#### This index should be cited as:

IPCC, 2018: Index. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 601-616.

Note: [\*] indicates the term also appears in the Glossary. Italicized page numbers denote tables, figures and boxed material. Bold page numbers indicate main discussion of topics. Supplementary Material is listed by section number, for example, 1.SM.3, 2.SM.1.3.4.

1.5°C pathways\*, 12-17, 51, 59-64, 93-174, 265-271, 278, 320, 1.SM.4, 1.SM.6 assumptions, 95, 98, 109-112 carbon dioxide removal (CDR)\* in, 17, 21, 95, 96, 118-125, 180, 277, 316 classification of, 99-100, 100, 113-114 CO<sub>2</sub> emissions, 1.SM.6 definition, 51, 53, 59-61 demand-side mitigation and, 97, 460-461 emissions and, 5, 6, 12, 13, 14-15, 18, 51, 95-96, 112, 1.SM.6 emissions, benchmark indicators for sectoral changes in, 4.SM.1 emissions evolution in, 115-118, 117, 119 feasibility\*, 18-19, 52, 56, 71-72, 380-386 four categories of, 59-61, 62, 63 future emissions in, 96, 104-107 impediments to, 93, 95, 110 implications of, 265-271 investments and economics, 16, 95-96, 150-151, 152-155, 264-265 key characteristics, 112-114, 129 knowledge gaps, 388-390 mitigation and adaptation options\*, 110-112, 316-317 mitigation measures, 14-15, 19-21, 51-52, 110-112 model pathways, 12, 14-15, 278 multiple strategies for, 157, 469 near-term action, implications of, 126-129, 128 one-in-two to two-in-three chance (of reaching limit) in, 60, 63, 113 overview of, 108-129, 129 pathway archetypes, 99-100, 100, 112-113, 113 pathways remaining below 1.5°C, 100, 113-114, 160 pathways temporarily exceeding 1.5°C, 100, 113-114, 160 policies, 112, 148-150 remaining carbon budget\*, 12, 96, 104–107, 108 scenarios, 98-100, 100 strengthening the global response, 18-23, 70-75, 313-443 sustainable development and, 19-23, 20-21, 98, 156-157, 156, 448-449, 463-472, 465 sustainable development pathways, 64, 448-449, 466-472, 469, 479-480 synergies and trade-offs, 18-21, 20-21, 316, 391 system/sector transitions, 14-15, 15-16, 323-349 time frame for mitigation, 95-96 transformations, 129-148, 322-323, 466 transitions, speed and scale of, 320, 322-323 See also Pathways

1.5°C warmer worlds\*, 4-6, 274-281 commonalities in, 277 definition, 53 energy supply and demand in (FAQ), 161, 162 equity and, 54-55, 451-453 impacts in, 7-10, 177-179, 319 importance of adaptation in (FAQ), 396-397, 397 key questions, 274-277 knowledge base for, 52, 53-56 poverty, equality, and equity implications, 451–453 projected climatic changes, 7-10, 186-188, 188, 189 projected risks and impacts, 7-10, 11, 51, 175-311 risks, vs. 2°C worlds, 5, 7-9, 11, 177-181, 277 storyline of this report, 77–78, 78 storylines of, 277 sustainable development and, 18-23, 55-56, 447 temperature in, 283 time frame for mitigation, 277, 278 variation in, 177, 277, 278 watershed management in, 356 See also Global warming of 1.5°C 2030 emissions gap, 358 emissions levels in, 18, 95, 114 2030 Agenda for Sustainable Development\*,

#### Α

56, 73, 469, 477

See also Sustainable Development Goals

Acceptability of policy or system change\*, 22, 368-369 Adaptability. See Adaptive capacity Adaptation\*, 5, 10 bottom-up approaches, 317, 368 community-based, 315, 330, 384, 458 definition, 51, 70, 396 ecosystem-based, 386, 457-458 FAQ on, 396-397, 397 feasibility, 380, 381, 385 finance, 21–22, 379, 456 implementing, 51, 315, 383-386 importance of, 396-397, 397 infrastructure investments, 21 integration with mitigation and sustainable development, 75-76, 448, 467 knowledge gaps, 388-391 levels of, 51 local participation, 456 maladaptation, 19, 386, 396 in Mekong River basin, 239-240 place-specific, 447, 458 potential for, 247-250 rate of temperature change and, 178 risk reduction and, 5, 10 sea level rise and, 10, 457 socio-economic challenges to, 110 specific sectors, 10 sustainable development and, 19, 447, 456-459 synergies, 18-19, 391, 447, 475 synergies with mitigation, 386-387, 475,

4.SM.4.5.1, 4.SM.5.2 transformational, 5, 315, 322-323, 384, 397, 456-457 Adaptation behaviour\*, See Human behaviour Adaptation limits\*, 10, 70, 454-456 examples of, 455 hard limits, 70, 455 residual risks and, 454-455 for Small Island Developing States, 235 soft limits, 70, 455 Adaptation options\*, 10, 19, 316-317, 319, 336-337 in agriculture, 70, 315, 457 cost-effectiveness, 316 education and learning, 337, 456 enabling conditions\*, 4.SM.2 energy system transitions, 4.SM.4.3.1 feasibility, 381, 384-386, 385, 4.SM.4.3.1-4.SM.4.3.5 industrial system transitions, 4.SM.4.3.4 land and ecosystem transitions, 4.SM.4.3.2 overarching, 336–337, 338, 385, 389, 4.SM.4.3.5 supporting transitions, 336-337, 338 sustainable development and, 457-458 synergies, 18, 19 urban, 10, 70, 263, 340-341, 384-386, 385 urban and infrastructure transitions, 4.SM.4.3.3 Adaptation pathways\*, 64, 70, 396, 458-459 place-specific, 458 Adaptive capacity\*, enhancing, 316, 319, 456-457 factors affecting, 69 limits to, 10 sustainable development and, 447 Adaptive governance. See Governance Aerosols\*, 12, 65, 118, 120, 267-268 aerosol cooling, 96, 267-268 knowledge gaps, 157 precursors, 98, 102-103, 118, 157 radiative forcing, 102-103 See also Black carbon Afforestation\*, 17, 21, 96, 121, 266, 270, 316, 343 co-benefits, 316 constraints, 316 FAQ, 394, 395 incentivization of, 147 land requirements, 125, 126, 265, 266, 269, 270, 316 trade-offs, 269 AFOLU. See Agriculture, forestry and other land-use Africa Fybnos and succulent Karoo biomes, 260, 261 Limpopo Watercourse Commission, 356 Sahel, 180, 236, 259, 261, 262-263 Southern Africa, 260, 261 tipping points\*, 262-263, 264 West Africa and the Sahel, 259, 261, 264 West African monsoon, 262-263, 264 Agreement\*. See Confidence; Evidence; Likelihood Agriculture adaptation options\*, 70, 315, 457 agroforestry, 328, 384

climate-smart agriculture\*, 457, 467 conservation agriculture\*, 267, 327, 384, 459 crop yields/productivity, 9, 11, 145, 145, 147, 179, 236-237, 252, 259, 263, 264, 267, 316, 327, 452, 3.SM.3.3.5 emissions, 12, 14, 95, 96, 116-118, 147, 147, 157, 265, 315-316 energy crops, 16, 97 intensification of, 266-267, 327 irrigation, 201, 215, 267, 267, 315, 328, 384, 466 land for, 16, 97, 112, 146, 327-329 livelihoods, 55, 315, 447 mitigation potential, 316 peri-urban, 316 risk reduction, 456 technological innovation and, 329, 370 tipping points\*, 263, 264 transformational adaptation in, 384 transitions, 315-316 water-energy-food (WEF) nexus, 386-387 Agriculture, forestry and other land-use (AFOLU), 144-148, 463 CDR and, 17, 121, 144-145 drivers of changes in, 145-146 emissions, 14-15, 114, 118, 268 mitigation options\*, 462-463 policy assumptions, 145-146 projections for, 17 Agroforestry, 328, 384 Air pollution/quality\*, 157, 241, 250, 267, 316, 464 Albedo\*, 70, 267 Algae, as bioenergy source, 111–112 Alpine regions, 259, 261 Amazon, 340 tropical forest, 221, 263, 340 Ammonia (NH<sub>3</sub>) emissions, 96 Anomalies\* global mean surface temperature, 183, 210 soil moisture\*, 198, 199, 200 Antarctic ice sheet, 7, 178, 208-209, 257, 258, 271, 282 Antarctic sea ice, 206, 225 Anthropocene\*, 52, 53, 54, 75 as boundary concept for 1.5°C warmer worlds, 54 geological dimension of, 54 Anthropogenic emissions\*, 5, 95 recent trends, 1.SM.7 Appliances, energy-efficient, 316, 331, 460, 461 Aquaculture, 8, 9, 237–238 hypoxia and, 224 production, 237-238 risks for, 228 AR5. See IPCC Fifth Assessment Report (AR5) Arctic region, 258–259, 338–339, 452, 3.SM.3.3.5 adaptation in, 339 economic effects of climate change, 339 ecosystems, 9, 11, 53, 220 as hotspot, 258, 261, 262, 270, 338 indigenous peoples, 9, 339 land regions, 259, 261 risks for, 9, 53, 251, 252, 253, 452 tipping points\*, 262, 264

warming in, 4 See also Arctic sea ice Arctic sea ice, 8, 205-206, 209, 254 beyond end of century, 270 fisheries and, 224-225 as hotspot and tipping point, 258, 261, 262, 270 projected changes, 205, 212, 254 sea-ice free summers, 8, 178, 205, 206, 254 temperature overshoot and, 8, 178, 206 Asian monsoon, 262, 264 Assessment frameworks, 75-76 climate models and simulations, 76 confidence, uncertainty, and risk, 77 cost-benefit analysis\*, 76 detection and attribution, 76 knowledge sources and evidence, 75–76 methodologies, 76 risk assessment\*, 183-186 **Atlantic Meridional Overturning Circulation** (AMOC), 205, 223, 257 Atlantic Multi-Decadal Oscillation (AMO), 201 Atmosphere-ocean general circulation model (AOGCM). See Climate models Attribution. See Detection and attribution Avoided impacts, 18, 68, 183, 253-265, 447 aggregated avoided impacts, 253-258 hotspots, 258-260, 261 poverty and inequality implications, 452-453, 453 Reasons for Concern, 253-259 reduced risks, 452-453, 453, 455 regional tipping points, 262-263, 264 sustainable development implications, 452-453, 453

# B

Baseline period. See Reference period Batteries, 325 Behavioural change. See Human behaviour Beijing, peak car use, 376 Bhutan, national goals, 387 Bio-based feedstocks, 315, 335-336, 335 Bio-technologies, 319 Biochar\*, 121, 268, 270, 345 Biodiversity\*, 8, 256-257 adaptation limits\*, 455 Aichi targets, 266 CDR and, 265, 266, 269 impacts and risks at 1.5°C vs. 2°C, 8, 179, 256-257 management, 10 Bioenergy\*, 12, 17, 97, 111-112, 124, 131, 324-325 carbon intensity of, 324-325 crops, 147 emissions increase with, 96 IAMs/modelling, 124, 2.SM.1.2.4 land use for, 19, 146, 147, 265, 269, 343 risks of implementing, 125 sugarcane for bioethanol in Brazil, 371 trade-offs, 97 water use and, 464-466 Bioenergy with carbon dioxide capture and storage (BECCS)\*, 17, 121, 268-270, 316,

342-343, 394, 395 in IAMs, 124 land requirements, 125, 126, 180, 265-266 net zero emissions and, 135 pathways with, 14-15, 17, 96, 180 risks, 125, 268-270 uncertainties, 158 Bioethanol, 371 Biofuel\*, 269, 324-325 Biomass\*, 131, 132-133, 138, 269, 324 Biome shifts, 216, 217, 247, 250, 256-257 Fybnos and succulent Karoo biomes, 260, 261 Bivalve molluscs, 180, 227, 228, 237, 238, 248, 3.SM.3.2.5, 3.SM.3.2.11 Black carbon (BC)\*, 12, 13, 96, 118, 120, 316, 341-342 main characteristics of, 342 reducing emissions of, 341-342 warming impact, 66 Blue carbon\*, 330, 462 Bolivian Altiplano, 458 Boreal forests, 8, 263, 264 Bottom-up approaches, 317, 368 Brazil bioethanol in, 371 National Adaptation Plan, 340 Buen Vivir, 480 Buildings, 15-16, 139, 140-142, 316 building codes, 332, 339, 377 decarbonization of energy supply, 316 decarbonization of investments, 378 electrification, 141 energy efficiency and, 332, 339, 377, 460 energy supply/use in, 139, 140-142, 141, 331 heating and cooling demand, 141-142, 331 long-lived infrastructure, 142 low-emission, 317, 460 technological innovations, 370 transitions, speed and scale of, 320 Burden sharing\*, 380, 470

# С

Cancun Agreement, 79, 353 Car use peak car use, 376 pricing policies and use reductions, 366 Carbon budget\*, 12, 96, 104-107 in 1.5°C pathways, 113-114 remaining carbon budget\*, 12, 24, 96, 104-107, 108 remaining carbon budget\*, assessment methods, 104-107, 2.SM.1.1.2 total, 24 uncertainties, 12, 96, 106, 108 Carbon cycle\*, 96, 103, 157 inertia, 107 oceans and, 257-258 terrestrial, 219, 220 uncertainties, 347 Carbon dioxide (CO<sub>2</sub>)\* cumulative emissions, 6, 12, 62, 67, 96, 105, 114, 123, 126-127, 127

emissions reductions, 18, 95, 96 net emissions, 12-17, 13, 14-15, 114, 116, 119 net zero emissions, 5, 12, 24, 95, 107, 116 permafrost release of, 104 sector-specific emissions, 119 time scales of warming due to, 64 Carbon dioxide capture and storage (CCS)\*, 14, 15, 97, 134-136, 136, 268, 277, 315 deployment in 1.5°C and 2°C pathways, 134-136, 136 direct air carbon dioxide capture and storage (DACCS)\*, 17, 125 fossil fuels with CCS, 97, 135 in industry sector, 335, 336 in power sector, 326-327 uncertainties, 136 See also Bioenergy with carbon dioxide capture and storage (BECCS) Carbon dioxide capture and utilisation (CCU)\*, 15, 335, 336 Carbon dioxide capture, utilisation and storage (CCUS). See Carbon dioxide capture and utilisation (CCU) Carbon dioxide removal (CDR)\*, 17, 70, 118-125, 268-270, 342-346, 4.SM.4.2.5 in 1.5°C pathways\*, 17, 21, 95, 96, 111, 114, 118-125, 122, 180, 265, 277, 316 AFOLU sector, 17, 121 co-benefits, 121, 266 comparison of removal options, 270 costs, 344, 4.SM.3 cross-cutting issues, 347 definition, 24, 70 deployment at scale, 17, 70, 96, 114, 121-124, 122, 180, 265-266, 269-270, 343, 4.SM.3 deployment potential, 344 design and implementation of, 21, 448 ethical aspects, 347 FAQ on, 394, 395 feasibility, 17, 121, 269, 316, 343, 383, 4.SM.4.2.5 governance and, 17, 347 key messages, 270 knowledge gaps, 158, 390 land-based, 268-270 land footprint of, 125, 126, 180, 265-266, 269, 270, 343 limitations of, 96 in model pathways, 12, 14–15 net negative emissions, 96, 114, 118 ramp-up rates for, 119, 123 reducing dependence on, 19, 149, 180, 277 risks of, 96, 114, 125, 265-266, 344 role of, 17, 21, 96, 111, 114, 122-123 side effects, 344, 4.SM.3 sustainability and, 21, 96, 114, 124-125 Sustainable Development Goals and, 448, 462 trade-offs, 21, 96, 462 types of measures employed, 17, 70, 96, 121, 125, 265, 268, 270, 316, 342-346, 394 uncertainties, 96, 158, 343, 347 Carbon intensity\*, 97 of bioenergy\*, 324-325

of electricity, 97, 130 of final energy sectors, 129-130, 130, 137-138, 139 of residual fuel mix, 130 Carbon leakage, 149, 375 Carbon neutrality\*, 14, 96 timing of, 12, 96 Carbon price\*, 95, 152-153, 153, 375-377 necessity and constraints, 375-377 policies on, 95, 317, 375-377, 460 uniform world carbon price, 375 Carbon sequestration\*, 67, 95, 112, 114, 121-124, 147, 266 marine, 17, 121, 125, 178, 227, 228, 229, 3.SM.3.2.8 in peatlands, 221 permanence of, 125 soil carbon sequestration (SCS)\*, 17, 121, 219, 268, 269, 270, 345 terrestrial, 112, 121, 125, 146-147, 219, 265, 316 tracking progress toward, 67 See also Blue carbon; Carbon dioxide capture and storage Carbon sink. See Carbon sequestration Carbonate chemistry, 178, 222, 223 Caribbean region, 260, 339-340 small island developing states and territories, 339–340 China peak car use in Beijing, 376 technology and renewables pathways, 471 Circular economy, 335-336 Cities, 330-334 impacts and risks, 180, 182 sea level rise, impacts, 231–232 transformation\* in, 472-474 See also Urban areas; and specific cities Civil society, 23, 317 Clean Development Mechanism (CDM)\*, 474 Climate change commitment\* constant composition commitment, 64 geophysical warming commitment, 64–66, 65 warming commitment from past emissions, 64-66, 65, 1.SM.5 zero emissions commitment, 64-65, 65 Climate education, 22, 317, 456 Climate extreme (extreme weather or climate event)\*, 4, 182 in 1.5°C warmer worlds\*, 7 human health and, 240-241 impacts, 7, 177-178, 182, 240 observed changes in, 4, 7, 177, 210, 223, 1.SM.1 precipitation extremes, 7, 178, 189, 190-192, 197 projected changes, 7, 177–178, 189, 190–191, 192 risks from, 11, 181 temperature extremes, 7, 177, 187, 189, 190-191, 192, 210, 255 Climate feedbacks\*, 5, 103 biophysical feedbacks, 266–267 Earth system feedbacks, 65, 103-104 land processes and, 268 Climate forcers. See Radiative forcing Climate models\*, 7, 76, 177, 183–184, 274, 3.SM.1.1

Coupled Model Intercomparison Project (CMIP)\*, 62,76 downscaling\*, 76, 186, 194 FAIR, 99, 101, 102, 103, 103, 158 HAPPI, 76 integrated multimodel studies, 99 knowledge gaps, 272 MAGICC, 99, 101, 102, 103, 103, 127, 127, 158 reduced-complexity, 2.SM.1.1.1 regional (RCM), 185 Climate monitoring, 317 Climate projections\* climate models and simulations, 76, 183-184 definition of, 184 Climate-resilient development pathways (CRDPs)\*, 22, 52, 73, 448-449, 450-451, 451, 468-472, 475-476 country and community strategies, 470-471 definition, 24, 64 development trajectories and equity, 469-470 FAQ on, 479-480, 480 low-carbon development pathways, 471-472 regional and national factors, 22 sustainable development and, 22, 448-449 trajectories and decision-making in, 451, 480 transformations, equity, and well-being in, 468-469, 472, 472-474 urban transformations\* in, 472-473 in Vanuatu, 471 Climate-resilient pathways\*, 64 Climate sensitivity\* equilibrium climate sensitivity\*, 103, 104 transient climate response\*, 96, 184-185 uncertainties, 12 See also Transient climate response to cumulative CO<sub>2</sub> emissions Climate services\*, 337, 338, 385 Climate system\*, 5, 208 as a global commons, 353 assessment of changes in, 183, 186 observed changes in, 177 tipping points in, 262-263, 270 Climate target\*, 98-99, 151 policy assumptions and, 149 stringent, 112, 126 Climate variability\*, 279-281 Coal, 96-97, 132, 132-133, 138, 461 Coastal communities, 9, 181, 182, 222, 453, Table 3.SM.4 adaptation, 226, 233, 457 adaptation limits\*, 455 coastal protection, 225, 226, 227-228, 3.SM.3.2.9 flooding, 11, 181, 231, 235, 249, 252, 252, 3.SM.3.3.3 groundwater, 181 infrastructure risks, 181, 226, 231, 235, 249 livelihoods, 9, 222, 226, 249, 447, 452 relocation of, 457 sea level rise and, 207, 225, 231-234, 243, 249, 252, 457 tourism, 229, 253

Coastal ecosystems, 8, 181, 182, 226, 249, 330, Table 3.SM.4 blue carbon\*, 330, 462 framework organisms in, 225-226, 248 integrated coastal zone management, 226 protection services, 227-228, 228, 248 restoration of, 330 saltwater intrusion, 8 sea level rise and, 207, 225, 249 storms/storm surge, 223, 249 stress management in, 330 Co-benefits\*, 2, 67, 157, 268, 316, 319, 323 of sustainable development\*, 447 **Common but Differentiated Responsibilities** and Respective Capabilities (CBDR-RC)\*, 318 Community-based adaptation, 315, 330, 360, 384, 458 Conference of the Parties (COP)\* COP 15, 378 COP 16 (Cancun), 353 COP 21, 66, 79, 372 Confidence\*, 77, 182 See also Evidence; Likelihood; Uncertainty Conflict, 245 Conservation agriculture\*, 267, 327, 384, 459 Consumption, 53, 56 resource-intensive, 95 responsible, 460 Cook stoves, 460 Cooperation, 23, 461 international, 22, 23, 95, 240 regional, 353-354 Copenhagen Accord, 353 Coral reefs, 8, 11, 179, 229-230, 3.SM.3.2.3, 3.SM.3.2.10, 3.SM.3.3.9 adaptation limits\*, 455 bleaching and mortality, 70, 228, 229, 254 Great Barrier Reef (Australia), 228, 251 heat stress, 226, 229 impacts, 221 observed loss of, 8, 228-229 projected losses, 8, 179 projected risks, 53, 225-226, 228, 228-229, 248, 251, 252, 254 protection for coastal areas, 228 storm damage, 222 Cost-benefit analysis\*, 76, 150-151 Cost-effectiveness\*, 150-151, 152-153, 316 **Costs**, 76 adaptation, 21-22, 316 economic damages from climate change, 243, 264–265 energy sector transition, 374-375 marginal abatement costs, 16, 95, 150 mitigation, 16, 22, 258, 264, 316 regional economic benefits, 258 social cost of carbon (SCC)\*, 150-151, 265, 375 See also Carbon price Coupled Model Intercomparison Project (CMIP)\*, 62,76 Covenant of Mayors initiative, 354, 355 Crop yields, 9, 11, 145, 145, 147, 179, 236-237, 252,

259, 263, 267, 327, 452, 3.SM.3.3.5 Cuba, risk management in, *339* Cultural practices and resilience, *360* 

#### D

**Danube River Protection Convention**, 356 Decarbonization\* of electricity, 95 of energy sector, 95, 148, 277, 316, 461 of industry sector, 140 of investments, 378 macro-level indicators, 129-130 rate of, 12, 468 transport sector, 333, 461 Decision-making, 321, 360, 365, 456, 462, 469 adaptation, 459 information provision and, 367 participatory, 386, 459 problem-solving, 448-449 sustainable development goals and, 451, 480 Decoupling\*, 56, 372, 376, 461 Definitions, 24 See also Glossary Deforestation\*, 263, 264 emissions from, 146 of mangroves, 226, 251 rates of, 146 reducing emissions from (REDD+), 329-330 tipping points\*, 263 Deltas and estuaries, 232-233 Demand and supply-side measures\*, 97, 111, 161, 317 demand-side measures\*, 97, 460-461 investments, 153-154 mitigation and, 97 supply-side measures\*, 111 See also Energy supply and demand Dengue fever, 9, 180, 241 Detection and attribution\*, 76, 183, 210-212 attribution methods, 3.SM.1.2 human influences on climate, 4, 51, 59, 81,82, 186-187, 210-212, 282, 1.SM.2, 1.SM.6, 3.SM.2.1 of impacts, 69, 213 regional precipitation on land, 3.SM.2.2.1 regional temperature on land, 3.SM.2.2.1 sea level rise, 252 **Developing countries** adaptation finance, 21 development trajectories, 469-470 international cooperation and, 23 Development pathways. See Climate-resilient development pathways; Pathways Diet, human, 19, 180, 316, 462, Table 3.SM.12 Direct air carbon dioxide capture and storage (DACCS)\*, 17, 125, 316, 346, 394 Disaster risk management (DRM)\*, 10, 316, 336, 338, 385 in Jamaica, 339-340 Disaster\* early warning systems\*, 338, 339, 370 preparedness, 339-340

reduction, technological innovations and, 370 Sendai Framework for Disaster Risk Reduction\*, 70 See also Hazard Discounting\*, 152 Disease, 9, 452 dengue fever, 9, 180, 241 diarrhoea, 452 geographic range shifts of vectors, 9, 180, 241 malaria, 9, 180, 241 vector-borne, 9, 180 See also Human health Displacement\*. See Migration Disruptive innovation\*, 22, 111, 319, 323 Double dividend\*, 376 Downscaling\*, 76, 186, 194, 204 Droughts\*, 182, 196-201, 211, 215, 247, 250, 255, 3.SM.3.1.1.2 hotspots, 199, 200, 260 management responses/examples, 356 in Mediterranean Basin and the Middle East, 200-201 observed changes, 196, 211 Palmer Drought Severity Index, 199, 215 precipitation minus evapotranspiration, 198-199, 198,255 projected, for 1.5°C warming, compared with 2°C, 7, 178, 196-201, 199, 211, 215, 247, 250, 255, 3.SM.3.1.1.2 regional changes, 198-200, 198, 199, 200-201 Drylands, 459

# Ε

Early warning systems (EWS)\*, 338, 339, 370 Earth system feedbacks, 65, 96, 103-104 inertia of, 64 Economic factors, 9, 150-151, 152-155, 264-265 access to finance, 21, 23, 155 circular economy, 335-336, 335 co-benefits ('double dividend'), 376 depreciation of assets, 375 'depression economics', 319 economic damages from climate change, 243, 264–265 green economy, 470-471 incentives, 317, 366, 377 marginal abatement costs, 16, 95, 150, 375 pricing instruments, 317 redistributive policies, 21 regional economic benefits, 258 See also Finance; Investments Economic growth, 53, 180-181, 182, 319 decoupling from emissions, 56, 372, 376, 461 impacts on, 180-181, 182 mitigation costs and, 258 regional economic benefits, 258 risks at 1.5°C, vs. 2°C, 9, 180–181, 182 in SSPs, 110, 149 Economic indicators/variables discounting\*, 152

economic diversification, 21, 71, 448 gross domestic product (GDP)\*, 158, 243, 256, 258, 265, 373 gross fixed capital formation (GFCF)\*, 317, 373 Economic sectors, 242-244, 256, 3.SM.3.5 energy systems, 243-244 global economic impacts, 256 impacts and risks, 180-181, 242-244, 250, 256 tourism, 242-243 transportation, 244 Ecosystem(s)\*, 179, 182, 216-230, 250 adaptation options\*, 384, 385, 4.SM.4.3.2 Arctic, 9, 11, 53, 220 coastal, 8, 181, 182, 226, 249, 330 drylands, 459 feasibility of mitigation options, 382 freshwater, 213-216, 221, 247 impacts and risks at 1.5°C, vs. 2°C, 5, 8–9, 11, 179, 182, 250, 453 impacts of temperature overshoot, 277 knowledge gaps, 388 large-scale shifts in, 69 mitigation and, 315, 4.SM.4.2.2 observed impacts, 253 ocean, 8–9, 179, 221–230, 248 resilience, 70 restoration of, 329-330, 459 risks of severe impacts, 53 risks, regional and ecosystem-specific, 219-221 succession in, 69 terrestrial, 8, 11, 179, 216-221, 247, 251, 3.SM.3.3.7 trade-offs, 19 transformations, 8 transitions, 315, 4.SM.4.2.2, 4.SM.4.3.2 Ecosystem-based adaptation, 386, 457–458 Ecosystem restoration, 16, 70, 329-330, 384 Ecosystem services\*, 17, 19, 179, 247 carbon sinks, 69, 220, 221 impacts and risks at 1.5°C, vs. 2°C, 8, 9, 179, 247, 256-257 irreversible impacts, 8 marine, 179, 221-230, 248 mitigation and, 315 observed changes, 5 terrestrial, 221 Education (climate education), 22, 317, 385, 456 Effective climate sensitivity. See Climate sensitivity Effective radiative forcing. See Radiative forcing El Niño-Southern Oscillation (ENSO)\*, 58, 201, 257 deforestation and, 263 La Niña events, 235 response in Guatemala, 356 Electric vehicle (EV)\*, 316, 332–333, 333 costs of, 325 Electricity generation/use, 15, 97, 133-134, 135, 138, 243-244, 326 carbon intensity\* of, 97 decarbonization, 95 disruptions of, 326 enabling conditions, 387 energy storage, 325-326

evolution of supply over time, 134, 135 investments, 154 from renewables, 15, 96, 134, 324 technological innovations, 370 Electrification, 15, 95, 97, 111, 134, 315, 316, 326 in industry sector, 335, 336 in transport sector, 332-333, 333, 460 Emission pathways\*, 12-17, 13, 14-15, 137, 184, 274–276 in a prospective scenario, 276 definition and categories, 24, 59-61, 62 See also Pathways Emissions 1.5°C pathways\*, 6, 12-17, 13, 14-15, 95, 112, 113-118, 113, 117, 463 aggregate, 67–68, 115 anthropogenic, recent trends, 1.SM.7 in archetype pathways, 112-113, 113 benchmark values, 115, 4.SM.1 calculating, 66-68 carbon budget\* and, 96 CO2 equivalent emission\*, 67, 127 cumulative CO<sub>2</sub>, 6, 12, 62, 67, 96, 113, 123, 1.SM.6 cumulative CO2 and temperature, 96, 104, 105, 126–127, 127 cumulative emissions\*, 6, 12, 62, 67, 123 at current rate, consequences of, 5 decoupling economic growth from, 56, 372, 376, 461 emissions gap, 126, 358 future emissions, commitment to, 66 global, in 2030, 6, 12, 13, 95 long-lived climate forcers, 66-68, 116-118, 117 measuring progress to net-zero emissions, 66-68 Nationally Determined Contributions (NDCs)\*, 56, 95, 126-129, 127, 128, 149 negative emissions\*, 17, 51, 70, 96, 114, 118 net-zero emissions, 12, 51, 95, 107, 116 net-zero, timing of, 95, 119 non-CO<sub>2</sub>, 12, 13, 96, 105–107, 115–116, 147, 1.SM.6 past emissions, global warming and, 51, 64-65, 65 peak, 95, 115, 129 peak, timing of, 115, 126-127, 129 reductions, 13, 15, 18, 95, 463 reductions, behaviour change and, 317, 363 reductions, near-term, 17, 96, 124, 126-129, 128 reductions, rate of, 51 reductions, remaining carbon budget and, 96 reductions, technologies and, 369–370 reductions, timing of, 5, 6, 18, 61, 95, 96, 107, 114, 116-118 sectoral pathways, 137 short-lived climate forcers, 64, 66-68, 118, 120, 316 timescales and, 5, 61, 64–66 timing of, 95, 117, 119 warming commitment from past emissions, 64-66, 65, 1.SM.5 zero emissions commitment, 64-65, 65 Enabling conditions\*, 18-19, 52, 148-150, 317-318, 338, 352, 386, 474-475, 4.SM.2 adaptation options\*, 4.SM.2 enabling behavioural and lifestyle changes, 362-369

enabling technological innovations, 369-372, 370 FAQ, 392-393 international cooperation, 22, 23 knowledge gaps, 390-391 Manizales, Colombia: enabling environment in, 361 for mitigation implementation, 381-383 Energy efficiency\*, 15, 96, 137, 140, 315, 316, 460-461 appliances, 316, 331, 460, 461 behavioural responses and, 460-461 building codes, 332, 339, 377 efficiency standards, 377, 378 food production systems, 315-316 improving, 377-378 in industry sector, 315, 335, 335 mitigation options, 460-461 policies, 149, 153, 377-378 sustainable development goals (SDGs) and, 448 Energy sector, 15, 129-144, 243-244, 315, 324-327 adaptation options\*, 384, 385 carbon dioxide capture and storage in, 326-327 carbon intensity, 129-130, 130, 137-138, 138, 139 decarbonization, 95, 148, 277, 316, 461 decarbonization, macro-level indicators, 129-130 diversification of, 21, 448 electrification, 15, 95, 97, 111, 134, 315, 316, 326 emissions, 96, 137, 138 end-use sectors, 136-144 energy security, 387 feasibility of mitigation options, 382 final energy, 137, 138 fuel switch, 460-461 hybrid systems, 326 infrastructure, 326, 384, 385 investments, 16, 22, 95-96, 153, 155, 372, 373-374 knowledge gaps, 388 low-carbon pathways, 462, 464-466 low-carbon technologies, 15, 16, 96 mitigation options, 12, 14, 460-461, 4.SM.4.2.1 renewable energy, 14, 15, 96, 111, 131, 132-133, 316, 324 solar energy, 96 synergies with Sustainable Development Goals, 19 transformation, 129-144, 316, 463 transitions in 1.5°C pathways\*, 15, 96-97, 130, 315, 316, 324-327, 374-375, 4.SM.4.2.1, 4.SM.4.3.1 transitions, speed and scale of, 320, 320 water and, 326, 384, 464-466 water-energy-food (WEF) nexus, 386-387 Energy supply and demand, 15, 17, 96-97, 129-136, 316, 460-461, 466 in 1.5°C warmer worlds, 161, 162, 316 access to energy, 464 air conditioning, 243 batteries, 325 bioenergy\*, 12, 17, 96, 111–112, 124, 324–325 carbon intensity of, 129-130, 130, 461 demand reductions, 95, 137 disruptions and vulnerabilities, 326 emissions pathways, 12, 14, 15, 95 energy storage, 316, 325-326

evolution of primary energy contributions, 130-132, 131, 132-134 final energy demand, 137, 138 fossil fuels, 96-97 grid flexibility resources (GFR), 325 low-demand scenarios, 110, 111, 448 mitigation options, 460-461 primary energy supply, 96-97, 130-132, 131, 132-133 smart grids, 316 in SSPs, 109-110, 110 sustainable development goals (SDGs) and, 447-448 synergies and trade-offs, 19, 20-21, 448 transformations in, 129-136, 130-135 urban, 331 See also Electricity generation/use Enhanced weathering\*, 17, 112, 268, 269, 270, 345-346, 462-463 costs, 316, 345 side effects, 345-346 Equality\*, 448-449, 451-453 in 1.5°C warmer worlds\*, 451–453 inequality, 456 inequality, reducing, 18-23, 445-538 Equilibrium climate sensitivity. See Climate sensitivity Equity\*, 18, 23, 51, 54-55, 448-449, 456, 469-470, 479 in 1.5°C warmer worlds\*, 451-453 burden sharing\*, 380, 470 climate-resilient development pathways\*, 22, 448-449, 469-470 conditions for achieving, 474-475 disproportionate impacts and, 51 fairness\* and, 449, 469, 479 gender equity\*, 23 intergenerational equity\*, 55 international equity, 55 justice and, 22, 55, 456, 470 mitigation efforts and, 18, 55 national equity, 55, 470 policies and, 22, 456 procedural equity\*, 55, 73 research gaps, 475-476 responsibility-capacity-need assessment, 470 in social-ecological systems\*, 338-341 trade-offs, 19 Ethics\*, 51, 52 European Union, Covenant of Mayors, 354, 355 Evidence\*, 451 Exposure\* factors influencing, 53 numbers of people exposed, 178, 246, 453 See also Hazard; Risk; Vulnerability Extinction, 8, 179, 218, 256-257 commitment to, 218 Extratropical cyclone\*, 203–204, 211 See also Tropical cyclone Extreme weather events\*, 182, 255 floods and droughts, 214-215, 255 frequency of, 223

heavy precipitation, 255 See also Climate extreme Extremes. See Climate extreme; and specific topics, e.g., precipitation

## F

Fairness\*, 449, 469, 479 nation-level fair shares, 470 FAQs. See Frequently Asked Questions Farmer managed natural regeneration (FMNR), 459 Feasibility\*, 18-19, 52, 56, 71-72, 380-386, 381, 392-393, 393 adaptation options\*, 381, 384-386, 385, 4.SM.4.3.1-4.SM.4.3.5 assessment of, 71-72, 380, 381, 382-383, 4.SM.4.1 definition, 52 dimensions of, 71-72, 380, 381, 392 enabling conditions\*, 18-19, 52, 56 mitigation options\*, 381, 381, 382-383, 4.SM.4.2.1-4.SM.4.2.5 Feedback. See Climate feedbacks Fiji, freshwater resources, 368 Finance, 21-22, 23, 148-149, 317, 361-362, 372-380, 474 access to, 21, 23, 155, 317, 456 adaptation financing, 21-22, 379, 456 challenges of, 372-375, 373-374, 379 climate-friendly products, 378 de-risking, 317, 378-379 global and national systems for, 317-318, 380 Green Climate Fund, 74, 379 green instruments, 378, 474 innovative, 315, 380 knowledge gaps, 391 low-emission assets, 317 mobilization of, 19, 456 multilateral and national development banks, 317 new forms of, 374, 380, 474 policy instruments and, 317, 372-380 private sector, 21, 22 public-private partnerships, 317, 474 public sector, 21, 317 redirection of, 317, 374, 378 See also Investments Financial institutions\*, 361–362 Fires, 244, 259 forest fires, 8, 247 tundra, 262 Fisheries, 8, 9, 11, 237-238, 248, 452 adaptation measures, 238 fin fish, 180, 226-227, 237-238, 3.SM.3.2.7, 3.SM.3.3.10, 3.SM.3.2.12, 3.SM.3.2.13 foodwebs and, 226-227, 248 hypoxia and, 224 livelihoods, 452 management, 227 productivity change, 225, 249, 258 projected impacts, 8, 9, 11, 178, 222, 228, 248, 257 range shifts, 222, 248 restoration of, 330 risks, 180, 228, 237-238, 251, 252, 257

Floods\*, 11, 182, 201-203, 211, 214-215, 3.SM.3.1.1.2 coastal, 181, 231, 235, 249, 252, 252, 3.SM.3.3.3 damage from, 214, 215 Danube River Protection Convention, 356 fluvial, 201-203, 214, 247, 251-252, 252, 3.SM.3.3.4 management in Rotterdam, The Netherlands, 342 numbers of people at risk, 452 observed changes, 201, 211 Philippines, flood measures, 368 projected changes, 179, 201–203, 202, 211, 214, 3.SM.3.1.1.2 risks, with 1.5°C warming, compared with 2°C, 7, 178, 179, 181, 201-203, 202, 214-215, 247, 251-252, 252 sea level rise and, 8 Fluorinated gases, 118, 120 Food, Table 3.SM.12 GHG-intensive foods, 97, 147 healthy diets and choices, 19, 97, 147, 180, 462 land use for, 97, 145 plant-based proteins, 112 prices, 447, 462, 464 quality/nutrition, 327, Table 3.SM.12 water-energy-food (WEF) nexus, 386-387 Food demand reducing, 464, 466 in SSPs, 110, 110, 111 Food production systems, 178, 236-240, 250, 252, 327-329, 453, 464, Table 3.SM.5 climate-smart food production, 239 efficiency of, 315-316, 464 genome modification, 329 land use and, 327-329 mixed crop-livestock production, 315, 328 projected impacts, 179-180, 236-240, 250 technological innovations, 316, 329 tipping points\*, 263, 264 See also Agriculture; Crop yields Food security\*, 180, 182, 237, 238-240, 250 decline in, 53 enhancing, 315-316 food insecurity, 447 mitigation pathways and, 464 projected impacts, 179-180, 239, 250, Table 3.SM.5 risks to, 238-239 strategies for improving, 239-240 Food shortages, 9 Food wastage\*, 316, 328-329, 462 Forcing. See Radiative forcing Forest fires, 8, 247 Forests\*, 220, 316, 329-330 agroforestry, 328, 384 Amazon tropical forest, 221, 263, 340 Australian rainforest, 254 boreal, 8, 263, 264 as carbon sinks, 340 CDR options and, 316 ecosystem restoration, 329-330 emissions, 14 impacts, 220

land area for, 16, 97 land-use change, 146 rainforests, 254, 263, 264 REDD+, 329-330 responsible sourcing of products, 462 risks, 8, 220-221 tipping points\*, 263, 264 See also Afforestation; Deforestation; Reforestation Fossil fuels\* in 1.5°C pathways\*, 14-15, 15, 96-97 combined with CCS, 97, 135 countries/economies dependent on, 448, 461, 462 energy sector use, 15, 96-97, 131, 131, 132-133, 138 greenhouse gas emissions, 53, 114 market preference, shifting, 317 reducing investments in, 378 Framing and context, 49–92 assessment and methodologies, 75-76 confidence, uncertainty and risk, 77 feasibility, 71-72 framing asymmetries, 55 global response, 70-75 impacts, 69–70 knowledge base, 53-56, 75-76 sustainable development, 73-75 transformation and transitions, 73 understanding 1.5°C, 56-64 Frequently Asked Questions (FAQs) How Close are we to 1.5°C?, 81, 82 What are Carbon Dioxide Removal and Negative Emissions?, 394, 395 What are the Connections between Sustainable Development and Limiting Global Warming to 1.5°C above Pre-Industrial Levels?, 477-478, 478 What are the Impacts of 1.5°C and 2°C of Warming?, 282-283, 283 What are the Pathways to Achieving Poverty Reduction and Reducing Inequalities while Reaching a 1.5°C World?, 479-480, 480 What do Energy Supply and Demand have to do with Limiting Warming to 1.5°C?, 161, 162 What Kind of Pathways Limit Warming to 1.5°C and are we on Track?, 159, 160 What Transitions Could Enable Limiting Global Warming to 1.5°C?, 392-393, 393 Why are we Talking about 1.5°C?, 78, 80 Why is Adaptation Important in a 1.5°C-Warmer World?, 396-397, 397 Freshwater systems, 182, 213-216, 221, 247 adaptation initiatives, 368 extreme events, 214-215 freshwater stress, 181 knowledge gaps, 272 water temperature, 214 See also Water resources Fuel switch, 460-461, 481-506 Fybnos and succulent Karoo biomes, 260, 261

# G

Gender equity\*, 23, 452 General circulation model (GCM). See Climate models Genome modification techniques, 329 Geophysical relationships, 101–107 climate and Earth-system feedbacks, 103-104 geophysical uncertainties, 96, 101–104 knowledge gaps, 157–158 non-CO<sub>2</sub> climate forcers, 101–103, 103 Geophysical warming commitment, 64-66, 65 Glaciers\*, 206 Global climate model (GCM). See Climate models Global financial systems, 317–318 Globalisation, 319 Global mean surface temperature (GMST)\*, 56-57, 57, 177, 186, 274 1.5°C rise, factors in, 4, 274 anomalies\*, 183, 210 definition, 24 measurement of, 12 observed, 4, 6, 186 past emissions and, 51 Global mean surface air temperature (GSAT)\*, 12,56 Global response, strengthening, 18-23, 70-75, 313-443 1.5°C-consistent pathways, implications of, 320-321, 320, 448 accelerating the response, 319-320 adaptation options, 321, 336-337, 338 change, far-reaching and rapid, 352–380, 392 change, historical rates of, 322 cooperation, 22, 23 enabling change, 21-22, 315-318 feasibility assessments, 380-386, 381, 382-383, 385 finance and investments, 317, 321, 361-362, 372-380 governance and policies, 23, 71, 315, 316, 317, 321, 352-355 implementation, 23, 70, 71, 315, 317, 319, 320-323, 352-380 implementing adaptation, 383-386, 385 implementing mitigation, 381-383 integration and enabling transformation, 380-387 knowledge gaps, 318, 387, 388-391 levels of ambition, raising, 315 monitoring and evaluation (M&E)\*, 386 policy instruments and finance, 372-380 response options, 19-21, 70-71, 316-317 sustainable development and, 18, 22, 316, 321 synergies and trade-offs, 316, 386–387 system transitions, and rates of change, 322-323 systemic changes, 323–349 transformation and transitions, 70, 73, 315, 380-387 transitions, speed and scale of, 317, 320, 320 Global Temperature-change Potential (GTP), 66-68 Global warming\*, 4–6 commitment to continued warming, 64-66, 65,

#### 1.SM.5

current level of, 4, 51, 53, 76, 106, 177, 1.SM.1 definition, 24, 51, 56 with emissions continuing at present rate, 4 geophysical warming commitment, 64-66, 65 human experience of present-day, 53, 1.SM.1 human-induced, 4-5, 51, 53, 53, 54, 59, 81, 82, 186-187, 282, 1.SM.2, 1.SM.6 level in 2017, 51, 59, 81 maximum temperature reached, 5 observed, 4, 51, 53, 53, 58-59, 189-190, 1.SM.1, 1.SM.2, 1.SM.3, 1.SM.6 past emissions and, 51, 64-65, 65, 72 peak in, 5, 65, 96, 101, 177, 277, 278 pre-industrial\* reference period, 51, 56, 57-59, 184 projections, 4, 81, 82, 95, 187-188, 188 reference periods, 56-59, 184 regional/seasonal variations in, 4, 59, 60, 81 temperatures used for definition, 51, 106 timescales and persistence, 5 total warming, 59, 61 See also Global mean surface temperature; Temperature Global warming of 1.5°C, 4-6, 56-64, 187, 274 1.5°C pathways\*, 12-17, 51, 93-174 already experienced in some regions and seasons, 4, 51, 59, 68, 81, 452 closeness to (FAQ), 81, 82 context of sustainable development and poverty eradication, 18-23 framing and context, 4-6, 49-92 future emissions and, 6, 13 impacts and risks, compared with 2°C, 5, 7-10, 11, 51, 175-311, 261 not considered 'safe', 447, 455 projected climatic changes, 7-10, 186-188 projected timeline for reaching, 4, 95-96, Table 3.SM.7 Reasons for concern (RFCs)\*, 10, 11, 181 reference period, 56-59, 184 returning to, after overshoot, 5, 17, 61, 96 stabilization responses/scenarios, 147, 158, 182, 184-185 strengthening the global response, 18-23, 70-75, 313-443 synergies and trade-offs, 19 temperature range for, 51, 187, 188, 275 See also 1.5°C warmer worlds\* Global warming of 2°C, 100 emissions and, 116 impacts and risks, compared with 1.5°C, 5, 7–10, 11, 175-311, 261 OECD scenario for, 373 Reasons for concern (RFCs)\*, 10, 11 regions with high risks, 247-250 runoff and floods, 178, 211 Global warming of 3°C, 18, 261 rainforests and, 263 Global Warming Potentials (GWPs), 66-68 Governance\*, 19, 71, 316, 317, 352-355 adaptive governance\*, 315

challenges in 1.5°C pathways, 95 Covenant of Mayors initiative, 354, 355 governance capacity\*, 71 governance framework, 317, 359 inclusive, 475 international, 352-354, 474 knowledge gaps, 390 linkages across sectors, 71 local and regional, 316, 354, 355 multilevel governance\*, 19, 23, 317, 352-355, 355, 356, 384, 386, 474-475 national, 316, 353, 361 partnerships among actors, 23 sub-national, 354 water-energy-food (WEF) nexus, 386-387 See also Policies Green bonds, 378 Green Climate Fund, 74, 379 Green economy, 470-471 Green infrastructure\*, 10, 316, 334, 334, 384, 385 investment in, 316 Greenhouse gas(es) (GHGs)\*, long-lived, 64-66, 66-68, 116-118 short-lived, 64, 66-68, 316 See also Carbon dioxide; Methane; Nitrous oxide; Ozone Greenhouse gas emissions, 14-15, 18 aggregate, 115 benchmark values, 115 cumulative emissions\*, 6, 12, 62 drivers of, 53 global, in 2030, 12, 13 reductions in, 6, 12, 13, 14-15, 95 reporting of, 66 timing of reductions, 6, 13, 95 See also Emissions Greenhouse gas removal\*. See Carbon dioxide removal (CDR) Greenland ice sheet, 7, 178, 206, 208-209, 257, 271, 282 Gross domestic product (GDP)\*, 158, 243, 256, 258.265.373 Gross fixed capital formation (GFCF)\*, 317, 373 Gross world product (GWP), 256 Groundwater, 15, 3.SM.3.1.1.3 coastal, 181 Guatemala Indigenous Table for Climate Change, 360 Maya watershed meteorological forecasts, 360 response to drought and El-Niño, 356 Gulf Cooperative Council (GCC) countries, 462

#### Η

Happiness index (Bhutan), 387 Hazard\*, 68, 186–212, 210–212 collocated and/or concomitant, 188 *See also* Disaster; Risk; Vulnerability Health. See Human health Heat-related morbidity and mortality, 9, 11, 180, 240–241, 250, 252, 252, 263, 264, 3.5M.3.3.1 Heat stress, 452

coral reefs, 226, 229 Heatwaves\*, 9, 263, 264 in cities, 242 deadly, 263, 264 extreme, 177 marine, 177 numbers of people exposed, 178 observed changes, 177 projected changes, 177-178 tipping points\*, 263, 264 Holocene\*, 53 Holocene Thermal Maximum (HTM), 208 Hotspots, 182, 258-260, 261 drought\*, 199, 200 precipitation, 193, 194 temperature, 190-191, 193 Human behaviour\*, 362-369 adaptation behaviour\*, 363 adaptation options\*, 457 behavioural change\*, 19, 21, 22, 97, 315, 317, 461 behavioural change, enabling, 362-369 behavioural change, knowledge gaps, 390-391 dietary choices, 19, 97, 147, 180, 316, 462 energy efficiency\* and, 460-461 factors affecting, 364-365 habits, heuristics, and biases, 365, 461 knowledge and, 364 mitigation behaviour\*, 362, 363 motivation and, 364-365 rebound effect, 460 See also Values Human health, 9, 178, 182, 240-241, 250, 385 adaptation limits\*, 455 air quality and, 241, 250, 464, Table 3.SM.9 benefits of emissions reductions, 12 co-benefits, 157 cold-related mortality, 241 heat-related morbidity and mortality, 9, 11, 180, 240-241, 250, 252, 252, 263, 264, 3.SM.3.3.1 impacts and risks at 1.5°C, vs. 2°C, 9, 180, 182, 240-241, 250, 252, 453 occupational health, 241, 250 population health, 337, 338, 385, 457 risks, 180, 240-241, 252 temperature-related risks, Table 3.SM.8 tipping points\*, 263, 264 trade-offs, 19 urban areas, 180 vector-borne diseases, 9, 180, 241, Table 3.SM.10 Human-induced warming, 4, 51, 59, 81, 82, 186-187, 188, 282, 1.SM.2, 1.SM.6 equal to observed warming, 51, 59 rate of, 66 Human population, 51, 319 current, 319 displacement/migrations of, 180, 181, 244-245, 337, 338, 385 growth of, 95, 319 in regions where 1.5°C already exceeded, 51 in SSPs, 109, 110 Human rights\*, 55, 450, 460, 469-470, 475 Human security\*, 9

Hydrofluorocarbons (HFCs), 12, 96, 118, 341–342, *342* radiative forcing from, 342 Hydrogen, 15, 315, 335, 336 Hydrological cycle\*, 191–196 Hydropower, 201, 214, 243, 466

#### I

Ice sheets\* albedo and, 257 Antarctic ice sheet, 7, 178, 208-209, 257, 258, 271, 282 Greenland ice sheet, 7, 178, 206, 208-209, 257, 271, 282 marine ice sheet instability (MISI), 257, 258 sea level rise and, 7, 178, 206, 208, 257, 271 thresholds, 257 time frame for loss of, 257 tipping points, 282 (Climate change) Impact assessment\*, 76, 185-186 Impacts\*, 7-10, 68-70, 175-311 in 1.5°C and 2°C warmer worlds\*, 7-10, 177-179, 182, 319 in 1.5°C pathways, vs. overshoot pathways, 51, 61, 62 attribution for, 69, 213 avoided, 18, 68, 183, 253-265, 447, 452-453, 453, 475 climate extremes and, 7, 177-178, 182 coastal and low-lying areas, 231-234, Table 3.SM.4 definitions, 24, 68 direct vs. indirect, 69 disproportionate, 11, 51, 447, 452 distribution of, 10, 11, 18, 181, 255-256 drivers of, 69 economic sectors and services, 180-181, 182, 242-244, 250, 256 ecosystems, 178, 179, 182 emission pathways\* and, 51, 282 FAQ on, 282-283, 283 food systems, 179-180, 182, 236-240, 250, Table 3.SM.5 global aggregate, 10, 11, 181, 182, 256-257 global and regional climate changes, 186-212, 210-212 human health, 9, 180, 182, 240-241, 250, 252, 453 impact assessment\*, 76, 185-186 impact cascades, 69, 245, 452 irreversible, 5, 61, 177, 251, 252, 254 knowledge gaps, 272-273 land use, 179-180 livelihoods, poverty, and migration, 244-245, 447 marine ecosystems, 8-9, 179, 221-230 non-linearity, 69-70 observed, 5, 53, 212-253 ocean, 5, 8-9, 178, 179, 180, 182, 221-230, 228, 248-249, 3.SM.3.2.1-3.SM.3.2.13 projected risks, 7-10, 212-253 regional, 9, 68, 180-181, 182, 189-196 sea level rise, 7-8, 181, 182, 206-207, 212

small islands and coastal areas, 181, 182 summary of, 182-183, 182, 247-250, 251-253 terrestrial ecosystems, 8, 11, 179, 216-221, 252, Table 3.SM.2 time-integrated, 61, 62 timescales of, 61, 62 uncertainties\*, 69 uncertainty propagation, 3.SM.1.3 urban areas, 241-242 water resources, 179, 3.SM.3.1.1.2-3.SM.3.1.1.4 Implementation. See Global response, strengthening Inclusion/inclusive processes, 331, 333, 353, 381, 449, 475 cultural considerations, 384 decision-making, 456 Incremental adaptation. See Adaptation India, technology and renewables pathways, 471 Indigenous knowledge\*, 22, 315, 337, 338, 339, 385, 456, 480 community adaptation and, 360 in Guatemala, 360 Indigenous Table for Climate Change (Guatemala), 360 in Pacific Islands and small island developing states, 360 in Tanzania, 360 Indigenous peoples, 23, 447 in Arctic, 9, 339 cultural beliefs, 364 land tenure, 462 Maya (in Guatemala), 360 risks and impacts, 9 Industry sector, 334–336, 4.SM.4.3.4 adaptation options\*, 385, 386 bio-based feedstocks, 335-336, 335 carbon capture and storage (CCS), 335, 336 changes in structure of, 375 decarbonization, 140 electrification and hydrogen, 335, 336, 460 emissions, 15, 114, 140, 334 energy efficiency, 315, 335, 335, 460 energy-intensive industry, 334 feasibility of mitigation options, 383 final energy demand and use, 138-140, 139 knowledge gaps, 389 mitigation options\*, 335, 4.SM.4.2.4 substitution and circularity, 335, 335, 460 technological innovations, 370, 460 transitions in, 15, 334-336, 460, 4.SM.4.3.4 transitions, speed and scale of, 320, 320 Inequality in 1.5°C warmer world\*, 447 adaptation pathways\* and, 458-459 increased, 53, 319 persistent, 471 reducing, 18-23, 72, 445-538, 456, 475 research gaps, 475-476 See also Equality Information and communication technology (ICT)\*, 316, 319 Information flow and sharing, 377-378, 456, 457

Infrastructure adaptation options\*, 384-386, 385, 4.SM.4.3.3 climate-resilient, 386 coastal, 181, 226, 231, 235, 249 decommissioning of existing, 374 feasibility of mitigation options, 382 floods and, 181 green infrastructure\*, 10, 316, 334, 334, 384, 385 investments in, 21, 333, 373-374, 374 knowledge gaps, 388–389 lock-in of carbon-emitting, 18, 126 low-emission, 317, 374 mitigation options\*, 4.SM.4.2.3 sea level rise and, 8, 231, 249 transitions in, 15-16, 4.SM.4.3.3 urban, 331, 333 Insects, 254-255 phenology, 216, 218 pollination by, 216, 218, 255 range loss, 254–255, 256–257 species loss, 179, 218 Institutional capacity\*, 19, 71, 359-362 cooperative institutions and social safety nets, 362 enhancing, 359–362, 384 monitoring, reporting, and review, 361 policy design and implementation, 359-360 Institutions\*, 359-362, 474-475 financial, 361-362 institutional capacities, 359-362 knowledge gaps, 390 monitoring, reporting, and review, 361 reform: Manizales, Colombia, 361 Integrated assessment\*, 95 Integrated assessment models (IAMs)\*, 99, 100-101, 108-109, 136-137 assumptions, 2.SM.1.2.2, 2.SM.1.2.3 bioenergy and BECCS deployment in, 124, 268 CDR and, 268-269 global economic impacts, 256 knowledge gaps, 158 land use and bioenergy modelling, 2.SM.1.2.4 multiple IAMs, 463–464 scope, use and limitations, 2.SM.1.2.1 Integrated assessment model (IAM) scenario database configuration, 2.SM.1.3.1 data collected, 2.SM.1.3.4 modelling Framework Reference Cards, 2.SM.2 Part 2 overview of mitigation measures, 2.SM.1.2.6 overview of scenarios, 2.SM.1.3.2 overview of studies, 2.SM.1.3.3 scenario classification, 2.SM.1.4 summary of models, Table 2.SM.7 Interconnectivity, 52, 54, 319 International agreements, 70, 317 International cooperation, 22, 23, 95 Mekong River Commission, 240 International governance, 352-354, 474 Internet of Things (IoT)\*, 331 Invasive species, 8, 9, 223

Investments, 21, 95-96, 149, 153-155, 316, 372-380 decarbonization\*, 378 energy-related, 16, 95-96, 153, 155 green investment, 474 incentives, 317 investment needs, 373-374 knowledge gaps, 158 low-emission, 154, 317, 378 mitigation, 21, 95-96, 466 policy instruments and, 317 speed and scale of change, 321 upscaling of, 15, 317 world investment, 317, 373 See also Finance IPCC Fifth Assessment Report (AR5), 51, 81 IPCC Special Report on 1.5°C (SR1.5), 4, 74, 79 storyline, 77-78, 78 timeline of, 80 Iron fertilization. See Ocean fertilization Irreversibility\*, 5, 61, 177, 251, 252, 254, 262, 277 temperature overshoot and, 8, 61, 179 See also Tipping points Italy, Province of Foggia, multilevel governance in, 355

# J

Jamaica, 339–340 Justice\*, 448–449, 456, 469 distributive justice\*, 55 justice-centered pathways, 470 procedural justice\*, 55 social justice\*, 22, 448–449 See also Equity; Ethics; Fairness; Human rights

# Κ

Kampala, Uganda, Climate Change Action Strategy, 340 Kigali Amendment, 118 Kiribati, adaptation in, 368, 471 Knowledge gaps, 157–158, 388–391 impacts and risks, 272-273 See also specific topics Knowledge sources, 52, 53–56, 75–76 grey literature, 76, 451 indigenous knowledge\*, 22, 315, 337, 338, 339, 385, 456, 480 local knowledge\*, 22, 339, 457 scientific literature, 75, 451 Krill, 227, 228, 3.SM.3.2.6 Kyoto Protocol\*, 80, 353 Kyoto GHG-emissions, 14, 115-116, 117, 119, 126

# L

Land management, 17, 19, 180 carbon dioxide removal and, 121, 180 Land surface air temperature\*, 56 Land use\*, 144–148, 180, 327–329 adaptation options\*, 384, *385*, 4.SM.4.3.2

for agriculture and food, 16, 97, 112, 146, 327-329 carbon dioxide removal (CDR)\* and, 125, 126, 265-266, 268-270, 343 climate-resilient, 333 feasibility of mitigation options, 382 governance and, 17 intensification of, 16 knowledge gaps, 388 mitigation options, 148, 265-266, 382, 462-463, 4.SM.4.2.2 mitigation potential, 315 modelling, 2.SM.1.2.4 planning: Manizales, Columbia example, 361 risks of carbon release, 221 sustainability of, 16, 97 synergies and trade-offs, 19, 20-21 transitions in, 16, 17, 96, 97, 144-148, 315, 327-329, 4.SM.4.3.2 urban, 316, 333 Land-use change (LUC)\*, 112, 126, 144-148, 179, 180 in agricultural sector, 98, 144-148 bioenergy production and, 69 biophysical feedbacks, 266-267 CDR and, 268-269 overview of, 145 pace of, 145, 146 risks in mitigation pathways, 69, 97, 265-266 in SSPs, 145 Large scale singular events, 10, 11, 181, 254, 257-258 Last Glacial Maximum (LGM), 208 Lifestyles, 315 choices, 97, 180 consumption and, 53, 56, 95, 97 emissions reduction through, 317 lifestyle change, enabling, 362-369 lifestyle change, knowledge gaps, 390-391 low energy demand, 97 low resource use, 97 mitigation and adaptation behaviour, 362-363 in SSPs, 110 sustainable, 276 See also Food; Human behaviour Likelihood\*, 77, 182 Limpopo Watercourse Commission, 356 Livelihoods\*, 73, 182, 244 agricultural, 55, 315, 447 coastal, 9, 222, 226, 249, 447, 452, 455 impacts and risks of 1.5°C warmer worlds\*, 452 poverty and, 244 security, promoting, 456-457 Livestock, 9, 180, 264, 327-328 animal feed, 112 emissions, 147, 327 land use, 97 mixed crop-livestock production, 315, 328 production, 237 in the tropics and subtropics, 263, 264 Local communities, 23 Local knowledge\*, 22, 339, 457 Local participation, 456

Lock-in\*, 18, 126, 129 London, U.K. adaptation and disaster risk management, 458 car use/policies, *366* Long-lived climate forcers (LLCF)\*, *66–68*, 116–118, *117* time scales, 64–66 Loss and Damage\*, *454–456* Low-carbon pathways, 471–472

# Μ

Maharashtra, India, water resources, 368 Maladaptive actions (Maladaptation)\*, 19, 386, 396 Malaria, 9, 180, 241, 452 Mangroves, 225, 226, 228, 228, 248, 252, 462, 3.SM.3.2.1, 3.SM.3.3.8 replanting, 330, 457 Manizales, Colombia, 361 Marginal abatement costs, 16, 95, 150, 375 Marine ecosystems. See Ocean ecosystems Mayan K'iché population in Guatemala, 360 Mediterranean region, 259, 261 droughts, 200-201 threatened systems, 254 Mekong River basin, 239-240 Methane (CH<sub>4</sub>)\*, 268, 316, 341, 342 AFOLU sector, 118, 147, 147 agricultural, 96 emissions, 13, 118, 120 emissions, evolution of, 96 emissions reduction, 12, 95, 102, 157, 268, 316 mitigation potential, 118 release from permafrost\*, 12, 104 release from wetlands, 12 zero emissions commitment (ZEC), 65 Migration\*, 180, 181, 232, 244-245, 337, 338, 385 as adaptation, 457 (internal) displacement\*, 245 sea level change\* and, 232 Millennium Development Goals (MDGs)\*, 74, 450, 477 Mitigation\*, 19-21, 70, 93-174 in 1.5°C pathways\*, 12-17, 51-52, 93-174, 465 adaptation and, 19, 386-387, 4.SM.4.5.1 classification of, 99-100, 100 costs, 16, 22, 258, 264, 316 decisions after 2030, 56 definition, 70 demand-side measures\*, 97 equity considerations, 55 feasibility, 15, 380, 381 global response, strengthening, 19-21, 70-75, 313-443 implementing, 381-383 integrated mitigation studies, 95 investments, 21, 95-96, 466 knowledge gaps, 388-391 non-CO<sub>2</sub> mitigation, 95, 96, 105-106, 108, 115-116, 120, 265, 268 risks and risk reduction, 5, 179, 448

socio-economic challenges to, 110 sustainable development and, 12, 19-21, 97, 156-157, 447-448, 459-466, 465, 481-509 synergies and trade-offs, 18-21, 20-21, 72, 97, 157, 316, 386-387, 391, 459-463, 465, 4.SM.4.5.1 synergies with adaptation, 386-387, 475, 4.SM.4.5.1, 4.SM.5.2 time frames for, 277, 278, 279-281 See also 1.5°C pathways; Pathways Mitigation behaviour. See Human behaviour Mitigation options\*, 19-21, 316-317, 319, 323, 324-347, 463, 481-509 1.5°C pathways\*, 100, 110-112, 316-317, 465 CDR, 4.SM.4.2.5 emissions reduction with, 12, 13, 14-15 enabling conditions, 381-383 energy supply and demand, 460-462, 4.SM.4.2.1 feasibility assessment, 381, 381, 382-383, 4.SM.4.2.1-4.SM.4.2.5 industrial system, 4.SM.4.2.4 land-based, 16, 462-463, 4.SM.4.2.2 mitigation-SDG table, 481-509 overview, 2.SM.1.2.6 SDGs and, 19-21, 20-21, 448 synergies and trade-offs, 459-463, 463, 465, 4.SM.4.5.1 urban and infrastructure, 4.SM.4.2.3 Mitigation pathways\*, 93-174, 265-271 1.5°C pathways\*, 12-17, 13, 14-15, 60-61, 98, 101, 102, 108-129, 110, 2.SM.1.5 2°C pathways, 96, 100, 101, 102 adaptive mitigation pathway, 60-61 carbon dioxide removal (CDR) in, 118-125, 180 challenges, opportunities, and co-impacts, 147-157 emissions and, 12, 14-15 four model pathways, 12, 14-15, 61, 62 geophysical characteristics, 101-104 groups/classification, 61, 62, 113-114, 113 land-use change, 265-266 overview, 108-129, 129 prospective, 60, 63 scenarios in, 98-100, 100, 277, 279-281 sustainable development and, 463-472, 465, 2.SM.1.5 synergies and trade-offs, 465 transformations, 129-157, 466 See also 1.5°C pathways; Pathways Mitigation potential, 118, 315, 363 Mitigation scenarios\*. See Mitigation pathways Models. See Climate models; Integrated assessment models (IAMs) Monitoring and evaluation (M&E)\*, 386 Monitoring, reporting, and review institutions, 361 Monsoon, 194, 262-263, 264 Montreal Protocol, 118, 353 Mosquitoes, 241 Motivation\*, 364-365 Mountain ecosystems, 254

#### Ν

Narratives\*, 52, 109 Nationally Determined Contributions (NDCs)\*, 56, 95, 126-129, 127, 128, 149, 159, 357-359 adaptation and, 359 consistency of, 357-359 remaining carbon budget and, 113-114 uncertainties and, 358 Natural gas, 97 NDCs. See Nationally Determined Contributions (NDCs) Negative emissions\*, 17, 51, 70, 118-121, 394, 395 474 CDR, role in, 70, 114, 118 FAO on, 394, 395 See also Net-zero emissions; Net-zero CO<sub>2</sub> emissions Net negative emissions\*, 51, 96, 114, 116, 474 Net-zero emissions\*, 5, 24 Net-zero CO2 emissions\*, 12, 51, 95, 116 definition, 24 measuring progress to, 66-68 necessary to stabilize GMST, 116, 161 timing of, 5, 12, 13, 61, 95, 107, 116, 119 New York, United States, adaptation initiatives, 340 Nitrogen fertilizer, 116 Nitrous oxide (N2O)\*, 13, 66 agricultural, 96, 116-118, 147 bioenergy and, 12 emission increases, 96 emission reductions, 116-1118 Non-CO<sub>2</sub> climate forcers, 96, 120, 341–342 geographical variation in, 103 reductions in, 95 uncertainties, 101-103, 103, 106, 108 Non-CO2 emissions\*, 12, 13, 96, 106, 115-116, 265, 1.SM.6 agricultural, 147, 147 reducina, 341 remaining carbon budget\* and, 105-107, 108 Non-governmental organizations, 22 Non-overshoot pathways. See Overshoot; Pathways Nuclear energy, 14, 15, 325, 461 costs of, 325 role in primary energy supply, 130–131, 132, 132-133 safety of, 325 water use and, 466

#### 0

Ocean(s), 8–9, 178, 182, 221–230, 248–249, 3.5M.3.2, Table 3.5M.3 adaptation options, 225 biodiversity, 8 carbon sequestration, 17, 121, 178, 222, 227, 228, 248, 257–258 carbon uptake, 17, 121, 178, 227, 228, 229, 3.5M.3.2.8 circulation, 204–205, 212, 223, 248 foodwebs, 226–227, 228, 248

heatwaves\*, 177 hypoxia and dead zones, 179, 210, 224, 248 impacts and risks at 1.5°C, vs. 2°C, 5, 8-9, 178, 179, 180, 182, 221-230, 228, 248-249, 3.SM.3.2.1-3.SM.3.2.13 irreversible impacts, 8 knowledge gaps, 272-273 productivity/fisheries, 8, 179, 249 projected changes, 8-9 pteropods, 224, 226–227, 3.SM.3.2.4 Reasons for Concern, 3.SM.3., Table 3.SM.6 salinity, 209 Southern Ocean, 257–258 storms, 222-223, 249 stratification, 222, 224, 248 temperature, 8, 177, 204–205, 212, 222, 223–224, 248 thermal inertia/expansion of, 64-65, 107, 282 warming over, 4, 51 See also Coastal communities; Coral reefs; Fisheries; Sea level change Ocean acidification (OA)\*, 8, 209-210, 212, 223-224, 248, 282 pH\*, 212, 222, 223 reversal of, 5, 67 risks from, 180, 223-224, 227 Ocean alkalinization, 17, 121, 345-346 Ocean chemistry, 209-210, 223-224 carbonate chemistry, 178, 222, 223 Ocean ecosystems, 8-9, 179, 221-230, 248 blue carbon\*, 330, 462 critical thresholds, 179 ecosystem services, 227-229, 228 foodwebs, 226-227, 228, 248 framework organisms, 225–226, 248 impacts, 8, 9, 178, 179, 221-230, 228, 248 ocean circulation and, 223, 248 species range shifts, 222, 248 Ocean fertilization\*, 346, 462-463 Organization for Economic Co-operation and Development (OECD), 373 Overshoot\*, 12, 14-15, 18, 51, 100, 179, 265 CDR and, 17, 95 definition, 24 emission reductions and, 13, 14–15, 18, 95, 116 impacts of, 60 irreversible impacts, 61, 179 low-OS vs. high-OS, 100 magnitude and duration of, 179, 265 no or limited overshoot, 12-17, 13, 14-15, 60-61,62 returning to 1.5°C after overshoot, 5, 17, 61, 96 risks of, 5, 177, 179, 277 Ozone (O3)\*, 268 ozone-related mortality, 9, 180, 250 precursors, 98, 118, 241 tropospheric, 236

# Ρ

Pacific decadal variability (PDV), 201 Paris Agreement\*, 4, 18, 77, 79, 353

aim and context, 54-55, 66, 74, 77, 79, 359 equity principle, 51, 54, 479 goal of adaptation, 359 goal of limiting warming, 51 time horizon for, 74 transparency framework, 361 Pathway archetypes, 99-100, 100, 112-113, 113, 147 cumulative CO<sub>2</sub> emissions, 123 electricity generation, 135 land-use change (LUC)\*, 126, 145 land use/footprint, 147 primary energy contributions, 130–131, 131 Pathways, 12-17, 49-64, 62-64, 93-174 1.5°C pathways\*, 12-17, 14-15, 52, 59-64, 93-174, 100, 160, 265-271, 274-276, 320, 1.SM.4, 1.SM.6 2°C pathways, 96, 100, 101, 102 adaptation pathways\*, 64, 70, 396, 458-459 assumptions, 95, 109-112 bioenergy with carbon dioxide capture and storage (BECCS)\*, 17, 96 carbon dioxide removal (CDR)\* in, 17, 21, 95, 96, 111, 118-125, 180, 265-266 classification of, 61, 62, 99-100, 100, 113-114, 113 climate-resilient development pathways, 22, 52, 64, 73, 448-449, 450-451, 451, 468-472, 475-476, 479-480, 480 definitions of, 59-61, 63-64 emissions in, 12-17, 13, 14-15, 24, 95, 96 four categories/model pathways, 12, 14-15, 59-61, 62, 63, 265-271 geophysical characteristics, 101-104 implications beyond end of century, 270-271, 278 net-zero CO<sub>2</sub> emissions\*, 12, 61, 66-68, 116 nexus approaches, 467 no or limited overshoot, 12-17, 13, 14-15, 60-61, 62, 100 non-CO2 mitigation, 265, 268 overshoot pathways, 12, 14-15, 18, 24, 51, 60-61, 62, 100, 277 overview, 108-129 portfolio of measures, 12, 15 prospective mitigation pathways, 60, 63 Representative Concentration Pathways (RCPs)\*, 62 scenarios used, 98-100, 100 sector and system transitions, 14-15, 15-16 Shared Socio-economic Pathways (SSPs)\*, 62-63, 109–110, 110, 111, 448, 467–468 sustainable development and, 18-23, 98-101 156-157, 156, 463-466, 465 Sustainable Development Pathways, 64, 448-449, 466-472, 469, 479-480 temperature pathways, 59-61, 62, 63 time frame for, 95-96 transformation pathways\*, 70, 148-157 transformations, whole-system, 129-148 transitions, speed and scale of, 15, 320, 320, 392 uncertainty, 60, 98 used in this report, 59-61, 62, 63 See also 1.5°C pathways; Climate-resilient development pathways; Pathway archetypes; Scenarios

Peatlands, 221 Permafrost\*, 182, 262, 271 beyond end of century, 271 feedbacks, 103-104, 262 irreversible loss of carbon from, 262, 264 remaining carbon budget and, 12 thawing, 8, 12, 104, 220, 259, 262 tipping points\*, 262, 264 pH\*. See Ocean acidification Phenology, 216-218 Philippines, flood measures, 368 Phytoplankton, 224, 226 Policies\*, 19, 21-22, 71, 148-150, 317, 372-380 acceptability\* of, 22, 368-369 assumptions in 1.5° pathways, 112, 149 car/transport pricing policies, 366 carbon pricing, 95, 317, 375-377, 460 coordination and monitoring of, 449 design and implementation, 71, 321, 359-360, 460 enabling climate finance, 372-380 equity in, 22 innovation, 22 integrated policy packages, 379-380, 383 international agreements, 70, 317 internationally cooperative, 22, 23, 95 investment, 22 knowledge gaps, 391 for low-emission transition, 372-375 mobilization and integration of, 150, 317 national, 316 promoting climate action, 366-368 redistributive, 21, 448 regulatory measures, 377-378 for residual risk and loss and damage, 456 Sustainable Development Goals and, 448 technology, 95, 148, 370-371 See also Governance Population. See Human population Poverty\*, 9, 53, 180, 182, 244 in 1.5°C warmer worlds\*, 447, 451-453 adaptation limits\*, 455 avoided impacts of 1.5°C vs. 2°C, 452-453 climate change influence on, 55, 282, 447, 450, 452 disproportionate impacts, 9, 51 energy poverty, 464 increase in, 180 livelihoods\* and, 244 multidimensional, 55, 450, 457 Multidimensional Poverty Index, 55 numbers of people at risk, 447, 452 'poverty scenario' (SSP4), 452 projections for, 9, 10, 180 Poverty eradication\*, 18-23, 55, 72, 445-538 conditions for achieving, 474-475 mitigation pathways and, 22 research gaps, 475-476 sustainable development and, 450 Power asymmetries, 449, 459, 462, 471, 475 Prairie pothole ecosystems, 221, 254 Precipitation, 182, 191-196 extremes, observed, 191-192, 197

extremes, projected, 189, 197, 214-215 extremes, Sub-Saharan Africa, 197 heavy precipitation, 7, 177, 178, 194-196, 195, 211, 255 hotspots, 193, 194 monsoon, 194, 262-263, 264 observed changes, 177, 191-194, 211 projected changes, 7, 178, 187-188, 188, 211 regional, 191-196, 196, 3.SM.2.3.1, 3.SM.2.3.2 runoff\*, 201-203, 211 See also Droughts; Floods Precursors\*, 64, 65, 98, 102-103, 118 Pre-industrial\*, 24 reference period, 51, 56, 57-59, 81, 184 Procedural equity. See Equity Pteropods, 224, 226-227, 3.SM.3.2.4 Public acceptability, 22, 317, 368-369

## R

Radiative forcing\*, 59, 66-67, 188 aerosols\*, 102-103 long-lived climate forcers (LLCF)\*, 64-66, 66-68, 116-118 natural forcings, 59, 66-67 non-CO<sub>2</sub> forcers, 5, 6, 95, 96, 101–103, 103 recent trends, 1.SM.7 short-lived climate forcers (SLCF)\*, 64, 66-68, 118, 120, 316 uncertainties in, 96, 101-104, 103 Rainfall. See Precipitation Reasons for concern (RFCs)\*, 10, 11, 181, 182, 251-258, 3.SM.3.3.1-3.SM.3.3.7 RFC1 (Unique and threatened systems), 10, 11, 181, 251, 253-255, 254 RFC2 (Extreme weather events), 10, 11, 181, 251–252, 254, 255 RFC3 (Distribution of impacts), 10, 11, 181, 251-253, 254, 255-256 RFC4 (Global aggregate impacts), 10, 11, 181, 251-254, 254, 256-257 RFC5 (Large scale singular events), 10, 11, 181, 254, 257-258 Recycling, 335, 335, 460 **Reducing Emissions from Deforestation and** Forest Degradation (REDD+)\*, 329-330 Reference period\*, 56-59, 81, 184 periods shorter than 30 years, 51 pre-industrial\* temperatures, 51, 56, 57-59 30-year period used, 51, 56 Reforestation\*, 17, 70, 121, 265, 266, 270, 316, 343, 394, 395 constraints, 316 incentivization of, 147 trade-offs, 269 Region(s)\*, 187 climate differences in, 177-178 cooperation and governance, 353-354 with high risks at 2°C, 247-250 hotspots, 258-260, 261 regions used in this report, 187 tipping points, 262-263, 264

68, 81, 452 See also specific regions and countries Regional climate change, 68, 177, 188–191 drought\*, 198-200, 198, 199, 200-201, 260 runoff\*, 201-202, 202, 211 temperatures on land, 188-191, 189, 192, 193, 196, 197 See also Regional impacts; Regional precipitation; **Regional temperatures** Regional impacts, 9, 68, 177-178, 182 crop production, 9, 259, 263 economic growth, 9, 180-181 variation in, 450 Regional precipitation, 191–196, 196 observed changes, 191-194, 3.SM.2.3.1 projected changes, 193, 194–196, 195, 196 3.SM.2.3.2 Sub-Saharan Africa, 197 Regional temperatures, 59, 60, 189-191, 196, 283 observed changes, 189-190, 197, 1.SM.1, 1.SM.3, 3.SM 2.2.1 projected changes, 189, 190-191, 192, 193, 196, 197, 283, 3.SM.2.2 Regulatory measures, 377–378 Remaining carbon budget\*, 12, 96, 104-107, 2.SM.1.1.2 1.5°C pathways\*, 113-114 agricultural emissions and, 147 assessment of, 104-107, 108 CO2 and non-CO2 contributions, 105-107, 108 definition, 24, 96 overshoot minimization and, 177 permafrost thawing and, 105, 107 uncertainties, 12, 96, 108 Remedial measures, 70-71 Renewable energy, 14, 15, 96, 111, 131, 132-133, 316, 324 acceptability of, 368-369 deployment and scaling up, 461, 464-466 feasibility of, 324 hybrid systems, 326 water demands for, 464 Representative Concentration Pathways (RCPs)\*, 62 Resilience\*, 316, 456 climate-resilient land use, 333 cultural practices and, 360 See also Climate-resilient development pathways (CRDPs); Vulnerability Risk(s)\*, 5, 7-10, 177-181, 186-253, 210-212, 247-250 confidence and likelihood qualifiers, 77, 182 de-risking policies and investments, 317, 378-379 definition, 24, 68 ecosystems\*, 8-9, 11 factors influencing, 5, 277 with global warming of 1.5°C, compared with 2°C, 5, 7–10, 11, 177–181, 186–253, 210–212, 247–250, 453 human health, 180, 182, 250 interacting and cascading, 245, 452

warming of >1.5°C already experienced, 4, 51,

key elements of, 251-253, 252 multi-sector, 246 multiple and compound, 10, 178, 181 to natural and human systems, 178, 179–181, 212-253, 247-250 Reasons for concern (RFCs)\*, 10, 11, 181 residual, 454-456 social-ecological systems, 338-341 summary of, 247-250, 251-253 of temperature overshoot, 5, 177, 179 of unavoidable impacts, 455 uncertainty, 77 urban areas, 183 to vulnerable populations, 53 Risk assessment\*, 55, 183-186 Risk management\*, 336 adaptation\* and, 5, 10 Sendai Framework\*, 70 See also Disaster risk management Risk sharing, 316, 336-337, 338, 385 Rotterdam, The Netherlands, adaptation strategy, 341 Runoff\*, 178, 201-203, 211 observed changes, 201, 211 projected changes, 201–203, 202, 211

# S

Sahel, Africa, projected risks and impacts in, 180, 236, 259, 261, 262-263 Scenarios\*, 52, 62-64, 98-100, 276, 277, 279-281 1.5°C- and 2°C scenarios, 98-100, 100, 184 comparison of, 279-281 database of, 99 definition of, 63 emission scenarios\*, 184, 276 faster transition scenario, 131, 135 inclusion of CDR in, 277 OECD scenario for 2°C, 373 primary energy supply in, 132–133 socio-economic scenario\*, 62-63 SRES, 62 used in this report, 63 See also Narratives; Pathways Scientific evidence, 52 Scientific institutions, 23, 317, 451 Sea ice\*, 182, 205-206, 212, 224-225, 249, 270 Antarctic, 206, 225 Arctic, 8, 178, 205–206, 209, 212, 224, 254, 258, 261, 262 beyond end of century, 270 irreversible changes, 257, 262 temperature overshoot and, 8 as tipping point, 261, 262, 270 Sea level change\*, 7-8, 182, 206-207, 212, 225, 231-234, 248, 249 adaptation and, 10 beyond end of century, 271 coastal areas and, 207, 231-234, 243, 248, 249, 252 commitment to continued rise, 7, 51, 67, 207, 257, 271.282 deltas and estuaries, 232-233

detection and attribution, 252 emissions and, 5, 7, 51 glaciers and, 206 global mean sea level rise, 178, 206–207, 212 ice sheets\* and, 7, 178, 206, 208, 257, 271 impacts, 178, 181, 182 migration due to, 232 multi-metre rise, 7, 178, 271 numbers of people at risk, 178, 231, 232, 234, 256 past climate episodes and, 208 projected, for 1.5°C, vs. 2°C, 7-8, 178, 206-207, 207, 212, 231-234, 234 regional, 178, 207, 234 sea level rise, 7-8, 67, 178, 206-207, 225, 231-234, 248, 249, 252 small islands and, 7, 8, 232 time-integrated impacts, 61, 62 UNESCO World Heritage sites at risk, 243 Sea surface temperature (SST)\*, 204, 223-224, 248 in definition of 1.5°C, 51 Seagrasses, 225-226, 228, 248, 3.SM.3.2.1 Seasonal warming, 4, 51, 59, 60, 68 Sendai Framework for Disaster Risk Reduction\*, 70 Sequestration. See Carbon sequestration Shared Socio-economic Pathways (SSPs)\*, 62-63, 109-110, 110, 111, 448, 467-468 land-use change and, 145 policy assumptions, 149 SDGs and, 321, 448, 467-468 Shipping, 333 Short-lived climate forcers (SLCF)\*, 64, 66-68, 118, 120, 316, 341-342 co-benefits of reducing, 342, 342 emission reductions, 67, 316, 341-342 knowledge gaps, 389 main characteristics of, 342 mitigation options\*, 341 projected emissions, 96, 157 SDGs and, 157 Singapore, road pricing and car use, 366 Sink\*. See Carbon sequestration Small Island Developing States (SIDS)\*, 9, 234-235, 255, 260, 261 adaptation approaches, 339-340 adaptation limits, 235, 455 in Caribbean, 339-340 climate hazards for, 234-235, 471 climate-resilient development pathways\* in, 471, 471 disproportionate impacts/risks, 9, 53, 447 flooding, 235 freshwater resources, 9, 213, 234, 235 Kiribati, adaptation in, 368, 471 livelihoods, 232, 235 migration and, 181 multiple, compounded risks, 10, 178, 181, 260, 261 Pacific Islands, indigenous knowledge in, 360 risks, 9, 181, 232, 255 sea level rise and, 7, 8, 232, 234–235 storm damage, 235

tourism, 229 Vanuatu, planning for climate-resilient development, 449, 471 Snow, 182 Social cost of carbon (SCC)\*, 150-151, 265, 375 Social costs\*, 67, 265, 317, 365, 375 Social-ecological systems\*, 338-341 Social learning\*, 449, 475 Social safety nets, 362, 385 Societal choices, 98, 99 Societal (social) transformation. See Transformation Socio-economic drivers, 109-110, 110 Socio-economic scenario\*, 62-63 Soil carbon sequestration (SCS)\*. See Carbon sequestration Soil erosion, 216 Soil moisture\*, 190, 191, 196 anomalies, 198, 199, 200 Solar energy, 96, 131, 131, 132-133 water use and, 464-466 Solar radiation modification (SRM)\*, 12–13, 70–71, 347-349, 349-352 carbon budget and, 351 in context of 1.5°C pathways\*, 349-352 feasibility, 347-349, 351-352 governance, 347–348 impacts and ethical issues, 71, 317, 349, 351 knowledge gaps, 390 overview/main characteristics, 348 risks of, 13, 347 social acceptability of, 349 sustainable development and, 351 timing and magnitude, 349-351 uncertainties and limitations, 12-13, 316-317 Southeast Asia, vulnerability and risks in, 259, 261 Southern Ocean, role in global carbon cycle, 257-258 Special Report on 1.5°C. See IPCC Special Report on 1.5°C (SR1.5) Species interactions, phenology and, 216-218 invasive, 8, 9, 223 loss and extinction, 8, 179, 218 range loss/shifts, 8, 179, 218, 222, 247, 248, 256-257 SSPs. See Shared Socio-economic Pathways (SSPs) Stabilisation (of GHG or CO<sub>2</sub>-equivalent concentration)\*, 116, 122, 147, 158, 184-185 Stockholm, congestion charge and car use, 366 Storms, 181, 222-223, 249 extratropical, 203-204 storm surge, 223 tropical cyclones, 203-204, 211 Stranded assets\*, 18 Structured Expert Dialogue (SED), 79 Sub-national actors\*, 23 Sub-Saharan Africa, changes in climate extremes, 197 Sulphur dioxide (SO2), 96, 118, 120 Supply-side measures. See Demand and supply-side measures

Surface air temperature (SAT) in definition of 1.5°C, 51, 56 global average temperature and, 56-57 Sustainable development (SD)\*, 18-23, 72, 73-75, 445-538 and 1.5°C pathways\*, 93, 97, 98, 156-157, 253, 450-451, 463-466, 465 and 1.5°C warmer worlds\*, 55–56, 447, 451–453 adaptation and, 19, 447, 456-459 avoided impacts and, 452-453, 453, 475 climate-resilient development pathways (CRDPs)\* and, 22, 52, 64, 448-449, 450-451, 451, 468-472, 475-476, 479-480 co-benefits, 447 conditions for achieving, 474-475 definition, 73 equity and, 55-56, 448-449 integration with adaptation and mitigation, 75-76, 448.467 mitigation and, 12, 18, 19-21, 97, 156-157, 156, 447-448, 459-466, 481-509 mitigation pathways and, 463-466, 465 overview, 450, 475-476 pathways to 1.5°C, 466-472, 469, 479-480 research gaps, 475-476 risks to, 253 in social-ecological systems\*, 338-341 synergies and trade-offs, 457-458, 459-463, 463, 475 trajectories, 451, 469-470, 480 transformation\* and, 22, 56, 73, 448, 456, 466 Sustainable Development Goals (SDGs)\*, 18, 19-21, 73-75, 156-157, 156 adaptation options\* and, 457-458 avoided impacts and, 18, 68, 183, 253-265, 447, 453, 475 CDR and, 448, 462 climate change and, 73, 74, 75, 157, 158, 252 energy efficiency and, 448 equity and, 51 food security and nutrition, 238 mitigation options and, 19-21, 20-21, 448, 459-463 mitigation pathways, interactions with, 2.SM.1.5 mitigation-SDG table, 481-509 overview, 450 policy instruments and, 448 prioritizing, 447 risks from 1.5°C, vs. 2°C, 453 SDG Global Index Scores, 53 SDG-interaction scores\*, 481-509 Shared Socio-economic Pathways\* and, 321, 448, 467-468 synergies and trade-offs, 19-21, 21-22, 319, 447, 463, 475 system transitions and, 317 Sustainable Development Pathways, 64, 448-449, 466-472, 469, 479-480 Synergies, 18-19, 20-21, 72, 269, 316, 477, 4.SM.4.5.1, 4.SM.5.2 adaptation and SDGs, 447 knowledge gaps, 391

mitigation and SDGs, 19–21, 20–21, 157, 459–463, *463, 465* mitigation and sustainable development, 459–463, *463,* 475 uneven distribution of, 466 **Synfuels**, 333 **Systemic changes/transitions**, *14–15*, 15–16, 21–22, 315, **323–349**, 449, 476 enabling, 315–318 rates of change, 322–323 *See also* Transitions

## T

Tanzania, indigenous knowledge used in, 360 Technology, 22 access to, 23 biotechnology/genome modification, 319, 329 deployment of, 72 disruptive, 22, 111, 319, 323 general purpose technologies (GPT)\*, 369-370, 383 information and communication technology (ICT)\*, 316, 319 innovation in, 19, 21, 22, 316, 369-370 innovation, enabling, 369-372 innovation, examples of, 370 innovation, knowledge gaps, 391 low-carbon, 15, 16, 96, 153, 331 new, 15, 22, 319 policies, 95, 148, 370-371 Power-2-X, 111 smart technology/IoT, 331 standards, 332, 378 Technology transfer\*, 19, 23, 371–372, 371, 449, 474 Temperature, 182 carbon budget, emissions, and, 96 datasets, 53, 56, 57, 58, 59, 1.SM.1 fluctuations in, natural, 56, 59 global average, defined, 56-57, 81 global mean surface temperature (GMST)\*, 56-57, 57, 177, 186 heat-related morbidity and mortality, 9, 11, 180, 240-241, 250, 252, 252, 263, 264, 3.SM.3.3.1 heatwaves\*, 9, 177-178, 263, 264 land-sea contrast in warming, 8, 51, 59, 187, 190, 205 land surface air temperature\*, 56 number of hot days, 190, 193, 210 observed warming, 6, 51, 53, 53, 58, 106, 189-191, 1.SM.1, 1.SM.2, 1.SM.3, 1.SM.6 peak in, 5, 96, 101, 104, 177, 277 peak, reducing after, 17, 18, 278 projections, 4, 7, 177, 187-188, 188, 190-191, 192, 193 rate of change, 54, 177, 178 regional variation in, 177, 283 sea surface temperature (SST)\*, 51, 204, 223-224, 248 temperatures used in definition of 1.5°C, 51, 187, 188 See also Global warming Temperature extremes, 255, 263 hotspots (key risks), 190-191, 193

and human health, 263, 264 observed, 210 probability ratio of, 192 projected, 7, 177, 189, 190-191, 192, 210, 255 Sub-Saharan Africa, 197 Temperature overshoot\*. See Overshoot Temperature threshold, 65, 66 Terrestrial ecosystems, 8, 179, 216-221, 247, 252, 3.SM.3.3.7 biomass and carbon stocks, 219, 220 biome shifts, 216, 217, 247, 250 ecosystem function, 219 impacts and risks at 1.5°C, vs. 2°C, 8, 11, 179, 216-221, 247, 251, 252, 3.SM.3.3.7, Table 3.SM.2 knowledge gaps, 272 phenology, 216-218 productivity, 220 regional and ecosystem-specific risks, 219-221 respiration, 219 severe ecosystem changes, 217 Thermohaline circulation. See Atlantic Meridional Overturning Circulation (AMOC) Tipping points\*, 182, 262-263, 264, 270, 282 identifying, 458 See also Irreversibility Tourism, 11, 178, 181, 242-243, 253, 3.SM.3.3.2 coastal areas, 229, 253 observed impacts, 181 projected impacts, 181, 242-243, 253 risks, 181, 253 seasonal, 181, 243 Trade-offs, 18–19, 72, 73, 269, 4.SM.4.5.1, 4.SM.5.2 example of, 477 knowledge gaps, 391 mitigation options and sustainable development, 459-463, 465 reconciling, 467 with SDGs, 19, 73 specific mitigation options, 97 uneven distribution of, 466 Transformation\*, 22, 52, 70, 73, 112, 129-157, 315, 468-469 1.5°C pathways\*, 95, 112-113, 129-148, 448, 472 1.5°C warmer worlds\*, 73 challenges, opportunities, and co-impacts, 148-157 cities/urban areas, 472-474 in climate-resilient development pathways, 468-469 context-specific, 469 energy system, 129-144, 463 FAQ on, 392-393, 393 feasibility of, 52, 72 fundamental elements of, 73 implementing, 276 societal (social) transformation\*, 22, 52, 73, 448-449, 466 sustainable development and, 22, 448, 456 trade-offs, 73 upscaling and accelerating, 314 whole systems approach, 392 See also Transitions Transformation pathways\*. See Pathways

Transformational adaptation. See Adaptation Transient climate response\*, 184–185 See also Climate sensitivity Transient climate response to cumulative CO<sub>2</sub> emissions (TCRE)\*, 96, 104, 106 Transition Movement, 480 Transition Towns (TTs), 473-474 Transitions\*, 14-15, 15-16, 21-22, 73, 315-318, 323-349, 4.SM.4.2.1-4.SM.4.2.5, 4.SM.4.3.1-4.SM.4.3.5 adaptation options\* supporting, 321, 336-337, 338 enabling, 19, 21-22, 315-318 in energy sector, 15, 96-97, 315, 324-327, 374-375, 4.SM.4.2.1, 4.SM.4.3.1 equity\* in, 22 FAQ on, 392-393, 393 in land use, 16, 17, 96, 97, 315, 327-329, 4.SM.4.3.2 policies supporting, 22 risks and ethics, 319 speed and scale of, 15, 314, 317, 320, 320, 322-323, 392, 394 sustainable development and, 22 synergies, 316, 4.SM.5.2 system/sector transitions, 14-15, 15-16, 21-22, 96-97, 315-318, **323-349** See also specific sectors Transnational emission reduction initiatives (TERIs), 149 Transport sector, 244, 316, 332-333 biofuels, 325 car/transport pricing policies, 366 decarbonization\* of, 316, 461 demotorization, 316, 366, 376 electric vehicle (EV)\*, 316, 332-333, 333 electrification of, 332-333, 333, 460 emissions, 96, 114, 142-144, 143 emissions reduction, 366 final energy demand and use, 139, 142-144, 143, 332 impacts of weather and climate on, 244 international transport, 333 investments in, 373-374 road safety for pedestrians, 461 road transport, 142-143, 461 strategies to reduce energy consumption, 142 sustainable transport, 332 technological innovations, 370 transitions, 15-16, 316 transitions, speed and scale of, 320, 320 urban environments, 316, 332 Tropical cyclone\*, 203-204, 211 Cyclone Pam, 471 Tundra, 8, 179, 216, 220 tipping points\*, 262, 264

#### U

Uncertainty\*, 69, 77 of climate response to mitigation, 60, 63 geophysical, 96, 101–104 in mitigation pathways, 60, 63

propagation of, 3.SM.1.3 Unique and threatened systems, 10, 11, 181, 251, 253-255, 254 United Kingdom Overseas Territories (UKOT), 339 **United Nations Framework Convention on** Climate Change (UNFCCC)\*, 79, 80, 353 adaptation financing, 21 Conference of the Parties (COP)\*, 79 Green Climate Fund, 74, 379 Uptake\*. See Carbon sequestration Urban areas, 180, 241-242, 330-334 adaptation examples, 340-341 adaptation options\*, 10, 70, 263, 384-386, 385, 4.SM.4.3.3 agriculture in, 316 demotorization, 316, 366, 376 energy systems, 331 feasibility of adaptation options, 384-386, 385 feasibility of mitigation options, 382 global urbanization, 472 governance, 473 green infrastructure\*, 10, 334, 334, 385 heat island effect, 9, 180, 242 heat-related extreme events, 241-242 impacts and risks, 180, 182, 183, 241-242 informal urban settlements, 473 infrastructure, 331, 333 knowledge gaps, 388–389 land use, 316, 333 low-carbon cities, 331 mitigation options\*, 4.SM.4.2.3 numbers of people in, 330, 340 peri-urban agriculture, 316 poverty and, 242 risks and risk reduction, 331, 456 sea level rise and, 231-232, 241 transformation\* in, 472-474 transformational adaptation, 386 Transition Towns (TTs), 473-474 transitions, 15-16, 316, 330-334, 4.SM.4.2.3, 4.SM.4.3.3 transport, 316, 331, 332-333 urban planning, 148 water services, 316, 334 See also specific cities Urban heat islands, 9, 180, 242

#### V

Values, 22, 71, 317, 364–365 re-examination of, 449, 469, 475 societal, 448, 476 value judgements, 55
Vanuatu, planning for climate-resilience, 449, 471
Vector-borne disease, 9, 180, 241 *Aedes* mosquitoes, 241
Vulnerability\*, 69, 447 disproportionate impacts and, 9, 51, 447 factors influencing, 53 international cooperation and, 23 multiple, interrelated climate risks, 10 new vulnerabilities, 10 redistributive policies and, 21 reducing, 19, 447, 457 risks and, 53, 452 sustainable development and, 447 systemic, 22, 447, 457

### W

Warm Spell Duration Index (WSDI), 190 Water availability, 178, 213-214 Water cycle. See Hydrological cycle Water management, 10 Water resources, 179, 182, 213-216, 464-466 bottom-up initiatives, 368 demand for, 464-466 groundwater, 181, 215, 3.SM.3.1.1.3 impacts and risks, 213-216, 247 irrigation, 201, 215, 267, 267, 315, 328, 384, 466 projections, 179 regional, 179, 247 in urban areas, 316, 334 water-energy-food (WEF) nexus, 386-387 water quality, 215-216, 3.SM.3.1.1.4 water temperature, 214 watershed management, 356 See also Precipitation Water scarcity, 179, 213, 452, 453, 466 Water security, 464-466 Water stress, 9, 181, 247, 452, 466 Well-being\*, 18, 180 Bhutan's happiness index, 387 place-specific adaptation and, 447 well-being for all, 469 Wetlands, 179, 225, 254, 330, Table 3.SM.2 management, 330 methane release from, 12 salinization of, 233 sea level rise and, 233 Wind energy, 96, 131, 131, 132-133

# Ζ

Zero emissions commitment (ZEC), 64–65, 65