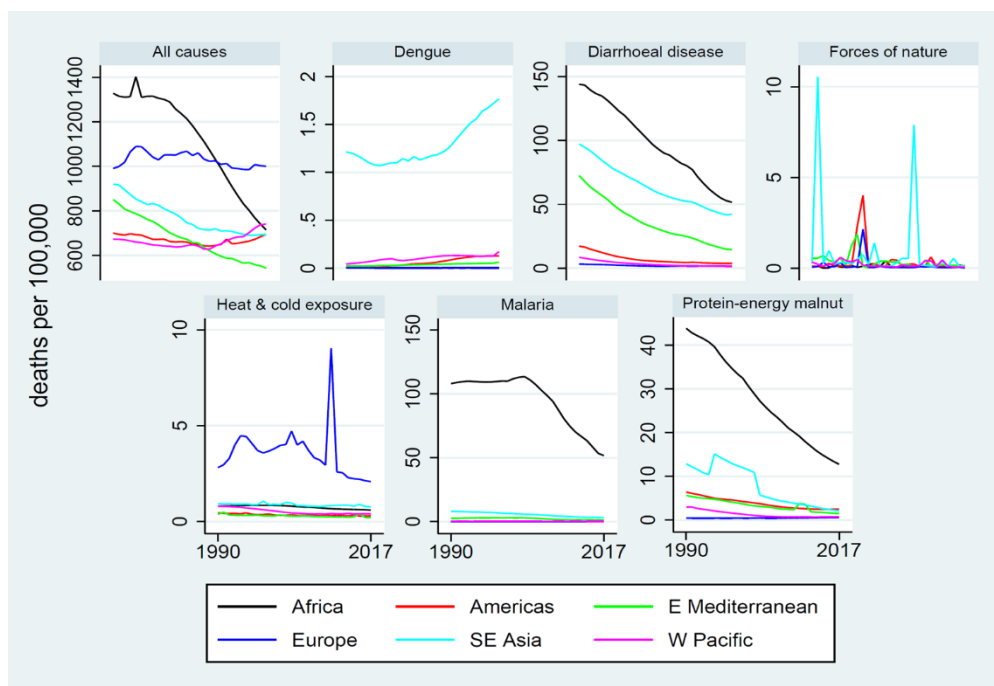
777 [Indicator 1.3: Global health trends in climate-sensitive diseases](#)

778 **Headline finding:** *Whilst large improvements are occurring in mortality due to diarrhoeal*
779 *diseases, malnutrition, and malaria, mortality due to dengue is rising in regions most*
780 *affected by these diseases.*

781 As described in the preceding indicators, climate change affects a wide range of disease
782 processes. Corresponding health outcomes result from a complex interaction between the
783 direct and indirect effects of climate change and social dynamics, such as population
784 demographics, economic development, and access to health services.¹³ This indicator
785 provides a macro view of these interactions, using GBD data to track mortality due to
786 diseases which are sensitive to climate change.⁵² Mortality due to earthquake and volcano
787 events is removed from the GBD category of 'forces of nature' to give estimates for
788 weather-related events.

789 Figure 6 presents global trends in climate-sensitive disease mortality from 1990 to 2017,
790 with all-cause mortality as a reference. Death from diarrhoeal diseases and protein-energy
791 malnutrition has declined considerably over this period in regions most affected (Africa,
792 South East Asia and Eastern Mediterranean). Likewise, Africa has experienced a marked
793 decrease in malaria mortality since the 2000s. Socioeconomic development, improved
794 access to healthcare, and major global health initiatives in sanitation and hygiene, and
795 vector control, have all contributed to these improvements in health outcomes.^{13,53}
796 However, mortality from dengue fever continues to rise, particularly in South East Asia.

797



798
 799 *Figure 6: Global trends in all-cause mortality and mortality from selected causes as estimated by the*
 800 *Global Burden of Disease 2017*⁵² for the 1990-2017 period, by WHO regions.

801
 802

803 **Indicator 1.4: Climate-sensitive infectious diseases**

804 *Indicator 1.4.1: Climate suitability for infectious disease transmission*

805 **Headline Finding:** *Due to a changing climate, environmental conditions are increasingly*
 806 *suitable for the transmission of numerous infectious diseases. Suitability for disease*
 807 *transmission has increased for dengue, malaria, Vibrio cholerae and other pathogenic Vibrio*
 808 *species. The number of suitable days per year in the Baltic for pathogenic Vibrio reached 107*
 809 *in 2018, the highest since records began, and double the early 1980s baseline.*

810 Climate change affects the distribution and risk of many infectious diseases.⁴⁷ The 2019
 811 Lancet Countdown report updates its analysis of dengue virus, malaria and *Vibrio* with the
 812 most recently available data, and presents an additional analysis of *V. cholerae*
 813 environmental suitability in coastal areas.

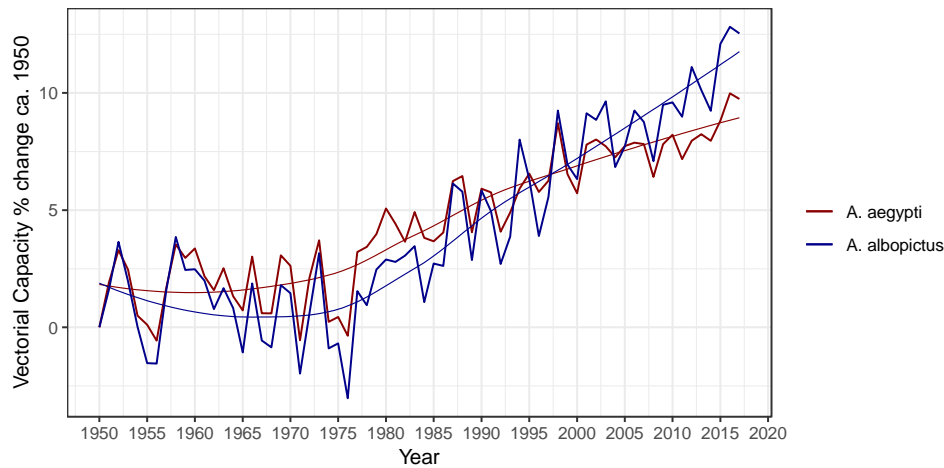
814 Malaria and dengue fever are endemic in many parts of the world and, as described in the
 815 previous indicator, continue to contribute substantially to burden of disease, with young
 816 children particularly vulnerable. Suitability for transmission of mosquito-borne infectious
 817 diseases is affected by factors such as temperature, humidity and precipitation. For dengue,
 818 vectorial capacity (VC), which expresses the average daily rate of subsequent cases in a
 819 susceptible population resulting from one infected case, is calculated using a formula
 820 including the vector to human transmission probability per bite, the human infectious

821 period, the average vector biting rate, the extrinsic incubation period and the daily survival
822 period.⁵⁴ For malaria, the number of months suitable for transmission of *Plasmodium*
823 *falciparum* and *P. vivax* malaria parasites is calculated based on temperature, precipitation
824 and humidity. Climate suitability for both of these mosquito-borne diseases is averaged for
825 the most recent five years for which data is available and compared with a 1950s baseline.

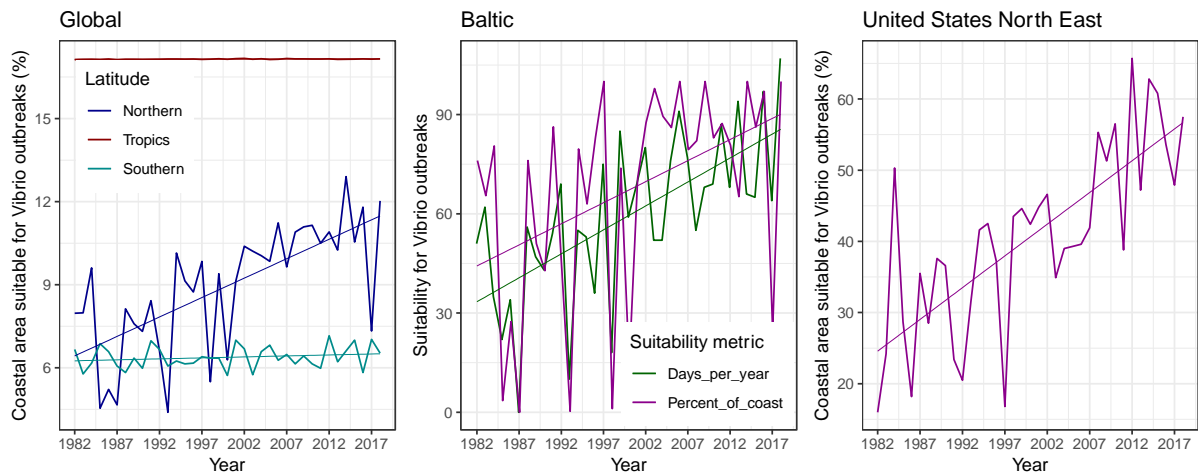
826 *Vibrio* species cause a range of human infections, including gastroenteritis, wound
827 infections, septicemia, and cholera. *Vibrio* species are found in brackish marine waters and
828 cases of infections are influenced by sea surface salinity (SSS), sea surface temperature
829 (SST), and chlorophyll-a concentrations.⁵⁵⁻⁵⁷ Climate suitability for *Vibrio* species was
830 estimated based on SSS and SST globally and focally for two regions (the Baltic and USA
831 Northeast coastlines) in which *Vibrio* (excluding *V. cholerae*) infections are most frequently
832 observed. For pathogenic *Vibrio* species (excluding *V. cholerae*), an average of the five most
833 recent years for which data is available is compared with a 1980s baseline, whereas the new
834 *V. cholerae* specific analysis compares the most recent three years with a 2003-2005
835 baseline (based on data availability). Full detail on methods can be found in the appendix.

836 Climate suitability for transmission is rising for each of the pathogens studied. The second
837 highest VC for both dengue vectors was recorded in 2017, with the 2012-2017 average 7.2%
838 and 9.8% above baseline for *Aedes aegypti* and *Aedes albopictus*, respectively (Figure 7).
839 This continues the upward trend of climate suitability for transmission of dengue, with nine
840 of the ten most suitable years occurring since 2000. Malaria suitability continues to increase
841 in highland areas of Africa, with the 2012-2017 average 29.9% above baseline. The
842 percentage of coastal area suitable for *Vibrio* infections in the 2010s has increased at
843 northern latitudes (40-70° N) by 3.8% compared to a 1980s baseline, with 2018 the second
844 most suitable year on record (5% above the baseline) (Figure 8). The area of coastline
845 suitable for *Vibrio* has increased by 31% and 29% for the Baltic and USA Northeast
846 respectively. Additionally, the number of days per year suitable for *Vibrio* in the Baltic
847 reached 107 in 2018, which is double the early 1980s baseline and the highest on record.
848 Globally, environmental suitability for coastal *V. cholerae sensu lato* has increased by 9.9%,
849 driven by regional increases in Asia, Europe, Middle East, North America, and Northern and
850 Western Africa.

851



852
853 *Figure 7: Changes in global vectorial capacity for the dengue virus vectors Aedes aegypti and Aedes*
854 *albopictus 1950-2017.*



855
856 *Figure 8: Change in suitability for pathogenic Vibrio outbreaks as a result of changing sea surface*
857 *temperatures a) globally, divided into three latitudinal bands (northern latitudes = 40-70°N; tropical*
858 *latitudes = 25°S-40°N; and southern latitudes = 25-40°S); b) the Baltic and c) United States North East*
859 *coast.*

860 *Indicator 1.4.2: Vulnerability to mosquito-borne diseases*

861 **Headline finding:** *Climate change induced risk of mosquito-borne diseases may be offset by*
862 *improvements in public health systems. Dramatic investments in public health have resulted*
863 *in a 31% fall in global vulnerability observed from 2010–2017. However, this success is not*
864 *spread equally, with vulnerability to recurrent dengue outbreaks increasing in the Western*
865 *Pacific and South East Asia over the same period.*

866 Whilst the previous indicator describes the influence of climate over the transmission of
867 several infectious diseases, this indicator tracks vulnerability to one of these (dengue).
868 Importantly, population vulnerability to this phenomenon is modulated by human, social,
869 financial, and physical factors as well as to the adaptive capacity of a community.^{53,58}

870 Country-level data relating to surveillance, preparedness and response from the World
871 Health Organization (WHO) International Health Regulations' (IHR) core capacities for the
872 years 2010 to 2017,⁵⁹ are used as a proxy for adaptive capacity. *Aedes aegypti* vulnerability
873 is defined by abundance and VC as described in Indicator 1.6.1. This index estimates the
874 population-level risk of exposure to *Aedes* mosquitoes, accounting for the public health core
875 capacity to cope with the potential impacts. A full account of the methods can be found in
876 the appendix.

877 A contraction of the vulnerability to dengue is observed from 2010 to 2017 in tropical and
878 sub-tropical areas of South America, Africa and Asia. However, this decrease in vulnerability
879 has levelled off in recent years, with a reversing trend in the Western Pacific and South East
880 Asia Regions.

881

882 [Indicator 1.5: Food security and undernutrition](#)

883 [Indicator 1.5.1: Terrestrial food security and undernutrition](#)

884 **Headline finding:** *All major crops tracked – maize, wheat, rice, and soybean – demonstrate*
885 *that increases in temperature have reduced global crop yield potential.*

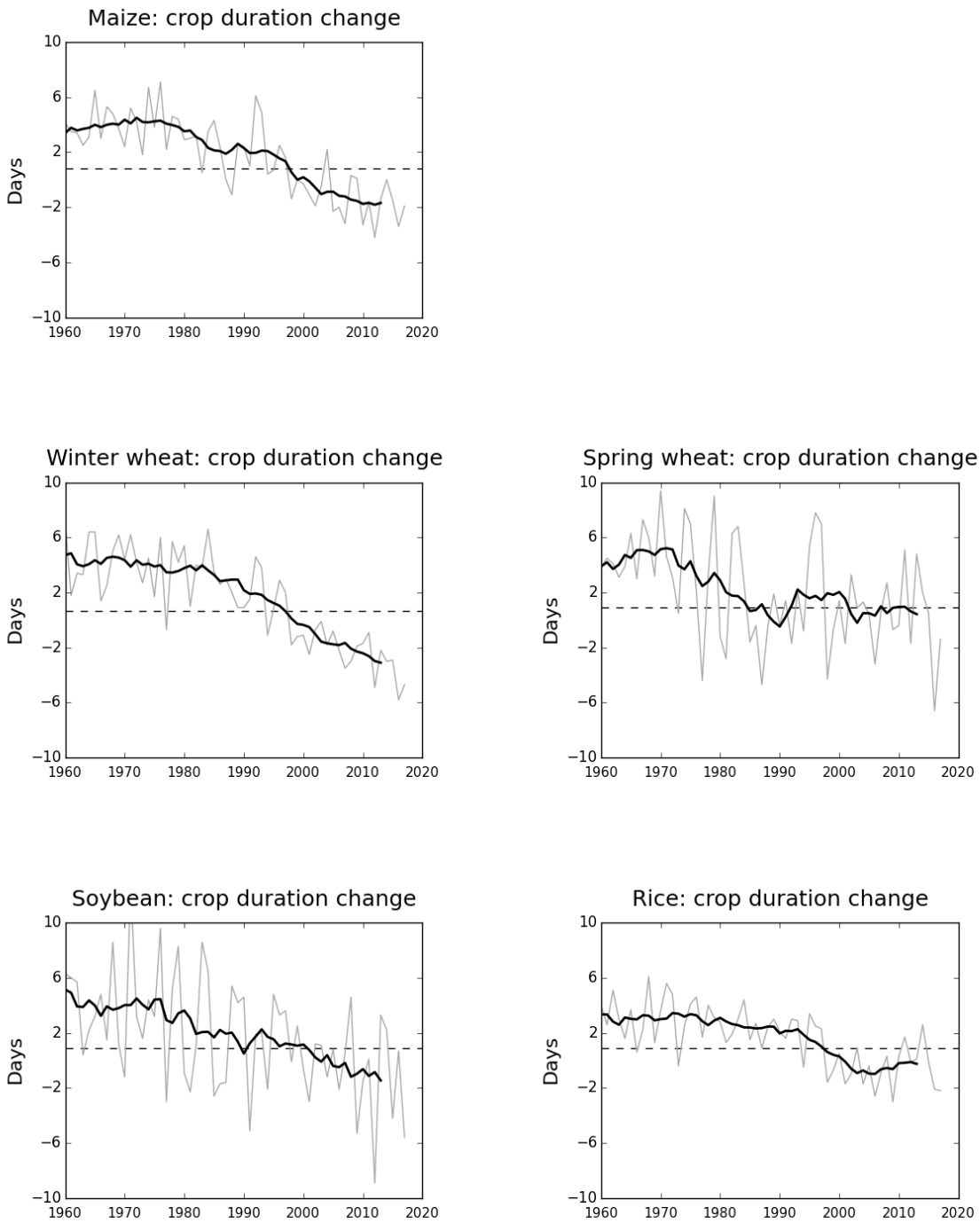
886 Currently, improvements in nutrient and water management, as well as expansion of
887 agricultural area in lower income countries, are causing global food production rise.^{60,61}
888 However, the global number of undernourished people appears to have been increasing
889 since 2014, driven by challenges to access, availability, and affordability of food.⁶²
890 Undernutrition overwhelmingly affects children under five, causing intrauterine growth
891 restriction, stunting, severe wasting, micronutrient deficiencies and poor breastfeeding.⁶³
892 There is growing evidence that crop production is threatened in complex ways by changes in
893 the incidence of pests and pathogens;⁶⁴ increasing water scarcity;⁶⁵ and increased frequency
894 and strength of extreme weather conditions that can damage or even wipe out harvests.⁶⁶

895 Crop yield potential was tracked for wheat, rice, soybean, and maize. Change in crop growth
896 duration is used as a proxy for yield potential. It is based on the time taken in a year to
897 accumulate a reference period (1981-2010) accumulated thermal time. A reduction in crop
898 duration means the crop matures too quickly with lower seed yield.⁶⁷ This methodology is
899 described in full, in the appendix, alongside a full description of the CRU database used.⁴⁴

900 Globally, crop yield potential for maize, winter wheat, and soybean has reduced in concert
901 with increases in temperature (Figure 9), challenging efforts to achieve SDG 2 to end hunger
902 by 2030.⁶⁶ This data resonates with a meta-analysis of the literature by Zhao et al. (2017).⁶⁸
903 which suggests that global yields of these four key crops are reduced by 6%, 3.2%, 7.4%, and
904 3.1% globally for each 1°C increase in global mean temperatures.

905

Global



906

907

908

909

910

Figure 9: Change in crop growth duration (days) for five crops. The dashed line shows the average change in crop duration compared with the reference period 1981-2010 baseline. Grey line: annual global area-weighted change. Black line: running mean over 11 years (5 years forward, five years backward).

911

912 *Indicator 1.5.2: Marine food security and undernutrition*

913 **Headline finding:** *Between 2003 and 2018, sea surface temperature rose in 34 of 64*
914 *investigated territorial waters, undermining marine food security.*

915 Fish provide almost 20% of their animal protein intake to 3.2 billion people, with a greater
916 reliance on fish sources of protein often in low- and middle-income countries (LMICs),
917 particularly small island developing states (SIDS).⁶⁹ Climate change threatens fisheries and
918 aquaculture in a number of ways, including through SST rise, intensity, frequency, and
919 seasonality of extreme events, sea level rise, and ocean acidification.⁷⁰ Acute disturbances
920 such as thermal stress lead to impaired recovery of the coral reefs, which threatens marine
921 fish populations and therefore marine primary productivity, a key source of omega3 fatty
922 acids for many populations.⁷¹

923 This indicator tracks SST in territorial waters, selected for their geographical coverage and
924 importance to marine food security, using data sourced from FAO, NASA and NOAA with all
925 methods described in full in the appendix.⁷²⁻⁷⁴ This has been further developed and now
926 includes 64 territorial waters (including countries where data is available) located in 16 FAO
927 fishing areas This indicator is complemented by monitoring of coral bleaching due to
928 thermal stress (abiotic indicators), and per-capita capture-based fish consumption (biotic
929 indicator) (see appendix). Between 2003 and 2018, SST has risen in 34 of the 64 territorial
930 waters, with the maximum increase in SST observed over this time being 3.5°C in Finland.

931

932

933 *Conclusion*

934 The indicators presented in this section provide evidence of the exposures, vulnerabilities
935 and impacts of climate change on health. They demonstrate worsening exposures and
936 vulnerabilities along a range of temperature and precipitation pathways, the reduction in
937 crop yield potentials, and rises in vectorial capacity for a number of climate-sensitive
938 diseases. As has been stated, it is clear that these effects are felt most acutely by low- and
939 middle-income countries across the world.

940 Continued work on attribution remains an important consideration here. For example, in
941 earlier reports, migration was addressed, where questions of attribution to climate change
942 remain particularly challenging.^{20,46} Irrespective of how climate change migrants are
943 counted,⁷⁵ many factors contribute to health risks faced by migration. Health impacts
944 depend on both pre-existing conditions (e.g. mental health and nutritional status, desire or
945 not to migrate, and existing health systems) along with interventions (e.g. healthcare
946 access, provision of food and shelter, and changing health-related resources).

947 Similarly, in 2018 the links between climate change and mental health were highlighted.⁴⁶
948 Mental health may variously be affected negatively by heatwaves, loss of property and

949 livelihoods due to floods, or climate-induced migration. However, although links between
950 climate and mental health are many and varied, they are highly socially and culturally
951 mediated. Attempting to operationalise such an idea as a single-number indicator linking
952 climate change and mental health outcomes remains elusive, yet quantifying these impacts
953 is of clear importance.⁷⁶

954

955

956 Section 2: Adaptation, Planning, and Resilience for Health

957 As knowledge of the health consequences of climate change increases, so too does the
958 urgent need to redouble efforts to protect people from adverse effects, particularly given
959 the lack of dramatic material progress on mitigation. Health systems will be placed under
960 increasing and overwhelming pressure, and it is now clear that adaptation is essential, even
961 with the most ambitious mitigation efforts.⁵⁸ An adaptation gap is apparent, signalled in
962 some of the impacts discussed above, and the rapid introduction of better-developed and
963 funded adaptation initiatives across all sectors is necessary to close this divide. The health
964 sector was highlighted as one of the top three priority areas for adaptation in an analysis of
965 Intended Nationally Determined Contributions (NDCs) prepared for the Paris Agreement.⁷⁷

966 By their very nature, adaptation and resilience measures are local and specific to regional
967 hazards and underlying population health needs. Identifying readily available global metrics,
968 with adequate data and proximity to climate change and to health adaptation is particularly
969 challenging.⁷⁸⁻⁸⁰ Beyond this, evaluating the success of any interventions is difficult, given
970 that the goals of adaptation are inherently long-term, and no counterfactual is readily
971 available. Rising to this challenge, the work in this section has expanded, from the initial
972 three indicators proposed in 2016,¹⁹ to the eight presented here. The structure of these
973 indicators, and this section, builds on the WHO Operational Framework for building climate
974 resilient health systems,⁸¹ monitoring progress across the following selected domains:

- 975 • Adaptation planning and assessment (Indicators 2.1.1, 2.1.2 and 2.1.3)
- 976 • Adaptive information systems (Indicator 2.2)
- 977 • Adaptation delivery and implementation (Indicators 2.3.1 and 2.3.2)
- 978 • Adaptation financing (Indicators 2.4.1 and 2.4.2)

979 True to an iterative approach, many indicators have been further developed. For the
980 indicators evaluating national health adaptation planning and vulnerability mapping
981 (Indicators 2.1.1 and 2.1.2), the number of country respondents have increased from 40 to
982 101. Additional information on implementation and government funding is included
983 alongside qualitative analysis, undertaken as part of the validation of the self-reported data.
984 A new indicator focuses on air conditioning use as an adaptive measure to heat mortality
985 (Indicator 2.3.2). This is the first of a new suite of indicators under development, which

986 monitor adaptation to a specific exposure pathway, complementing existing work on health
987 adaptation efforts as a whole.

988 A number of indicators in this section rely on self-reported data in surveys of national and
989 subnational governments to track health adaptation, with clear strengths and limitations to
990 this approach. Self-reported survey data is subject to response and nonresponse error with
991 local verification difficult,⁷⁹ however the datasets here – from the WHO and the Carbon
992 Disclosure Project (CDP) – provide the best available information on national- and city-level
993 health-specific adaptation globally. More information on the validation of the national data
994 can be found in the appendix.

995

996 [Indicator 2.1: Adaptation planning and assessment](#)

997 [Indicator 2.1.1: National adaptation plans for health](#)

998 **Headline finding:** *Recognition of the need for health adaptation to climate change is*
999 *widespread, and planning is underway. In 2018, half of countries surveyed reported having a*
1000 *national health and climate change plan in place.*

1001 Over the past decade, there has been a steady increase in countries scaling up health
1002 adaptation projects to build climate resilience.⁸² This indicator, based on data from the 2018
1003 WHO Health and Climate Country Survey Report,⁸³ tracks the number of countries that have
1004 a national health and climate change plan or strategy, current levels of their implementation
1005 and the commitment of national health funds for achieving the health adaptation and
1006 mitigation priorities outlined by governments in these documents. Importantly, the country
1007 response rate has more than doubled, with 101 of the 194 Member States reporting in the
1008 2018 survey compared with 40 reporting in the 2015 survey presented in earlier Lancet
1009 Countdown reports.²⁰

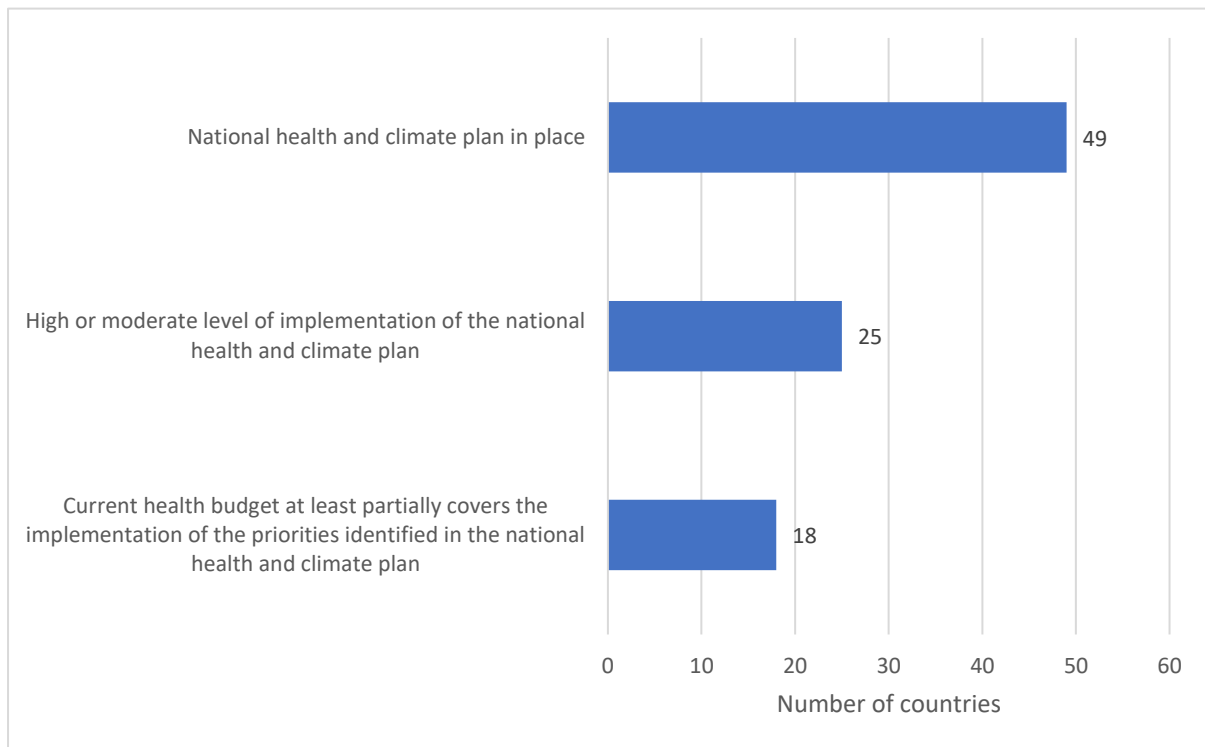
1010 Global coverage of national adaptation plans for health is growing, with 51 out of 101
1011 countries now having a national health and climate change plan in place. Just over half of
1012 these countries report at least a moderate level of implementation of their plans (Figure
1013 10), however challenges to full implementation remain, with less than 20% of countries
1014 reporting that action is being taken on a majority of their key priorities. National funding for
1015 implementation of health and climate change plans was identified as a central constraint
1016 with fewer than 4 in 10 countries reporting to have at least partial funding for the
1017 implementation of their main health adaptation and mitigation priorities (Figure 10).

1018 A further analysis of approximately 40 strategies/plans, collected as part of the survey,
1019 highlights that the comprehensiveness and scope of the national health and climate
1020 strategies/plans varied widely, with only a small number of plans directly linked to the
1021 National Adaptation Plan (NAP) process as part of the UN Framework Convention on
1022 Climate Change (UNFCCC). Finally, about 30% of the national health and climate change

1023 plans were published over five years ago. Opportunities therefore exist in national health
1024 and climate planning to update and expand the comprehensiveness of plans and for these
1025 to be developed into health components of NAP (HNAPS),⁸¹ thereby anchoring health within
1026 national climate processes and potentially strengthening access to international climate
1027 finance for health adaptation.

1028

1029



1030
1031 *Figure 10: Number of countries with a national health and climate change plan or strategy (n=101).*

1032

1033 *Indicator 2.1.2: National assessments of climate change impacts, vulnerability, and*
1034 *adaptation for health*

1035 **Headline finding:** *Of 101 countries surveyed in 2018, 48 indicated that a national*
1036 *assessment of health vulnerability to climate change had been conducted. However, of*
1037 *these, just over 40% reported that assessment findings had influenced the allocation of*
1038 *human and financial resources.*

1039 An adequate health adaptation response requires an assessment of the vulnerability of
1040 populations to different kinds of health effects, an assessment of local geographical and
1041 meteorological trends, and the corresponding capacity of health services. A health

1042 vulnerability and adaptation (health V&A) assessment serves as a baseline analysis, against
1043 which changes in disease risks and protective measures can be monitored, and strengthens
1044 the case for investment in health protection.⁸⁴ As above, data for this indicator is sourced
1045 from the 2018 WHO Health and Climate Country Survey Report.⁸³ Additional information on
1046 the survey methods and data can be found in the appendix.

1047 An increasing number of countries are undertaking national V&A assessments for health,
1048 the majority of countries indicating that these assessments are having at least some
1049 influence over policy prioritisation. However, translating evidence into funding decisions
1050 remains an issue, with only about 40% of countries reporting that resource allocation is
1051 guided by evidence generated from V&A assessments for health.

1052

1053 *Indicator 2.1.3: City-level climate change risk assessments*

1054 **Headline finding:** *In 2018, 54% of global cities surveyed expected climate change to seriously*
1055 *compromise their public health infrastructure, with 69% of cities actively developing or*
1056 *having completed a comprehensive climate change risk or vulnerability assessment.*

1057 The effects of climate change are experienced locally, with cities and local government
1058 forming a crucial component of any health adaptation response. For this indicator, the
1059 Lancet Countdown works with the CDP to include data from their annual global survey of
1060 cities.⁸⁵ Two components of this data are analysed: the number of global cities that have
1061 undertaken a city-wide climate change risk or vulnerability assessment; and their perceived
1062 vulnerability of critical health infrastructure to climate change. In 2018, 489 cities
1063 participated in the survey, with most (61%) coming from high-income countries.

1064 Just over half (52%) of all responding cities have undertaken an assessment and a quarter
1065 either have an assessment in progress (17%) or intend to undertake an assessment in the
1066 future (7%). This represents a small, but steady increase from 2017.⁴⁶ The health impacts of
1067 climate change are of increasing concern for cities, with 54% of responding cities noting that
1068 critical assets and/or services related to public health would be impacted by climate change,
1069 compared with 51% in 2017.⁴⁶

1070

1071

1072

1073 *Indicator 2.2: Climate information services for health*

1074 **Headline finding:** *Progress has been observed in the number of countries providing climate*
1075 *services to the health sector, increasing from 55 in 2018 to 70 in 2019.*

1076 It is essential that meteorological and hydrological services work with health services to
1077 monitor and prepare for the climate-related risks to health tracked in section 1.⁸¹ This
1078 indicator tracks national climate information services for health, which help monitor and
1079 prepare for climate-related health risks, using data reported by national meteorological and
1080 hydrological services to the World Meteorological Organization (WMO) Country Profile
1081 Database integrated questionnaire.

1082 Seventy national meteorological and hydrological services of WMO Member States reported
1083 providing climate services to the health sector, 15 more than reported in the 2018 Lancet
1084 Countdown report.⁴⁶ Of these, 18 were from Africa, 5 from the Eastern Mediterranean, 22
1085 from Europe, 13 from the Americas, 4 from South East Asia, and 8 from the Western Pacific.
1086 Additional detail was provided by 47 respondents, with a number of services working with
1087 the health sector and creating products accessible to the health sector. However, whilst
1088 climate services can be used for health in a range of ways, including monitoring, provision of
1089 early warning systems and forecasting of environmental risks, application of these services
1090 to policymaking remains low, with only 4 out of the 47 Member States reporting that
1091 climate services are guiding health sector policy decisions and investments plans.

1092
1093

1094

1095 [Indicator 2.3: Adaptation delivery and implementation](#)

1096 [Indicator 2.3.1: Detection, preparedness and response to health emergencies](#)

1097 **Headline finding:** 109 countries have medium to high implementation of a national health
1098 emergency framework, preparing for all public health events and emergencies.

1099 The International Health Regulations (IHR) are an international legal instrument aimed at
1100 helping the global community prevent and respond to acute public health risks.⁵⁹ These are
1101 assessed through a set of core capacities, reported in an annual survey of State Parties. The
1102 survey has been improved from a yes/no questionnaire from 2010 to 2017, to a more
1103 detailed tool which assesses the degree of implementation (see appendix). Capacity 8 (C8)
1104 of the IHR focuses on countries' national health emergency framework (NHEF), which
1105 applies to all public health events and emergencies, covering disease outbreaks, air
1106 pollution, extreme temperatures, droughts, floods and storms, as well as societal hazards
1107 (such as conflict and financial crisis). The survey includes three components: planning for
1108 emergency preparedness and response mechanism; management of health emergency
1109 response operations; and emergency resource mobilisation.⁸⁶

1110 In 2018, 182 WHO Member States completed the survey relating to C8. Of these, 109
1111 countries had medium to high implementation of the three components for this core
1112 capacity. However, the degree of implementation varied greatly by region, with Africa and

1113 Europe reporting having achieved 21.3% and 75.5% medium-high implementation
1114 respectively.

1115

1116 *Indicator 2.3.2: Air conditioning – benefits and harms*

1117 **Headline finding:** *Use of air conditioning as an adaptation measure is a double-edged*
1118 *sword: on the one hand, global air conditioning use in 2016 reduced heatwave-related*
1119 *mortality by 23% compared with a world without any air conditioning; on the other hand, it*
1120 *also confers harms, by contributing to climate change, worsening air pollution, substantially*
1121 *adding to peak electricity demand on hot days, and enhancing the urban heat island effect.*

1122 Indoor cooling is an important adaptation to extreme heat, with air conditioning emerging
1123 as a primary mechanism. Access to household air conditioning is highly protective against
1124 heatwave-related mortality;⁸⁷ however it is also associated with substantial indirect harms.
1125 On hot days in locations with high air conditioning prevalence, this can account for more
1126 than half of peak electricity demand⁸⁸ which, if sourced from fossil fuels, contributes to both
1127 CO₂ and PM_{2.5} emissions. Additionally, waste heat from air conditioning can paradoxically
1128 increase external night time temperatures by more than 1°C.⁸⁹ Hydrofluorocarbon (HFC)
1129 refrigerants used for air conditioning can escape into the atmosphere where they act as
1130 powerful GHGs. In baseline scenarios, these HFC emissions will rise to 1-2 GtCO₂e per year
1131 by 2050.^{90,91} Consequently, a nuanced approach to heat adaptation must be deployed,
1132 which protects vulnerable populations across the world from heat-related morbidity and
1133 mortality, whilst minimising the health and other co-harms of air pollution, the urban heat
1134 island effect, and worsening climate change.

1135 This new indicator includes four components: the proportion of households using air
1136 conditioning; the prevented fraction of heatwave-related mortality attributable to air
1137 conditioning use; CO₂ emissions attributable to air conditioning use; and premature
1138 mortality from air conditioning attributable PM_{2.5}. Unpublished data for household air
1139 conditioning use, electricity consumption, and CO₂ emissions was provided by the
1140 International Energy Agency (IEA). The prevented fraction,⁹² the percent reduction in
1141 heatwave-related deaths due to a given proportion of the population having household air
1142 conditioning, compared with a complete absence of household air conditioning, was
1143 calculated using a relative risk for heatwave-related mortality of 0.23 for having household
1144 air conditioning compared with not having household air conditioning,⁸⁷ and the proportion
1145 of populations with household air conditioning. The air pollution source attribution methods
1146 discussed in section 3 (Indicator 3.3.2) were used to calculate deaths due to PM_{2.5} emissions
1147 from air conditioning.

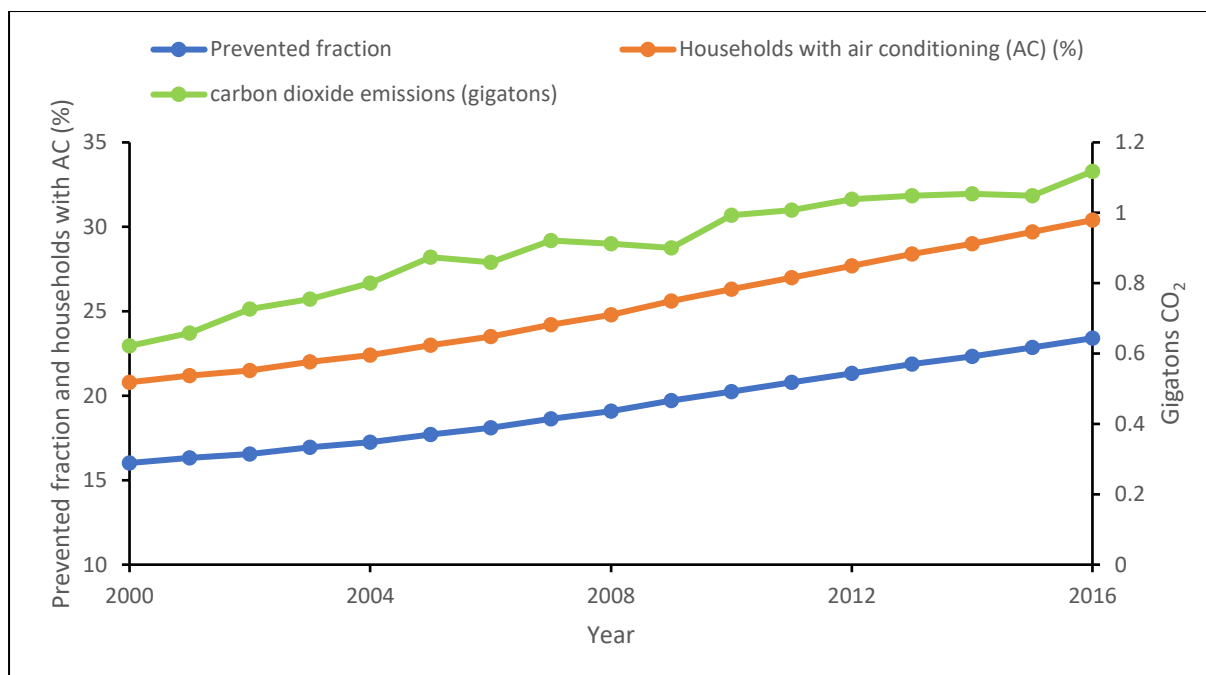
1148 Between 2000 and 2016, the world's air conditioning stock (residential and commercial)
1149 more than doubled to 1.62 billion units and the proportion of households with air
1150 conditioning increased from 21% to 30% (Figure 11). In 2016, this proportion was 4% in
1151 India, 14% in the European Union, 58% in China, and ≥90% in the USA and Japan.

1152 Correspondingly, the global prevented fraction of heatwave-related mortality increased
1153 from 16% in 2000 to 23% in 2016, ranging from <10% in India, Indonesia, and South Africa to
1154 $\geq 66\%$ in the USA, Japan and Korea. It is important to remember that the relative risk
1155 estimate used for these calculations is based on studies focused on European and US
1156 populations, and further research is required to fully understand the effect modification
1157 across different contexts.⁸⁷

1158 These trends have also been associated with significant harms. In 2016, air conditioning
1159 accounted for 10% of global electricity consumption and 18.5% of electricity used in
1160 buildings.⁹³ Under the IEA's baseline scenario, these figures will increase in 2050 to 16% and
1161 30%, respectively.⁹³ Following the trend in the proportion of households with air
1162 conditioning, CO₂ emissions from air conditioning use tripled from 0.35 gigatons in 1990 to
1163 1.1 gigatons in 2016 (Figure 11), and are projected to rise to 2 gigatons in 2050 in the IEA's
1164 baseline scenario.⁹³ In 2016 the number of premature deaths due to PM_{2.5} exposure
1165 attributable to air conditioning was 2480 in India, 2662 in China, 1088 in the European
1166 Union, and 749 in the USA.

1167 Fortunately, one path forward provides for adaptation against heat-related mortality for
1168 those who need it, without the associated harms of GHGs and PM_{2.5} emissions, excessive
1169 electricity demand, and undue contribution to the urban heat island effect. Air conditioning
1170 use could be reduced by promoting energy efficient appliances and energy efficient building
1171 design through strong, enforced building codes.⁹³ Traditional building designs in tropical and
1172 sub-tropical regions reduce thermal stresses by providing shade, thermal mass, insulation,
1173 and ventilation.⁹³ There is great potential to reduce the harms of air conditioning by
1174 increasing its efficiency,⁹³ by generating electricity from non-fossil-fuel sources, and by
1175 implementing the Kigali Amendment to the Montreal Protocol to phase-down HFCs.⁹⁴

1176



1177 Figure 11: Global proportion of households with air conditioning (orange line), prevented fraction of
 1178 heatwave-related mortality due to air conditioning (blue line), and CO₂ emissions from air
 1179 conditioning (green line) 2000-2016.
 1180

1181
 1182 **Indicator 2.4: Spending on adaptation for health and health-related activities**

1183 **Headline finding:** In 2018, global spending on health adaptation to climate change was
 1184 estimated to be 5% (£13 billion) of all adaptation spending, and health-related spending was
 1185 estimated at 13.5% (£35 billion). These estimates represent increases in absolute and
 1186 relative terms over previous data.

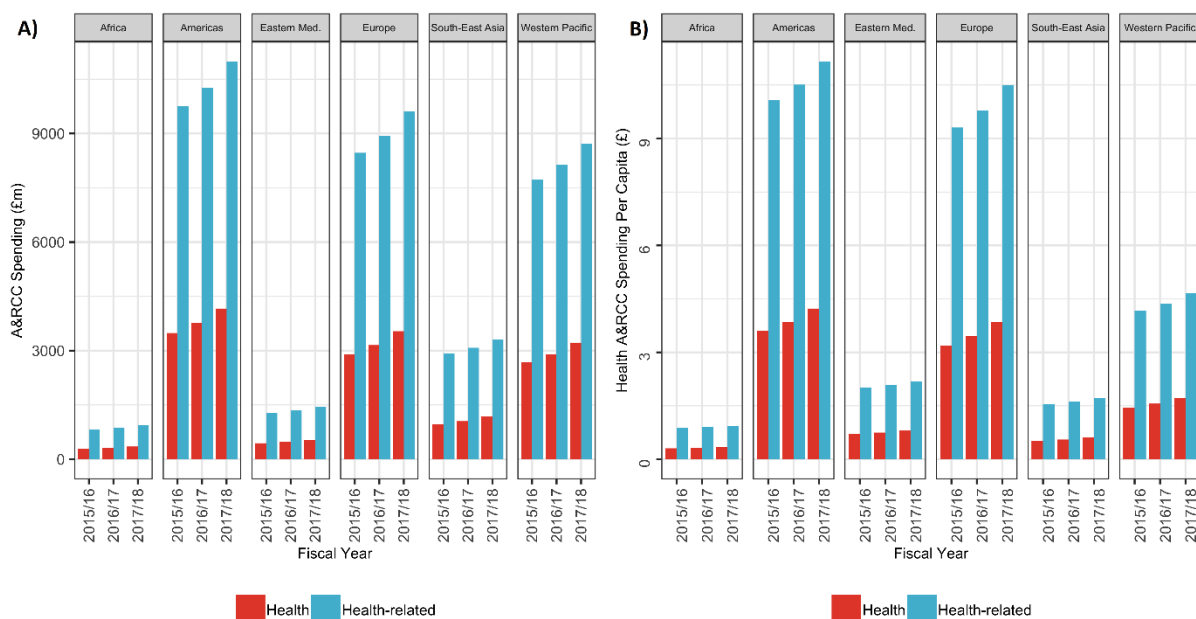
1187 A higher demand for health adaptation measures requires increased adaptation funding.
 1188 This indicator tracks adaptation spending, using 2015/16, 2016/17 and 2017/18 data from
 1189 the Adaptation and Resilience to Climate Change (A&RCC) dataset produced by kMatrix,⁹⁵ as
 1190 described in the 2017 and 2018 reports.^{20,46} “Health adaptation” spending is defined as
 1191 national adaptation spending specifically within the formal healthcare sector, whereas
 1192 “health-related adaptation” follows adaptation spending in the disaster preparedness and
 1193 agriculture, in addition to healthcare. Data in this year’s indicator covers 191 countries and
 1194 territories that have data reported in the A&RCC dataset. Per capita values are based on 183
 1195 countries with population estimates from the International Monetary Fund (IMF) World
 1196 Economic Outlook.⁹⁶

1197 Spending on adaptation to climate change in health and healthcare increased by 11.2% in
 1198 2017/18, compared to 2016/17 data. This percentage increase is, notably, larger than the
 1199 change in adaptation spending as a whole (an increase of 6.5% on last year). At the country
 1200 level, growth of health adaptation spending ranged from 17.5% (United Kingdom) to 10.0%
 1201 (Latvia). There were lower increases and lower variation in the health-related values, from

1202 11.1% (United Kingdom) to 6.8% (Kazakhstan). Importantly, health still represented a small
 1203 proportion of total adaptation spend, having grown from 4.6% in 2015/2016 to 5.0% in
 1204 2017/2018.

1205 Grouped by WHO Region, the highest percentage change for health adaptation spending is
 1206 in Europe (12.1%), and the highest per capita spending is in the Americas (£4.2 for health,
 1207 £11.2 for health-related) (Figure 12). By comparison, in the African, Eastern Mediterranean
 1208 and South East Asian regions, per capita health adaptation spending is less than £1.

1209



1210
 1211 *Figure 12: Adaptation Spending for Financial Years 2015/16 to 2017/18. A) Total health and health-*
 1212 *related A&RCC spending (£m), B) Health and health-related A&RCC per capita (£). Plots are*
 1213 *disaggregated by WHO Region. 'Eastern Med.' denotes the Eastern Mediterranean Region.*

1214

1215 Conclusion

1216 Whilst many of the indicators presented in section 2 are moving in a positive direction, the
 1217 pace of the adaptation response from the health community remains slow. The number of
 1218 countries with national adaptation plans for health and the number of countries and cities
 1219 that have assessed health risk and vulnerabilities has increased, along with the spending on
 1220 health adaptation. Thorough consideration of the best adaptation options is required before
 1221 implementation goes ahead. For example, the health benefits of adaptation measure such
 1222 as air conditioning may be counteracted by the harms they cause through a contribution to
 1223 heat generation, climate change and air pollution (Indicator 2.3.2).

1224 These findings and those from the UN Environment Adaptation reports, show that further
1225 work is required globally, both in terms of the planning and implementation of adaptation
1226 for health.^{97,98}
1227

1228

1229

1230 Section 3: Mitigation Actions and Health Co-Benefits

1231 As section 1 highlighted, the health impacts of climate change are already occurring, and
1232 require an urgent response, both in terms of health adaptation (section 2) and also,
1233 importantly, in mitigation, in order to minimise future climate change.

1234 In keeping with the Paris Agreement’s commitment of “well below 2°C”, and to pursue a
1235 1.5°C target, it is necessary for global emissions to peak as soon as possible (some studies
1236 suggest 2020) and then follow a steep decline to 2050.² However, current mitigation actions
1237 and commitments are not consistent with this goal. Indeed, at 53.5 GtCO₂e, total global
1238 GHG emissions for 2017 were the highest ever recorded.⁹⁹ Current commitments under the
1239 Paris Agreement are far from sufficient, with 2030 emissions estimated to be lowered by
1240 only 6 GtCO₂e - half the reduction required to achieve a 2°C scenario and one fifth for a
1241 1.5°C scenario.⁹⁷

1242 Discussions of GHG emissions reductions must be more directly coupled with the positive
1243 economic and health benefits that they bring. Mitigation actions improve health in the long
1244 term, through avoided climate change, but also in the near term through numerous
1245 pathways such as, reductions in risk of respiratory and cardiovascular disease attributable to
1246 air pollution,⁸ reductions in the risk of diseases related to physical inactivity and obesity due
1247 to increased cycling and walking,¹⁰⁰ and a suite of improvements that result from healthier
1248 diets.¹⁰¹

1249 Section 3 of the 2019 Report of the Lancet Countdown tracks mitigation and its health
1250 consequences, by sector:

- 1251 • Energy (Indicators 3.1.1, 3.1.2, 3.2)
- 1252 • Air pollution (Indicators 3.3.1, 3.3.2)
- 1253 • Transport (Indicator 3.4)
- 1254 • Agriculture (Indicator 3.5)
- 1255 • Healthcare (Indicator 3.6)

1256 Crucially, it adds two new indicators of great importance to health – emissions attributable
1257 to livestock and crops (allowing a more nuanced discussion about the health and climate
1258 benefits of reductions in ruminant meat consumption), and emissions from national
1259 healthcare systems. This section will continue to expand in future years by monitoring

1260 mitigation and health co-benefits in other important sectors including industry, buildings,
1261 and land-use.

1262 Overall CO₂ emissions from fossil fuels have risen by 2.6% from 2016 to 2018 (Indicator
1263 3.1.1). Concerningly, coal phase-out has reversed, with a 1.7% increase from 2016 to 2018
1264 seen in total primary energy supply (Indicator 3.1.2). However, more encouragingly, growth
1265 in renewables continues apace and comprised 45% of total growth in electricity generation.
1266 Currently, modern renewables represent 5.5% of global electricity generation (Indicator
1267 3.1.3), but are predicted to reach 30% by 2023.¹⁰² The implication for air pollution of both of
1268 these trends is important. With continued demand for fossil fuels and an increase in coal
1269 consumption, ambient air pollution attributable deaths have remained stagnant, resulting in
1270 2.9 million deaths in 2016 (Indicator 3.3.2).

1271 The transport sector is an equally entrenched emitter (Indicator 3.4), with GHG emissions
1272 and fuel use maintaining a modest growth trajectory of 0.7% per capita CO₂e in 2016. While
1273 there has been a dramatic increase in electric vehicle (EV) use they continue to represent a
1274 small proportion of the global fleet. Yet countries such as China have positioned EVs as the
1275 future of driving with electricity in transport, with 21.4% growth in per capita usage from
1276 2015 to 2016, rising to 1.8% of total fuel use.

1277 Feeding the global population is a critically important aspect of health and wellbeing along
1278 with ensuring economic stability and security. However, the agriculture and food sector are
1279 both energy and carbon intense and an important area for climate change mitigation.
1280 Global agricultural GHG emissions (Indicator 3.5) have increased between 2000 to 2016 by
1281 14% for livestock and 10% for crops.

1282 The health sector is on the frontline of climate change and plays a vital role in any response.
1283 It is also a major contributor to GHG emissions (Indicator 3.6), with global estimates as high
1284 as 4.6% of global emissions in 2016.

1285

1286 [Indicator 3.1: Emissions from the energy system](#)

1287 [Indicator 3.1.1: Carbon intensity of the energy system](#)

1288 **Headline Finding:** *In 2018, the carbon intensity of the energy system remained flat, at the*
1289 *same level as in 1990. However, GHG emissions from fossil fuel combustion has returned to a*
1290 *growth trajectory, rising by 2.6% from 2016 to 2018. Limiting warming to 1.5°C would*
1291 *require a 7.4% year-on-year reduction from 2019 to 2050.*

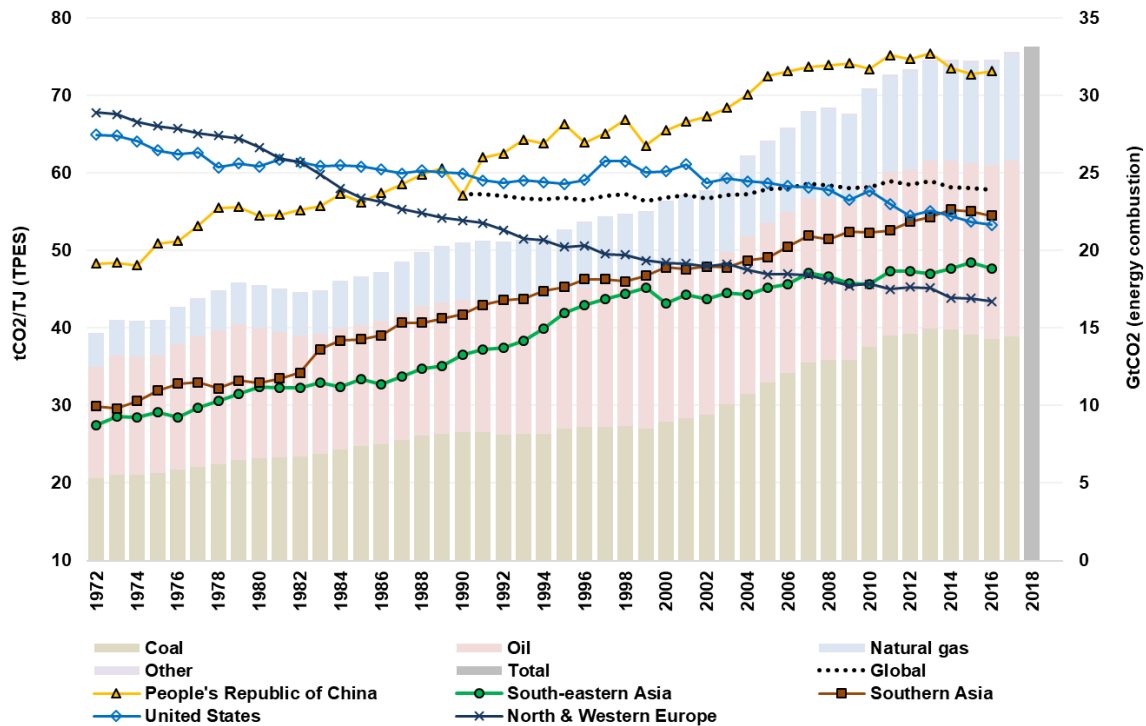
1292 In the 2019 Lancet Countdown report, this indicator includes data to 2016, supplemented
1293 with additional statistics for global CO₂ emissions from energy combustion for 2017¹⁰³ and
1294 2018.¹⁰⁴ It tracks the carbon intensity of the energy system, monitoring the CO₂ emitted per
1295 terajoule of total primary energy supply (TPES). TPES reflects the total amount of primary

1296 energy used in a specific country, accounting for the flow of energy imports and exports.
 1297 Key improvements in this analysis are seen in the disaggregation of fuel type, the extension
 1298 of data back to 1970, and the inclusion of new projections forward to 2050. A full
 1299 description of the data and methods is provided in the appendix.

1300 Global emissions of CO₂ from fossil fuel combustion, having been flat between 2014-16,
 1301 have increased to a new high of 33.1 GtCO₂ in 2018 (Figure 13).¹⁰⁴ This 2.6% increase over
 1302 the last two years is due to continued growth in energy demand, mostly from fossil fuels.

1303 The carbon intensity of the energy system will need to reduce to near zero by 2050. In the
 1304 last 15 years, carbon intensity has largely plateaued, as the growth of low carbon energy has
 1305 been insufficient to displace fossil fuels. However, recent IEA data suggests that carbon
 1306 intensity may be starting to reduce, with gas slowly displacing coal (Figure 13).¹⁰⁴

1307



1308
 1309 *Figure 13: Carbon intensity of Total Primary Energy Supply (TPES) for selected regions and countries,*
 1310 *and global CO₂ emissions from energy combustion by fuel type, 1972-2018. Carbon intensity is shown*
 1311 *by lines (primary axis) and global emissions by stacked bars (secondary axis). This carbon intensity*
 1312 *metric estimates the tonnes of CO₂ for each unit of total primary energy supplied (tCO₂/TJ). For*
 1313 *reference, carbon intensity of fuels (tCO₂/TJ) are as follows: coal 95-100, oil 70-75, and natural gas*
 1314 *56.*

1315 *Indicator 3.1.2: Coal phase-out*

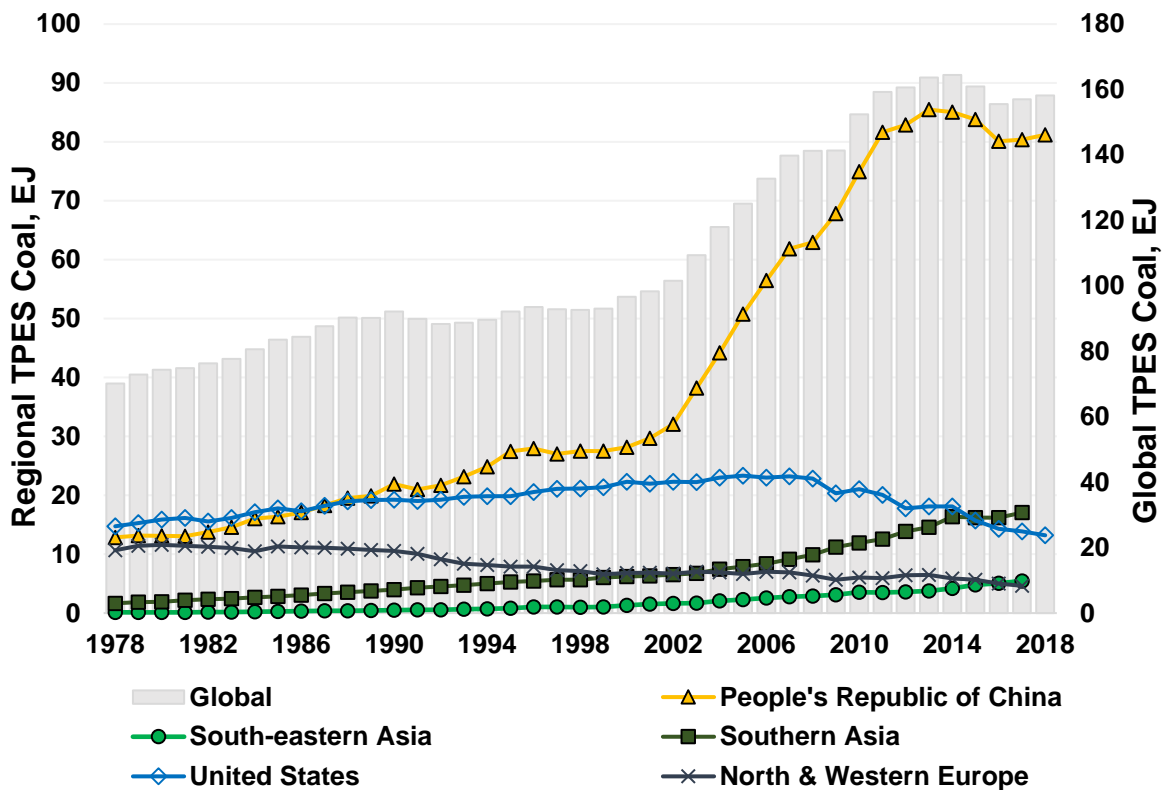
1316 **Headline Finding:** *From 2016 to 2018, TPES from coal increased by 1.7%, driven by growth in*
1317 *China and other Asian countries.*

1318 Coal phase-out is essential, not only as a key measure to mitigate climate change, but also
1319 to reduce morbidity and mortality from air pollution.⁸ As of December 2018, 30 national
1320 governments, along with many sub-national governments and businesses, have committed
1321 to coal phase-out for power generation through the Powering Past Coal Alliance.¹⁰⁵ In this
1322 year's Lancet Countdown report, this indicator tracks total primary energy supply from coal,
1323 plus projections for coal phase-out, using the scenarios that informed the
1324 Intergovernmental Panel on Climate Change Special Report on Global Warming of 1.5°C.²

1325 Coal has returned to a growth trajectory from 2016 to 2018 (Figure 14), however, due to the
1326 overall growth in global energy demand, the share of coal in primary energy supply
1327 continues to fall (see appendix). Coal continues to be the second largest contributor to
1328 global primary energy supply (after oil) and the largest source of electricity generation (at
1329 38%, compared to gas, the next highest at 23%). Most of the growth in TPES of coal has
1330 been in Asia, notably China, India and South East Asia.

1331 Rapidly decreasing coal use to zero is critical to meeting the commitments of the Paris
1332 Agreement. For example, nothing short of an 80% reduction in coal use from 2017 to 2050
1333 (a 5.6% annual reduction rate) is consistent with a 1.5°C trajectory (see appendix). However,
1334 given that the technology to support coal phase-out exists, this represents a low-hanging
1335 fruit for climate change mitigation and a more rapid reduction rate is likely feasible.

1336



1338

1339

1340 *Figure 14: Total Primary Energy Supply (TPES) coal use in selected countries and regions, and global*1341 *TPES coal, 1978-2018. Regional primary energy supply of coal is shown by the trend lines (primary*1342 *axis) and total global supply by the bars (secondary axis). Data are shown to at least 2017, and**extended to 2018 for selected regions and global supply (where data allows).*

1343

1344 *Indicator 3.1.3: Zero-carbon emission electricity*1345 **Headline Finding:** *In 2018, renewable energy continues to account for a large share (45%) of*1346 *growth in electricity generation, with 27% of growth coming from wind and solar.*1347 With the power generation sector accounting for 38% of total energy-related CO₂ emissions,

1348 it is crucial that renewables displace fossil fuels. This indicator tracks total low carbon

1349 electricity generation (which includes nuclear and all renewables, including hydro) and new

1350 renewable electricity generation (excluding hydro), using the World Extended Energy

1351 Balances dataset from the IEA.¹⁰⁴ Renewable electricity generation was also projected using1352 the scenarios that informed the IPCC Special Report on Global Warming of 1.5°C.² A full

1353 description of the datasets, methods, and these projections is provided in the appendix.

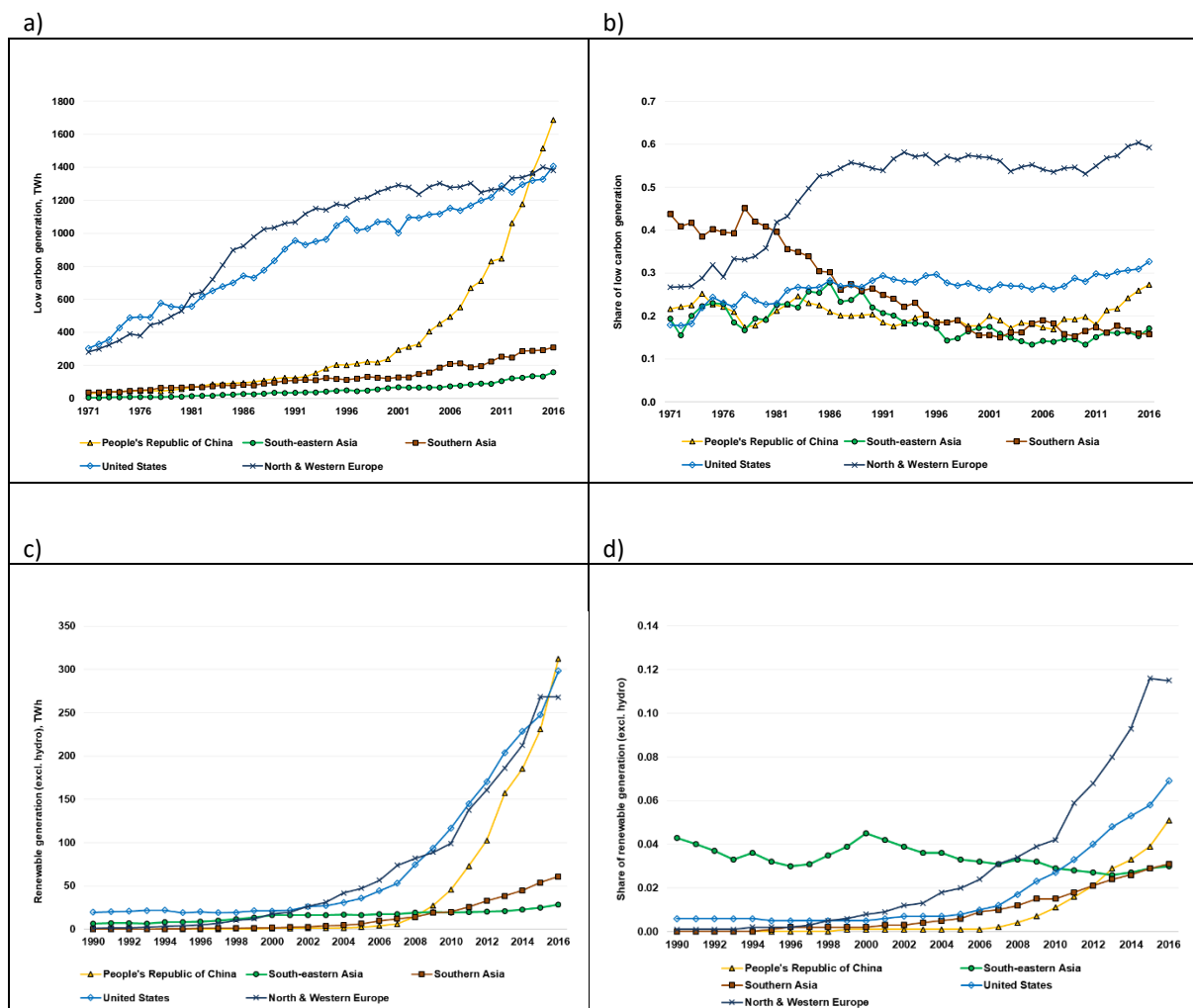
1354 In 2016, low-carbon electricity globally accounted for 32% of total global electricity

1355 generation (Figure 15). As costs continue to fall, solar generation continues to grow at an

1356 unprecedented rate of around 30% per annum (but still only accounting for 2% of total
 1357 global generation).¹⁰⁶

1358 An assessment of 1.5°C compliant scenarios highlights that generation from new
 1359 renewables sources (solar, wind, geothermal, wave and tidal) needs to increase by 9.7% per
 1360 annum, to a level in 2050 that is larger than the total global electricity generation today.
 1361 Since 1990, the annual growth rate for these renewable sources was over 14%, a very
 1362 promising trend, but one that must be maintained for a further three decades.

1363



1364 *Figure 15: Renewable and zero-carbon emission electricity generation (excluding bioenergy), 1990-*
 1365 *2016. a) Electricity generated from zero carbon sources, TWh; b) Proportion of electricity generated*
 1366 *from zero carbon sources; c) Electricity generated from renewable sources (excl. hydro), TWh; d)*
 1367 *Proportion of electricity generated from renewable sources (excluding hydro).*

1368

1369 Indicator 3.2: Access and use of clean energy

1370 **Headline Finding:** *Almost 3 billion people live without access to clean fuels and technologies*
1371 *for cooking, and usage remains at just 7.5% of households in low-income countries.*

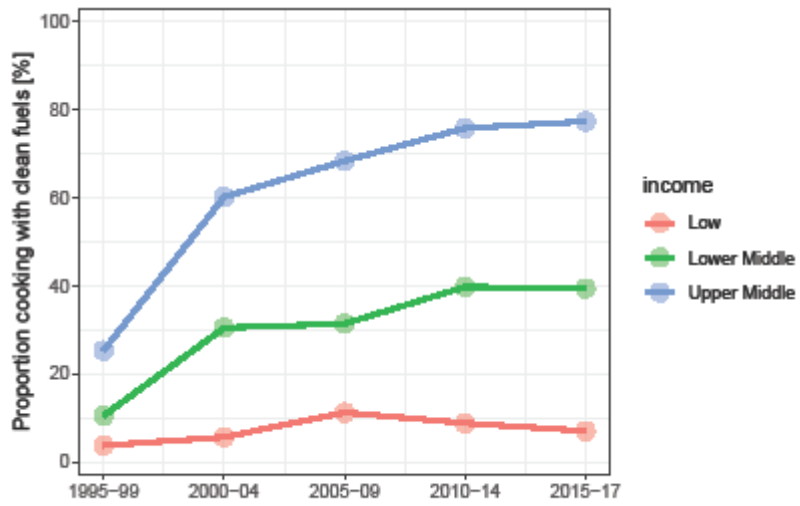
1372 Globally, it is estimated that 3.8 million deaths per year are attributable to household air
1373 pollution,¹¹⁰ largely due to the use of solid fuels, such as coal, wood, charcoal, and biomass,
1374 for cooking. Efforts to provide clean cooking and heating technologies could therefore result
1375 in substantial health co-benefits in addition to reducing GHG emissions and short-lived
1376 climate pollutants (SLCPs).¹⁰⁷⁻¹¹⁰ Additionally, universal access to affordable, reliable,
1377 sustainable, and modern energy for all is a key determinant of economic and social
1378 development and is central to health and well-being.^{111,112}

1379 This indicator combines both a top-down and bottom-up approach from both IEA and WHO
1380 datasets, capturing total household energy use and household fuel use for cooking
1381 respectively.^{113,114} The new data on household clean fuel use presented here represents an
1382 impressive effort from the WHO, bringing together thousands of national household surveys
1383 across three decades and over 140 countries. Full details of the methods, definitions, and
1384 data for this indicator are provided in the appendix.

1385 Drawing on this data, use of clean fuels and technologies for cooking for 2015-2017 remains
1386 low, at 7.5% in households in low-income countries, and 40% in households in lower-
1387 middling income countries (Figure 16). This reflects slow improvement in access to clean
1388 cooking fuels and technologies, which has increased by just 1% since 2010, with almost 3
1389 billion people remaining in access-deficit.¹¹⁵

1390 Concerningly, although access to electricity has risen from 83% in 2010 to 87% in 2016,
1391 residential clean energy usage – which, at point of demand, includes electricity of all
1392 sources, solar thermal and geothermal – remains low. In 2016, the global proportion of
1393 clean energy use in the residential sector was approximately 24%, up from 17% in 2010.¹¹³
1394 Solid biomass, which contributes to respiratory and cardiovascular disease attributable to
1395 household air pollution,¹¹⁶ is currently estimated to account for 36% of total residential
1396 sector energy use.

1397 Future forms of this indicator will work to link residential energy and fuel use to household
1398 air pollution morbidity and mortality across the world. Panel 2 provides an example of one
1399 possible approach to achieving this, using slum housing in Viwandani in Nairobi, Kenya.



1400
1401

Figure 16: Proportion of clean fuel use for cooking 1995-2017 by World Bank income group.

This case study focuses on indoor exposure to PM_{2.5}, the mortality attributable to this exposure, and CO₂e emissions in slum housing in Viwandani, Nairobi, Kenya. In this setting, cooking is done with solid fuels (14.6%), kerosene (72.9%), or electricity (12.5%). Most dwellings lack space heating (84.6%), with the rest using solid fuel heaters from June to August. Houses without electricity use kerosene-burning koroboi lamps for lighting year-round; 8-hour average ambient outdoor pollution levels are around 67µg/m³.¹¹⁷

Current indoor exposure and space heating estimates were estimated using EnergyPlus,¹¹⁸ calibrated to monitored indoor levels in dwellings using different fuel types and ventilation behaviours.¹¹⁹ Two scenarios were modelled, involving the following changes in exposure and heating energy consumption:

- 1) Electrification of all existing stoves, lamps, and heaters using the current electrical network, which was assumed to reduce outdoor pollution by 40% based on the estimated contribution of residential combustion to annual mean air pollution in Nairobi from the GAINS model.¹²⁰
- 2) Electrification as in (1), but with low energy lighting, and heaters installation extended to all dwellings. Additionally, upgrades to dwelling energy efficiency and airtightness in-line with local sustainable design guidelines.¹²¹

Current mean 24-hour exposures in Viwandani are estimated to average 60 µg/m³ with the fuels producing an estimated 425 kg of CO₂e per household year. Electrification was estimated to result in appreciable reduction of both GHG emissions and PM_{2.5} air pollution (and hence PM_{2.5}-related premature deaths – see table below). For upgrades to the building envelope and increased electric heating and lighting coverage, the decrease in CO₂e emissions was broadly similar to that for electrification, but with substantially greater reduction in PM_{2.5} concentrations and hence air pollution-related premature deaths. Such wholesale changes, however, do not reduce indoor exposures to less than the WHO-recommended limit of 10 µg/m³. Therefore, reduction of indoor PM_{2.5} to adequate levels would also necessitate further significant reductions in outdoor ambient levels or the application of additional technologies such as air filtration systems.

Scenario	Annual CO ₂ e emissions (kg CO ₂ e/household/year)	Annual average PM _{2.5} air pollution (µg/m ³)	Reduction in air pollution-attributable premature deaths
Current	425	60	--
Electrification	210	31	22%
Upgrading dwellings	211	25	28%

1402 Panel 2: Household air pollution conditions in Nairobi, Kenya

1403

1404 **Indicator 3.3: Air pollution, transport, and energy**

1405 Exposure to ambient air pollution, most importantly fine particulate matter (PM_{2.5}),
1406 constitutes the largest global environmental risk factor for premature mortality, causing
1407 several million premature deaths due to cardiovascular and respiratory diseases every
1408 year.^{8,122,123} Over 90% of children are exposed to PM_{2.5} levels above the WHO guidelines,¹²⁴
1409 which can affect their health throughout their life, from increased risk of lung damage,
1410 impaired lung growth and pneumonia, to subsequent risk of development of asthma and
1411 chronic obstructive pulmonary disease.¹²⁵ Most of the exposure to PM_{2.5} results from
1412 anthropogenic activities, and much of this is associated with combustion of coal and other
1413 fossil fuels for electricity generation, industrial production, transport, and household
1414 heating and cooking, and therefore PM_{2.5} emissions share many of the same sources as GHG
1415 emissions.¹²⁶

1416 Indicators 3.3.1 and 3.3.2 report on source contributions to ambient air pollution and its
1417 health impacts, drawing from the GAINS model,¹²⁷ which calculates emissions of all
1418 precursors of PM_{2.5} on a detailed breakdown of economic sectors and fuels used. Underlying
1419 activity data are based on statistics reported by the IEA.¹²⁸ A more detailed methodology is
1420 provided in the appendix.

1421

1422 **Indicator 3.3.1: Exposure to air pollution in cities**

1423 **Headline finding:** *Urban citizens are continuing to be exposed to high levels of air pollution,*
1424 *with 83% of cities exceeding the WHO's recommended safe level. A major share of the*
1425 *pollution is associated with energy use, particularly residential combustion.*

1426 The world is becoming increasingly urbanised, with almost 70% urbanisation of the global
1427 population expected by 2050.¹²⁹ Due to the concentration of population and emissions,
1428 many cities have become hot spots of air pollution. Few cities worldwide have achieved
1429 PM_{2.5} concentration levels below the WHO guideline of an annual mean of 10µg/m³, and
1430 many cities exceed this standard several fold.¹³⁰ The highest measured concentrations in
1431 recent years have been reported in South and East Asia, while big data gaps exist in other
1432 world regions. Particularly concerning is the fact that these high concentration levels have
1433 been further increasing or stagnant in many regions of the developing world. A positive
1434 exception to this trend is China, where many highly polluted cities have experienced strong
1435 improvements in air quality in recent years due to ambitious emission control efforts. Cities
1436 in Europe and the US have seen slowly decreasing PM_{2.5} levels thanks to effective
1437 implementation of air pollution control legislation and regulation.

1438 This analysis estimates source contributions to ambient PM_{2.5} concentration levels in urban
1439 areas outside Europe (more than 3,500 cities with over 100,000 inhabitants), with results

1440 aggregated to the WHO world regions. It is calculated here that 83% of these cities do not
1441 meet the WHO guideline on ambient PM_{2.5}.

1442 In most regions, residential combustion of solid fuels for cooking and heating was the
1443 dominant source of PM_{2.5} concentrations for 2016. While coal is prominent in some
1444 countries, the majority of the burden comes from the use of biomass in traditional stoves,
1445 which is often associated with net GHG emissions as well, due to unsustainable harvesting.

1446

1447 *Indicator 3.3.2: Premature mortality from ambient air pollution by sector*

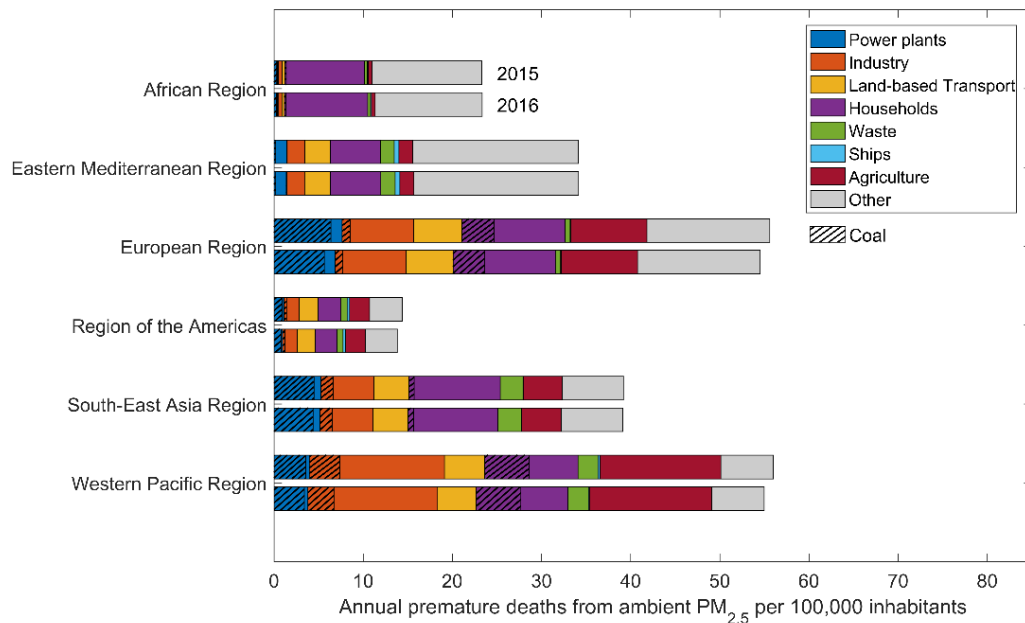
1448 **Headline finding:** *In 2016 there were 2.9 million premature deaths due to ambient PM_{2.5}*
1449 *pollution, with global mortality approximately stagnant. On a decadal scale, improvements*
1450 *are seen in some regions due to efficient emission controls, particularly from industrial*
1451 *processes and power generation.*

1452 Knowing the sources of ambient air pollution is essential for designing efficient mitigation
1453 measures that maximise benefits for human health and climate. This indicator estimates the
1454 source contributions to ambient PM_{2.5} and their health impacts on a global level, quantifying
1455 contributions from individual economic sectors and highlighting coal combustion across
1456 sectors.

1457 Results for 2016 are similar to the estimates for 2015, with an overall number of premature
1458 deaths attributable to ambient PM_{2.5} estimated at 2.9 million. The dominant contribution
1459 varies between and within world regions: in Africa household cooking is the overwhelming
1460 source; while in other regions industry, traffic, electricity generation, and agriculture play
1461 bigger roles (Figure 17). Small decreases are visible in the European Region (mainly from
1462 closing of coal power plants) and in the Western Pacific region. These regions have also seen
1463 some sustained improvements over the last 10 years, presumably due to implementation of
1464 end-of-pipe emission controls on power plants (Western Pacific) and also other emission
1465 sectors in Europe. However, worldwide currently still more than 440,000 premature deaths
1466 are estimated to be related to coal burning.

1467

1468



1469

1470

1471

1472

Figure 17: Premature deaths attributable to ambient PM_{2.5} in 2015 (upper bars) and 2016 (lower bars), by economic source sectors of pollutant emissions, for the 2015 population. Coal as a fuel is highlighted by hatching.

1473

1474 Indicator 3.4: Sustainable and healthy transport

1475

1476

1477

Headline Finding: Global road transport fuel use increased 0.7% from 2015 to 2016 on a per capita basis. Fossil fuels continue to dominate, but their growth is being tempered somewhat by rapid increases in biofuels and electricity.

1478

1479

1480

1481

1482

1483

1484

1485

1486

1487

1488

1489

As with electricity generation, transition to cleaner fuels for transport is important for climate change mitigation and will have the added benefit of reducing mortality from air pollution.¹⁰⁰ Fuels used for transport currently produce more than half the nitrogen oxides emitted globally and a significant proportion of particulate matter, posing a significant threat to human health particularly in urban areas (Indicator 3.3).¹³¹ Additionally, the health benefits of increasing uptake of active forms of travel (walking and cycling) have been demonstrated through a large number of epidemiological and modelling analyses.^{49,100,132-134} Encouraging active travel, in particular cycling, has become increasingly central to transport planning, and there is growing evidence that bikeway infrastructure, if appropriately designed and implemented, can increase rates of cycling.¹³⁵ A modal shift in transport could also result in reductions in air pollution from tyre, brake and road surface wear in addition to exhaust related particulates.¹³⁶

1490

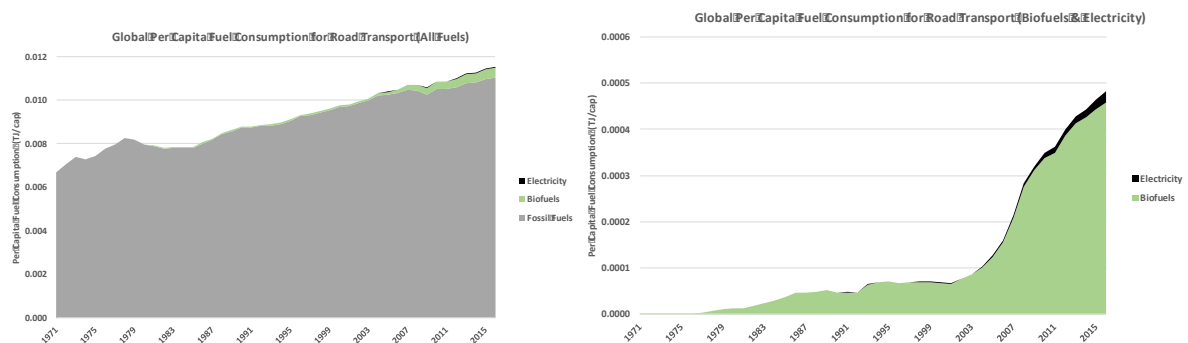
1491

Global trends in levels of fuel efficiency and the transition away from the most polluting and carbon-intensive transport fuels are monitored using data from the IEA; specifically, it

1492 follows the metric of fuel use for road transportation on a per capita basis (TJ/person) by
 1493 type of fuel.^{46,137} In response to feedback, this year's indicator displays data in three
 1494 categories of fuel: fossil fuels, biofuels, and electricity.

1495 Globally, per capita fuel use increased by 0.7% from 2015 to 2016 (Figure 18). Although
 1496 fossil fuels continue to contribute 95.8% of total fuel use for road transport, the use of clean
 1497 fuels is growing at an increasing rate: fossil fuels grew by 0.5% compared to 3.3% growth in
 1498 biofuels and 20.6% growth in electricity. In China electricity now represents 1.8% of total
 1499 transportation fuels use. This is more than any other country and an 80% higher share than
 1500 that seen in Norway (0.85%), who have committed to having 100% of new vehicles sold
 1501 being zero-emission by 2025.¹³⁸ A growing number of countries and cities have announced
 1502 plans to ban vehicles powered by fossil fuels and auto-maker Volkswagen has announced
 1503 that it will stop developing engines that run on petrol or diesel after 2026.¹³⁹

1504



1505
 1506 *Figure 18: Per capita fuel use by type (TJ/person) for road transport with all fuels (left) and non-fossil*
 1507 *fuels only (right).*

1508 As an important case study, a number of cities have made considerable progress towards
 1509 improving levels of cycling. Vitoria-Gasteiz in Spain is notable, where cycling mode share has
 1510 increased from close to zero to almost 15% in less than a decade.¹⁴⁰ The city's transport
 1511 policy has strongly promoted cycling through the expansion of the cycle lane network,
 1512 improved cycle parking facilities and the introduction of safety courses and new cycling
 1513 regulations as well as communication on the health benefits of cycling.¹⁴¹ The search for a
 1514 more comprehensive metric of active transport remains elusive, principally limited by
 1515 scarcity of data access in this field.

1516

1517 [Indicator 3.5: Emissions from livestock and crop production](#)

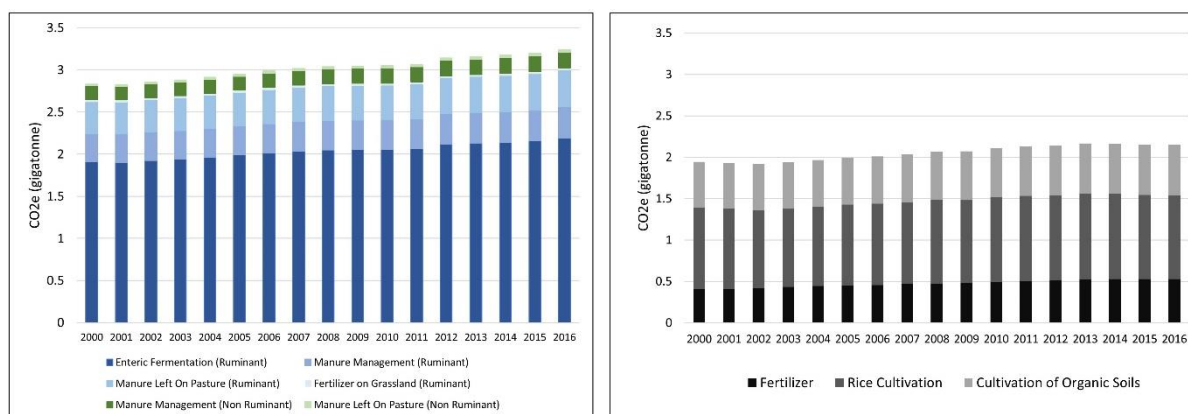
1518 **Headline finding:** Total emissions from livestock and crop production have increased by 14%
 1519 and 10%, respectively, from 2000 to 2016, with 93% of livestock emissions attributed to
 1520 ruminants.

1521 Obesity and undernutrition present two great challenges to global public health, and both
 1522 these forms of malnutrition share many common systemic drivers with climate change.¹⁴²
 1523 Current dietary trends are contributing to both non-communicable diseases (NCDs) and
 1524 GHG emissions, as well as other impacts on the planet, including biodiversity loss and
 1525 impacts on water and land use.¹⁰¹ In particular, excess red meat consumption contributes to
 1526 both the risk of cardiovascular disease and type 2 diabetes as well as GHG emissions.¹⁴³ To
 1527 this end, whilst total emissions from crops and livestock will need to decline significantly in
 1528 the future, particular attention should be given to capitalising on low-carbon production
 1529 processes, and reducing the consumption of ruminant meat and other animal source foods,
 1530 particularly in high income settings.^{20,46} Importantly, the nuance and complexity of any such
 1531 indicator must be stressed, and it is clear that there is no ‘one-diet-fits-all’ solution.¹⁰¹

1532 For the 2019 Lancet Countdown report, this indicator focuses on emissions from livestock
 1533 and crop production. The new analysis added here provides a novel method of
 1534 understanding the emissions profile of agricultural groups – for example, ruminant
 1535 livestock. A full description of the methods and data is provided in the appendix.

1536 Overall emissions from livestock have increased by 14% since 2000 to over 3.2 GtCO₂e in
 1537 2016 (Figure 19). Ruminants contribute 93% of total livestock emissions (3 GtCO₂e per year),
 1538 with non-dairy cattle (used for meat) contributing 62-65% of this (see appendix). However,
 1539 the largest increase in emissions from 2000 to 2016 has come from poultry, which has an
 1540 increase in emissions of 58% (rising from 30.6 million tonnes CO₂e in 2000 to 48.5 million in
 1541 2016), more than double that of non-dairy cattle.

1542



(a) Emissions from Livestock

(b) Emissions from Crop Production

1543
 1544 *Figure 19: Global livestock (a) and crop (b) GHG emissions annually from 2000-2016, by process.*

1545 Total emissions from crop production have increased by 10% since 2000, to around 2 billion
 1546 tonnes of CO₂e in 2016. Paddy rice cultivation, which releases methane, contributes around
 1547 half of these emissions (47-50%), with cultivation of organic soils (such as peatlands), and
 1548 addition of nitrogen fertilisers (synthetic and manure) to soils contributing 27-29% and 21-
 1549 25% respectively.

1550 **Indicator 3.6: Mitigation in the healthcare sector**

1551 **Headline Finding:** *Global healthcare sector GHG emissions were approximately 4.6% of the*
1552 *global total emissions.*

1553 Section 2 makes clear that the healthcare sector is central in managing the health damages
1554 of a changing climate, however, it is also a significant contributor of GHG emissions, both
1555 directly and indirectly through purchased goods and services. Recent national-level studies
1556 for the US,¹⁴⁴ Canada,¹⁴⁵ and Australia¹⁴⁶ have used environmentally-extended input-output
1557 (EEIO) modelling, finding that healthcare sector emissions represent between 4-10% of total
1558 GHG emissions in those countries. EEIO models have been in wide use since the 1970s,¹⁴⁷
1559 and underpin consumption-based accounting of emissions performed at national and global
1560 scales.¹⁴⁸ An important advantage of using EEIO modelling is that estimates of healthcare
1561 sector emissions are performed on a life cycle basis, meaning that all emissions are
1562 accounted for, from the electricity usage of healthcare facilities, to the energy to produce
1563 and transport medical equipment and pharmaceuticals.

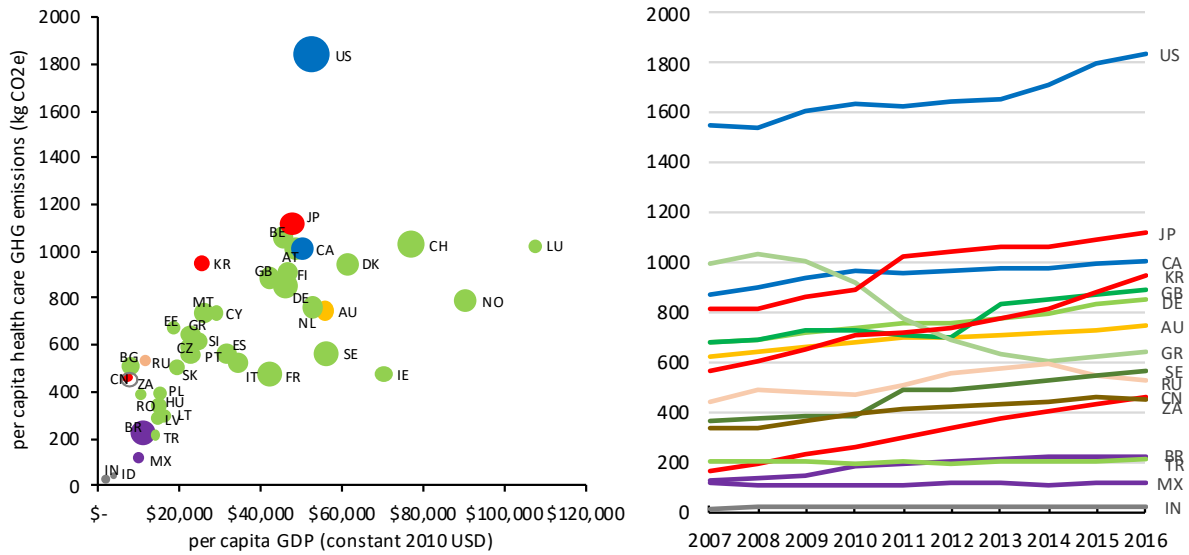
1564 National-level studies cannot easily be compared due to differences in how emissions
1565 inventories, monetary input-output tables, and health expenditure data are collected in
1566 each country. In addition, some portion of healthcare sector emissions in each country is
1567 imported from other countries as embodied carbon in traded commodities, thus requiring a
1568 global scope and the use of multi-region input-output (MRIO) models that cover more than
1569 one country. For this edition of the Lancet Countdown, a standardised, international
1570 measure of healthcare sector GHG emissions was created using multiple MRIO models
1571 (EXIOBASE, WIOD) that cover 40-47 countries and rest-of-world regions, in combination
1572 with WHO health expenditure data for 187 countries, assigned to the MRIO model
1573 geographic units.

1574 Figure 20 shows variations in per capita healthcare-related GHG emissions as a function of
1575 time, affluence, and the proportion of national economic output spent on healthcare. Per
1576 capita, US emissions are significantly higher than those of any other country, and have risen
1577 steadily over the study period 2007-2016. However, per capita healthcare emissions of
1578 other countries have increased even more significantly, albeit from a lower base, including
1579 China (CN, 180%), South Korea (KR, 75%) and Japan (JP, 37%). In contrast, Greece's
1580 healthcare GHG emissions showed a marked decrease (GR, -35%), likely reflecting economic
1581 hardships in that country. Results using the WIOD MRIO model show similar trends but
1582 slightly lower absolute GHG emissions. The lowest per capita emissions modelled were for
1583 India (IN) and Indonesia (ID), at less than 1/40th those for the USA. Comparison of emissions
1584 per capita and Gross Domestic Product (GDP) per capita show a levelling off trend of
1585 healthcare emissions versus affluence, again with the exception of the US.

1586 Overall, healthcare was responsible for approximately 2250 Mt CO₂e in 2016, or 4.6% of the
1587 global total emissions (excluding land use change). A parallel global analysis using a different
1588 MRIO model (EORA) just looking at CO₂ (excluding other GHGs) for 36 countries determined

1589 a healthcare contribution of 4.4% to the global total for the countries considered,¹⁴⁹
 1590 corroborating the results presented here.

1591



1592
 1593 *Figure 20: Per capita healthcare GHG emissions by country: (left) as a function of GDP per capita,*
 1594 *bubble widths indicate proportion of national spending on healthcare; (right) over time 2007-2016.*
 1595 *Colour key: green=Europe, light brown=Africa; grey=South Asia/South East Asia, pink=North/Central*
 1596 *Asia, red=East Asia, yellow=Oceania, blue=North America; purple=Latin America. Abbreviations*
 1597 *follow ISO two-letter country codes.*

1598

Health systems are increasingly faced with the dual challenges of responding to the health impacts of climate change and reducing the contribution of the healthcare sector to GHG emissions. From 2013 to 2018, participants from health systems, health centres and hospitals, from 19 different countries, and representing 9,199 health centres and 1,693 hospitals, have participated in the Health Care Climate Challenge. The Challenge addresses key areas including local climate change risk assessments, health adaptation plans, fossil fuel and renewable energy project investments, and work with government agencies to support GHG emissions reductions and healthcare sector adaptation.

A leader in climate action progress is Kaiser Permanente (KP), one of the largest not-for-profit health systems in the US, serving 12.3 million members. Between 2008 and 2017, KP reduced its operational GHG emissions by 29% while increasing its membership by 36%. As of early 2018, 36 of its facilities hosted onsite solar panels. KP is working to increase its purchasing of renewable electricity to 100% of total usage by 2020. Anesthetic gases account for 3% of KP's GHG emissions. Between 2014 and 2018, KP achieved a 24% reduction in GHG emissions associated with its use of anesthetic gases through progressive elimination of the drug Desflurane.¹⁵⁰

The largest example of a health system taking steps to reduce GHG emissions and other environmental impacts comes in the form of the UK National Health Service (NHS). A national-level detailed analysis of government funded healthcare, demonstrates that the NHS, public health and social sector in England reduced its GHG emissions (excluding CFCs) by 18.5% from 2007 to 2017, while clinical activity increased by 27.5% over the same time period.¹⁵¹ Efforts are also being made to reduce water use, plastic waste and air pollution from the NHS.

1599 *Panel 3: Healthcare sector response to climate change*

1600

1601 Conclusion

1602 The indicators of section 3 present a mix of encouraging and concerning trends. Renewable
1603 electricity generation continues to grow, as does access to energy and the rate of electric
1604 vehicle sales. However, the carbon intensity of the energy system remains unchanged, with
1605 coal supply increasing, reversing the recent trend, and significant effort is required to
1606 decarbonise the agricultural and healthcare sectors. The summation of all of this is that GHG
1607 emissions continue to rise. Next year (2020) is important for two reasons – it is the year the
1608 implementation period of the Paris Agreement begins, and the year most studies suggest
1609 global emissions must peak then in order to remain on a 1.5°C pathway. To meet both
1610 commitments, a substantially stronger global response is required urgently, to reduce GHG
1611 emissions and minimise the future health risks of climate change. The health sector has an
1612 important role to play in achieving these goals, both by reducing its own emissions and
1613 working with policymakers to help design and implement measures that reduce GHG
1614 emissions and maximise health co-benefits.

1615

1616

1617 Section 4: Economics and Finance

1618 Section 4 examines the financial and economic dimensions of the impacts of climate change,
1619 and of mitigation efforts required to respond. Although many indicators in this section may
1620 appear to be distant from human health, they are key to tracking the low-carbon transition
1621 that underpins current and future determinants of human health and wellbeing described in
1622 sections 1-3.

1623 The projected economic cost of inaction to tackle climate change is enormous. For example,
1624 compared with maintaining a 2°C limit, the costs of 3°C of warming are expected to reach
1625 US\$4 trillion per year by 2100 (around 5% of total global GDP in 2018), whilst the total
1626 economic costs of a 4°C rise are estimated at US\$17.5 trillion (over 20% of GDP in 2018).¹⁵²

1627 Investment to mitigate climate change substantially reduces these risks, and generates
1628 further economic benefits. For example, the UK's independent Committee on Climate
1629 Change calculated that achieving net-zero emissions in the UK in 2050, in line with the more
1630 ambitious objective of the Paris Agreement, is likely to require investments of 1-2% of the
1631 UK's GDP in 2050. However, if the economic value of co-benefits to human health (and
1632 savings to the NHS, for example from reduced air pollution), and the creation of low-carbon
1633 industrial opportunities are considered, the economic implications are likely to be
1634 positive.¹⁵³ Global economic benefits are likely to be maximised (and costs minimised) if
1635 strong policy action is taken as soon as possible to accelerate the low-carbon transition.

1636

1637 The nine indicators in this section fall into four broad themes:

- 1638 • Economic costs of climate change (Indicator 4.1);
- 1639 • Economic benefits of tackling climate change and air pollution (Indicator 4.2);
- 1640 • Investing in a low-carbon economy (Indicators 4.3.1, 4.3.2, 4.3.3, and 4.3.4);
- 1641 • Pricing GHG emissions from fossil fuels (Indicators 4.4.1, 4.4.2 and 4.4.3).

1642 The 2019 report adds an additional indicator tracking the economic value of change in
1643 mortality due to air pollution (Indicator 4.2).

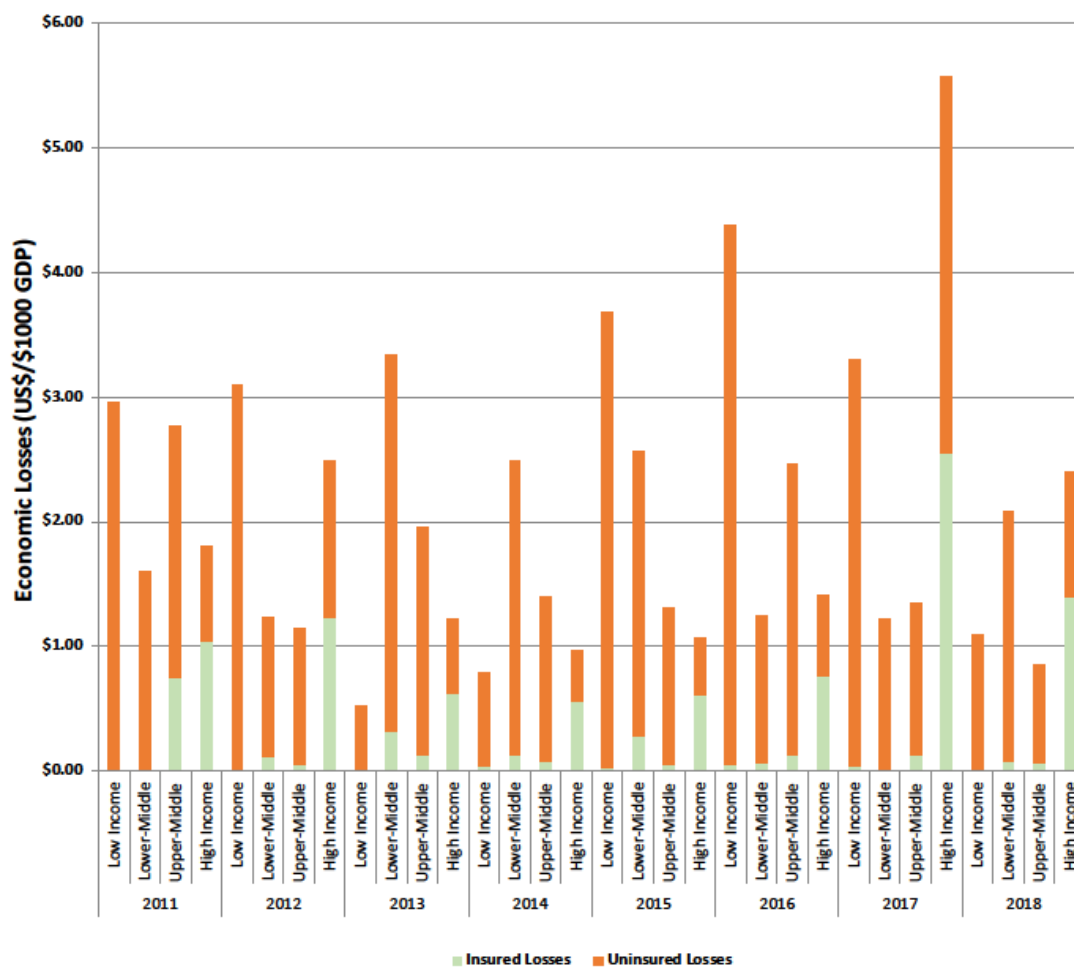
1644

1645 [Indicator 4.1: Economic losses due to climate-related extreme events](#)

1646 **Headline Finding:** *In 2018, a total of 831 climate-related extreme events resulted in US\$166*
1647 *billion in overall economic losses. Although most losses were in high-income countries and*
1648 *insured, no measurable losses due to events in low-income countries were covered by*
1649 *insurance.*

1650 The indicators in section 1 presented changes in exposures and resulting health impacts of
1651 climate-related extreme events (Indicators 1.2.1, 1.2.2 and 1.2.3). The economic costs of
1652 extreme climate-related events may also exacerbate the direct health impacts they
1653 produce. This indicator tracks the total annual economic losses (insured and uninsured)
1654 across country income groups relative to GDP, resulting from climate-related extreme
1655 events.

1656 The data for this indicator is sourced from Munich Re's NatCatSERVICE,¹⁵⁴ with climate-
1657 related events categorised as meteorological, climatological, and hydrological events
1658 (geophysical events are excluded) as well as data from the World Bank Development
1659 Indicator Database.¹⁵⁵ The methodology remains the same as was used in the 2018 Report
1660 of the Lancet Countdown,⁴⁶ and full methodology, along with data for 1990-2018 can be
1661 found in the appendix.



1662

Figure 21: Insured and uninsured Economic Losses from Climate-Related Events Relative to GDP by World Bank income group.

1663 Figure 21 presents both insured and uninsured economic losses due to extreme climate-
 1664 related events relative to GDP. Absolute global economic losses in 2018 were US\$166
 1665 billion, around half the value experienced in 2017, but still higher than any other year since
 1666 2005. As in previous years, economic losses are highest in high-income countries, but well
 1667 over half of these losses in high-income countries were insured. By contrast, although in
 1668 previous years less than 1% of losses in low-income countries were insured (for example,
 1669 US\$20 million of US\$1.9 billion losses in 2017), in 2018 not a single event recorded created
 1670 measurable losses covered by insurance.

1671

1672 [Indicator 4.2: Economic costs of air pollution](#)

1673

1674 **Headline Finding:** Across Europe, improvements in particulate air pollution from human
 1675 activity were seen from 2015 to 2016. If the levels of pollution for these two years remained

1676 *the same over the course of a person's life, this difference would lead to an annual average*
1677 *reduction in Years of Life Lost worth €5.2 billion saved.*
1678

1679 Indicator 4.2 is a new indicator for the 2019 report and is the first indicator on the
1680 economics of the health co-benefits of climate change mitigation, capturing the economic
1681 costs of the impact of air pollution on human health (Indicator 3.3.2). It will be developed
1682 into a full suite of metrics over the coming years, with 2019 presenting values for the
1683 European Union alone. It places an economic value on the Years of Life Lost (YLL) that result
1684 from exposure to PM_{2.5} from anthropogenic sources, for the EU.

1685 This indicator is based on estimates of the total YLL to the 2015 population of EU member
1686 states that results from the change in anthropogenic PM_{2.5} exposure experienced from 2015
1687 to 2016, if such emissions and subsequent population exposure were to remain constant
1688 over the course of their remaining lifetimes. Each YLL is assigned a 'Value of a Life Year'
1689 (VLY) of €50,000, which is the lower bound estimate as suggested by the EU Impact
1690 Assessment Guidelines.¹⁵⁶ Complete details for this indicator can be found in the appendix.

1691 As described under Indicator 3.3.2, anthropogenic PM_{2.5} pollution decreased between 2015
1692 and 2016 in Europe, largely due to a reduction in emissions from the power sector. If the
1693 population of the EU in 2015 were to experience anthropogenic PM_{2.5} emissions at 2016
1694 levels consistently to 2115, instead of levels experienced in 2015, the total annual average
1695 economic value of the reduction in YLLs would be around €5.2 billion. However, even at
1696 2016 levels of anthropogenic PM_{2.5} pollution, the total annual average cost to the 2015
1697 population would still be €129 billion, with the greatest costs generally found in countries
1698 with the largest populations. The greatest projected average life lost per person is in
1699 Hungary, Romania and Poland (at over 8 months per person), with an EU average of 5.7
1700 months of life lost per person.

1701 For the first iteration of this indicator, it was not possible to calculate annual YLLs
1702 attributable to PM_{2.5} exposure in a given year. However, methodological refinements should
1703 allow this metric to be reported in the 2020 report.

1704

1705 [Indicator 4.3: Investing in a low-carbon economy](#)

1706 [Indicator 4.3.1: Investment in new coal capacity](#)

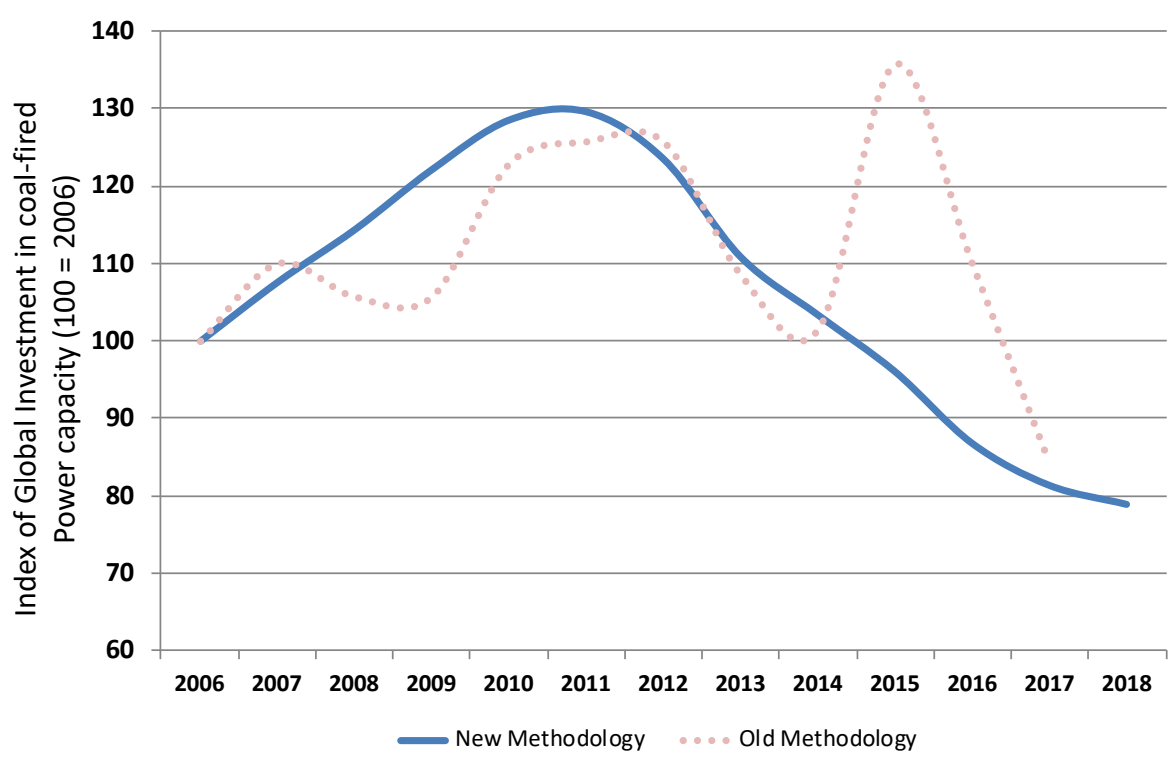
1707 **Headline Finding:** *Global investment in new coal-fired electricity capacity declined again in*
1708 *2018, continuing the downward trend experienced since 2011.*

1709 Whilst Indicator 3.1.2 tracks progress on coal phase-out through the total primary energy
1710 supply of coal, this indicator looks to the future of coal-fired power generation through
1711 tracking investments in coal-fired capacity.

1712 The data source for this indicator (IEA) remain the same as in the 2017 Lancet Countdown
 1713 report,²⁰ however the methodology has altered, and been retrospectively applied to
 1714 recalculate all data presented. The revised approach considers ‘ongoing’ capital spending,
 1715 with investment in a new plant spread evenly from the year new construction begins, to the
 1716 year it becomes operational. Previously, data was presented as ‘overnight’ investment, in
 1717 which all capital spending on a new plant is assigned to the year in which the plant became
 1718 operational. Further details are found in the appendix. Data for 2006-2017 using the old
 1719 methodology are also presented in Figure 22 for comparison.

1720 Whilst TPES for coal increased in 2018 (Indicator 3.1.2), investment in new coal-fired
 1721 electricity generating capacity continued the downward trend experienced since 2011.
 1722 Interestingly, this decline was in large part due to reduced investment in the same countries
 1723 that increased their coal TPES in 2018 (China and India), providing hope for coal phase-out.
 1724 The number of total Final Investment Decisions (i.e. the decision to begin construction)
 1725 declined 30% in 2018, with costs and construction times for new plants generally increasing
 1726 due to larger, more efficient and complex designs, and the use of advanced pollution control
 1727 systems, in response to concerns over air quality.¹⁵⁷

1728



1729 *Figure 22: Annual global investment in coal-fired capacity 2006-2018 (an index score 100*
 1730 *corresponds to 2006 levels) (Source: IEA, 2019).¹⁵⁷*

1731

1732 *Indicator 4.3.2: Investments in zero-carbon energy and energy efficiency*

1733 **Headline Finding:** Trends in energy investments are currently heading in the wrong
 1734 direction. In 2018, investments in fossil fuels increased, whilst investments in zero-carbon
 1735 energy decreased.

1736 Indicator 4.3 monitors global investment in zero-carbon energy, energy efficiency, fossil
 1737 fuels, and electricity networks. It complements the tracking of zero-carbon electricity
 1738 generation (Indicator 3.1.3) in section 3 and potentially predicts future trends in this
 1739 indicator. All values reported are in US\$2018, with data sourced from the IEA.¹⁵⁷ The data
 1740 sources for this indicator remain the same as described in the 2017 Lancet Countdown
 1741 report,²⁰ however the methodology has been updated somewhat (see appendix).

1742

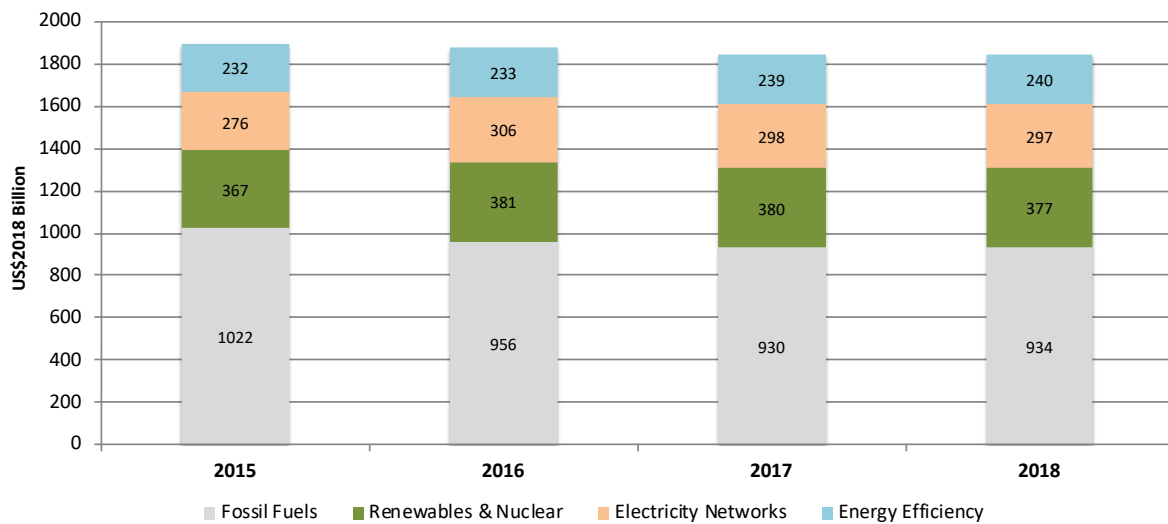


Figure 23: Annual Investment in the Global Energy System.

1743 Total investment in the global energy system remained stable at around US\$1.85 trillion in
 1744 2018, following a steady decline between 2015 and 2017 (Figure 23). Investment in fossil
 1745 fuels increased slightly, driven by an increasing oil price, whilst investment in zero-carbon
 1746 energy slightly decreased, driven by reduced investment in renewable electricity – partly
 1747 the result of continually declining costs. Investments in energy efficiency and electricity
 1748 networks remained stable between 2017 and 2018.

1749 In contrast with growth in zero-carbon electricity generation (Indicator 3.1.3), these
 1750 investment trends are currently not consistent with limiting warming to well below 2°C. The
 1751 IEA estimate that in order to achieve a pathway consistent with the goals of the Paris
 1752 Agreement, investment in zero-carbon energy, electricity networks that enable it, and
 1753 energy efficiency, must collectively grow by two-and-a-half times by 2030 (even with further
 1754 expected reductions in the cost of such technologies and actions), and account for at least
 1755 65% of total annual investment in the global energy system.^{157,158}

1756 *Indicator 4.3.3: Employment in renewable and fossil fuel energy industries*

1757 **Headline Finding:** In 2018, renewable energy provided 11 million jobs – an increase of 4.2%
 1758 from 2017. Employment in fossil fuel extraction industries also increased to 12.9 million – a
 1759 2% increase from 2017.

1760 There are well documented occupational health consequences of working in some key fossil
 1761 fuel industries, such as risk of injury and respiratory disease as well as risk of damage to
 1762 hearing and skin.²⁰ On the other hand, with appropriate planning and policy, the transition
 1763 of employment opportunities from high to low-carbon industries may yield positive
 1764 consequences for both the economy and human health.¹⁵⁹

1765 This indicator tracks global direct employment in fossil fuel extraction industries (coal
 1766 mining and oil and gas exploration and production) and direct and indirect (supply chain)
 1767 employment in renewable energy, presented in Figure 24. The data for this indicator are
 1768 sourced from the International Renewable Energy Agency (IRENA) (renewables) and IBIS
 1769 World (fossil fuel extraction).¹⁶⁰⁻¹⁶² The data for fossil fuel extraction employment for 2012-
 1770 2017 differs significantly from that presented in the 2018 Countdown report, due an
 1771 improved methodology in the data collection and estimation methodology for global coal
 1772 mining employment by IBISWorld. Similarly, values for Hydropower and Other Technologies
 1773 for renewable energy employment have been revised, following methodological changes.
 1774 Further detail is found in the appendix.

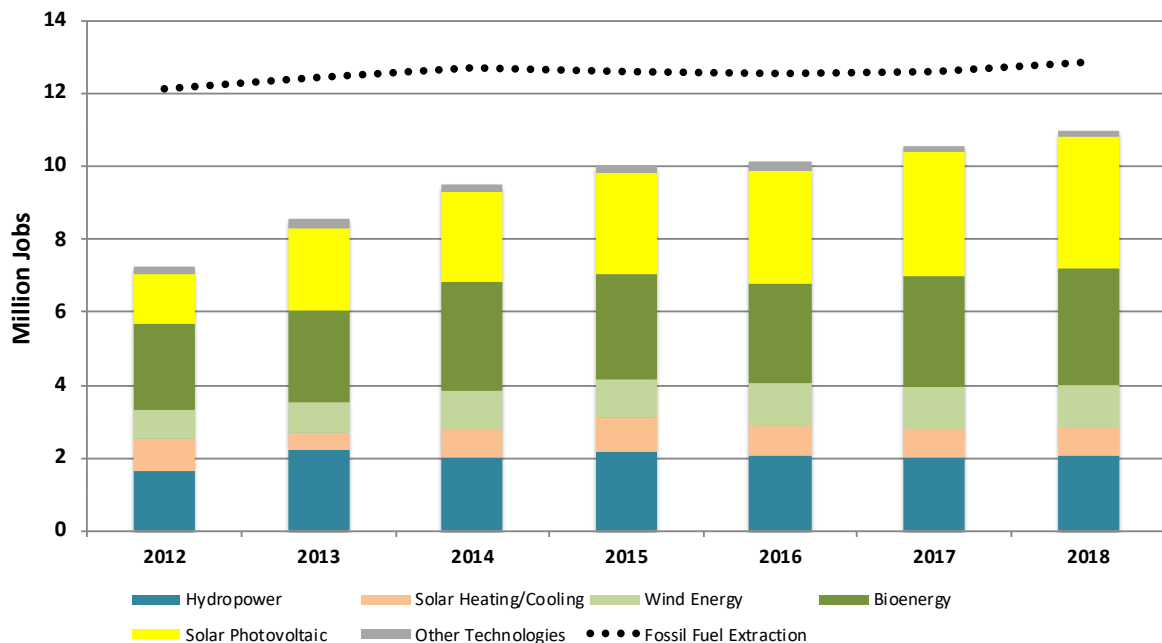


Figure 24: Employment in Renewable Energy and Fossil Fuel Extraction Sectors

1775

1776 In 2018, around 11 million people were employed either directly or indirectly in the global
1777 renewable energy industry. This represents a 4.2% increase from 2016, with growth in five
1778 out of six categories. Employment related to solar PV grew by over 7%, and remains the
1779 largest employer, with China responsible for nearly-two thirds of related jobs. Overall, 32%
1780 of global renewable energy jobs are held by women.¹⁶²

1781 Growth in employment in the fossil fuel extractive industries has been driven by both the
1782 growth of coal mining in China and other emerging markets (particularly India), despite a
1783 decline in many higher-income countries, and the upstream oil and gas industries, following
1784 rising prices in 2018. However, it is expected that employment in both industries will
1785 decrease in the coming years due to slowing growth in demand for coal in key markets such
1786 as China, and a decline in other (particularly high-income) markets, as the transition to low-
1787 carbon electricity continues, along with a potential decline in oil and gas prices coupled with
1788 increasing efficiency.^{160,161}

1789

1790 *Indicator 4.3.4: Funds divested from fossil fuels*

1791 **Headline Finding:** *The global value of new funds committed to fossil fuel divestment in 2018*
1792 *was US\$2.135 trillion, of which health institutions accounted for around US\$66.5 million; this*
1793 *represents a cumulative sum of US\$7.94 trillion since 2008, with health institutions*
1794 *accounting for US\$42 billion.*

1795 Originating in the late 2000s, the divestment movement seeks to both remove from the
1796 fossil fuel industry its 'social license to operate' and guard against the risk of losses due to
1797 'stranded assets', by encouraging investors to commit to divest themselves of assets related
1798 to the industry. The debate on the direct and indirect consequences of these approaches is
1799 nuanced and complex, with evidence on their effects only just beginning to emerge.¹⁶³

1800 This indicator tracks the total global value of funds divested from fossil fuels, and the value
1801 of divested funds coming from health institutions, using data provided by 350.org,¹⁶⁴ with
1802 full methodology described in the appendix.

1803 From 2008 to the end of 2018, 1,026 organisations with cumulative assets worth at least
1804 US\$7.94 trillion, including 23 health organisations with assets of around US\$42 billion, had
1805 committed to divestment, including the World Medical Association, the British Medical
1806 Association, the Canadian Medical Association, the UK Royal College of General
1807 Practitioners, and the Royal Australasian College of Physicians. The annual value of new
1808 funds committing to divesting increased from US\$428 billion in 2017 to US\$2.135 trillion in
1809 2018. However, health institutions have divested at a reduced rate, with just US\$866.5
1810 million divested in 2018, compared to US\$3.28 billion in 2017.

1811

1812 Indicator 4.4: Pricing greenhouse gas emissions from fossil fuels

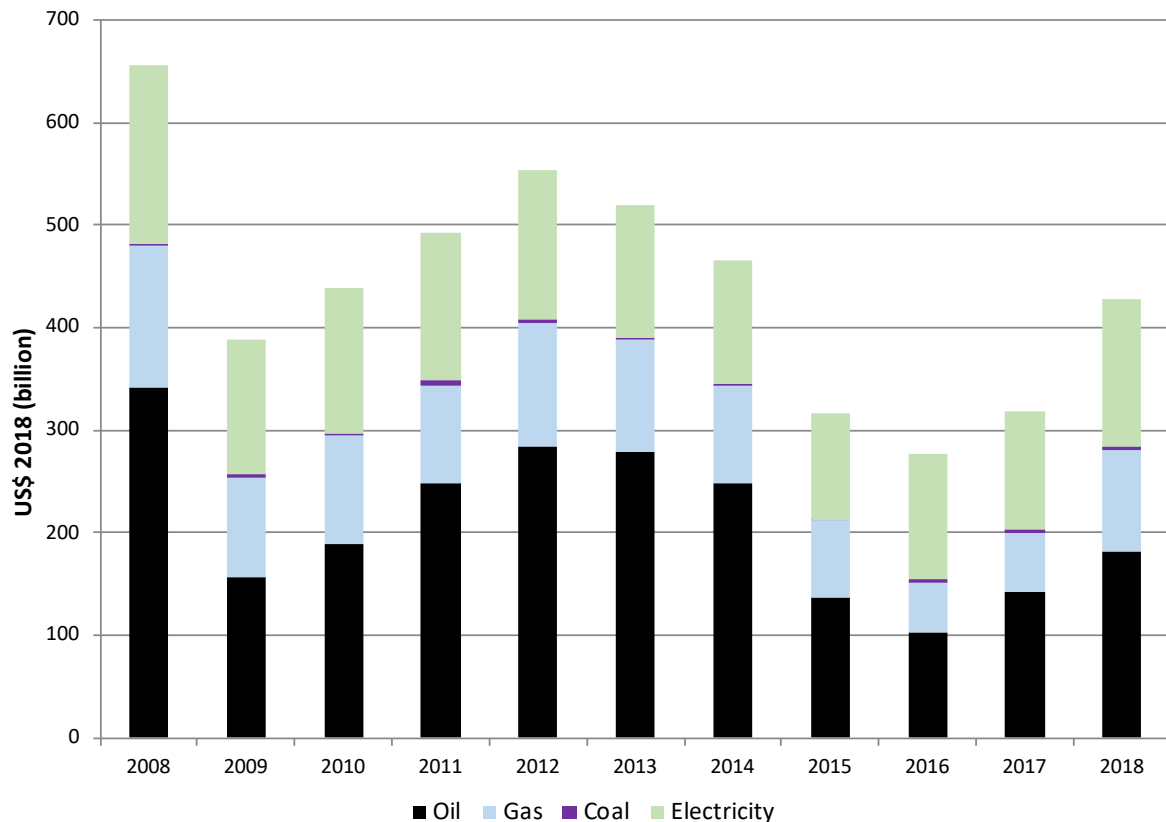
1813 *Indicator 4.4.1: Fossil fuel subsidies*

1814 **Headline Finding:** *In 2018, fossil fuel consumption subsidies increased to US\$427 billion - over*
1815 *a third higher than 2017 levels, and over 50% higher than 2016 levels.*

1816 Negative externalities, including the various direct and indirect consequences for human
1817 health and the natural environment, mean that the true cost of fossil fuels is far greater
1818 than their market price.¹⁶⁵ Fossil fuel subsidies (both for their consumption and their
1819 extraction) artificially lower prices even further, promoting overconsumption, further
1820 exacerbating both GHG emissions and air pollution.

1821 This indicator tracks the value of fossil fuel consumption subsidies in 42 (mostly non-OECD)
1822 countries. Although these countries account for a large proportion of such subsidies around
1823 the world, they are by no means comprehensive, meaning that the values reported are
1824 conservative. The methodology and data source (IEA) for this indicator remains unchanged
1825 since the 2017 Lancet Countdown report,⁴⁶ and is described there and the appendix. Data
1826 for 2008 and 2017, which was previously not available, is now included.

1827 Whilst fossil fuel subsidies declined between 2012 and 2016, this trend was reversed in both
1828 2017 and 2018, reaching US\$319 billion and US\$427 billion, respectively (Figure 25). The
1829 values presented above do not include the economic value of the unpriced negative
1830 externalities. If these were to be included, the IMF estimated that in 2017 global subsidies
1831 to fossil fuels increase to US\$5.2 trillion – equivalent to 6.3% of Gross World Product
1832 (GWP).¹⁶⁶



1833

1834 *Figure 25: Global Fossil Fuel Consumption Subsidies 2008-2018.*

1835

1836 *Indicator 4.4.2: Coverage and strength of carbon pricing*

1837 **Headline Finding:** Carbon pricing instruments in early 2019 continue to cover 13.1% of
 1838 global anthropogenic GHG emissions, but average prices were around 13% higher than in
 1839 2018.

1840 Adequately pricing carbon emissions is an essential component in shifting investment to
 1841 develop a low-carbon economy. This indicator tracks the extent to which GHG emissions
 1842 around the world are subject to a carbon price, and the weighted-average price these
 1843 instruments provide (

1844 Table 1), using data from the World Bank Carbon Pricing Dashboard.¹⁶⁷ The full
 1845 methodology is presented in the appendix and remains unchanged from the 2017 Lancet
 1846 Countdown report.

1847 The coverage of carbon pricing instruments remained at around 13.1% of global
 1848 anthropogenic GHG emissions between 2018 and 2019, implemented through 44 national
 1849 and 27 sub-national instruments.
 1850

1851 *Table 1: Carbon Pricing – Global Coverage and Weighted Average Prices per tCO₂e. * Global*
 1852 *emissions coverage is based on 2012 total anthropogenic GHG emissions.*

1853

	2016	2017	2018	2019
Global Emissions Coverage*	12.1%	13.1%	13.1%	13.1%
Weighted Average Carbon Price of Instruments <i>(current prices, US\$)</i>	\$7.79	\$9.28	\$11.58	\$13.08
Global Weighted Average Carbon Price <i>(current prices, US\$)</i>	\$0.94	\$1.22	\$1.51	\$1.76

1854

1855
1856

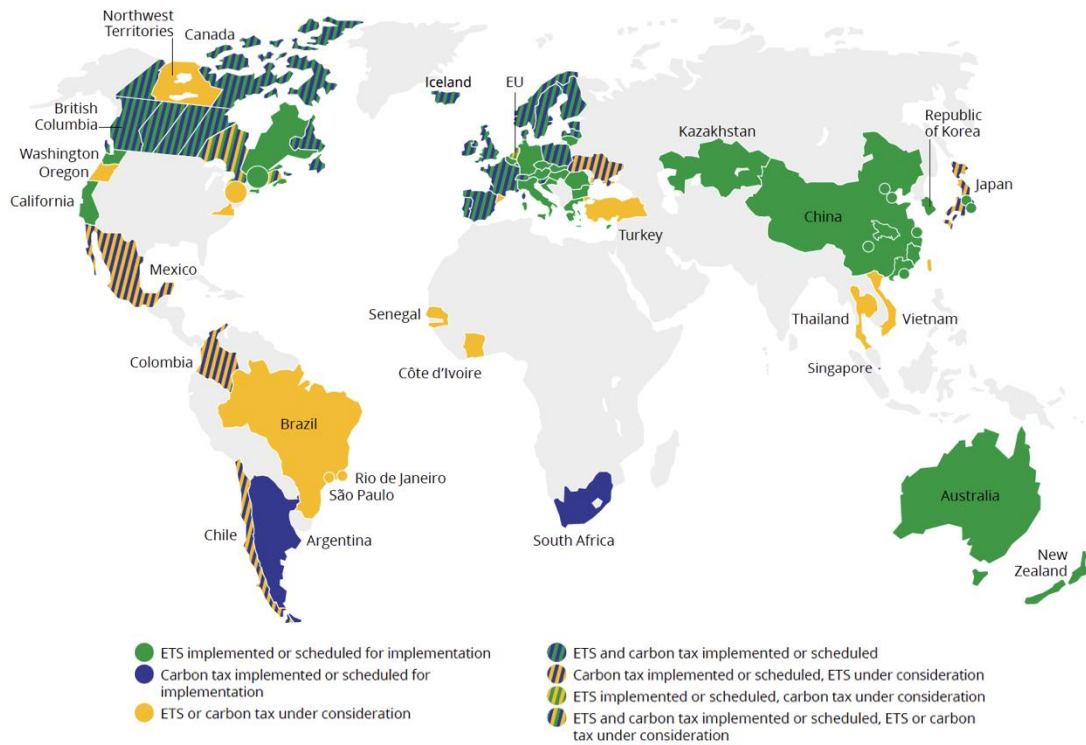


Figure 26: Carbon pricing instruments implemented, scheduled for implementation, and under consideration. Adapted from World Bank Group (2019).

1857 The range of carbon prices across instruments continues to be vast (from <US\$1 /tCO₂e in
1858 Poland, Ukraine and the Chongqing and Shenzhen pilot schemes in China , to US\$127 /tCO₂e
1859 in Sweden), although weighted-average prices in early 2019 were 13% above 2018 levels,
1860 driven in large part by an increasing price under the EU Emissions Trading Scheme (EU ETS)
1861 (the largest carbon pricing instrument in the world, responsible for nearly half the economic
1862 value of all instruments combined). However, the weighted average of these carbon pricing
1863 instruments remains insufficient to remain “well below 2°”, which would require a carbon
1864 price of US\$40-80 /tCO₂e by 2020,¹⁶⁸ and the revenue generated through carbon pricing
1865 (which is described in Indicator 4.4.3) is far less than the potential annual impacts of
1866 unmitigated climate change on global GDP.¹⁵²

1867 As illustrated in Figure 26, further carbon pricing instruments are under consideration. With
1868 the addition of these instruments – and in particular the Chinese national ETS (replacing the
1869 existing sub-national ‘pilots’), over 20% of global anthropogenic GHG emissions will be
1870 subject to a carbon price.¹⁶⁹

1871
1872

1873 *Indicator 4.4.3: Use of carbon pricing revenues*

1874 **Headline Finding:** Revenues from carbon pricing instruments increased by US\$10 billion
 1875 between 2017 and 2018, reaching US\$43 billion, with US\$24.4 billion allocated to further
 1876 climate change mitigation activities.

1877 As the previous indicator outlined, adequately pricing carbon is essential for mitigating GHG
 1878 emissions. How the revenue generated by these pricing instruments is used will also have
 1879 important consequences. Four ways the revenue may be used include: investment in further
 1880 mitigation; investment in adaptation; recycling for other purposes (such as enabling the
 1881 reduction of other taxes or levies); and contributing to other general government funds.
 1882 This indicator tracks the total government revenue from carbon pricing instruments and
 1883 where this is allocated.

1884 Data on revenue generated is provided on the WBG Carbon Pricing Dashboard,¹⁶⁷ with
 1885 revenue allocation information obtained from various sources. Only instruments with
 1886 revenue estimates and with revenue received by the administering authority before
 1887 redistribution are considered. Further information on the methodology and various sources
 1888 used to obtain information on revenue allocation can be found in the appendix.

1889
 1890 *Table 2: Carbon pricing revenues and allocation in 2018.*

	Mitigation	Adaptation	Revenue Recycling	General Funds	Total Revenue (US\$)
Proportion of total funds (%)	56.6%	0.6%	12.8%	30%	-
Value (US\$)	\$24.36 billion	\$258 million	\$5.50 billion	\$12.91 billion	\$43.03 billion

1891 Government revenue generated from carbon pricing instruments in 2018 totalled over
 1892 US\$43 billion; a US\$10 billion increase from the \$33 billion generated in 2017. This was
 1893 driven by increasing prices of allowances sold at auction in the EU ETS, higher tax rates for
 1894 instruments in Alberta, British Columbia and France, and allowance sales in California and
 1895 Quebec.¹⁷⁰

1896 The revenue allocated to mitigation activities increased by around US\$10 billion between
 1897 2017 and 2018, and revenue allocated to revenue recycling and general funds also increased
 1898 slightly. Revenue allocated to adaptation however reduced significantly, from over US\$1.5
 1899 billion to around US\$250 million.

1900 Conclusion

1901 Section 4 has presented indicators on the economic impacts of climate change, the finance
1902 and economic underpinnings of climate change mitigation, and the economic value of the
1903 health-related benefits it brings. The results of these indicators suggest that the shift to a
1904 low carbon global economy is in some respects slowing, and in yet other cases, previously
1905 promising trends highlighted in the 2018 report are falling into reverse gear. Given the need
1906 to transition the global economy to net-zero GHG emissions by 2050 in order to limit
1907 warming to well below 2°C, governments at all levels, in collaboration with the private
1908 sector and the population at large, must take immediate steps towards implementing
1909 strong, ambitious policy and related action to steer and rapidly accelerate their economies
1910 towards a low-carbon state. The health sector and health professionals are able to
1911 contribute here through the removal of institutional investment in fossil fuels, assessments
1912 of the health economics of mitigation co-benefits, and by communicating the negative
1913 externalities associated with the continued use of fossil fuels.

1914

1915

1916 Section 5: Public and Political Engagement

1917 As earlier sections have made clear, climate change is human in both its origins and its
1918 impacts. Its origins lie in the burning of fossil fuels, particularly by early-industrialising and
1919 richer societies, and its impacts include an increasing toll on human health. Reductions in
1920 global GHG emissions at the speed required by the Paris Agreement depend upon
1921 engagement by all sectors of society.

1922 In the 2019 Lancet Countdown report section 5 focuses on engagement in four domains: the
1923 media, government, corporate sector and, for the first time, individual engagement. It
1924 tracks trends in engagement across the last decade, complementing this evidence with
1925 analyses of the content and dynamics of engagement in 2018. The methods for an indicator
1926 relating to a fifth domain, scientific engagement, are currently being refined to ensure the
1927 long-term sustainability of this work, and will be reported again in 2020. In every case,
1928 indicators in this section build on methods used in earlier Lancet Countdown reports, which
1929 continue to be refined and extended.

1930 The media is central to public understanding of climate change; it provides a key resource
1931 through which people make sense of climate change and assess the actions of governments
1932 to address it.¹⁷¹⁻¹⁷⁴ The media indicator (5.1) includes an analysis of global coverage of
1933 health and climate change in 62 newspapers from 2007 to 2018. For the 2019 Countdown
1934 report, this has expanded to include coverage of health and climate change in China's
1935 *People's Daily* (in its Chinese-language edition, *Renmin Ribao*). As the official outlet of the
1936 Chinese party-state, the *People's Daily* is China's most influential newspaper.¹⁷⁵ The
1937 indicator has been further enhanced by a content analysis of the elite press in two

1938 contrasting societies, India and the USA. Elite newspapers both reflect and shape
 1939 engagement in climate change by governments and elite groups.¹⁷⁶⁻¹⁸⁰

1940 The internet is an increasingly important medium of civic engagement and has transformed
 1941 individual access to global knowledge and debates. The second indicator tracks engagement
 1942 in health and climate change through individuals' information-seeking behaviour on the
 1943 online encyclopaedia, Wikipedia.¹⁸¹ Because of its accessibility, breadth and user trust,
 1944 Wikipedia is one of the most widely-used online resources.¹⁸²⁻¹⁸⁶

1945 Recognising that that climate change is harming people, the global public support
 1946 government action to limit GHG emissions.¹⁸⁷⁻¹⁸⁹ The third indicator relates to government
 1947 engagement in health and climate change and focuses on high-level government
 1948 engagement in health and climate change at the United Nations General Assembly. It tracks
 1949 references at the UN General Debate, the major international forum where national leaders
 1950 have the opportunity to address the global community on issues they consider
 1951 important.^{190,191}

1952 The fourth indicator relates to the corporate sector, recognised to be central to achieving a
 1953 rapid transition to a carbon-free economy, both through its business practices and via its
 1954 wider political and public influence.¹⁹²⁻¹⁹⁴ Focusing on the health sector, the indicator tracks
 1955 engagement in health and climate change through analyses of the annual reports submitted
 1956 by companies signed up to the UN Global Compact, the world's largest corporate
 1957 sustainability initiative.¹⁹⁵

1958

1959 [Indicator 5.1 Media coverage of health and climate change](#)

1960 **Headline finding:** *Media coverage of health and climate change continued to increase*
 1961 *between 2007 and 2018 with the elite press paying attention to the health impacts of*
 1962 *climate change and the co-benefits of climate change action.*

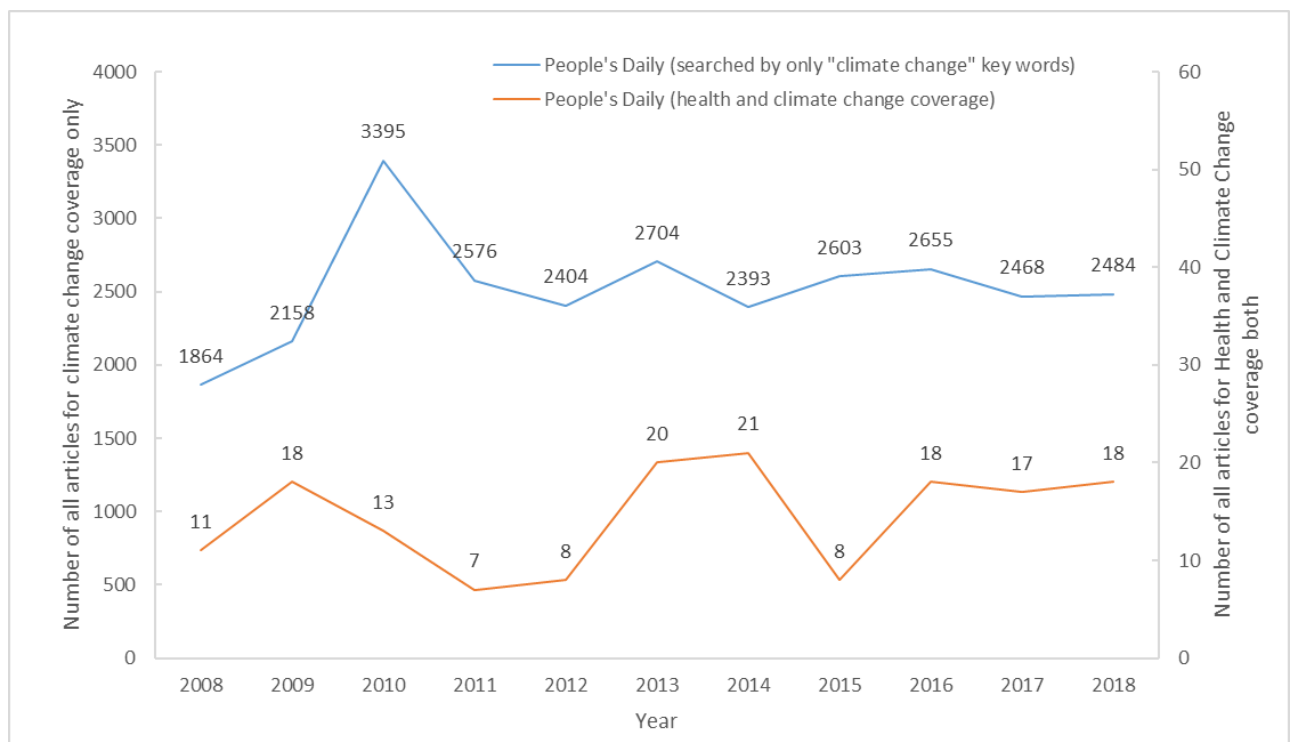
1963 This indicator tracks coverage of health and climate change in the global media, including in
 1964 the Chinese People's Daily. Additionally, it provides insight into what aspects of the health-
 1965 climate change nexus are receiving attention in the elite media in India and the USA. For the
 1966 2019 Report of the Lancet Countdown, methods to track newspaper coverage have been
 1967 improved; greater attention is also given to the content of coverage.

1968 Global media coverage of health and climate change has increased since 2010. As with
 1969 broader coverage of climate change, spikes in media engagement with health and climate
 1970 change coincided with major events in climate governance.¹⁹⁶ These include the 2009 and
 1971 2015 UNFCCC Conferences of Parties (COPs) in Copenhagen and Paris and, in 2016, the Paris
 1972 Agreement and the Sustainable Development Goals coming into force. Nonetheless, health
 1973 continued to represent only a small proportion of wider coverage of climate change.
 1974 Analysis details, together with data sources and methodological enhancements, are

1975 described in the appendix. The indicator is based on 62 newspapers (English, German,
 1976 Portuguese, Spanish) selected to provide a global spread of higher-circulation papers.

1977 Extending this analysis, Figure 27 tracks coverage of health and climate change in the
 1978 *People's Daily*. While the Chinese media has changed and diversified in recent decades, the
 1979 *People's Daily* retains its dominance.^{175,197,198} Across the 2008-18 period, there was an
 1980 average of 2519 articles per year relating to climate change. A small proportion of these
 1981 related to human health, with a mean of 14 articles a year. Spikes in coverage are less
 1982 closely tied to landmarks in global climate change governance (such as the signing of the
 1983 Paris Agreement in 2015) than in the global media. The explanation may lie in the timing of
 1984 *People's Daily* coverage of global events, including the COPs, which occurs after their
 1985 conclusion; coverage of November/December COPs may therefore occur in the following
 1986 calendar year.

1987 This addition to Indicator 5.1 was based on the *People's Daily* online archive,¹⁹⁹ and
 1988 combined electronic searching of the text corpus (key word searches and algorithm-based
 1989 natural language processing) with manual screening of the filtered articles. Full details of
 1990 methods are provided in the appendix.



1991
 1992 **Figure 27: Number of articles reporting on climate change and on both health and climate change in**
 1993 **the *People's Daily* 2008-2018.**

1994 The analysis of the content of coverage focused on the high-circulation elite press in India
 1995 and the USA: *Times of India (ToI)*, *Hindustan Times (HT)*, *New York Times (NYT)* and
 1996 *Washington Post (WP)*. Two time-periods were selected to cover months (July-September)
 1997 where both countries experienced extreme weather events (monsoon flooding and wildfires)

1998 respectively) together with months (November-December) covering the 2018 COP in
1999 Katowice. Articles in international news databases Nexis and Factiva were keyword
2000 searched and manually screened for inclusion. Template analysis was used to identify
2001 themes; *a priori* coding (Lancet Countdown indicator-derived) and inductive coding (from
2002 recurrent topics in the data) were employed.²⁰⁰ Full details of methods are provided in the
2003 appendix, together with additional analyses.

2004 Coverage of health and climate change clustered around three broad connections between
2005 health and climate change (Panel 4). The first theme related to the health impacts of climate
2006 change. Discussed in 62% of the articles, these impacts related to climate change-related
2007 stressors (e.g. increased temperatures, wildfires, precipitation extremes, food security,
2008 population displacement) and health sequelae (e.g. vector-borne disease, heat stress,
2009 mental ill-health). Heat-related health impacts were the most commonly-mentioned
2010 impact. A second theme (44% of articles) focused on the common determinants of health
2011 and climate change, particularly air pollution, and the co-benefits to be derived from
2012 mitigation strategies to address them (e.g. investment in clean energy, active travel and
2013 plant-based diets). The third theme related to adaptation. Evident in 13% of the articles, it
2014 included both emergency response and longer-term planning. The three themes were
2015 represented in similar proportions in *HT*, *NYT* and *WP* while *ToI* gave greater emphasis to
2016 common causes and co-benefits (see appendix for further details).

Health impacts of climate change

'Climate change [is] making mosquitoes bolder and the germs they transmit stronger, leading to a spurt in mosquito-borne diseases, particularly chikungunya' (ToI, 9 August).

'As large wildfires become more common – spurred by dryness linked to climate change – health risks will almost surely rise ... a person's short-term exposure to wildfire can spur a lifetime of asthma, allergy and constricted breathing.' (NYT, 17 November)

Benefits of addressing climate change and health together

'To protect our future, new infrastructure must be low-carbon, sustainable and resilient... In 2030, this kind of climate action could also prevent over 700,000 premature deaths from air pollution annually...If cities are built in more compact, connected and coordinated ways, they can improve residents' access to jobs, services and amenities while increasing carbon efficiency.' (HT, 5 December)

'For a short time on Thursday night, a small but fiercely determined group of marchers took over a busy D.C. street to demand better safety for pedestrians and bicyclists... The District has reported 31 traffic deaths so far this year, up from 29 in all 2017.... Yet lives could be spared ... even if it means taking the space from curbside parking. Gove said. "This is a public health crisis. This is a climate change crisis."' (WP, 16 November)

Adaptation

'Ahmedabad Municipal Corporation (AMC) has adopted a heat action plan which necessitates measures such as building heat shelters, ensuring availability of water and removing neonatal ICU from the top floor of hospitals. It has helped bring down the impact of heatwave on vulnerable populations.' (ToI, 29 November)

'We rarely do much to protect our cities until disaster strikes.... (the) effects of climate change, including the ways it boosts droughts, floods and wildfires, would put more pressure on cities to adapt, mitigate the effects of climate change and become resilient... preparing for disasters and recovering from weather challenges require many different strategies, including holding that rainwater, keeping the flow from going into the drains faster, raising your homes above the flood line.' (NYT, 13 December)

2017
2018 Panel 4: Dominant themes in elite newspaper coverage of health and climate change in India and the USA

2019

2020 Indicator 5.2 Individual engagement in health and climate change

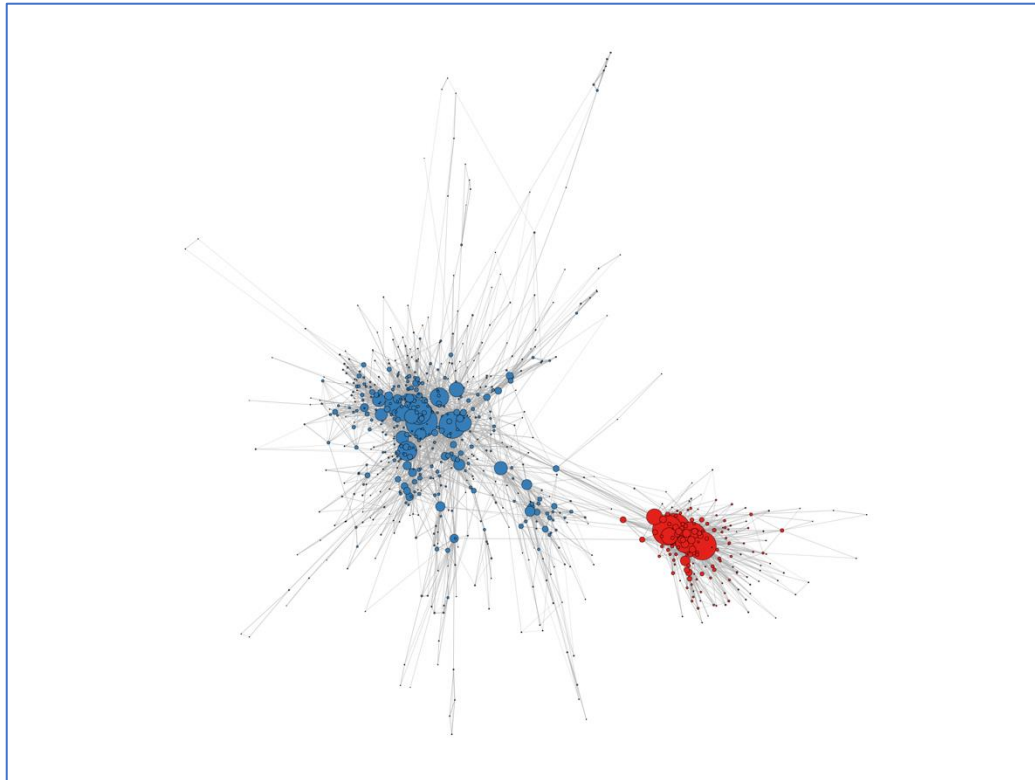
2021 **Headline finding:** *Individuals typically seek information about either health or climate*
2022 *change; where individuals seek information across these areas, it is primarily driven by an*
2023 *initial interest in health-related content.*

2024 The internet is an increasingly important domain of public engagement, particularly for
2025 information-seeking on issues that engage people’s attention.²⁰¹ This indicator tracks
2026 individual-level engagement in health and climate change in 2018 through an analysis of
2027 usage of Wikipedia, the world’s largest encyclopaedia. With reviews noting its
2028 accuracy,^{182,202} Wikipedia is one of most-visited websites worldwide,¹⁸³ with a high
2029 correlation between user visits to Wikipedia and search activity on Google.²⁰³ The analysis is
2030 based on the English Wikipedia, which represents around 50% of global traffic to all
2031 Wikipedia language editions.

2032 This is a new indicator for the 2019 Report of the Lancet Countdown and its analysis uses
2033 the online footprint of Wikipedia users to map the dynamics of public information-seeking
2034 in health and climate change.^{181,204} It analyses ‘clickstream’ activity, reported on a monthly
2035 basis, that captures visits to pairs of articles, for example an individual clicking from a page
2036 on human health to one on climate change.²⁰⁵

2037 Articles were identified via key words and relevant hyperlinks within articles, refined using
2038 Wikipedia categories and then filtered by the initial key words. Data and methods are
2039 described in the appendix, together with further analysis.

2040 Figure 28 indicates that articles on health and on climate change are internally networked,
2041 with extensive co-visiting within these clusters. However, it points to little connectivity
2042 between the clusters. Health and climate change are seldom topics that an individual
2043 connects when they visit Wikipedia; initial engagement in one topic rarely triggers
2044 engagement in the other. The proportion of co-clicks from a health article to a climate
2045 change article represented only 0.18% of total health article co-clicks to articles of any topic,
2046 and only 1.12% of climate change article co-clicks were to a health article This data also
2047 reflects the greater interest of the individual in health articles compared with climate
2048 change articles, with the majority (79%) of co-visits originated from a health-related page.



2049

2050 *Figure 28: Connectivity graph of Wikipedia articles on health (blue) and climate change (red) visited*
 2051 *in 2018. Popularity of articles is indicated by node size; lines represent co-visits in clickstream data.*

2052

2053 [Indicator 5.3 Government engagement in health and climate change](#)

2054 **Headline finding:** *National leaders are increasingly drawing attention to health and climate*
 2055 *change at the UN General Debate (UNGD) in a trend led by small island developing states*
 2056 *(SIDS), with SIDS making up 10 out of 28 countries referencing the climate change-health link*
 2057 *at the UNGD in 2018.*

2058 This indicator tracks high-level political engagement with climate change and health through
 2059 references to this topic in annual statements made by national leaders in the UNGD. The
 2060 UNGD takes place at the start of the annual UN General Assembly (UNGA) and provides a
 2061 global platform for all UN member states to speak about their priorities and concerns.

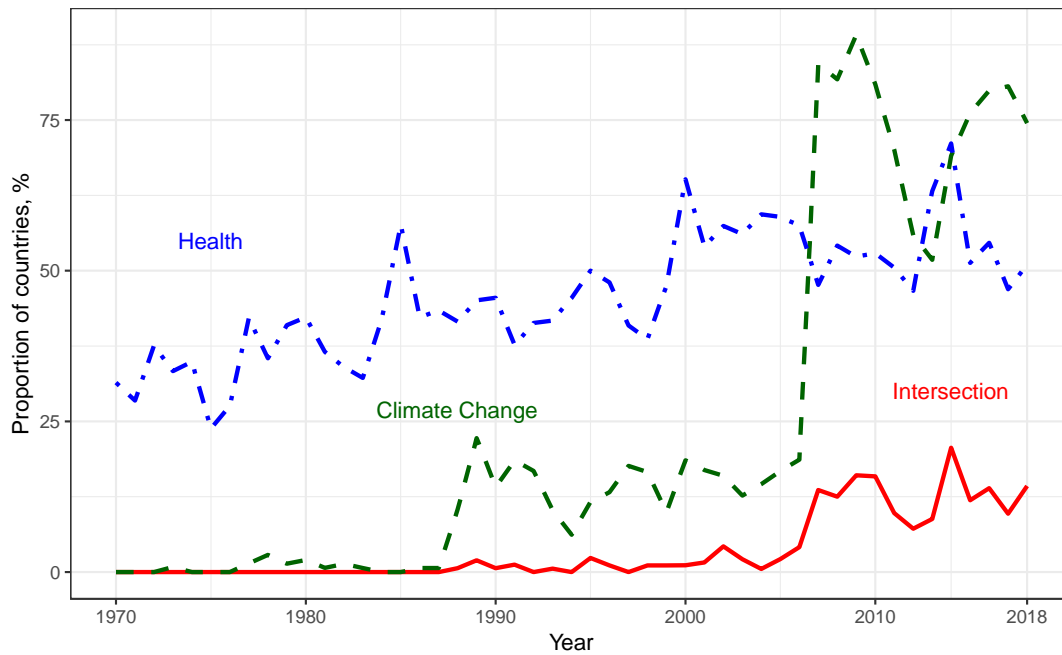
2062 An updated dataset, *the United Nations General Debate corpus*, was used for the analysis,
 2063 based on 8,093 statements (1970-2018).^{206,207} Key word searches used sets of health-related
 2064 and of climate change-related terms; engagement in the health-climate change nexus was
 2065 determined by the proximity of relevant key words within the statement. Methods and
 2066 data, as well as further analyses are presented in full in the appendix.

2067 Figure 29 shows the proportion of countries that make reference to the links between
 2068 health and climate change in their UNGD statements, together with the proportion referring

2069 separately to climate change and/or to health. In 2018, 28 countries referenced the climate
2070 change and health link at the UNGD.

2071 It points to an upward trend in government engagement in health and climate change since
2072 1970, and one in-line with broader trends for engagement in climate change. This increase
2073 is particularly noticeable since 2004, peaking in 2014, when more than 20% of national
2074 leaders spoke of the links between climate change and health. This spike coincided with the
2075 transition from the Millennium Development Goals (MDGs) to the Sustainable Development
2076 Goals (SDGs) and preparations for the COP 21 in Paris. Since 2014, conjoint references to
2077 health and climate change have remained broadly stable; in 2018, 13% of countries made
2078 such references. However, Figure 29 points to much higher levels of engagement in health
2079 and climate change as separate issues. Around 75% of all countries referred to climate
2080 change and 50% to health issues in their 2018 UNGD statements.

2081 The upward trend in engagement in health and climate change is led by the SIDS, for
2082 example, Fiji, Palau, Samoa, Dominica, and St Kitts and Nevis, with 10 SIDS making reference
2083 to the climate change-health link. In these speeches, connections between climate change
2084 and health are explicitly made and linked to wider inequalities between and within
2085 countries. For example, the 2018 address by St Kitts and Nevis notes that “NCDs and climate
2086 change are two sides of the same coin” while Dominica’s statement makes clear that
2087 “climate change arises from activities that support and reflect inequalities... It is the poor
2088 whose lands are impacted by severe droughts and flooding and whose homes are destroyed
2089 and whose loved ones perish. It is the poor who have the least capacity to escape the heavy
2090 burdens of poverty, disease and death.” The social justice theme is echoed in other
2091 speeches; for example, the Malawi address notes that “the hostile consequences of climate
2092 change, food insecurity and malnutrition are serious threats in a country that still relies on
2093 rain-fed subsistence agriculture.”



2094

2095 *Figure 29: Proportion of countries referring to climate change, health, and the intersection between*
 2096 *the two in their UNGD statements, 1970-2018.*

2097

2098 **Indicator 5.4 Corporate sector engagement in health and climate change**

2099 **Headline finding:** *Engagement in health and climate change remains low among companies*
 2100 *within the UN Global Compact (UNGC), including companies in the healthcare sector.*

2101 This indicator tracks corporate sector engagement through references to health and climate
 2102 change in companies that are part of the UNGC, a UN-supported platform to encourage
 2103 companies to put a set of principles, including environmental responsibility and human
 2104 rights, at the heart of their corporate practices.²⁰⁸ While the UNGC has been the subject of
 2105 criticism, it remains the world’s largest corporate citizenship initiative.²⁰⁹⁻²¹¹

2106 Companies submit annual Communication of Progress (CPs) reports with respect to their
 2107 progress in advancing UNGC principles. Over 12,000 companies have signed up to the UN
 2108 Global Compact from more than 160 countries.¹⁹⁵

2109 Analysis was based on key word searches of sets of health-related and of climate change-
 2110 related terms in CP reports in the UNGC database,¹⁹⁵ conjoint engagement in health and
 2111 climate change was identified by the proximity of relevant key words within the CP report.
 2112 Methods, data and additional analyses are presented in full in the appendix. With very few
 2113 reports available prior to 2011, the analysis focuses on the period from 2011 to 2018.

2114 Up to 2017, a small proportion of companies made reference to the links between health
 2115 and climate change.⁴⁶ The pattern continues in the 2018 CP reports. While around 45% and

2116 60% of the 2018 reports refer to climate change and to health respectively, only 15% refer
2117 to them together (see appendix). This pattern was even more pronounced in the corporate
2118 healthcare sector, which might be expected to be the global leader in addressing links
2119 between health and climate change. In 2018, while the majority of health sector companies
2120 referred to health (72%) and an increasing minority to climate change (47%), only 12% made
2121 conjoint reference to both.

2122

2123 Conclusion

2124 Engagement by all sectors of society is essential if action on climate change is to be
2125 mobilised and sustained. Section 5 has focused on key domains of engagement, including
2126 the media, governments, the corporate sector and, in a new indicator, individual-level
2127 engagement. Each is recognised to be central to moving global emissions onto a pathway
2128 that holds global temperature increases to below 1.5°C.²¹²

2129 Two broad conclusions can be drawn from the analyses presented in section 5. First,
2130 engagement in health and climate change has increased over the last decade, with a more
2131 pronounced upward trend for engagement by the media and government than by the
2132 corporate sector. With respect to the elite media, there is evidence of informed and
2133 detailed engagement with the health impacts of climate change and with the co-benefits of
2134 climate change action. At the global forum of the UN General Assembly, an increasing
2135 number of countries are giving attention to the health-climate change nexus. Led by the
2136 SIDS, these countries are highlighting the north-south inequalities in responsibility for, and
2137 vulnerability to, climate change and its adverse health impacts.

2138 Although media engagement is increasing, it is episodic rather than sustained, with ‘issue
2139 attention’ increasing at key moments in global climate governance, particularly the UNFCCC
2140 COPs. The role of the COPs in public and political engagement has been noted elsewhere,
2141 with the meetings providing a global stage for both national leaders and non-government
2142 organisations, including scientists, religious leaders and health professionals, to contribute
2143 to the public debate.^{196,213} The pattern for the corporate sector, including the healthcare
2144 sector, is different; it does not display spikes in engagement linked to the global governance
2145 of the planet.

2146 Second, while engagement has increased over the last decade, these indicators suggest that
2147 climate change is being more broadly represented in the media and by governments in ways
2148 that do not connect it to human health. As this suggests, the human face of climate change
2149 can be easily obscured. The analysis of individual engagement illustrates this pattern. The
2150 online footprint of Wikipedia users confirms that, while health is a major area of individual
2151 interest, it is rarely connected with climate change. In the public’s mind, it appears that
2152 ‘health’ and ‘climate change’ represent different and separate realms of knowledge and
2153 concern and, where connections are made, this is driven by an interest in health rather than
2154 climate change.

2155 Taken together, these two conclusions point to modest progress in making health central to
2156 public and political engagement in climate change but underline the challenge of mobilising
2157 action at the speed and magnitude required to protect the health of the planet and its
2158 populations.

2159

2160 Conclusion: The 2019 Report of the Lancet Countdown

2161 *The Lancet Countdown: Tracking Progress on Health and Climate Change* was formed four
2162 years ago, building on the work of the 2015 Lancet Commission. It remains committed to an
2163 open and iterative process, always looking to strengthen its methods, source new and novel
2164 forms of data, and partner with global leaders in public health and in climate change. The 41
2165 indicators presented in the 2019 report represent the consensus and work of the last 12
2166 months, and are grouped into five categories: climate change impacts, exposures, and
2167 vulnerabilities; adaptation, planning, and resilience for health; mitigation actions and health
2168 co-benefits; economics and finance; and public and political engagement.

2169 The data published here elucidate ongoing trends of a warming world threatening human
2170 wellbeing. As the fourth hottest year on record, 2018 saw a record-breaking 220 million
2171 additional exposures to extremes of heat, coupled with corresponding rising vulnerability
2172 across every continent. As a result of this and broader climatic changes, vectorial capacity
2173 for the transmission of dengue fever was the second highest ever seen, with 9 out of the
2174 last 10 most suitable years occurring since 2000. Progress in mitigation and adaptation
2175 remains insufficient, with the carbon intensity of the energy system remaining flat; 2.9
2176 million ambient air pollution deaths; and a reversal of the previous downward trend of coal
2177 use.

2178 And yet, as the material effects of climate change reveal themselves, so too does the
2179 world's response. Just under 50% of countries tracked have developed national health
2180 adaptation plans, 70 countries provide climate information services to the health sector,
2181 109 countries have medium to high implementation of a national health emergency
2182 framework, and 69% of cities have mapped out risk and vulnerability assessments. Health
2183 adaptation funding continues to climb, with health-related funding now responsible for
2184 11.8% of global adaptation spend. Finally, public and political engagement continues to
2185 grow, with flash-points around the school climate strikes, the UNFCCC's annual meetings,
2186 and divestment announcements from medical and health associations.

2187 The last three decades have witnessed the release of increasingly concerning scientific data
2188 demonstrating the importance of a reduction in greenhouse gas emissions. Whilst there are
2189 a number of positive indicators published here, CO₂ continues to rise. The health
2190 implications of this are apparent today, and will most certainly worsen without immediate
2191 intervention.

2192 Despite increasing public attention over the last 12 months, the world is yet to see a
2193 response from governments which matches the scale of the challenge. Here, the role of the
2194 health profession is essential – communicating the health risks of climate change, and
2195 driving the implementation of a robust response which maximises human health and
2196 wellbeing.

2197 With the full force of the Paris Agreement being implemented in 2020, there is a crucial shift
2198 that must now occur – one which moves from discussion and commitment, to meaningful
2199 reductions in emissions.
2200

2201 References

- 2202 1. Haustein K, Allen M, Forster P, et al. A real-time global warming index. *Scientific reports*
2203 2017; **7**(1): 15417.
- 2204 2. IPCC. Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of
2205 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the
2206 context of strengthening the global response to the threat of climate change. Geneva, Switzerland:
2207 World Meteorological Organization, 2018.
- 2208 3. NASA, NOAA. 2018 Fourth Warmest Year in Continued Warming Trend, According to NASA,
2209 NOAA. NASA; 2019.
- 2210 4. Cooper A, Johnson C. Now near 100 million bpd, when will oil demand peak? Reuters. 2018.
- 2211 5. IEA. Market Report Series: Gas 2017. Paris, France: International Energy Agency, 2018.
- 2212 6. IEA. Coal 2018: Analysis and forecasts to 2023. Paris, France: International Energy Agency,
2213 2019.
- 2214 7. Global Carbon Project. Carbon Budget 2018. 2018.
2215 <https://www.globalcarbonproject.org/carbonbudget/> (accessed 4 June 2019).
- 2216 8. WHO. Ambient Air Pollution: A global assessment of exposure and burden of disease.
2217 Geneva, Switzerland: World Health Organization, 2016.
- 2218 9. Anderson K, Bows A. Beyond 'dangerous' climate change: emission scenarios for a new
2219 world. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering*
2220 *Sciences* 2011; **369**(1934): 20-44.
- 2221 10. Costello A, Abbas M, Allen A, et al. Managing the health effects of climate change: Lancet
2222 and University College London Institute for Global Health Commission. *Lancet* 2009; **373**(9676):
2223 1693-733.
- 2224 11. Legendre M, Bartoli J, Shmakova L, et al. Thirty-thousand-year-old distant relative of giant
2225 icosahedral DNA viruses with a pandoravirus morphology. *Proceedings of the National Academy of*
2226 *Sciences* 2014; **111**(11): 4274-9.
- 2227 12. Revich BA, Podolnaya MA. Thawing of permafrost may disturb historic cattle burial grounds
2228 in East Siberia. *Global Health Action* 2011; **4**(1): 8482.
- 2229 13. Watts N, Adger WN, Agnolucci P, et al. Health and climate change: policy responses to
2230 protect public health. *Lancet* 2015; **386**(10006): 1861-914.
- 2231 14. Pecl GT, Araújo MB, Bell JD, et al. Biodiversity redistribution under climate change: Impacts
2232 on ecosystems and human well-being. *Science* 2017; **355**(6332): eaai9214.
- 2233 15. Global Governance Project. Health: A political choice. Delivering Universal Health Coverage
2234 2030, 2019.
- 2235 16. Markandya A, Sampedro J, Smith SJ, et al. Health co-benefits from air pollution and
2236 mitigation costs of the Paris Agreement: a modelling study. *The Lancet Planetary Health* 2018; **2**(3):
2237 e126-e33.
- 2238 17. Wolking B, Haas W, Bachner G, et al. Evaluating Health Co-Benefits of Climate Change
2239 Mitigation in Urban Mobility. *Int J Environ Res Public Health* 2018; **15**(5).
- 2240 18. New Climate Economy. Unlocking the Inclusive Growth Story of the 21st Century:
2241 Accelerating Climate Action in Urgent Times. Washington, 2018.
- 2242 19. Watts N, Adger WN, Ayeb-Karlsson S, et al. The Lancet Countdown: tracking progress on
2243 health and climate change. *The Lancet* 2017; **389**(10074): 1151-64.
- 2244 20. Watts N, Amann M, Ayeb-Karlsson S, et al. The Lancet Countdown on health and climate
2245 change: from 25 years of inaction to a global transformation for public health. *The Lancet* 2017.
- 2246 21. Prime Minister's Office, Clark G, May T. PM Theresa May: we will end UK contribution to
2247 climate change by 2050. London: UK Government; 2019.
- 2248 22. Felix B. France sets 2050 carbon-neutral target with new law. Reuters. 2019.
- 2249 23. UNFCCC. Paris Agreement. 2015.

- 2250 24. Hochman Z, Gobbett DL, Horan H. Climate trends account for stalled wheat yields in
2251 Australia since 1990. *Global Change Biology* 2017; **23**(5): 2071-81.
- 2252 25. Erda L, Wei X, Hui J, et al. Climate change impacts on crop yield and quality with CO2
2253 fertilization in China. *Philosophical Transactions of the Royal Society B: Biological Sciences* 2005;
2254 **360**(1463): 2149-54.
- 2255 26. Högy P, Brunnbauer M, Koehler P, et al. Grain quality characteristics of spring wheat
2256 (*Triticum aestivum*) as affected by free-air CO2 enrichment. *Environmental and Experimental Botany*
2257 2013; **88**: 11-8.
- 2258 27. Erbs M, Manderscheid R, Jansen G, Seddig S, Pacholski A, Weigel H-J. Effects of free-air CO2
2259 enrichment and nitrogen supply on grain quality parameters and elemental composition of wheat
2260 and barley grown in a crop rotation. *Agriculture, Ecosystems & Environment* 2010; **136**(1): 59-68.
- 2261 28. Fernando N, Panozzo J, Tausz M, Norton R, Fitzgerald G, Seneweera S. Rising atmospheric
2262 CO2 concentration affects mineral nutrient and protein concentration of wheat grain. *Food*
2263 *Chemistry* 2012; **133**(4): 1307-11.
- 2264 29. Szekely M, Carletto L, Garami A. The pathophysiology of heat exposure. *Temperature*
2265 (*Austin, Tex*) 2015; **2**(4): 452.
- 2266 30. Sanz-Barbero B, Linares C, Vives-Cases C, Gonzalez JL, Lopez-Ossorio JJ, Diaz J. Heat wave
2267 and the risk of intimate partner violence. *The Science of the total environment* 2018; **644**: 413-9.
- 2268 31. Levy BS, Sidel VW, Patz JA. Climate Change and Collective Violence. *Annual review of public*
2269 *health* 2017; **38**: 241-57.
- 2270 32. Xu Z, Sheffield PE, Su H, Wang X, Bi Y, Tong S. The impact of heat waves on children's health:
2271 a systematic review. *International journal of biometeorology* 2014; **58**(2): 239-47.
- 2272 33. Arbuthnott KG, Hajat S. The health effects of hotter summers and heat waves in the
2273 population of the United Kingdom: a review of the evidence. *Environmental health : a global access*
2274 *science source* 2017; **16**(Suppl 1): 119.
- 2275 34. European Centre for Medium-Ranged Forecasts. Climate reanalysis. Reading, UK: European
2276 Centre for Medium-Ranged Forecasts; 2018.
- 2277 35. NASA. Gridded Population of the World. 4 ed; 2019.
- 2278 36. Carbon Brief. Media reaction: The 2018 summer heatwaves and climate change. 2018.
2279 <https://www.carbonbrief.org/media-reaction-2018-summer-heatwaves-and-climate-change>
2280 (accessed 12 June 2019).
- 2281 37. WBG. Population ages 65 and above, total. Washington, DC, USA: World Bank Group; 2017.
- 2282 38. Flouris AD, Dinas PC, Ioannou LG, et al. Workers' health and productivity under occupational
2283 heat strain: a systematic review and meta-analysis. *The Lancet Planetary Health* 2018; **2**(12): e521-
2284 e31.
- 2285 39. Kjellstrom T, Freyberg C, Lemke B, Otto M, Briggs D. Estimating population heat exposure
2286 and impacts on working people in conjunction with climate change. *International Journal of*
2287 *Biometeorology* 2018; **62**(3): 291-306.
- 2288 40. ILO. ILOSTAT. 2019.
- 2289 41. ECMWF. ERA Interim, Daily. 2019.
- 2290 42. Black C, Tesfaigzi Y, Bassein JA, Miller LA. Wildfire smoke exposure and human health:
2291 Significant gaps in research for a growing public health issue. *Environmental toxicology and*
2292 *pharmacology* 2017; **55**: 186-95.
- 2293 43. Doerr SH, Santin C. Global trends in wildfire and its impacts: perceptions versus realities in a
2294 changing world. *Philosophical Transactions of the Royal Society B: Biological Sciences* 2016;
2295 **371**(1696).
- 2296 44. NASA EarthData. Active Fire Data. 2019. [https://earthdata.nasa.gov/earth-observation-
2297 data/near-real-time/firms/active-fire-data](https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms/active-fire-data) (accessed 4 February 2019).
- 2298 45. Knowlton K. Where There's Fire, There's Smoke: Wildfire Smoke Affects Communities
2299 Distant from Deadly Flames. New York, NY, USA: National Resources Defense Council, 2011.

- 2300 46. Watts N, Amann M, Arnell N, et al. The 2018 report of the Lancet Countdown on health and
2301 climate change: shaping the health of nations for centuries to come. *The Lancet* 2018; **392**(10163):
2302 2479-514.
- 2303 47. Smith KR, Woodward A, Campbell-Lendrum D, et al. Human health: impacts, adaptation, and
2304 co-benefits. In: Field CB, Barros VR, Dokken DJ, et al., eds. *Climate Change 2014: Impacts,*
2305 *Adaptation, and Vulnerability Contribution of Working Group II to the Fifth Assessment Report of*
2306 *the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press; 2014:
2307 709–54.
- 2308 48. Centre for Research on the Epidemiology of Disasters. EM-DAT The International Disaster
2309 Database. 2019.
- 2310 49. Miranda JJ, Castro-Ávila AC, Salicrup LA. Advancing health through research partnerships in
2311 Latin America. *British Medical Journal* 2018; **362**: k2690.
- 2312 50. Novillo-Ortiz D, Dumit EM, D’Agostino M, et al. Digital health in the Americas: advances and
2313 challenges in connected health. *BMJ innovations* 2018; **4**(3): 123-7.
- 2314 51. Vogenberg FR, Santilli J. Healthcare trends for 2018. *American health & drug benefits* 2018;
2315 **11**(1): 48.
- 2316 52. IHME. Global Burden of Disease Study (2017) Data Resources. 2019.
- 2317 53. Hales S, Kovats S, Lloyd L, Campbell-Lendrum D. Quantitative risk assessment of the effects
2318 of climate change on selected causes of death , 2030s and 2050s. Geneva, Switzerland: World Health
2319 Organization, 2014.
- 2320 54. Rocklöv J, Tozan Y. Climate change and the rising infectiousness of dengue. *Emerging Topics*
2321 *in Life Sciences* 2019; **3**(2): 133-42.
- 2322 55. Martínez-Urtaza J, Trinanés J, Abanto M, et al. Epidemic Dynamics of *Vibrio*
2323 *parahaemolyticus* Illness in a Hotspot of Disease Emergence, Galicia, Spain. *Emerging Infectious*
2324 *Diseases* 2018; **24**(5): 852-9.
- 2325 56. Martínez-Urtaza J, van Aerle R, Abanto M, et al. Genomic Variation and Evolution of *Vibrio*
2326 *parahaemolyticus* ST36 over the Course of a Transcontinental Epidemic Expansion. *MBio* 2017;
2327 **14**(8).
- 2328 57. Wang H, Tang X, Su Y, Chen J, Yan J. Characterization of clinical *Vibrio parahaemolyticus*
2329 strains in Zhoushan, China, from 2013 to 2014. *PLoS ONE* 2017; **12**(7).
- 2330 58. Hasegawa T, Slade R. Impacts of 1.5°C of Global Warming on Natural and Human Systems.
2331 In: Masson-Delmotte V, Zhai P, Pörtner H-O, et al., eds. *Global warming of 15°C An IPCC Special*
2332 *Report: Intergovernmental Panel on Climate Change;* 2018.
- 2333 59. WHO. International Health Regulations (IHR) monitoring framework: implementation status
2334 of IHR core capacities, 2010-2017. Geneva, Switzerland; 2018.
- 2335 60. Mueller ND, Gerber JS, Johnston M, Ray DK, Ramankutty N, Foley JA. Closing yield gaps
2336 through nutrient and water management. *Nature* 2012; **490**(7419): 254.
- 2337 61. Alexander P, Rounsevell MD, Dislich C, Dodson JR, Engström K, Moran D. Drivers for global
2338 agricultural land use change: The nexus of diet, population, yield and bioenergy. *Global*
2339 *Environmental Change* 2015; **35**: 138-47.
- 2340 62. FAO, IFAD, UNICEF, WFP and WHO. *The State of Food Security and Nutrition in the World.*
2341 *Building Climate Resilience for Food Security and Nutrition.* Rome: FAO, 2018.
- 2342 63. Black RE, Allen LH, Bhutta ZA, et al. Maternal and child undernutrition: global and regional
2343 exposures and health consequences. *The Lancet* 2008; **371**(9608): 243-60.
- 2344 64. Deutsch CA, Tewksbury JJ, Tigchelaar M, et al. Increase in crop losses to insect pests in a
2345 warming climate. *Science* 2018; **361**(6405): 916-9.
- 2346 65. Meng Q, Chen X, Lobell DB, et al. Growing sensitivity of maize to water scarcity under
2347 climate change. *Scientific Reports* 2016; **6**: 19605.

- 2348 66. UNDP. SDG 2: Zero Hunger. 2019.
 2349 [https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-2-zero-](https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-2-zero-hunger.html#targets)
 2350 [hunger.html#targets](https://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-2-zero-hunger.html#targets) (accessed 8 May 2019).
- 2351 67. Challinor AJ, Koehler A-K, Ramirez-Villegas J, Whitfield S, Das B. Current warming will reduce
 2352 yields unless maize breeding and seed systems adapt immediately. *Nature Climate Change* 2016;
 2353 **6**(10): 954.
- 2354 68. Zhao C, Liu B, Piao S, et al. Temperature increase reduces global yields of major crops in four
 2355 independent estimates. *Proceedings of the National Academy of Sciences* 2017; **114**(35): 9326-31.
- 2356 69. FAO. The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable
 2357 development goals. Rome: Food and Agriculture Organization of the United Nations, 2018.
- 2358 70. Porter J, Xie A, Challinor A, et al. Food Security and Food Production Systems. In: Field C,
 2359 Barros V, Dokken D, et al., eds. Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A:
 2360 Global and Sectoral Aspects Contribution of Working Group II to the Fifth Assessment Report of the
 2361 Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge
 2362 University Press; 2014.
- 2363 71. Ortiz J-C, Wolff NH, Anthony KR, Devlin M, Lewis S, Mumby PJ. Impaired recovery of the
 2364 Great Barrier Reef under cumulative stress. *Science advances* 2018; **4**(7): eaar6127.
- 2365 72. Food and Agriculture Organization. Food balance sheets. 2017/2019).
- 2366 73. NASA NEO. Sea surface temperature (1 month – AQUA/MODIS). 2017.
- 2367 74. NOAA. NOAA Coral Reef Watch Version 3.1 Daily Global 5-km Satellite Coral Bleaching
 2368 Degree Heating Week Product. 2018.
- 2369 75. Kelman I. Imaginary Numbers of Climate Change Migrants? *Social Sciences* 2019; **8**(5): 131.
- 2370 76. Berry HL, Waite TD, Dear KBG, Capon AG, Murray V. The case for systems thinking about
 2371 climate change and mental health. *Nature Climate Change* 2018; **8**(4): 282-90.
- 2372 77. UNFCCC. Aggregate effect of the intended nationally determined contributions: an update,
 2373 2016.
- 2374 78. Ford J, Berrang-Ford L, Lesnikowski A, Barrera M, Heymann S. How to track adaptation to
 2375 climate change: a typology of approaches for national-level application. *Ecology and Society* 2013;
 2376 **18**(3): 40.
- 2377 79. Ford JD, Berrang-Ford L. The 4Cs of adaptation tracking: consistency, comparability,
 2378 comprehensiveness, coherency. *Mitigation and adaptation strategies for global change* 2016; **21**(6):
 2379 839-59.
- 2380 80. Noble IR, Huq S, Anokhin YA, et al. Adaptation needs and options. In: Field CB, Barros VR,
 2381 Dokken DJ, et al., eds. Climate Change 2014: Impacts, Adaptation, and Vulnerability Part A: Global
 2382 and Sectoral Aspects Contribution of Working Group II to the Fifth Assessment Report of the
 2383 Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press; 2014.
- 2384 81. WHO. Operational framework for building climate resilient health systems. Geneva,
 2385 Switzerland: World Health Organization, 2015.
- 2386 82. WHO. COP24 Special Report: Health and Climate Change. Geneva, Switzerland: World Health
 2387 Organization, 2018.
- 2388 83. WHO. 2018 WHO Health and Climate Country Survey Report Geneva, Switzerland: World
 2389 Health Organization, 2019.
- 2390 <https://www.who.int/globalchange/resources/countries/en/>
- 2391 84. WHO. Protecting health from climate change: vulnerability and adaptation assessment
 2392 Geneva, Switzerland: WHO, 2013.
- 2393 85. CDP. Data cities. 2019.
- 2394 86. WHO. International Health Regulations (2005) State Party Self-Assessment Annual Reporting
 2395 Tool. Geneva, Switzerland: World Health Organization, 2018.
- 2396 87. Bouchama A, Dehbi M, Mohamed G, Matthies F, Shoukri M, Menne B. Prognostic factors in
 2397 heat wave related deaths: a meta-analysis. *Archives of internal medicine* 2007; **167**(20): 2170-6.

- 2398 88. Waite M, Cohen E, Torbey H, Piccirilli M, Tian Y, Modi V. Global trends in urban electricity
2399 demands for cooling and heating. *Energy* 2017; (127): 786-802.
- 2400 89. Salamanca F, Georgescu M, Mahalov A, Moustou M, Wang M. Anthropogenic heating of
2401 the urban environment due to air conditioning. *Journal of Geophysical Research-Atmospheres* 2014;
2402 (119): 5949-65.
- 2403 90. Purohit P, Hoglund-Isaksson L. Global emissions of fluorinated greenhouse gases 2005-2050
2404 with abatement potentials and costs. *Atmospheric Chemistry and Physics* 2017; (17): 2795-816.
- 2405 91. Velders G, Fahey D, Daniel J, Andersen S, McFarland M. Future atmospheric abundances and
2406 climate forcings from scenarios of global and regional hydrofluorocarbon (HFC) emissions.
2407 *Atmospheric Environment* 2015; (123): 200-9.
- 2408 92. Miettinen OS. Proportion of disease caused or prevented by a given exposure, trait or
2409 intervention. *Am J Epidemiol* 1974; **99**(5): 325-32.
- 2410 93. IEA. The future of cooling: opportunities for energy-efficient air conditioning. 2018.
2411 <https://webstore.iea.org/the-future-of-cooling> (accessed 11 April 2019).
- 2412 94. OzonAction. The Kigali Amendment to the Montreal
2413 Protocol: HFC Phase-down. Paris: United Nations Environment Program, 2016.
- 2414 95. kMatrix Ltd. Adaptation and Resilience to Climate Change dataset. 2019.
- 2415 96. International Monetary Fund. World Economic Outlook, April 2019
- 2416 Growth Slowdown, Precarious Recovery. Washington: International Monetary Fund, 2019.
- 2417 97. UNEP. The Adaptation Gap Report 2018. Health Report. Nairobi: United Nations
2418 Environment Program, 2018.
- 2419 98. UNEP. The Adaptation Gap Report 2017. Towards Global Assessment. Nairobi: United
2420 Nations Environment Program, 2017.
- 2421 99. UNEP. The Emissions Gap Report 2018. Nairobi, 2018.
- 2422 100. Woodcock J, Edwards P, Tonne C, et al. Public health benefits of strategies to reduce
2423 greenhouse-gas emissions: urban land transport. *The Lancet* 2009; **374**(9705): 1930-43.
- 2424 101. Willett W, Rockstrom J, Loken B, et al. Food in the Anthropocene: the EAT-Lancet
2425 Commission on healthy diets from sustainable food systems. *Lancet* 2019; **393**(10170): 447-92.
- 2426 102. IEA. Renewable Energy 2018: Market Analysis and Forecast from 2018 to 2023. Paris, France:
2427 International Energy Agency, 2018.
- 2428 103. IEA. World Energy Outlook 2018. Paris, France: International Energy Agency, 2018.
- 2429 104. IEA. World Extended Energy Balances. UK Data Service; 2019.
- 2430 105. Powering Past Coal Alliance. Powering Past Coal Alliance. 2019.
2431 <https://poweringpastcoal.org/> (accessed 6 May 2019).
- 2432 106. ILO. Solar PV. 2019. <https://www.iea.org/tcep/power/renewables/solarpv/#> (accessed 25
2433 May 2019).
- 2434 107. Patange OS, Ramanathan N, Rehman I, et al. Reductions in indoor black carbon
2435 concentrations from improved biomass stoves in rural India. *Environmental science & technology*
2436 2015; **49**(7): 4749-56.
- 2437 108. Scovronick N. Reducing global health risks through mitigation of short-lived climate
2438 pollutants: Scoping Report for Policy Makers. Geneva, Switzerland: World Health Organization, 2015.
- 2439 109. Venkataraman C, Sagar A, Habib G, Lam N, Smith K. The Indian national initiative for
2440 advanced biomass cookstoves: the benefits of clean combustion. *Energy for Sustainable*
2441 *Development* 2010; **14**(2): 63-72.
- 2442 110. Wilkinson P, Smith KR, Davies M, et al. Public health benefits of strategies to reduce
2443 greenhouse-gas emissions: household energy. *The Lancet* 2009; **374**(9705): 1917-29.
- 2444 111. UNDP. Sustainable Development Goal 7. 2019. <https://sustainabledevelopment.un.org/sdg7>
2445 (accessed 5 June 2019).

- 2446 112. WHO. Energy access and resilience. 2019. [https://www.who.int/sustainable-](https://www.who.int/sustainable-development/health-sector/health-risks/energy-access/en/)
2447 [development/health-sector/health-risks/energy-access/en/](https://www.who.int/sustainable-development/health-sector/health-risks/energy-access/en/) (accessed 5 June 2019).
- 2448 113. IEA. World Energy Outlook 2018. Global Residential Sector Energy Consumption. Paris,
2449 France: International Energy Agency, 2018.
- 2450 114. WHO. Household fuel use for cooking. 2019.
- 2451 115. IEA, IRENA, WMO, WBG, WHO. Tracking SDG7: The Energy Progress Report 2018: The World
2452 Bank, 2018.
- 2453 116. WHO. Burden of disease from Household Air Pollution for 2016. Geneva, Switzerland: World
2454 Health Organization, 2018.
- 2455 117. Egondi T, Muindi K, Kyobutungi C, Gatari M, Rocklöv J. Measuring exposure levels of
2456 inhalable airborne particles (PM_{2.5}) in two socially deprived areas of Nairobi, Kenya. *Environmental*
2457 *research* 2016; **148**: 500-6.
- 2458 118. United States Department of Energy. EnergyPlus V8. 2013.
- 2459 119. Muindi K, Kimani-Murage E, Egondi T, Rocklöv J, Ng N. Household Air Pollution: Sources and
2460 Exposure Levels to Fine Particulate Matter in Nairobi Slums. *Toxics* 2016; **4**(3).
- 2461 120. IIASA. Air Quality and Greenhouse Gases (AIR). 2018.
- 2462 121. UN Habitat. Sustainable building design for tropical climates : principles and applications for
2463 eastern Africa. Nairobi, 2015.
- 2464 122. Burnett R, Chen H, Szyszkowicz M, et al. Global estimates of mortality associated with long-
2465 term exposure to outdoor fine particulate matter. *Proceedings of the National Academy of Sciences*
2466 2018; **115**(38): 9592-7.
- 2467 123. Gakidou E, Afshin A, Abajobir AA, et al. Global, regional, and national comparative risk
2468 assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of
2469 risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet*
2470 2017; **390**(10100): 1345-422.
- 2471 124. WHO. Air Pollution and Child Health: Prescribing Clean Air. Geneva, Switzerland: World
2472 Health Organization, 2018.
- 2473 125. Landrigan PJ, Fuller R, Fisher S, et al. Pollution and children's health. *Science of The Total*
2474 *Environment* 2019; **650**: 2389-94.
- 2475 126. Lelieveld J, Evans JS, Fnais M, Giannadaki D, Pozzer A. The contribution of outdoor air
2476 pollution sources to premature mortality on a global scale. *Nature* 2015; **525**(7569): 367.
- 2477 127. Amann M, Bertok I, Borken-Kleefeld J, et al. Cost-effective control of air quality and
2478 greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling & Software*
2479 2011; **26**(12): 1489-501.
- 2480 128. IEA. World Energy Outlook 2017. Paris, France: International Energy Agency; 2017.
- 2481 129. United Nations DESA/Population Division. World Urbanization Prospects: 2018 Revision.
2482 2018.
- 2483 130. WHO. WHO Global Urban Ambient Air Pollution Database (Update 2018). Geneva,
2484 Switzerland: World Health Organization; 2018.
- 2485 131. IEA. World Energy Investment 2016. Paris, France: International Energy Agency, 2016.
- 2486 132. Chapman R, Keall M, Howden-Chapman P, et al. A Cost Benefit Analysis of an Active Travel
2487 Intervention with Health and Carbon Emission Reduction Benefits. *International Journal of*
2488 *Environmental Research and Public Health* 2018; **15**(5).
- 2489 133. Maizlish N, Linesch NJ, Woodcock J. Health and greenhouse gas mitigation benefits of
2490 ambitious expansion of cycling, walking, and transit in California. *Journal of Transport & Health* 2017;
2491 **6**: 490-500.
- 2492 134. Wolkinger B, Haas W, Bachner G, et al. Evaluating Health Co-Benefits of Climate Change
2493 Mitigation in Urban Mobility. *International Journal of Environmental Research and Public Health*
2494 2018; **15**(5).

- 2495 135. Buehler R, Dill J. Bikeway networks: A review of effects on cycling. *Transport Reviews* 2016;
2496 **36**(1): 9-27.
- 2497 136. Grigoratos T, Martini G. Non-exhaust traffic related emissions. Brake and tyre wear PM.
2498 Ispra, Italy: European Commission Joint Research Centre Institute of Energy and Transport, 2014.
- 2499 137. IEA. World Energy Investment 2017. Paris, France: International Energy Agency, 2017.
- 2500 138. Norsk elbilforening. Norwegian EV policy. 2019. [https://elbil.no/english/norwegian-ev-](https://elbil.no/english/norwegian-ev-policy/)
2501 [policy/](https://elbil.no/english/norwegian-ev-policy/) (accessed July 29 2019).
- 2502 139. Allen J. Volkswagen will launch its last petrol and diesel-powered cars in 2026. *The Sunday*
2503 *Times*. 2018.
- 2504 140. EPOMM. The EPOMM Modal Split (TEMS) tool. Leuven, Belgium: European Platform on
2505 Mobility Management; 2019.
- 2506 141. Barberan A, Monzon A. How did bicycle share increase in Vitoria-Gasteiz? *Transportation*
2507 *Research Procedia* 2016; **18**: 312-9.
- 2508 142. Swinburn BA, Kraak VI, Allender S, et al. The Global Syndemic of Obesity, Undernutrition,
2509 and Climate Change: The Lancet Commission report. *The Lancet* 2019; **393**(10173): 791-
2510 846.
- 2511 143. Friel S, Dangour AD, Garnett T, et al. Public health benefits of strategies to reduce
2512 greenhouse-gas emissions: food and agriculture. *The Lancet* 2009; **374**(9706): 2016-25.
- 2513 144. Eckelman MJ, Sherman J. Environmental Impacts of the US Health Care System and Effects
2514 on Public Health. *PLoS ONE* 2016; **11**(6): e0157014.
- 2515 145. Eckelman MJ, Sherman JD, MacNeill AJ. Life cycle environmental emissions and health
2516 damages from the Canadian healthcare system: An economic-environmental-epidemiological
2517 analysis. *PLoS Medicine* 2018; **15**(7): e1002623.
- 2518 146. Malik A, Lenzen M, McAlister S, McGain F. The carbon footprint of Australian health care.
2519 *The Lancet Planetary Health* 2018; **2**(1): e27-e35.
- 2520 147. Leontief W. Environmental repercussions and the economic structure: An inputoutput
2521 approach. *Review of Economics and Statistics* 1970; **52**(3): 262-71.
- 2522 148. Hertwich EG, Peters GP. Carbon footprint of nations: a global, trade-linked analysis.
2523 *Environmental Science & Technology* 2009; **43**(16): 6414-20.
- 2524 149. Pichler P-P, Jaccard I, Weisz U, Weisz H. International comparison of health care carbon
2525 footprints. *Environmental Research Letters* 2019.
- 2526 150. Kaiser Permanente. Climate Action. 2019. [https://about.kaiserpermanente.org/community-](https://about.kaiserpermanente.org/community-health/improving-community-conditions/environmental-stewardship/climate-action)
2527 [health/improving-community-conditions/environmental-stewardship/climate-action](https://about.kaiserpermanente.org/community-health/improving-community-conditions/environmental-stewardship/climate-action) (accessed 12
2528 June 2019).
- 2529 151. NHS England, Public Health England. Reducing the use of natural resources in health and
2530 social care. London: NHS England, 2018.
- 2531 152. Kompas T, Pham VH, Che TN. The Effects of Climate Change on GDP by Country and the
2532 Global Economic Gains From Complying With the Paris Climate Accord. *Earth's Future* 2018; **6**(8):
2533 1153-73.
- 2534 153. CCC. Net Zero: The UK's contribution to stopping global warming. London: Committee on
2535 Climate Change, 2019.
- 2536 154. Munich Re. NatCatSERVICE. 2019.
- 2537 155. WBG. World Development Indicators. Washington, DC, USA: World Bank Group, 2019.
- 2538 156. European Commission. Part III: Annexes to Impact Assessment Guidelines. Brussels, Belgium:
2539 European Commission, 2009.
- 2540 157. IEA. World Energy Investment 2019. Paris, France: International Energy Agency, 2019.
- 2541 158. EIU. The cost of inaction: Recognising the value at risk from climate change: The Economist
2542 Intelligence Unit, 2015.
- 2543 159. WHO, Commission on Social Determinants of Health. Closing the gap in a generation. Health
2544 equity through action on the social determinants of health, 2008.

- 2545 160. IBISWorld. IBISWorld Industry Report: Global Coal Mining. Los Angeles, CA: IBISWorld, 2018.
- 2546 161. IBISWorld. IBISWorld Industry Report: Global Oil & Gas Exploration & Production. Los
2547 Angeles, CA: IBISWorld, 2019.
- 2548 162. IRENA. Renewable Energy and Jobs: Annual Review 2019. Abu Dhabi, United Arab Emirates:
2549 International Renewable Energy Agency, 2019.
- 2550 163. Braungardt S, van den Bergh J, Dunlop T. Fossil fuel divestment and climate change:
2551 Reviewing contested arguments. *Energy Research & Social Science* 2019; **50**: 191-200.
- 2552 164. 350.org. Divestment Commitments. 2019.
2553 <https://gofossilfree.org/divestment/commitments/> (accessed 7 May 2019).
- 2554 165. Machol B, Rizk S. Economic value of US fossil fuel electricity health impacts. *Environment
2555 international* 2013; **52**: 75-80.
- 2556 166. Coady D, Parry I, Le N-P, Shang B. Global Fossil Fuel Subsidies Remain Large: An Update
2557 Based on Country-Level Estimates: International Monetary Fund, 2019.
- 2558 167. WBG. Carbon Pricing Dashboard. Washington, DC, USA: World Bank Group; 2019.
- 2559 168. International Bank for Reconstruction and Development, International Development
2560 Association, WBG. Report of the High-Level Commission on Carbon Prices. Washington, DC, 2017.
- 2561 169. WBG. State and Trends of Carbon Pricing. Washington, DC, USA: World Bank Group, 2019.
- 2562 170. WBG. States and Trends of Carbon Pricing. Washington, DC, USA: World Bank Group, 2019.
- 2563 171. Ryghaug M, Holtan Sørensen K, Næss R. Making sense of global warming: Norwegians
2564 appropriating knowledge of anthropogenic climate change. *Public Understanding of Science* 2011;
2565 **20**(6): 778-95.
- 2566 172. Boykoff MT, Roberts JT. Media coverage of climate change: current trends, strengths,
2567 weaknesses. *Human Development Report* 2007; **2008**(3).
- 2568 173. Happer C, Philo G. New approaches to understanding the role of the news media in the
2569 formation of public attitudes and behaviours on climate change. *European Journal of
2570 Communication* 2016; **31**(2): 136-51.
- 2571 174. Nisbet MC. Communicating climate change: Why frames matter for public engagement.
2572 *Environment: Science and Policy for Sustainable Development* 2009; **51**(2): 12-23.
- 2573 175. Wang H, Sparks C, Huang Y. Measuring differences in the Chinese press: A study of People's
2574 Daily and Southern Metropolitan Daily. *Global Media and China* 2018; **3**(3): 125-40.
- 2575 176. Chapman G, Fraser C, Gaber I, Kumar K. Environmentalism and the mass media: the
2576 North/South divide. 1st ed. New York: Routledge; 2003.
- 2577 177. Nagarathinam S, Bhatta A. Coverage of climate change issues in Indian newspapers and
2578 policy implications. *Current Science* 2015; **108**(11): 1972-3.
- 2579 178. Billett S. Dividing climate change: global warming in the Indian mass media. *Climatic change
2580* 2010; **99**(1-2): 1-16.
- 2581 179. Schäfer MS, Ivanova A, Schmidt A. What drives media attention for climate change?
2582 Explaining issue attention in Australian, German and Indian print media from 1996 to 2010.
2583 *International Communication Gazette* 2014; **76**(2): 152-76.
- 2584 180. Shehata A, Hopmann DN. Framing Climate Change. *Journalism Studies* 2012; **13**(2): 175-92.
- 2585 181. García-Gavilanes R, Tsvetkova M, Yasseri T. Dynamics and biases of online attention: the
2586 case of aircraft crashes. *Royal Society Open Science* 2016; **3**(10): 160460.
- 2587 182. Giles J. Internet encyclopaedias go head to head. Nature Publishing Group; 2005.
- 2588 183. Alexa. The top 500 sites on the Web. 2018. <https://www.alexa.com/topsites>.
- 2589 184. Wikimedia Statistics. 2019. <https://stats.wikimedia.org/>.
- 2590 185. Mesgari M, Okoli C, Mehdi M, Nielsen FÅ, Lanamäki A. "The sum of all human knowledge": A
2591 systematic review of scholarly research on the content of Wikipedia. *Journal of the Association for
2592 Information Science and Technology* 2015; **66**(2): 219-45.
- 2593 186. Schroeder R, Taylor L. Big data and Wikipedia research: social science knowledge across
2594 disciplinary divides. *Information, Communication & Society* 2015; **18**(9): 1039-56.

2595 187. World Bank. Public attitudes toward climate change: findings from a multi-country poll.
2596 Background note to the world development report 2010. 2009.
2597 <http://siteresources.worldbank.org/INTWDR2010/Resources/Background-report.pdf>.
2598 188. Pew Research Center. Global concern about Climate Change. 2015.
2599 189. Leiserowitz A, Maibech E, Rosenthal S, et al. Climate change in the American mind:
2600 December 2018. New Haven, CT: Yale University and George Mason University, 2018.
2601 190. General Assembly of the United Nations. General Debate of the 73rd session: 25 September
2602 - 1st October 2018. 2018.
2603 191. Smith CB. Politics and process at the United Nations: the global dance: Lynne Rienner
2604 Boulder, CO; 2006.
2605 192. World Economic Forum. Two Degrees of Transformation. Businesses are coming together to
2606 lead on climate change. Will you join them? 2019. [https://www.weforum.org/reports/two-degrees-](https://www.weforum.org/reports/two-degrees-of-transformation-businesses-are-coming-together-to-lead-on-climate-change-will-you-join-them)
2607 [of-transformation-businesses-are-coming-together-to-lead-on-climate-change-will-you-join-them](https://www.weforum.org/reports/two-degrees-of-transformation-businesses-are-coming-together-to-lead-on-climate-change-will-you-join-them).
2608 193. Wright C, Nyberg D. Climate change, capitalism, and corporations: Cambridge University
2609 Press; 2015.
2610 194. Jeswani HK, Wehrmeyer W, Mulugetta Y. How warm is the corporate response to climate
2611 change? Evidence from Pakistan and the UK. *Business Strategy and the Environment* 2008; **17**(1): 46-
2612 60.
2613 195. United Nations Global Compact. <https://www.unglobalcompact.org/> (accessed 13.04.19.
2614 196. Schmidt A, Ivanova A, Schäfer MS. Media attention for climate change around the world: A
2615 comparative analysis of newspaper coverage in 27 countries. *Global Environmental Change* 2013;
2616 **23**(5): 1233-48.
2617 197. Zhengrong Hu. The Post-WTO Restructuring of the Chinese Media Industries and the
2618 Consequences of Capitalisation. *Javnost - The Public* 2003; **10**(4): 19-36.
2619 198. Hassid J. Controlling the Chinese Media: An Uncertain Business. *Asian Survey* 2008; **48**(3):
2620 414-30.
2621 199. People's Daily (Renmin Ribao). <http://data.people.com.cn/rmrb/20190116/1?code=2>.
2622 200. Brooks J, McCluskey S, Turley E, King N. The Utility of Template Analysis in Qualitative
2623 Psychology Research. *Qualitative Research in Psychology* 2015; **12**(2): 202-22.
2624 201. Liaw S-S, Huang H-M. An investigation of user attitudes toward search engines as an
2625 information retrieval tool. *Computers in Human Behavior* 2003; **19**(6): 751-65.
2626 202. Casebourne I, Davies C, Fernandes M, Norman N. Assessing the accuracy and quality of
2627 Wikipedia entries compared to popular online encyclopaedias: A comparative preliminary study
2628 across disciplines in English, Spanish and Arabic. Brighton, UK: Epic, 2012.
2629 203. Yoshida M, Arase Y, Tsunoda T, Yamamoto M. Wikipedia page view reflects web search
2630 trend. Proceedings of the ACM Web Science Conference; 2015: ACM; 2015. p. 65.
2631 204. Göbel S, Munzert S. Political Advertising on the Wikipedia Marketplace of Information. *Social*
2632 *Science Computer Review* 2017; **36**(2): 157-75.
2633 205. Wikimedia. Research: Wikipedia clickstream.
2634 https://meta.wikimedia.org/wiki/Research:Wikipedia_clickstream.
2635 206. Baturo A, Dasandi N, Mikhaylov SJ. Understanding state preferences with text as data:
2636 Introducing the UN General Debate corpus. *Research & Politics* 2017; **4**(2): 2053168017712821.
2637 207. Jankin Mikhaylov S, Baturo A, Dasandi N. United Nations General Debate Corpus. In: Jankin
2638 Mikhaylov S, editor. V5 ed: Harvard Dataverse; 2017.
2639 208. United Nations Global Compact. Corporate sustainability in the world economy. New York:
2640 UN Global Compact, 2008.
2641 209. Nason RW. Structuring the Global Marketplace: The Impact of the United Nations Global
2642 Compact. *Journal of Macromarketing* 2008; **28**(4): 418-25.
2643 210. Rasche A, Waddock S, McIntosh M. The United Nations Global Compact: Retrospect and
2644 Prospect. *Business & Society* 2012; **52**(1): 6-30.

- 2645 211. Voegtlin C, Pless NM. Global Governance: CSR and the Role of the UN Global Compact.
2646 *Journal of Business Ethics* 2014; **122**(2): 179-91.
- 2647 212. Akenji L, Lettenmeier M, Koide R, Toiviq V, Amellina A. 1.5-Degree Lifestyles: Targets and
2648 options for reducing lifestyle carbon footprints. 2019. [https://pub.iges.or.jp/pub/15-degrees-](https://pub.iges.or.jp/pub/15-degrees-lifestyles-2019)
2649 [lifestyles-2019](https://pub.iges.or.jp/pub/15-degrees-lifestyles-2019).
- 2650 213. Newell P. Climate for change: Non-state actors and the global politics of the greenhouse:
2651 Cambridge University Press; 2006.

2652