# Index

Note: \* indicates the term also appears in the Glossary (Appendix I). Page numbers in bold indicate page spans for entire chapters. Page numbers in italics denote tables, figures and boxed material.

A regional database, which lists all references and can be searched by region and by topic, is on the CD-ROM included in this volume.

#### A

**Abatement**, 757-758 Abrupt climate change, 35, 374, 375, 377-378, 596 Access to technology/resources, 441, 791, 813, 816, 826-827 Acclimation/ Acclimatisation\*, 246-248, 557 Acidification. See Ocean acidification Active layer\*, 88, 663 Adaptability. See Adaptive capacity Adaptation\*, 65-76, 81-82, 117, 717-743, 748, 781 Adaptation Policy Framework (APF), 732-733 anticipatory, 723, 798 autonomous (See Autonomous adaptation) barriers to, 69, 525-526, 638, 719, 733-737, 798, 815 context, 378 costs and benefits (See Adaptation costs and benefits) deficit, 835 definition, 27, 750 differences from mitigation, 750 enhancement, opportunities and constraints, 731-737 examples of, 65, 722 factors in, 378, 383-384, 719, 720 implementation, 53, 65, 766-770, 815-816 indigenous knowledge in, 456-457, 832, 833 inter-relationship with mitigation (See Adaptation and mitigation inter-relationships) international and national actions, 53, 416-417, 731-733 introduction, 719-720, 748-750 key issues, 383-384 limits to, 69, 199, 417, 492, 719, 733-737 mainstreaming, 55, 65, 471, 513, 637-638, 639, 732, 749, 768, 818, 832-836 mitigation and (See Adaptation and mitigation interrelationships) multiple stresses and, 719, 729, 816-819 National Adaptation Programmes (Plans) of Action (NAPAs), 69, 719, 731-732 opportunities, co-benefits and challenges for, 832-836 opposing views on, 786 planned (See Planned adaptation)

policy window hypothesis, 733 portfolio, 71-72, 76, 747, 749, 760-763, 813, 827 potential, 69, 782, 786, 798, 804 practices/examples, 65, 117, 719, 720-727, 821 process/processes, 513, 720-721 reactive vs. proactive, 452, 719, 721 regional, 111-112, 722, 757-760 resilience and, 721 response capacity, 763-766, 767 response strategies, 69, 70, 781-782, 797-804 scales of, 747, 749, 753-754, 767-769 scenarios, 156-158, 719, 724 substitutability for mitigation, 749, 753-754, 766-767 sustainable development and, 813, 814-816 synergies, 72, 747, 754-756, 762-763, 813, 835 technology and, 727-728, 734 thresholds, 733-734 wealth, resources and development and, 43, 69, 276, 279, 620, 719, 755, 764-766, 767, 791, 814 See also Adaptation assessment; Adaptive capacity; specific systems and regions Adaptation and mitigation inter-relationships, 70-73, 745-777, 827-832 climate policy and institutions, 766-769 complementarity, 749, 750 cost-benefit analyses, 747, 754, 756, 757, 800 cost-effectiveness analyses, 755, 800 decision processes, stakeholder objectives and scale, 72, 747,752-754 definitions, 749 differences, similarities and complementarities, 750 implementation, 766-770 inter-relationships and damages avoided, 747, 754-760, 783 inter-relationships, types of, 747, 750, 761, 762 introduction, 748-750 mainstreaming, 749, 768 overview, 748, 761 portfolio, 71-72, 76, 747, 749, 760-763, 813, 827

regions and sectors, 757-760 response capacity and development pathways, 747, 763-766, 767, 771 scales, 747, 749, 753-754, 767-769 substitutability, 749, 753-754, 766-767 summary of knowledge from TAR, 751-752 sustainable development and, 747, 751, 765-766 synergies, 72, 76, 747, 749, 754-756, 762, 813, 827-832, 837 Tolerable Windows Approach (TWA), 754-755, 802 trade-offs, 72, 747, 749, 751, 754-756, 762 uncertainties, unknowns and priorities for research, 770-771 Adaptation assessment\*, 137-138, 717-743 assessment of adaptive capacity, 727-731 as bottom-up approach, 136, 749 characteristics summarised, 137 concepts and methods, 719-720 costs and benefits, 719, 724-727, 734, 800 current adaptation practices, 720-727 enhancing adaptation, 731-737 introduction, 719-720 See also CCIAV assessment Adaptation costs and benefits\*, 65, 719, 724-727, 734-735, 756-757, 781-782, 798, 836 in Africa, 435, 452, 453-454, 453 in coastal systems, 40-41, 317, 336-339, 342, 343, 725 comprehensive estimates, lack of, 69 cost-benefit analyses, 747, 754, 756, 757, 800 cost-effectiveness analyses, 755, 800 damages avoided, 77-78, 295, 754-760, 798-803 weighing, 72, 782 See also Trade-offs Adaptive capacity\*, 69, 72-73, 382-383, 727-731, 786 in Africa, 48-49, 64, 69, 435, 454, 459 in Asia, 492 assessment of, 727-731 in Australia/New Zealand region, 50 changes over time, 729-731 in coastal systems, 317, 318-322, 324-336, 344, 786 determinants of, 791, 814 development and, 69, 317, 336, 364, 755 differences across human societies, 383 differential, 719, 728-729, 730 elements of, 727-728 in Europe, 547 exceedence of, 781 in food, fibre and forest products, 275, 279-280 in human health, 43, 393, 406 in India, 71 in Latin America, 584, 605 mitigation and, 750, 827-832 in mountain ecosystems, 52 multiple stresses and, 719, 729 perceptions of, 735 in polar regions, 658-660, 661 of poor communities, 359, 492, 720 in small islands, 706-709

of social systems, 782, 791, 798 sustainable development, linkages with, 76, 817-819, 837 in water sector, 199 See also Capacity building; Coping ranges; Response capacity; specific systems and regions Advances in knowledge, 76-78 Aedes aegypti (now Stegomyia aegypti), 403-404, 524 Aeroallergens, 402-403 Aerosols\* from biomass burning, 53, 583, 590 direct and indirect effects, 84 human health and, 402, 590 Afforestation\*, 599, 750, 758, 759, 761 Africa, 48-49, 59, 433-467 access to resources/technology, 441 adaptation, 416, 452-454, 459, 722, 726, 767-769 adaptation limits, 734 adaptive capacity, 48-49, 64, 435, 454, 459 agriculture, 48, 297, 435, 439, 441, 442, 445, 447-448, 451, 452, 459 assumptions about future trends, 443-444 biodiversity, 48, 223, 242, 435, 439, 449, 449 case studies, 454-457 climate and weather, 436-437, 458 climate variability, 435, 436-437, 439, 448, 454 coastal zones, 40, 439-440, 448, 449, 450, 451 current sensitivity/vulnerability, 435, 436-443, 451 disasters and conflicts, 442-443, 447, 451, 459 droughts, 237, 278, 287, 437, 734 economies, 440-441, 454 ecosystems, 48, 213-214, 243-244, 435, 439, 442, 449, 451,459 energy, 442, 446, 459, 767-769 extreme weather events, 377, 437, 444 fires, 435, 442 fisheries, 281, 435, 448, 449 floods, 377, 398, 414, 435, 437, 447 food security/insecurity, 38, 48, 275, 280, 297, 300, 399, 435, 440, 454-456, 719 forests, 299, 435, 439, 442 future impacts and vulnerabilities, 38, 48-49, 59, 280, 444-450, 451, 788, 791, 825, 829 globalisation, trade and market reforms, 440-441 governance and institutions, 441 HIV/AIDS in, 69, 399, 406, 440, 441, 442, 448 hotspots/risk areas, 438 human health, 48, 108-109, 399-400, 416, 435, 436, 437-439, 441, 442, 446-447, 459 human population, 441 human settlements, industry and infrastructure, 439-440, 450 hydropower generation, 768-769 indigenous knowledge systems, 456-457 infrastructure, 439-440, 441, 450, 453 introduction, 435-436 Kilimanjaro, Mt., 48, 439, 440, 449 livestock, 278, 287, 447, 448 malaria, 48, 108-109, 400, 404, 406, 408, 409, 437-439,

#### 446

market impacts, 791 migration, 437, 441, 452 multiple stresses, 48, 69, 435, 436, 440, 442, 454, 457 New Partnership for Africa's Development (NEPAD), 767 observed changes, 30, 91, 108-109, 115-116 pastoralist coping strategies, 293, 457 population and environment interactions, 441 precipitation, 151, 436 resilience in, 48-49, 452, 453 rivers/river basins, 445, 446, 767-769 Sahel region, 216, 224, 237, 436, 437, 444 savannas, 225, 226 sea-level rise, 346, 435, 447, 450 smallholder farmers, 731 socio-economic scenarios, 297, 444 sustainable development, 457 temperature, 150, 436 tourism, 435, 439, 449, 450, 459 uncertainties and research priorities, 457-460 ungulates, 226 urban indicators, 363 vegetation cover, 436-437 vulnerability/risk, 40, 48-49, 64, 444-450, 451, 459, 788, 791 water resources, 48, 91, 284, 370, 377, 435, 437, 441-442, 444-446, 451, 458-459 water stress, 48, 435, 437, 444, 445, 451 West African Monetary Union (WAMU), 767 African horse sickness (AHS), 555 African Succulent Karoo, 223, 243, 449, 792 Aggregate impacts\*, 64-65, 75, 784, 787, 790, 796-797, 813, 821-825 estimates of, history and present state of, 64-65, 813, 821-824 larger-scale aggregation, 82, 112-116 limitations of, 43, 65, 813 spatially-explicit methods, 824-825, 836 Agriculture adaptation, 38-39, 117, 294-296, 300, 721, 725-726, 760 adaptation costs, 725-726, 734 adaptation options, 70 in Africa, 48, 297, 435, 439, 441, 442, 445, 447-448, 451, 452,459 in Asia, 49, 471, 472, 475, 479-483 in Australia/New Zealand region, 50, 509, 516, 518-520, 525, 528, 529 biotechnology and, 296, 452, 555-556 in coastal systems, 333 costs, 296-297 El Niño Southern Oscillation (ENSO) effects on, 277 in Europe, 52, 543, 545-546, 548-549, 554-556, 558, 560-561, 565 extreme events and, 277, 277, 278 global area in cropland, 816 global production, temperature increase and, 790 growing season (See Growing season) importance of, 276

in Latin America, 54, 281, 584, 586, 591, 592, 597, 598, 601-602 multiple stresses, 279 in North America, 620, 623-624, 627, 631, 636 observed changes, 81-82, 104-106 phenology, 31, 81, 105 in polar regions, 668 projected changes, 38 in small islands, 58, 689, 698-700 soil erosion and, 190 subsistence and smallholder, 39, 275, 279, 281-282, 293-294, 413, 435, 490, 731 supply and demand in, 280-281 trade and, 275, 276, 284, 297, 300 vulnerability/risk, 31, 82, 787, 790, 791, 802 wastewater irrigation of crops, 189 water balance and, 280 See also Crop yields; Crops; Food, fibre and forest products; Livestock; Soil; specific crops AIR-CLIM Project, 139 Air pollution, 84 direct and indirect effects, 84 effects on plants, 276, 278 in Europe, 557-558 from forest fires, 402 human health and, 401-402, 408-412 in North America, 632 Air quality, 84, 372, 394 in Asia, 487 disease and, 401-402, 408-412, 413 Albedo\*, 84, 231 global effect of regional changes in, 661 increase due to planned adaptation, 381 in polar regions, 655, 656, 661 Algal blooms\*, 97, 188, 277, 449, 487, 551 algal community changes, 98 dissolved inorganic carbon and, 329-330 harmful (HAB), 96, 234, 328, 400, 551, 556 red tides, 485 See also Phytoplankton; Zooplankton Alien species. See Invasive species and invasive alien species (IAS) Allergens, 31, 82, 109, 393, 402-403, 558 Alpine\* ecosystems, 50, 52, 99, 232-233 adaptation limits/limitations, 52, 543, 559 See also Mountain regions Alps. See Europe, European Alps **Amazon region** drought in, 400 fire in, 588 forest replacement by savanna, 54, 583 forests, 54, 218, 241, 243, 281, 594-595, 596 Large Scale Biosphere-Atmosphere Experiment, 604 **AMICA project**, 769 Amphibians in Europe, 52, 543, 554, 565 extinctions of, 103, 230, 233, 586, 590 in Latin America, 586, 590

in North America, 622, 630 phenology, 100 Analogues, 32, 145, 146, 382 Andes region, 28, 184, 187, 585 Annular modes, 794 Anopheles, 416 Anopheles arabiensis, 108, 439 Anopheles gambiae, 439 Antarctic Oscillation (AAO), 794 Antarctic region. See Polar regions. See also Small islands Anthropogenic\* climate change, 26, 28, 81, 781 larger-scale attribution studies, 112-116 linking climate-change causes with observed effects, 29 See also Climate change; Dangerous anthropogenic interference; Detection and attribution; Vulnerability assessment AOGCM. See Climate models Aquaculture\*, 276-277, 281, 291-292 in Asia, 49, 281, 482 in Europe, 555-556, 561 in Latin America, 593 Aquatic ecosystems. See Freshwater resources and management; Marine ecosystems Aquifers\* coastal. 331 in North America, 629 observed changes, 90 salinisation of, 179, 186 Aragonite\*, 38, 94, 213, 234, 235, 236 Arboviruses\*, 555 Arctic Ocean, 656, 662, 692 See also Polar regions Arctic Oscillation (AO), 95, 794 Arctic region. See Polar regions Arid regions\* afforestation in, 758 in Africa, 435, 439, 442 in Asia, 478 freshwater resources in, 36, 175, 176, 193-194, 331 vulnerability/risk in, 788 See also Desertification; Deserts Arsenic in groundwater, 179, 587 Artificial experiments, 144-146 Asia, 49-50, 59-60, 469-506 adaptation, 471, 490-493, 722 adaptive strategies, 472, 490 agriculture, 49, 471, 472, 475, 479-483 aquaculture, 49, 281, 482 assumptions about future trends, 478-479 biodiversity, 49, 471, 478, 485-487, 491 case studies, 493-494 climate, 471, 472-473, 475, 478-479, 480 climate variability, 471, 472-478, 475, 479 coastal areas, 49, 92, 472, 477, 479, 484, 491 coral reefs, 471, 472, 477, 485, 486 crop yields, 49, 106, 297, 471, 479-481 current sensitivity/vulnerability, 472-478 cyclones/typhoons, 473, 476, 479, 489

deltas/megadeltas, 279, 327, 471, 481, 484-485, 493, 496 dengue fever, 478, 487 development, 471, 472, 488-489, 494-495 droughts, 49, 473, 476 ecosystems, natural, 49, 471, 477, 485-487, 491 El Niño/ENSO in, 473, 475, 477 energy, 111, 488-489 extreme weather events, 473, 476, 479, 488, 489 financial aspects/insurance, 489 fires, 471, 472, 477-478, 486 fisheries, 49, 279, 281, 471, 482, 489 floods, 49, 398, 414, 471, 472, 476, 489 food security, 297, 399, 471, 479-481, 482-483 forests/forestry, 471, 472, 477-478, 481, 485-486, 488 future impacts and vulnerabilities, 49-50, 59-60, 479-489, 788, 791, 825, 829 glaciers, 49, 471, 472, 477, 481, 483-484, 487, 493, 494 grasslands, rangelands and endangered species, 483, 486 heatwaves, 396-397, 476, 478, 492, 733 hotspots, 481 human dimensions, 487-489, 491-492 human health, 50, 395, 408, 472, 478, 481, 487, 491, 791 human population, 49, 477, 479, 484, 488, 491 human settlements/megacities, 472, 485, 491, 493 hydrology, 471-472, 477, 483-484, 490-491 industry, 488-489 infrastructure, 471, 488-489, 492 introduction, 471-472 livestock, 287, 482, 483 malaria, 408, 478, 487 migration, 488, 491-492 multiple stresses, 50, 471, 492 natural resources, 474 observed changes, 30, 49, 92, 106, 115-116, 471, 472-478, 475-477, 479 permafrost, 49, 472, 477, 486-487 poverty and illiteracy, 489, 492, 494 precipitation, 151, 472, 476, 478-479, 480, 481 regional characteristics, 472 regions/countries included, 472, 473, 474 sea-level rise, 49, 346, 471, 472, 479, 481, 484-485, 492 socio-economics, 474, 479, 487-489 sustainable development, 488, 494-495 temperature, 150, 478, 479, 480, 481 tourism, 489, 492 uncertainties and research priorities, 495-497 urban indicators. 363 urbanisation, 488-489, 491, 494-495 vulnerability/risk, 64, 479-489, 788, 791 water resources, 49, 471, 471-472, 477, 481, 483-484, 490-491,791 water stress, 471, 472, 484 See also specific countries Assessment of adaptation (See Adaptation assessment) of observed changes and responses (See Observed changes and responses) participatory processes in, 813, 834

of response strategies, 797-804 of vulnerabilities (See Vulnerability assessment) See also CCIAV assessment; Impact assessment; Integrated assessment Assessment methods, 29, 31-35, 133-171 approaches, 136-141 conclusions and future directions, 161-162 coping ranges, 142-143 data needs for, 144 developments in, 141-144 downscaling, 135 future characterisations, 32-35, 135, 144-161 risk management, 135 stakeholder involvement, 31-32, 135, 141-142 thresholds and risk criteria, 141 top-down vs. bottom-up approaches, 136, 748-749 See also Adaptation assessment; CCIAV assessment Asthma, 523, 632, 689, 701 Atlantic cod. 670 Atmosphere\* carbon content, 214 composition, future scenarios, 152-153 projected changes, 662 See also specific gases and components Atolls. See Coral atolls Attribution. See Detection and attribution Australia/New Zealand region, 50-51, 60, 507-540 adaptation, 50, 509, 513-514, 524-526, 528, 530-531 adaptive capacity, 50 agriculture, 50, 509, 516, 518-520, 525, 528, 529 assumptions about future trends, 514-516 Bay of Plenty, North Island, New Zealand, 509, 528, 530 beef industry, 283 biodiversity, 50, 242-245, 509, 517-518, 518, 528 case studies, 526-528 climate scenarios, 50, 514-516 coasts, 50, 509, 520-521, 525, 525, 528, 529 costs of extreme weather events, 50, 511, 513 current sensitivity/vulnerability, 510-514 droughts, 50, 509, 510-511, 511, 515, 519 El Niño Southern Oscillation (ENSO), 510, 521 energy, 511, 516, 523-524, 529 extreme weather events, 50, 509, 511, 513 fires, 50, 509, 511, 517, 792 fisheries, 512, 521 flood and waste water management, 517 food security, 528-529, 529 forestry, 50, 509, 520, 525, 529 freshwater resources, 516-517 future impacts and vulnerabilities, 50-51, 60, 242-245, 516-524, 528, 529, 829 Great Barrier Reef, 50, 320, 509, 512, 518, 527 heatwaves, 50, 411, 509, 511, 524 horticulture, 519 hotspots, 50, 51, 509, 529, 530 human health, 395, 408, 409, 524, 525, 529 human population, 509, 510, 516, 522 human systems, 50, 509, 511

immigration/migration, 522, 531 indigenous people, 50, 522-523, 524 infrastructure, 50, 509, 525, 529 introduction, 510 invasive/alien species, 512, 518, 520 land degradation, 518-519, 520 land management, 751-752 migration corridors, 525 natural systems/ecosystems, 50, 509, 511, 512, 517-518, 525, 528, 529, 530 observed changes, 30, 50, 115-116, 509, 510-512, 512 pastoral/rangeland farming, 513, 519-520 phenology, 100 precipitation, 50, 151, 515 saltwater intrusion, 512, 517 savannas, 225, 226 sea-level rise, 50, 346, 509, 510, 512, 515-516, 520-521 settlements, industry and societies, 521-522 Sunshine Coast, 528 sustainable development, 528-529, 529 temperature, 50, 150, 509, 510-511, 514-515 tick infestation, 520 tourism and recreation, 523, 527, 529 uncertainties and research priorities, 529-531 vulnerability/risk, 50-51, 242-245, 509, 513, 516-524, 525, 529, 531, 829 water quality, 517 water resources, 50, 143, 199, 511-512, 514, 526, 528 water security, 50, 509, 516-517, 519, 525, 529 Wide Bay-Burnett, Queensland, Australia, 528 Autonomous adaptation in Australia/New Zealand region, 513 damage avoidance, 295, 754-760 definition, 294 in food, fibre and forest products, 294-295 in Latin America, 593 in North America, 637-638

# B

# Bangladesh

in small islands, 706

See also Adaptation; Adaptive capacity

adaptation, 719, 722, 724, 732, 832 deaths associated with cyclones, 338 floods, 36, 187, 399, 414, 484-485 groundwater salinisation, 483 human health, 399 human population, 488 migration, human, 365, 488 National Water Management Plan, 719, 724 water resources, 477 See also Asia Bartonella bacilliformis, 587 Baseline/reference climate\*, 35, 143, 147, 158, 782, 783 Basins\*. See River basins Batrachochytrium fungus, 233, 586 Bats, 216, 405 Beaches, 324-326

in Australia/New Zealand region, 511, 520, 522, 528 closure for bacterial counts, 625 erosion, 92, 318, 511, 520, 522, 696, 698 in North America, 625 recreational value, 523 in small islands, 696, 698 See also Coastal systems and low-lying areas Benthic communities\*, 38, 97, 213, 234, 236, 239 Biodiversity\*, 37, 38, 213, 215, 241-242, 247-248 adaptation option limitations, 52, 543, 559, 786 in Africa, 48, 242, 435, 439, 449, 449 in Asia, 49, 471, 478, 485-487, 491 in Australia/New Zealand region, 50, 509, 517-518, 518, 528 captive breeding and translocation, 247 in coastal systems, 335 conservation strategies, 560 Convention on Biological Diversity (CBD), 246, 247-248, 495.769 in deserts, 223-224 endemic species, 38, 54, 213, 216, 230, 241, 583, 786 in Europe, 52, 54, 543, 553-554, 558, 560, 565 in forests, 230 in grasslands/savannas, 226 in Latin America, 583, 586, 590, 592, 596, 603, 791 management, 769 in mountain ecosystems, 233 in North America, 630 in oceans, 95, 236, 665 in polar regions, 665 projected impacts, 37, 38, 242-245 in saltmarshes, 630 in small islands, 58, 689, 700 vulnerability/risk, 38, 74, 781, 788, 792, 795-796 See also Ecosystems; Extinction; Range shifts; Vulnerability hotspots Biofuels\*, 288, 299, 555, 602, 758 Biogeochemical cycles, 219-222, 234, 789, 792-793 Biological corridors. See Ecological corridors **Biological systems**, 26, 28-31, 83 adaptive capacity, 782, 798 key vulnerabilities, 74, 788-789, 792, 798 linking climate-change causes with observed effects, 29 locations of significant changes in, 30 See also Ecosystems Biomass\*, 56, 98, 214, 220 carbon dioxide and, 220, 486 forest, 52 modelling, 240 phytoplankton, 56, 96 Biomass burning, 53, 402, 583, 588, 590 **Biomes\***, 38, 214-215 biome changes, 38 biome shifts, 222, 237, 596 (See also Range shifts) cross-biome impacts, 237-239 See also Ecosystems; Sea-ice biome Biosphere\*, 38, 215-216, 604 Biota\*, 178, 213, 219-222, 249

Biotechnology, 296, 452, 555-556 Biotic feedback, 219-222 Birds in Africa, 449 in Australia/New Zealand region, 512, 518, 521 avian malaria, 700 breeding/breeding areas, 100, 103, 193, 518, 622 desert species, 223-224 extinction risks, 103, 230 habitat losses, 554 migration, 100, 223-224, 230, 239, 449, 625, 666, 696 migration, infectious diseases and, 403 in North America, 622, 625 observed changes, 95-96, 100, 101 in polar regions, 666 seabirds, 95-96, 521, 527, 696 West Nile virus and, 625 Bluetongue (BT), 555 Bogs\*, 230, 231, 233 Boreal Asia. See Asia Boreal forests\*, 217, 228, 276, 485-486 Bottom-up assessment approaches, 136, 749 Bottom-up risk reduction approach, 820 Brazil freshwater resources, 175, 179, 185 natural ecosystems, 592 runoff into coastal waters, 324 sedimentation in reservoirs, 179 See also Latin America Breakwater\*, 343 Bruntland Commission, 814, 819 Buildings. See Construction **Butterflies** in Australia/New Zealand region, 512 extinction of, 103 in North America, 622 observed changes, 103, 104 reproduction/diversity of, 103, 104 С C<sub>3</sub> plants\*, 224, 225, 483, 520 carbon dioxide effects on, 40, 282 C<sub>4</sub> plants\*, 224, 225, 483, 518, 520 carbon dioxide effects on, 40, 282 switchgrass (Panicum virgatum L.), 288 Calcareous organisms\*, 38, 222, 234, 235 See also Aragonite; Ocean acidification Calcite\*, 222

C<sub>3</sub> plants\*, 224, 225, 483, 520 carbon dioxide effects on, 40, 282
C<sub>4</sub> plants\*, 224, 225, 483, 518, 520 carbon dioxide effects on, 40, 282 switchgrass (*Panicum virgatum L.*), 288
Calcareous organisms\*, 38, 222, 234, 235 *See also* Aragonite; Ocean acidification
Calcite\*, 222 *Campylobacter*, 400
Canada adaptation, 722 agriculture, 623-624, 631 cities, climate change impacts in, 633 coast erosion, 92
Confederation Bridge, 65, 719, 724 energy use/demand, 626, 634-635 forest-dependent communities, 736-737 forest fires, 107, 217, 621, 623, 631

forestry, 218, 624, 630, 631 freshwater resources, 627-629 Hudson Bay, 92, 669 human health, 395, 410, 415, 416 indigenous peoples, 415, 416, 728, 730-731 infrastructure, 726 Okanagan, costs of climate change in, 195 phenology, 283, 621, 622 precipitation, 621, 622 temperature, 620, 621 tourism and recreation, 626, 634 transportation, 366, 726 wildlife, 622 See also North America Capacity building\*, 69, 72, 797 in Australia/New Zealand region, 514 food, fibre and forest products, 296 in small islands, 708-709, 710 Carbon carbon-climate interactions, 792-793, 795 dissolved organic (DOC), 234, 239, 665 pools, 283 social cost of, 65, 756, 771, 813, 821-824 storage (See Carbon sequestration\*; Carbon sinks) World Bank funds for, 753 Carbon cycle\*, 220-222, 792-793, 795 large-scale studies, 604 net carbon exchange in terrestrial ecosystems, 38, 213, 222 projections/vulnerability, 38, 792-793 Carbon dioxide (CO<sub>2</sub>)\* draw-down by oceans, 658, 662 effects on plant growth, 40, 54, 220, 225, 240, 276, 282-283, 285-287, 290, 300, 824 effects on soil water balance, 225 free-air CO<sub>2</sub> enrichment (FACE) experiments, 40, 276, 282.300 freshwater resources and, 184-185, 187 pollen production and, 632 projected global-scale impacts, 824, 825 projected levels in 2050, 825 projected levels in 2100, 213 scenarios, 34-35, 152-153, 158-160, 323, 799-802 stabilisation, crop production and, 284 stabilisation, global temperature response and, 158-159 stabilisation scenarios, 35, 77, 799-802 stabilisation targets, 799-802 See also Carbon dioxide fertilisation; Greenhouse gases (GHGs) Carbon dioxide fertilisation\*, 214, 220-221, 223, 228, 241 effects on food production, 54, 479-480 Carbon flux, 38, 213, 222, 552, 792, 795 in Arctic terrestrial ecosystems, 662, 665, 667-668 in Southern Ocean, 662 Carbon sequestration\*, 213, 219-222, 241 adaptation and mitigation decisions, 752, 758 by forests, 106, 214, 227-228, 552 by oceans, 234 tipping points for, 241

See also Carbon sinks Carbon sinks, 220, 237, 792-793, 795 in the Arctic, 662, 665, 667 global carbon stores, 214 potential reversal of, 38, 213, 222, 792 vulnerability of, 283 Carbon stocks, 213, 214, 220-221, 227-228, 552, 792-793 **Carbonate ion**, 234 Cardio-respiratory diseases, 43, 418 Cardiovascular diseases, 394, 402, 487 **Caribbean region** adaptation, 728, 732 climate, 691-692 coral reefs, 94, 235, 242, 321, 330 dengue fever, 701 hurricanes, 54, 692, 701 Organisation of Eastern Caribbean States (OECS), 690, 703 respiratory disease, 109 sea-level rise, 692 tourism, 336 urban indicators, 363 See also Small islands Caribou, 666, 668 Carrion's disease (Bartonella bacilliformis), 587 Catchments\*, 89, 90, 177, 184, 188 in Asia, 483 in Australia/New Zealand region, 516, 517, 524, 525, 528 in Europe, 550, 553 in Latin America, 593 modelling, 90, 181, 182, 201-202 in polar regions, 663 in small islands, 697, 708 See also River basins Cattle. See Livestock Cattle tick (Boophilus microplus), 283, 520 CCIAV (Climate change impact, adaptation and vulnerability) assessment, 31-35, 133-171 approaches, 135-141 conclusions and future directions, 161-162 coping ranges, 142-143 data needs for, 144 frameworks for, 136 future characterisations, 32-35, 135, 144-161 impact assessment, 136-137 integrated assessment, 136, 137, 139 methods. 31-35. 133-171 non-climate factors, 135 policy-based approach, 136 risk management, 135, 139-141 stakeholder involvement, 31-32, 135, 141-142 top-down vs. bottom-up approaches, 136 uncertainty management, 141 uncertainty/risk communication, 143-144 vulnerability assessment, 136, 137, 138-139 See also Adaptation assessment; specific approaches CDM. See Clean Development Mechanism\*

Central America. See Latin America

Cereal grains. See Grain crops Cerebral infarction/ischemia, 487 Chacaltaya glacier, Bolivia, 87 Chagas' disease\*, 601 Child mortality, 394, 401 China crop yields, projected, 297 deltas and coastal ecosystems, 64, 484-485, 493, 496 floods, 398, 484-485 groundwater salinisation, 483 heat watch and warning systems, 491 Huanghe River, 179, 319, 326, 485 human health, 398, 405, 414, 487 migration, human, 488 Qinghai-Tibet Railway, 724 schistosomiasis in, 405 water demand, 284 water level in deltas, 484 See also Asia Cholera\*, 398, 401, 439, 478, 599, 701 in Asia, 50, 471, 478, 481, 487, 791 Ciguatera fish poisoning, 400, 449, 701 Cities. See Urban settlements Clean Development Mechanism (CDM)\*, 248, 752, 753 Climate\* direct and indirect effects of, 362-363, 374 linkages with sustainable development, 818 See also Baseline/reference climate; Climate change; Climate variability; Detection and attribution Climate change\* definition. 27 direct and indirect drivers of, 816, 817 direct and indirect effects of, 359, 364, 374 as driver of ecosystem changes, 817 global cost estimates, 727 impacts (See Impacts. See also CCIAV assessment) multiple cause and stress context, 43, 75, 359 observed changes, 79-131 (See also specific systems and regions) perspectives on, 75-76, 811-841 positive and negative impacts of, 782 'reasons for concern,' 73-76, 781, 795-797, 800 regional (See Regional climate change) research needs, 77-78 reversible vs. irreversible, 785 summary of main findings, 25 sustainability and, 75-76, 811-841 vulnerabilities and risk from, 779-810 See also Anthropogenic climate change; Baseline/reference climate; Detection and attribution; Global warming; specific regions and ecosystems Climate change commitment\*, 748, 827 Climate change impact, adaptation and vulnerability assessment. See CCIAV assessment Climate change scenarios. See Scenarios; SRES scenarios Climate envelope modelling, 239-240, 241 Climate extremes. See Extreme weather events; specific climate conditions

Climate forecasting, 53, 416, 721, 727-728 Climate impacts. See Impacts, of climate change Climate impact assessment. See Impact assessment Climate models\*, 29, 32-33, 139, 148 AOGCMs, 32-33, 149-151 climate envelope modelling, 239-240, 241 Computable general equilibrium (CGE) model, 337 Earth System Models of Intermediate Complexity, 139 ensemble models, 77, 800 perturbed parameter ensemble, 800 See also Future characterisations Climate policy, 31, 766-769 adaptation/mitigation inter-relationships in, 747, 760-763 implementation, 747, 766-769 introduction, 748-750 mainstreaming, 31, 768, 818 methods in vulnerability assessment, 800 national, sub-national and local scales, 769 portfolio, 71-72, 76, 747, 749, 760-763, 813, 827 regional scale, 767-769 sustainable development and, 747, 751, 765-766 See also Adaptation; Adaptation and mitigation interrelationships; Mitigation **Climate prediction\*** ENSO-based, 591 indigenous knowledge in weather forecasting, 456-457 in Latin America, 53, 591-592, 604 limits on usefulness, 604 seasonal climate forecasting, 416, 721, 727-728 Climate projection\*, 31-35, 133-171 See also Scenarios; SRES scenarios Climate scenarios\*, 148-152, 155 See also Scenarios; SRES scenarios Climate sensitivity\*, 161, 758, 800-801 uncertainties in, 799 See also Sensitivity; specific regions Climate system\* dangerous anthropogenic interference with, 781, 782, 784, 798, 799, 801-802, 804 global, impacts of changes in polar regions, 655, 660, 661-662, 667-668 Climate thresholds\*, 37, 76, 781, 784-785, 802-803 systemic thresholds, 784, 802 See also Thresholds Climate variability\*, 38, 84, 86, 107 adaptation to, 111 in Africa, 435, 436-437, 439, 448, 454 in Asia, 471, 472-478, 475, 479 in Australia/New Zealand region, 510-512 biodiversity and, 103 in coastal systems, 92, 93 in Europe, 547, 550, 555 impacts on disturbance regimes, 38 in Latin America, 54, 583, 586, 591 modes of, 84, 794-795 in North America, 55, 626 in polar regions, 660, 671

projections of, 152

in small islands, 693, 708, 710 sustainable development and, 384 See also El Niño Southern Oscillation (ENSO); Extreme weather events; Indian Ocean Dipole (IOD); Interdecadal Pacific Oscillation (IPO); Modes of climate variability; North Atlantic Oscillation (NAO); Northern Annular Mode; Pacific Decadal Oscillation (PDO); Southern Annular Mode Cloud forests, 48, 230, 244, 439, 596, 700 CO<sub>2</sub> fertilisation. See Carbon dioxide fertilisation Coastal squeeze\*, 623, 630 Coastal systems and low-lying areas, 40-41, 45-46, 315-356 adaptation, 40-41, 317, 339-345, 491, 559, 719, 795 adaptive capacity, 317, 318-322, 324-336, 344, 786 agriculture, forestry and fisheries, 333 assumptions about future trends, 322-324 beaches, rocky shorelines and cliffed coasts, 324-326 biodiversity, 335 climate and sea-level scenarios, 322-324 climate change factors, 318 climate drivers, 323 coastal processes and zones, 92-94 coral reefs, 317, 320, 321-322, 330 costs and socio-economic aspects, 40, 317, 336-339 current sensitivity/vulnerability, 318-322 deltas, 40, 41, 317, 326-328, 327, 332, 484 El Niño Southern Oscillation (ENSO) and, 319, 623 erosion, 81, 92, 93, 317, 320, 324-326, 328, 338, 477, 484, 558,630 estuaries and lagoons, 328 exposure, 362, 372 external terrestrial and marine influences, 319-320 extreme events, lessons from, 340 extreme water level simulations, 325 freshwater resources, 179, 317, 331 future impacts and vulnerabilities, 40-41, 45-46, 324-336, 374, 795, 813, 828 geomorphology, 92 as high-risk areas, 359, 364 human health and, 43, 334-335, 407, 414, 471 human impacts of climate change, 330-336 human population in, 40, 317, 318, 319, 323, 327, 346, 364, 372, 399, 414, 630 human settlements, infrastructure and migration, 81, 331, 333-334, 359, 791 human utilisation/development of, 40, 317, 319, 326 infrastructure, 372, 619, 690 Integrated Coastal Zone Management (ICZM), 340-341, 491 interaction of natural and human sub-systems, 318 introduction. 318 inundation, 40, 64, 317, 320, 325, 333, 484, 813 mangroves, saltmarshes and sea grasses, 92, 328-330 multiple stresses, 40, 317, 336 natural systems, 318-319, 324-330 observed changes, 28, 40, 92-94, 115, 320 recreation and tourism, 320, 335-336 regional differences, 331, 336

sea-level rise and, 35, 40, 41, 81, 92, 317, 322-324, 325, 326, 336, 339, 346, 372, 414, 520, 630 socio-economic aspects, 317, 322, 323, 330-339, 331 sustainable development, 345 thermal stratification, 235 thresholds, 320, 321-322 uncertainties and research priorities, 345-347 vulnerabilities, risks and hotspots, 40-41, 317, 318-322, 336, 337, 399, 796 water management, 759 wetlands, 40, 92, 93, 317, 328-330 See also specific regions and countries Coccolithophores\*, 222, 658 **Coconuts**, 333, 450 Cod, 669, 670 Coffee growing/production, 597, 731 Cold-related mortality, 51, 108, 393, 407, 408, 411, 418, 557 Cold-waves, 375, 397-398 Colorado River basin, 193-194, 197, 627, 634 Columbia River basin, 627, 628, 633, 818-819 **Commitment to warming**, 827 Committed to extinction\*, 241, 242-245, 553, 630, 792 See also Ecosystems; Extinction; Extirpation Communicable diseases\*. See Infectious diseases Communication of uncertainty/risk, 143-144, 380, 735 Confederation Bridge, Canada, 65, 719, 724 Confidence\*, 27, 141, 786 See also Uncertainty; specific topics and executive summaries Conflicts and war, 442-443, 447, 451, 459 **Conservation.** 38 in Asia, 495 of coral reefs, 485 in Europe, 52, 544, 559, 560 in Latin America, 592, 602 of mangrove forests, 492 Construction, 367, 379, 635 See also Infrastructure Context, 359, 635 human systems, 361, 366, 374 multi-stress/multi-cause, 43, 75 Control run\*, 187 Convention on Biological Diversity (CBD), 246, 247-248, 495,769 **Convention on International Trade of Endangered Fauna** and Flora (CITES), 495 **Convention to Combat Desertification (CCD)**, 495 Copepods, 96 Coping ranges, 142-143 See also Adaptation; Vulnerability Coral atolls, 40, 697-698, 705, 707 See also Small islands Coral bleaching\*, 216, 235, 317, 321-322, 330, 512, 518, 527 El Niño Southern Oscillation (ENSO) and, 319, 321, 330, 439 observed changes, 94, 235, 439, 477 projected changes, 40, 57-58, 800 recovery time from, 527

sea surface temperature and, 94, 235, 321-322 thresholds, 485 Coral reefs\*, 235, 320, 321-322, 330, 512 adaptation potential, 235 in Asia, 49, 471, 472, 477, 485, 486 'crown-of-thorns' starfish, 439 ecosystems, 94, 214, 234, 235, 292, 477-478 endangerment status, 235 Great Barrier Reef, 242, 320, 509, 512, 518, 527 habitat and processes, 235 in Latin America, 590 non-climate-change threats, 699 observed changes, 28, 94, 235, 439, 477, 512, 816 ocean acidification and, 38, 94, 235, 793 pathogens, 590 projected changes, 40, 57-58, 471, 485, 518, 792 vulnerability/risk, 40, 216, 235, 240, 518, 730 white band disease (WBD), 590 See also Coral bleaching Corals\*, 213, 214, 235 calcification of, 235 cold-water, 213, 234, 236, 658, 793 ocean acidification and, 213, 234, 658 vulnerability/risk, 235, 240 See also Coral bleaching; Coral reefs Cost-benefit analyses (CBAs), 800, 802-803 in adaptation and mitigation, 747, 754, 756, 757 Cost-effectiveness analyses (CBEs), 755, 800, 803 COST725 project, 112, 113 Costs, 64-65, 78 adaptation (See Adaptation costs and benefits) aggregate, global, 64-65 of climate change, 65, 756, 771, 813, 821-824, 822 coastal systems, adaptation, 40, 317, 336-339, 345 computable general equilibrium (CGE) model, 337 cost estimates, 337, 359 ecosystem goods and services, 245-246 extreme weather events, Asia, 489 extreme weather events, Australia/New Zealand region, 50, 511, 513 extreme weather events, Europe, 362 extreme weather events, North America, 55, 332, 338, 369, 619, 621, 626 food, fibre and forest products, 296-297, 301 freshwater resources/management, 190-196 human health, 415 human vs. monetary, 365 industry, settlement and society, 362, 365, 376-379 methods and tools for characterising, 337 mitigation costs and benefits, 749, 756-757, 802 post-event impacts, 338 schematic overview of inter-relationships, 748 social cost of carbon, 65, 756, 771, 813, 821-824 tourism losses, 626 Crab, 669 Crop diversification, 624 Crop yields, 38, 282-285, 300, 413, 791 in Africa, 48, 297, 435, 448

in Asia, 49, 106, 297, 471, 479-481 in Australia/New Zealand region, 518, 519 carbon dioxide effects on, 38, 40, 54, 276, 282-283, 284, 300.824 climate extremes and, 284 damage avoidance, 295 in Europe, 548-549, 554-555 in Latin America, 597 in North America, 624, 631 ozone effects, 278 temperature and, 49, 275, 282-283, 284-285, 286, 295, 300, 301 See also Agriculture; Crops Crops, 275, 276, 283-285 adaptation strategies, 70, 294-295, 452, 721, 725-726 in Australia/New Zealand region, 518-519 bioenergy/biofuels, 288, 544, 555, 635, 758 biotechnology and, 296 El Niño Southern Oscillation (ENSO) effects, 277 in Europe, 52, 554-555 extreme events and, 277, 277, 278 genetic modification, 296 globalisation and, 730, 731 industrial, 288 mid- to high-latitude, 275, 276, 286, 296, 297, 300 in North America, 624, 635, 636 observed changes, 104-106 pests (See Insect pests) rain-red, 48, 50, 280, 448, 480 in small islands, 700 threshold responses, 277 varieties and planting times, 295, 452, 721, 725 See also Agriculture; Crop yields; Grain crops; specific crops 'Crown-of-thorns' starfish, 439 Crustacea. 291 Cryosphere\* future impacts, 184, 551, 558, 565 global impacts of changes in, 56-57, 655, 660, 661-662, 667-668 observed changes, 28, 81, 85-90, 115 observed trends, 177, 543, 546 See also Polar regions; specific components of cryosphere Cryptogams\*, 230 Cryptosporidium, 189, 398, 487, 671, 701 Culex mosquito, 625 Culicoides imicola, 555 Cutaneous leishmaniasis, 403, 587, 599 Cyclones. See Extra-tropical cyclones; Tropical cyclones

## D

Damages avoided, 77-78, 295, 754-760, 798-803 Dams, 181, 493, 768-769 impact on river sediments, 317, 319, 493 Dangerous anthropogenic interference, 781, 782, 784, 798, 799, 804 temperature threshold for, 801-802 *See also* Vulnerability assessment Deaths. See Mortality Decision analysis, 31, 752-753 Decision-making, 735-736, 750, 752-754 in adaptation and mitigation, 72, 747, 750, 752-760, 832-836 nature of decision problem, 752-753 participatory processes, 813, 832-834 support mechanisms, 813, 836 Deer Island sewage facility, U.S., 724 Deforestation\*, 216, 229-230, 281, 299, 757 in Africa, 442 in Latin America, 53, 583, 590, 594-595, 604, 606 Deltas, 40, 41, 317, 326-328, 327, 332, 484 See also Ganges-Brahmaputra delta; Megadeltas Dengue fever\*, 393, 403-404, 408, 410 in Asia, 478, 487 in Australia/New Zealand region, 408, 410, 524 climate-related factors and, 478 in Latin America, 404, 586, 591, 593, 599 in small islands, 689, 701 Dermatosis, 487 Desalination, 181, 525, 559, 689, 697, 759 Desertification\*, 767 in Africa, 439, 442 in Asia, 472, 486 Deserts\*, 222-224, 472 amelioration of, 223, 237, 238 carbon stocks, 214 Detection and attribution\*, 28, 29, 79-131, 781 confidence. 85 definitions/terminology, 83 joint attribution, 83, 112-116 larger-scale aggregation and attribution, 82, 112-116 linking climate-change causes with observed effects, 29 methods, 83-85 regions and systems, observed changes in, 85-116 research needs, 78, 117 summary, 81-82 synthesis of studies, 114-116 See also Climate change; Joint attribution; Observed changes and responses **Developed countries** adaptation deficits/challenges, 43, 55, 69, 397 energy use, 827 sea-level rise, costs of, 339, 339 vulnerabilities, 781, 792 water quality problems, 179 See also specific countries **Developing countries** adaptive capacity, 40 aggregate impacts, equity issues and, 821 agricultural adaptation, 726 agriculture, 279, 281-282 coastal area impacts/costs, 40, 317, 331, 336, 339 energy use, 827 human health impacts, 43 impacts/vulnerabilities in, 781, 784, 796 natural disaster-related deaths in, 373

per capita CO<sub>2</sub> emissions in, 826 sea-level rise, costs of, 339, 339 water quality problems, 179, 189 See also specific countries Development, 75-76 adaptive capacity and, 276, 279, 620, 719, 755, 767 CDM (Clean Development Mechanism), 248, 752, 753 climate-related vulnerabilities and, 813 as driver of water use, 182 environmental quality and, 76, 819-820, 835 equity issues, 494-495, 813, 826-827 linkages with adaptive capacity, 817-819 mainstreaming adaptation and, 832, 832-836 participatory processes, 813, 832-834 paths, 75, 494-495, 764-766, 771, 817-818 sustainable (See Sustainable development) syndromes/categories, 819 See also Sustainable development; specific regions **DGVMs.** See Dynamic Global Vegetation Models Diadromous\* fish species, 39, 275, 291, 300 Dialogue on Water and Climate (DWC), 197, 197 Diarrhoeal diseases, 43, 189, 393, 401, 410 in Africa, 437, 441 in Asia, 50, 471, 478, 481, 487 in Australia/New Zealand region, 524 flood-related, 399 morbidity/mortality from, 50, 471, 478, 481 projections, 407, 418 in small islands, 689, 701 water quality and, 335 Dimethyl sulphide (DMS), 222 Disasters, 109-111, 393 in Africa, 442-443, 447, 451, 459 costs in Australia/New Zealand region, 511 costs in North America, 626 disaster risk management/reduction, 813, 820-821 gender and, 398 mental disorders and, 399 observed changes, 109-111 preparedness programs, 492 See also Extreme weather events; specific disasters Discount rate\*, 65, 813, 822 Diseases, 43, 393-394, 403-405, 418 air quality and, 401-402 cold-related, 671 monitoring of, 43, 491 mosquito-borne, 400, 524, 625 (See also Malaria) non-communicable, 394 observed changes, 82, 107-109 rodent-borne, 404 tick-borne (See Tick-borne diseases) vector-borne (See Vector-borne diseases) water and, 400-401 water-borne (See Water-borne diseases) zoonotic, 625, 671 See also Human health; Infectious diseases; specific diseases Disturbance regimes\*, 37, 213, 214-215, 216

#### Index

in Africa, 439 climate variability and, 38 in North America, 56, 619, 620, 623, 631 projected changed, 38, 792 See also Fires; Insects Downscaling\*, 135, 148, 250-251, 594 Drosophila melanogaster, 104, 512 Droughts\*, 175, 186-187 adaptation, 70, 722 in Africa, 237, 278, 287, 437, 734 in Asia, 473, 476 in Australia/New Zealand region, 50, 509, 510-511, 511, 515, 519 current sensitivity/vulnerability, 177-178 extreme events, 187, 188, 789 human health impacts, 399-400 in Latin America, 400, 586 in North America, 619, 622, 623, 624, 625, 626 observed changes, 89, 90, 177 projected impacts and interactions, 42, 51, 375, 789 in small islands, 698 types of, 186-187 vulnerability/risk, 35, 74, 789 See also Extreme weather events Dust-related diseases/health effects, 108, 109, 400, 402, 439 Dykes\*, 457, 548, 559, 640 Dynamic Global Vegetation Models (DGVMs)\*, 219, 220, 222, 240, 241

#### Е

Early warning systems, 53, 417, 491, 544, 563, 591, 604 See also Extreme weather events; Heatwaves Earth System Models of Intermediate Complexity, 139 East Timor (Timor Lest), 706 Ecological communities\*, 103, 104, 214 See also Ecosystems Ecological corridors\*, 54, 525, 560, 583, 592, 769 Ecological surprises, 38, 242 **Economies** in Africa, 440-441, 454 in Europe, 52-53, 543-544, 545 in Latin America, 595-596 in North America, 627 in polar regions, 56, 655, 661, 665-666, 668, 676 of resource-dependent communities, 625 in small islands, 57, 695, 698, 701-702 See also Market impacts; Socio-economic impacts; specific regions Ecophysiological process\*, 240 Ecosystem approach\*, 246-248 Ecosystem services\*, 213, 215, 245-246 Ecosystems\*, 37-38, 44-45, 211-272 adaption and acclimation, 38, 213, 246-248 adaptive capacity, 52, 658-660 areal extent, 214 assumptions about future trends, 218-219 costs/valuation of goods and services, 245-246 cross-biome impacts, 237-239

current sensitivities, 213, 215-218 drivers of change, 213, 215-218, 219, 817 future impacts and vulnerabilities, 37-38, 213-214, 219-245, 792, 795-796 goods and services, 213, 215, 245-246 impacts, global synthesis of, 213-214, 239-245 introduction, 214-215 key issues, 215 management, 246-248 modelling, 218-219, 239-240, 250-251 multiple stresses, 213, 215, 241, 246-247 projected impacts, 37-38, 44-45, 213, 238, 240, 242-245, 828 resilience, exceedence projections, 37 scales and time lags, 214, 215, 547 sustainable development, 248-249 thresholds, 37, 215, 785, 802 uncertainties and research priorities, 249-250 vulnerability/risk, 37-38, 240, 788-789, 792, 795-796 See also Biodiversity; Extinction; Extirpation; specific ecosystems and regions Ecotone\*, 216, 228, 233, 237 Egypt, 339, 445, 448, 452, 485 El Niño Southern Oscillation (ENSO)\* agriculture effects, 277 in Asia, 473, 475, 477 in Australia/New Zealand region, 510, 521 coral bleaching and, 319, 321, 330 definition, 292 fisheries and, 292 forecasting and responses to, 591, 721 in Latin America, 585, 586, 591 malaria and, 404 marine ecosystems and, 95, 101 in North America, 623, 627, 630 projected changes and impacts, 794 in small islands, 689, 690, 691, 692 See also Modes of climate variability **Elderly population** disproportionate impacts of climate/weather events, 363, 399.730 mortality from extreme weather events, 362, 563 vulnerability of, 43, 64, 393, 399, 557, 791 Emigration. See Migration Emissions scenarios\*, 155, 529, 758 Encephalitis, 625 Endemic\* species, 213, 216, 230, 241, 583 vulnerability/risk, 38, 54, 786 See also Biodiversity Energy adaptation, 379 adaptation costs and benefits, 725, 726 in adaptation/mitigation decisions, 759, 760, 767-768 clean development, 248, 418-419, 752, 753, 835 future impacts and vulnerabilities, 36, 366-367, 371, 790 global cost estimates, 727 production, 193, 363, 367 vulnerability/risk, 790

See also Biofuels; Energy use/demand; Hydropower generation; Wind Energy use/demand in Africa, 442, 446, 459, 767-769 in Asia, 111, 488-489 in Australia/New Zealand region, 511, 516, 523-524 in Europe, 52-53, 543, 545, 548, 556, 561, 565 in North America, 367, 626, 633, 634-635 observed changes, 111 in small islands, 702 Ensemble\* models, 77, 800 **ENSO.** See El Niño Southern Oscillation (ENSO) **Environmental Impact Assessment (EIA)**, 724 Environmental quality, 76, 361-362, 365, 819-820, 835 Epidemics\*, 399-400, 404-405, 415-416 in Africa, 406, 438, 446, 447 in Latin America, 586 Equity issues, 76, 494-495, 784, 786, 813, 826-827, 835 **Erosion\*** in Australia/New Zealand region, 511, 520-521, 522 of beaches, 92, 318, 511, 520, 522 in coastal systems, 92, 93, 317, 320, 324-326, 328, 338, 623,630 in North America, 623, 630 soil, 179, 189-190, 558 Estuaries, 328 in Africa, 450 in Asia, 485 in Australia/New Zealand region, 517 salinisation of, 175, 179, 189 Europe, 51-53, 60-61, 541-580 adaptation and adaptive capacity, 52, 53, 117, 543, 544, 547, 559-562, 722, 724 agriculture and fisheries, 52, 543, 545-546, 548-549, 554-556, 558, 560-561, 565 assumptions about future trends, 547-549 biodiversity, 52, 543, 553-554, 558, 560, 565 biofuel use in, 299 case studies, 562-563 climate, 544, 545 climate projections, 51-52, 547-548 coastal and marine systems, 51, 543, 550-551, 558, 559, 565 COST725 project, 112, 113 cryosphere, 546 current sensitivity/vulnerability, 544, 545-547 economy/economic impacts, 52-53, 543-544, 545 ecosystem impacts, 243-244, 543, 546, 553-554 energy and transport, 52-53, 543, 545, 548, 556, 561, 565 European Alps, 28, 53, 102, 216, 546, 548, 551-552, 557 European Biomass Action Plan, 299 extreme events, 544, 548 fires, 51, 543, 552, 558 flood and drought risk, 51, 187, 188, 543, 550, 558 flood defenses, 333, 417, 559, 562 food and fibre products, 545 forests, shrublands and grasslands, 52, 106-107, 543, 545, 549, 552-553, 559-560, 565

future impacts and vulnerabilities, 51-53, 60-61, 549-558, 565,825,829 glaciers, 28, 52, 543, 549-550, 551, 558 greenhouse gas emissions, 545, 769-770 growing season, 99 heatwave of Summer 2003, 51, 217, 362, 397, 562-563 heatwaves, 544, 557, 733 human health, 51, 395, 403, 409, 543, 546, 557-558, 562, 565 human population, 545, 548 insurance/property insurance, 557, 561-562, 565, 723 introduction, 544 land use, 548-549 mitigation policy, 767, 769-770 mountains and sub-Arctic regions, 543, 551-552, 559, 565 natural resources, 51-52 observed changes, 30, 51, 92, 99-100, 115-116, 543, 546 phenology, 51-52, 99-100, 101, 113, 546, 551, 552, 553, 558 precipitation, 151, 545, 547 sea-level rise, 51, 52, 346, 543, 551, 554 socio-economic development, 548 sustainable development, 546-547, 563-564 temperature, 150, 545, 547 thermohaline circulation and, 563 tourism and recreation, 53, 336, 556-557, 561, 565 uncertainties and research priorities, 564, 566 urban indicators, 363 urbanisation in, 549, 550 water resources, 52, 543, 545, 549-550, 557, 558, 559, 560.565 water stress, 52, 543, 550, 552, 559 wetlands and aquatic ecosystems, 92, 543, 551, 553, 560, 565 windstorms/wind speed, 489, 547-548, 557 Eustatic sea-level rise. See Sea-level rise See also specific countries **Eutrophication\*** in Asia, 485 in Australia/New Zealand region, 517 in Europe, 551, 553, 558, 565 Evaporation\*, 55, 84, 89, 91, 300 Evapotranspiration\*, 64, 84, 91, 177, 184-186, 232 carbon dioxide enrichment and, 184-185 in mountain regions, 232-233 in North America, 621 observed trends, 177 Evolutionary processes, 104, 403 Exotic species. See Invasive species and invasive alien species (IAS) Exposure, 43, 791, 814, 821 Exposure unit, 141 Externalities\*, 69, 382, 719, 771 Extinction\*, 38, 213, 215, 241-242 in Africa, 48 of amphibians, 103, 230, 233, 586, 590 in Asia, 49, 471, 485-486 in Australia/New Zealand region, 517, 528

'committed to extinction,' 241, 242-245, 553, 630, 792 in Europe, 553 of fish, 39-40, 275, 291, 300 in freshwater ecosystems, 192, 193 irreversible impacts of, 213 in Latin America, 54, 586, 590, 596 in North America, 55, 630, 631 observed changes, 103 projected changes, 38, 213 See also Butterflies; Extirpation Extirpation\*, 226, 228, 247, 485 See also Extinction Extra-tropical cyclones, 109-110, 317, 324, 623, 627, 692 Extreme weather events\*, 41, 64, 68, 73-75 adaptation, 721, 723, 798 in Africa, 377, 437, 444 agriculture/livestock impacts, 275, 277, 277, 278 analogues, 146 in Asia, 473, 476, 479, 488, 489 in Australia/New Zealand region, 50, 509, 511 coastal systems, lessons from, 340 costs of, 55, 332, 338, 362, 489, 511, 513, 619, 621, 626, 630 in Europe, 362 food, fibre and forest products and, 275, 283, 284, 298, 299 gender-related differences in impacts, 398, 730 human health and, 338, 393, 418, 635 increase in frequency/intensity, 38, 109-111, 283, 359, 372, 473, 781, 796 industry, settlement and society and, 41, 359, 362, 369, 372, 377 infrastructure and, 625-626 in Latin America, 53, 583, 585, 594 megadeltas, vulnerabilities to, 377 mortality from, 393, 394 in North America, 332, 338, 619, 621, 625-626, 632-633 projected impacts and interactions, 38, 68, 375, 413 scenarios, 148-152 in small islands, 695 vulnerability/risk, 41, 64, 73-75, 781, 789, 795, 796 See also Climate variability; Droughts; Extra-tropical cyclones; Fires; Floods; Heatwaves; Hurricanes

# F

FACE experiments, 40, 276, 282, 300
Fagus sylvatica, 107, 232
Farming. See Agriculture; Crops; Crop yields; Grain crops; Livestock
Feedbacks\*
biotic, 219-222
carbon cycle, 792-793
cascading, in freshwater systems, 655, 660
from changes in polar regions, 56-57, 655, 660, 661-662, 667-668
Fiji, 695, 705
Filariasis, 689, 701
Financial sector, 721, 723

See also Insurance Fires, 229, 275, 290, 299, 300 in Africa, 435, 442 in Asia, 471, 472, 477-478, 486 in Australia/New Zealand region, 50, 509, 511, 517 carbon emission from, 107 controlled/prescribed burning, 247, 560 ecosystem effects, 217-218 in Europe, 51, 552, 558 fire-dependent biomes, 215 fire suppression, 218 in Latin America, 53, 596, 600 modelling, 290 in North America, 56, 619, 620, 621, 623, 631, 636 observed changes, 107 in peatlands, 477-478 projected changes, 38, 789, 792, 795 vulnerability/risk, 789, 792, 795 See also Disturbance regimes Fish. 236 biogeography, 95 distribution of species, 28, 233-234, 659 extinction, risk of, 631 extinctions at edges of ranges, 39-40, 275, 291, 300 growth, effect of temperature on, 291 migration, 98, 333 North America, 624, 629, 631-632 observed changes, 81, 95, 97 parasites, 292 in polar regions, 665, 669 projected changes, 49 salmon, 192-193, 275, 291, 624, 629 sea ice reduction and, 236 sturgeon, 275, 291 trout, 291, 665 tuna, 292, 482, 700 See also Fisheries Fisheries, 39-40, 275, 276-277, 291-292, 302 adaptation, 300 in Africa, 281, 435, 448, 449, 450 in Asia, 49, 279, 281, 471, 482, 489 Atlantic cod, 670 in Australia/New Zealand region, 512, 521 in coastal areas, 333 decadal variability and extremes, 292 economic impacts, 292, 790 in Europe, 52, 543, 545-546, 555-556, 561, 565 fin-fish, 669 globalisation and, 719, 730 importance of, 276 in Latin America, 281, 584, 587, 590, 593, 603 meridional overturning circulation and, 275, 292 multiple stresses, 279 in North America, 620, 624, 629, 631-632 observed changes, 81, 97, 816 pathogens/parasites, 292 in polar regions, 49, 291, 655, 659, 665, 669, 676 production, global, 291

projected changes, 39-40 in small islands, 57-58, 689, 700 supply and demand, 281 sustainability, 276 wild-capture, 281, 291-292 See also Fish Floods, 175, 186-187, 414 adaptation/defences, 70, 381, 517, 722, 724, 725 in Africa, 377, 398, 414, 435, 437, 447 in Asia, 398, 414, 471, 472, 476, 489 in Australia/New Zealand region, 517 coastal settlement and, 40, 64, 317, 331, 333-334, 484, 813 costs, 338 current sensitivity/vulnerability, 178 in Europe, 51, 187, 188, 550 extreme events, 109, 511, 789 flash floods, 51, 187, 789 future frequency of "100-year" floods, 372, 550, 633, 636 human health impacts, 398-399 Hurricane Katrina flood depths, 360, 414 insurance, 369, 377 in Latin America, 398, 586, 588 in North America, 55, 620, 626, 630, 633 observed changes, 89, 90, 177 projected impacts and interactions, 35, 196, 375, 789 river floods, 109 types of, 186 vulnerability/risk, 35, 789, 824 See also Extreme weather events Fluoride in groundwater, 179 Food-borne illnesses, 108, 109, 625, 701 See also Diseases; Human health Food chain\*, 81, 279, 291-292, 793 Food, fibre and forest products, 38-40, 45, 273-313 adaptation, 38-39, 275, 294-296, 300 adaptive capacity, 275, 279-280 air pollutants and UV-B radiation, 278 aquaculture, 276-277 assumptions about future trends, 280-282 biotechnology, 296 capacity building, 296 carbon dioxide effects on, 276, 282-284, 285-287, 290, 300 carbon pools, 283 climate and, 280 conclusions/summary, 275-276, 299-303 costs and socio-economic aspects, 296-299, 301 current sensitivity/vulnerability, 277-280 extreme events, 38, 275, 283, 284, 298, 299 fisheries, 39-40, 275, 276-277, 291-292 food-crop farming, 276, 283-285 food security (See Food security) forestry, 39, 275, 276, 283-285, 288-291, 301 future impacts and vulnerabilities, 38-40, 45, 275, 282-294,828 importance of, 276 industrial crops and biofuels, 288 introduction, 276-277

methods, 277 multiple stresses, 277-278, 279, 290 pastures and livestock production, 285-288, 301 subsistence and smallholder agriculture, 275, 279, 281-282, 293-294 supply and demand balance, 280-282 sustainable development, 276, 299 temperature and, 282-283, 284-285, 286, 287-288, 301 threshold responses, 277 trade and, 40, 275, 276, 284, 297, 300 uncertainties and research priorities, 276, 285, 290, 299-303 weeds, insect pests and animal health, 283 See also Agriculture; Crops; Fisheries; Food security; Forestry Food poisoning, 400, 410, 701 ciguatera fish poisoning, 400, 449, 701 Food safety, 400 Food security\*, 297-298, 299, 300, 394, 399 in Africa, 48, 275, 280, 297, 300, 399, 435, 440, 454-456, 719 in Asia, 297, 399, 471, 479-481, 482-483 in Australia/New Zealand region, 528-529, 529 gender-related vulnerability, 719, 729, 730 human health and, 394, 399, 413-414 in Latin America, 602 major components of, 455 projected changed, 40, 48 in small islands, 689, 698-700 See also Food supply; Hunger Food-sharing, 728 Food supply, 482-483, 816 adaptation, 797 vulnerability/risk, 74, 781, 787, 802 See also Agriculture; Food security Food utilisation, 298 Food web\*, 97, 216, 236 marine, 234, 236, 239, 793 Forecast. See Climate prediction; Climate projection Forest fires, 229, 290, 299, 300 in Africa, 442 air pollutants from, 402 in Asia, 471, 486 attribution for increases in, 114 in North America, 31, 107, 620, 621, 623, 631 observed changes, 107, 114 See also Fires Forest products. See Food, fibre and forest products; Forestry Forestry, 38, 39, 276, 283-285, 288-291 adaptation and mitigation decisions, 758, 759 adaptation strategies, 295-296, 300 in Australia/New Zealand region, 50, 509, 520, 525, 529 costs of climate change, 297 El Niño Southern Oscillation (ENSO) effects, 277 FACE experiments, 40, 276, 300 future impacts, 39, 40, 288-291, 297, 790 importance of, 276 insect damage control, 295

International Tropical Timber Organization (ITTO), 495 modelling, 290 in North America, 620, 622, 624, 630, 636 observed changes, 81-82, 106-107 projected changes, 39, 40 socio-economic impacts, 291, 297 summary of impacts, 301, 302 supply and demand in, 281 timber productivity, 275, 289, 290, 300 trade and, 40, 275, 289, 297, 300 vulnerability/risk, 31, 82 See also Food, fibre and forest products Forests, 227-230, 238 in Africa, 299, 435, 439, 442 in Amazonia, 54, 218, 241, 243, 281, 594-595, 596 in Asia, 471, 472, 477-478, 481, 485-486, 488 biodiversity, 230 boreal, 217, 228, 276, 289, 485-486 bushfire threat to, 442 carbon dioxide effects on growth, 40, 220-221, 228, 282-283 carbon stocks, 106, 214, 227-228, 231-232, 792-793 cloud, 48, 230, 244, 439, 596, 700 coastal areas, 317, 329, 333 deforestation (See Deforestation) dependent communities, 736-737 drought effects, 228 ecosystems, 213, 227-230, 238 in Europe, 52, 106, 543, 545, 552, 559-560, 565 growing season, 81 hurricane-induced mortality, 700 insect infestations/damage, 218, 228, 619, 623, 624, 631 land-use change and, 229-230 in Latin America, 106, 584, 592, 594-595, 602 mangrove (See Mangrove forests) in North America, 106, 620, 622, 624, 630, 735-736 phenology, 31 (See also Phenology) productivity, 39, 52, 81-82, 106, 228, 297 rainforest, Australia/New Zealand region, 516, 516, 518 range/biome shifts, 229, 237, 241 replacement by savannas, 583, 596 in small islands, 689, 700 tropical (See Tropical forests) See also Deforestation; Forest fires; Forestry; Reforestation Fossil fuels, 672-673, 826 Free-air CO<sub>2</sub> enrichment (FACE) experiments, 40, 276, 282,300 Freshwater lens\*, 36, 186, 689, 697 Freshwater resources and management, 35-37, 44, 90-92, 173-210 adaptation and risk management, 36, 175, 196-200 adaptation limits, 199 assumptions about future trends, 180-182 climatic drivers, 180-181 costs and socio-economic aspects, 190-196 current sensitivity/vulnerability, 176-180 decision-making under uncertainty, 199-200

Dialogue on Water and Climate (DWC), 197 ecosystems, 28-31, 97-98, 213, 214, 233-234, 239, 789 erosion and sediment transport, 179, 189-190 feedbacks, 660 floods and droughts, 177, 178, 186-187, 188, 196 future impacts and vulnerabilities, 35-37, 44, 182-190, 233-234, 789 groundwater, 90, 177, 179, 185-186 impact of human activities, 175-176 infrastructure, 36, 175, 191 Integrated Water Resources Management (IWRM), 196-197,200 introduction, 175-176 management policies, 175, 724 net negative impact of climate change, 175, 191 nonclimatic drivers, 181-182, 194 observed changes, 90, 97-98, 115-116, 177 runoff, 36, 175, 177, 182-184 sea-level rise and, 35 surface waters, 90, 177, 177, 182-185 sustainable development, 200-201 uncertainties and research priorities, 175, 200, 201-202 vulnerability/risk, 182-190, 233-234, 789 water chemistry, 89, 91 water demand/availability, 175, 191-194, 196-200, 197 water quality, 178-179, 188-189 water stress, 179, 193-194 water temperature/structure, 31, 36, 81, 91, 175, 176 See also Water resources; specific regions **Frogs.** See Amphibians Frozen ground, 88, 115, 486 See also Permafrost Fruit bats (Pteropus spp.), 216 Functional extinction\*. See Committed to extinction Fur seals (Arctocephalus gazella), 660, 669 Fusarium, 586, 597 Future characterisations, 32-35, 77-78, 135, 144-161 analogues, 32, 145, 146 artificial experiments, 144-146, 145 climate model data, 32 comprehensiveness, 145 definitions, 145 large-scale singularities, 35, 135, 160 non-climate scenarios, 34-35 plausibility, 145 probabilistic futures, 35, 135, 145, 160-161 projections, 145 scenarios, 76, 77, 145, 146-160 sensitivity analysis, 32, 145, 146 storylines, 32, 145, 146, 147 See also CCIAV assessment; Scenarios

# G

Ganges-Brahmaputra delta, 64, 327, 485, 496 See also Megadeltas Gastrointestinal disease, 487 Gender differential risk perception, 737

differential vulnerability and adaptive capacity, 719, 729, 730 natural disasters and, 398 General Circulation Model (GCM). See Climate models Generalists\*, 229, 241 Geo-engineering, 797 Geographically-distributed impact models, 824-825, 836 Geophysical systems, 74, 782, 789, 792-795 Giardia spp., 487, 671 Glacial lake outburst floods (GLOFs), 86-88, 395, 414, 477 Glacial lakes, 69, 86, 88, 719, 721, 723 Glaciers\*, 83, 86-88 adaptation to glacial retreat/melt, 719, 721, 722, 723, 781 in Africa, 439, 440 in Arctic, 656, 661-662 in Asia, 49, 471, 472, 477, 481, 483-484, 487, 493, 494 attribution for glacial retreat, 114 Chacaltaya glacier, Bolivia, 87 in Europe, 28, 52, 543, 549-550, 551, 565 Himalayan glaciers, 49, 481, 483, 487, 493, 494 in Latin America, 87, 584, 589, 598 observed changes, 28, 83, 86-88, 114, 177, 589, 661-662 in polar regions, 656, 657, 661, 663, 674 runoff from, 28, 89, 184 sea-level rise and, 663 vulnerability/risk, 781, 788 water supply from, 184, 187, 483 See also Ice sheets Global mean annual temperature (GMAT) carbon dioxide stabilisation and, 158-159 modelling/scenarios, 34 projections, 783, 804 (See also Temperature projections) **Global mean temperature (GMT)** aggregate impacts of increases in, 73, 781, 796-797, 803-804, 821-825 key vulnerabilities/risks from increases in, 73-76, 781, 787-789, 803-804 thresholds, 803 See also Scenarios; Temperature; Temperature impacts; Temperature projections **Global warming** commitment to, 827 global impacts of cryosphere changes, 655, 660, 661-662, 667-668 impacts of additional degrees of warming (See Temperature impacts) impacts of delay in addressing, 782, 802, 804 probability of exceeding 2°C above pre-industrial level, 801 risk-management timeline, 140 summary of future impacts, 44-47, 59-63, 66-68 summary of observed impacts, 26-31 See also Climate change; Scenarios; Temperature; Temperature impacts; Temperature projections Globalisation\*, 719, 730 adaptation and, 278, 729, 730, 797 in Africa, 440-441 food supply and, 482

in India, 719, 729, 730 in small islands, 693, 707 sustainable development and, 819 Governance/government interactions with social/cultural systems, 375 local, climate change adaptation and, 382 new global governance structures, 383 participatory, 834 scenarios, 364 **Grain crops** in Africa, 448 in Asia, 475, 479-481, 481 in Australia/New Zealand region, 518 cereal grains, 38, 275, 285, 286, 297-298, 302 El Niño Southern Oscillation (ENSO) effects, 277 in Europe, 545 in Latin America, 597 in North America, 624 projected changes, 38 sensitivity to climate change, 39 temperature and, 285, 286, 297 See also Agriculture; Crop yields; Food, fibre and forest products; specific crops Grasslands, 224-226, 285-288 in Africa, 435, 439, 449 in Asia, 483, 486 carbon dioxide effects on, 220, 225 carbon stocks, 214 in Europe, 549, 553, 560, 565 temperature impacts, 288 wildlife, 226 See also Rangelands; Savannas Great Barrier Reef, 50, 242, 320, 509, 512, 518, 527 See also Coral bleaching; Coral reefs; Corals Great Lakes, North America, 56, 619, 627-629, 628, 634 Greenhouse effect\*, 526, 605 Greenhouse gases (GHGs)\* in Asia, 479, 489, 495 in Australia/New Zealand region, 510 climate change commitment from, 748 comparison between, 823 costs and damages avoided, 756-757 emissions goals, 748, 753 emissions in developing countries, 826 in Europe, 545, 769-770 mitigation scenarios, 35, 76, 139-141, 158-160, 755-757, 799-802 in North America, 620 overshoot scenarios, 801-802, 804 in polar regions, 655, 662, 667, 672 potential release from permafrost, 88, 213, 231, 661, 662 risks of delay in mitigation, 782, 802 social cost of, 813, 821-824 stabilisation scenarios, 35, 71, 529, 758, 765, 799-802 stabilisation targets, 799-802 uncertainties in future emissions/scenarios, 800 See also Carbon dioxide; Methane Greenland ice sheet, 74, 655, 656, 657, 661-662

#### Index

deglaciation impacts, 64, 74 deglaciation parameters, 41, 73, 74, 781, 789, 793-794 See also Ice sheets Grenada, 693, 701, 702 Gross Domestic Product (GDP)\* extreme weather event impacts as percent of, 359, 376 global agriculture impacts as percent of, 296-297 global damage estimates with increases in temperature, 65, 822 impacts computed as a percent of, 821 sea-level rise protection costs as percent of, 725 Gross national product (GNP)\*, 245, 547, 592 Gross primary production\*. See Primary production Gross world product, 790 Groundwater, 185-186 arsenic/fluoride in, 179, 587 in Asia, 483 in Latin America, 587, 599, 602 in North America, 629 observed changes, 90, 177, 177 salinisation, 35, 175, 179, 189, 483, 693 in small islands, 186, 189, 693 See also Freshwater management Groundwater recharge\*, 36, 175, 185-186, 549 Growing season, 31, 81, 99, 666 in Africa, 435, 447-448 in Asia, 475, 483 See also Phenology **Groyne**\*, 343 Guardrail analysis, 800, 802

# H

Habitat\*, 817 fragmentation, 37, 213, 554, 666, 783 loss, 52, 583, 592 sea-level rise and, 554 See also Ecosystems; specific habitats Hantavirus\*, 404, 586-587, 625 Haplosporidium nelsoni, 292 Harmful algal blooms (HABs), 96, 234, 328, 400, 551, 556 Hawaii. See Small islands Health. See Human health Heat islands\*, 55, 372-373, 381, 489, 587, 633 adaptation for, 492 Heat-related deaths, 43, 108, 393, 396-398, 408, 411, 733 in Asia, 478 in Australia/New Zealand region, 519, 524, 525 in Europe, 397, 411, 548, 557 in Latin America, 587, 600 in North America, 55, 411, 619, 625 See also Heatwaves; Human health Heat stress, 38, 49, 487, 492, 599, 689 effect on livestock, 287, 447, 586 vulnerability/risk, 789 See also Extreme weather events Heatwaves, 51, 396-397 adaptation, 43, 70, 719, 721, 722 in Asia, 396-397, 476, 478, 492, 733

in Australia/New Zealand region, 50, 509, 511 early warning systems, 53, 417, 491, 544, 563 ecological impacts of, 217 energy use and, 111 in Europe, 51, 217, 362, 544, 548, 557, 563 human health and, 396-397, 413, 632 impacts of, 42, 217, 375, 396-397, 632, 733 mortality from, 394 in North America, 619, 620, 632 vulnerability/risk, 781 See also Extreme weather events; Heat-related deaths; Human health Hepatitis, 587-588 Herbaceous\* growth, 225-226, 552 Herring (Clupea harengus), 669 High-altitude regions. See Mountain regions High-latitude ecosystems, 38, 230-232 High-latitude islands, 58 biodiversity, 689, 700 sea-level trends, 692 temperature and precipitation, 694 Himalayan glaciers, 49, 473, 481, 487, 493, 494 Hindu Kush-Himalaya region, freshwater runoff, 49, 184, 187,483 HIV/AIDS, 399, 406 in Africa, 69, 440, 441, 442, 448 in Latin America, 587 malaria and, 404 Hotspots. See Vulnerability hotspots **Huanghe River** damming of, 326 sediment load, 319, 326, 485 water supply and, 179 Human capital, 816 See also Social capital Human health, 43, 47, 391-431 adaptation, 43, 415-418, 491, 727-728 adaptive capacity, 43, 64, 393, 406 in Africa, 108-109, 399-400, 416, 435, 436, 437-439, 441, 446-447, 459 air quality and, 401-402, 408-412, 418-419 in Asia, 50, 395, 408, 472, 478, 481, 487, 488, 491 assumptions about future trends, 405-406 in Australia/New Zealand region, 524, 525, 529 in coastal areas, 43, 334-335, 338, 393, 414 costs, 415 current sensitivity/vulnerability, 396-405 disasters and, 338, 393, 635 drought, nutrition and food security, 399-400, 407, 413-414 in Europe, 51, 546, 557-558 food safety, 400 future impacts and vulnerabilities, 43, 47, 372, 393, 406, 407-415, 787, 828 heat and cold health effects, 31, 393, 396-397, 396-398, 407, 411, 632 heatwaves and, 396-397, 413, 632 impact assessments, regional, 394, 395, 409-412

impacts, direction and magnitude of, 418 introduction, 393-395 in Latin America, 395, 403, 405, 408, 583, 584, 586-588, 599-601, 603-604 methods and gaps in knowledge, 394-395 modelling/projections, 405-415, 413 monitoring of diseases, 43, 491 national and international programmes, 43 in North America, 55, 619, 620, 625, 632, 635 observed changes, 31, 82, 107-109 occupational health, 405 pathways of climate change effects, 396 in polar regions, 657, 671-672 public health administration, 415-417 in small islands, 58, 689-690, 701 sustainable development, 418-419 ultraviolet radiation and, 405 uncertainties and research priorities, 419 vector-born, rodent-borne and other infectious diseases, 403-405, 409-410 vulnerability/risk, 407-415, 787 vulnerable populations and regions, 412-415 water and, 400-401, 413 wind, storms and floods, 393, 398-399 See also Diseases; specific diseases Human migration. See Migration, human Human population in Africa, 441 in Asia, 477, 479, 484, 488, 491 in Australia/New Zealand region, 509, 510, 516, 522 in coastal areas, 40, 317, 318, 319, 323, 327, 346 as driver of water use, 182 global, 406, 816 as key future condition, 363-364 in Latin America, 587, 595 population-environment interactions, 441 urban population, by size-class of urban centre, 363 Human settlements adaptation, 381-382 in Africa, 439-440, 450 in Asia, 472, 485, 491, 493 in Australia/New Zealand region, 521-522 in coastal areas, 81, 317-318, 331, 333-334, 359, 791 future impacts and vulnerabilities, 41-43, 46-47, 371-373 inertia in, 317-318 informal settlements, 372, 373-374 in North America, 620, 625-626, 632-633, 633 in polar regions, 56, 376, 656, 657, 661 rural settlements, 282, 383, 413, 491-492, 625 in small islands, 689, 690, 693, 695, 700-701 urban settlements, 361, 363, 371, 372 See also Construction; Industry, settlement and society; Urban settlements Human systems\*, 790-791 adaptive capacity, 798 changes in, 83 context for, 361, 366, 374 responses to climate change, 81-82, 366

scale and factors in, 366 See also Adaptation; Industry, settlement and society Hunger, risk of, 275, 298, 299, 300, 482-483 global-scale projections, 38, 813, 824, 825 See also Food security; Food supply Hurricanes costs of, 369, 376, 377, 489, 626, 798 human health impacts, 399 Hurricane Andrew, 369 Hurricane Catarina, 585 Hurricane Georges, 362 Hurricane Gudrun, 290 Hurricane Ivan, 693, 701, 702 Hurricane Katrina, 332, 333, 369, 377, 399, 625, 635, 815 Hurricane Katrina, flood depths, 360, 414 Hurricane Mitch, 376, 376, 730 Hurricane Rita, 92, 399 impacts, 399, 625-626 (See also specific hurricanes) mortality of wild organisms, 216 in North America, 621, 625-626, 627 (See also specific *hurricanes*) projected changes, 54 storm surge and, 92 tourism impacts, 336 See also Extreme weather events; Tropical cyclones Hydrographic events\*, 236 Hydrological systems\*, 81, 90-92 adaptation and mitigation in, 759-760 in Africa, 446 in Asia, 471-472, 477, 483-484, 490-491 observed changes, 28 in polar regions, 56, 655, 662, 664-665 rain-to-snow ratio, 662 See also Water resources Hydrology. See Freshwater resources and management; Hydrological systems; Water resources Hydropower generation, 193, 367, 760 in Africa, 768-769 in Asia, 483 climate-related impacts on, 626 development decisions and, 818-819 in Europe, 52, 543, 556 in Latin America, 586, 589, 591, 597-598 in North America, 619, 626, 628, 634, 818-819 projected changes, 36 Hypolimnetic\* oxygen concentration, 233 Hypoxic events\*, 235 See also Eutrophication

# I

Ice caps\*, 28, 48, 86-88, 449 Ice cover, 86-88 Ice jams, 89, 484 Ice, sea. *See* Sea ice Ice sheets\*, 64, 86-88, 661-662 Antarctic, 64, 73, 655, 656, 663, 781, 789, 793-794, 800 deglaciation, impacts of, 41, 64 deglaciation, thresholds for, 41, 73, 781, 793, 797, 800

Greenland, 64, 73, 74, 655, 656, 657, 661-662, 781, 789, 793-794,800 observed changed, 28, 793 projected scenarios, 793-794 sea-level rise and, 41, 317, 346, 793 vulnerability/risk, 64, 74, 781, 789, 793-794 Ice shelves\*, 28, 86, 674-675 **Immigration/migration** in Australia/New Zealand region, 522, 531 in coastal areas, 320, 323, 331, 333-334 in North America, 627, 632 See also Migration, human Impact assessment\*, 136-137 characteristics summarised, 137 distribution and aggregation of impacts, 784, 825 global warming timeline and, 140 methods, 136-137 as top-down approach, 136, 748-749 uncertainties and, 141 See also CCIAV assessment; Vulnerability assessment Impacts\*, of climate change, 26-31 aggregate, 64, 75, 784, 787, 790, 796-797, 821-825 assessment of (See Impact assessment; Vulnerability assessment) costing, 64-65 cumulative vs. systematic, 365 current knowledge about future impacts, 35-65 definition, 781, 782 direct and indirect, 362-363, 364, 821 disproportionate, 55, 363, 625 distribution of, 64, 65, 75, 781, 784, 786, 790-791, 796 ecosystems, global synthesis, 239-245 gender aspects, 729, 730 global, 821-825 global, associated with temperature increases, 64, 66, 828-829 global, of polar region/cryosphere changes, 56-57, 655, 660, 661-662, 667-668 global-scale, by 2080, 824 key impacts/vulnerabilities, 73-75, 781, 783-797 multiple stresses and, 813, 816-819 non-climate factors and, 135 regional, associated with temperature increases, 829 spatially-explicit methods, 824-825, 836 summarised, 44-47, 59-63, 66-68 unavoidability of, 65-69, 782, 813, 827 (See also Mitigation) See also specific systems and regions; Vulnerability assessment Inca civilization, 605 Income gap, 364 India adaptive capacity to multiple stresses, 71 agriculture, 719, 729, 730 aquaculture, 281 disaster preparedness, 378 globalisation/trade, 719, 729, 730 heatwaves, 396, 478

human health, 395, 399, 409, 413, 487 human population, 488 malaria, 395, 409, 413 megadeltas, 496 projected crop yields, 297 water resources, 477, 481, 483, 484 wetlands, 234 See also Asia **Indian Ocean** climate regimes, 691 relative sea-level rise, 692 tropical storms, 692 Indian Ocean Dipole (IOD), 319 See also Modes of climate variability Indigenous peoples\*, 31, 74, 81 adaptation, 82, 416, 673-674, 719, 728, 729-730 adaptive capacity, 509, 522, 661, 728, 729-730 in Africa, 456-457 in Australia/New Zealand region, 509, 522-523, 524 changes in livelihood strategies, 82, 673, 719 economies of, 82, 103, 373, 625 human health, adaptation measures, 416 knowledge systems of, 456-457, 523, 666, 673-674, 832, 833 in Latin America (pre-Colombian), 605 in North America, 55, 619, 625, 639, 719, 730-731 in polar regions, 31, 56, 82, 657, 659, 661, 673-675, 730-731 resilience of, 56, 655, 673, 674 vulnerability/risk, 74, 788, 791, 796 Industrial Revolution\*, pre-industrial temperatures, 783 Industry, settlement and society, 41-43, 46-47, 357-390 adaptation, 359, 379-384 adaptation, key issues, 383-384 adaptation, local government and, 382 assumptions about future trends, 363-364 costs and socio-economic issues, 362, 365, 376-379 current sensitivity/vulnerability, 361-363 direct and indirect climate change impacts, 367 environmental migration, 365 extreme weather events and, 41, 359, 362, 369, 372, 377 future impacts and vulnerabilities, 41-43, 46-47, 361, 364-376 human settlement, 371-373 human systems in context, 361, 366, 374 industry, 366-367, 378-379 insurance, 369-370 introduction, 359-361 linkages, 43, 359, 362, 365, 366, 374, 382 multiples stresses, 361, 372, 373, 374-376, 377 retail and commercial services, 368 sanitation and urban drainage, 371 scale, 360, 366 services, 367, 379-381 social issues, 373-374, 382-383 social systems, 362 sustainable development, 384 thresholds, 359, 361, 365

tourism, 363, 368-369 trade, 367-368 transportation, power and communication infrastructures, 371 uncertainties and research priorities, 378, 385 utilities/infrastructure, 359, 362, 365, 370, 374, 381 vulnerability/risk, 31, 43 water supplies, 370-371 See also Construction; Human settlements; Urban settlements Infectious diseases\*, 393, 403-405, 407, 418 in Australia/New Zealand region, 524 bird migration and, 403 climate-related factors and, 478 current sensitivity/vulnerability, 403-405 drought and, 399-400, 478 in North America, 625 phytoplankton blooms and, 487 projections, 43 See also Diseases; Human health; Vector-borne diseases; Water-borne diseases; specific diseases Infrastructure\*, 359, 365, 367 adaptation, 381 adaptation costs and benefits, 725 in Africa, 439-440, 441, 450, 453 in Asia, 471, 488-489, 492 in Australia/New Zealand region, 50, 509, 525, 529 in coastal systems, 331, 333-334 deterioration/damage of, 88, 362, 661, 675 extreme events and, 625-626 freshwater resources/management, 36, 175, 191 future impacts and vulnerabilities, 359, 370, 374, 787 lifetimes, 638 linkage systems, 362 in North America, 55, 619, 625-626, 632, 633, 635, 636, 638 in polar regions, 376, 655, 661, 675 in small islands, 57, 689, 690, 702-703 sustainable development and, 639 transport, power and communications, 371, 556 vulnerability/risk, 787 water-supply, 36, 365, 371 See also Human settlements; Transportation; specific regions Insect pests, 38, 107, 400, 483 damage control, 295 distribution, transmission and seasonality of, 393, 404, 435, 437-439, 446, 487 forest infestations in North America, 56, 218, 619, 623, 624,631 impacts on coffee growing, 597 impacts on food, fibre and forest products, 217, 218, 283, 290 pine and spruce beetles, 107, 228, 283, 623, 624, 631, 667 spread of, 792 spruce budworm, 218, 623 See also Disturbance regimes; Insects Insects

climate change impacts on, 512 evolutionary processes, 104 impacts on food, fibre and forest products, 217, 218, 283, 299 impacts on forests, 228, 623, 624 impacts on livestock, 555 morphology and reproduction, 103 See also Disturbance regimes; Insect pests; specific insects **Insurance**, 489, 735 adaptation, 380-381, 723 catastrophe models, 337 disaster losses, 110, 377 future impacts and vulnerabilities, 369-370, 790 Hurricane Katrina claims, 377 non-availability/withdrawal of, 380-381 property insurance in Europe, 557, 561-562, 565 reinsurance, 110, 369, 370, 376 in small islands, 707 Integrated assessment\*, 136, 139, 337, 822 adaptation and mitigation inter-relationships, 754-760 characteristics summarised, 137 global warming timeline, 140 See also Integrated Assessment Models (IAMs) Integrated Assessment Models (IAMs), 155-156, 749, 754-756, 757, 770-771 Integrated Coastal Zone Management (ICZM), 340-341, 491 Integrated Water Resources Management (IWRM)\*, 196-197, 200, 370-371 Inter-relationships. See Adaptation and mitigation interrelationships Inter-tropical Convergence Zone (ITCZ), 584 Interdecadal Pacific Oscillation (IPO), 691 See also Modes of climate variability **Intergenerational ethics**, 835 International agreements, 72, 495, 748 **International Convention for the Prevention of Pollution** from Ships, 495 **International Federation of Red Cross and Red Crescent** Societies (IFRCRCS), 442, 732 International Tropical Timber Organization (ITTO), 495 **Inuit people,** 719, 729-730 Invasive species and invasive alien species (IAS)\*, 103, 216, 218, 232, 247 in Australia/New Zealand region, 512, 517, 518, 520 direct and indirect effects of, 84 in Europe, 551, 554 in North America, 619, 635, 640 observed changes, 95 in small islands, 58 Irrigation wastewater re-use for, 418 water demand for, 36, 481, 482 water use for, 179, 182, 192, 284, 550, 559 Irrigation water-use efficiency\*, 284 Islands. See Small islands Isohyet\*, 224 Ixodes scapularis, 625, 632

# J

Japan coastal flooding, 324 construction, 379 cyclones/typhoons, 473, 489 floods, 484-485 growing season, 99 heat islands, 489 human health, 395, 487 phenology, 100, 478 precipitation, 481 rice yields, 480 sea-level rise, 484-485 ski industry, 489 temperature, 479, 481 See also Asia Joint attribution\*, 83, 112-116 See also Detection and attribution

# K

Kala-azar, 403 Kelp, 94, 95 Keystone species\*, 230, 241, 658 Kilimanjaro, Mt., 48, 439, 440, 449 Kiribati, 689, 697, 698, 706, 708, 792 Krill, 56, 88, 95, 236, 521, 655, 660, 669 Kyoto Protocol\*, 495, 748, 752, 754, 766

#### L

La Niña. See El Niño Southern Oscillation (ENSO) Lakes, 233-234, 664 chemistry, 91 epishelf, 90 eutrophication, 551, 553 future impacts, 184 lake ice, 83, 88-89, 664 observed changes, 28, 81, 90, 91, 97, 98, 177 phenology, 97, 98 thermal structure, 91 See also Freshwater resources and management; Glacial lakes; Thermal expansion; Thermal stratification Land cover change, 49, 84, 816 carbon balance and, 793 direct and indirect effects, 84 in Latin America, 53, 590 projections, 157 Land degradation, 229, 518-519, 520 See also Erosion Land-use change, 49, 84 direct and indirect effects, 84 effects on ecosystems, 213, 216-217, 237-239, 241 effects on forests, 229-230 future scenarios, 155-156, 157 in Latin America, 53, 583, 590, 594-595, 606 Landslides\* in Asia, 472, 473, 477 in Australia/New Zealand region, 50

in Latin America, 599 Large-scale singularities\*, 35, 64, 75, 135, 160, 797, 802, 828 See also Abrupt climate change Last glacial maximum\*, 214, 220 Latin America, 53-55, 61, 581-615 adaptation, 55, 583, 591-593, 600-604, 605, 722 adaptive capacity, 584, 605 agriculture, 54, 281, 584, 586, 591, 592, 597, 598, 601-602 Amazon forest, 218, 241, 243, 281, 594-595, 596 aquaculture, 593 assumptions about future trends, 593-596 biodiversity, 583, 586, 590, 592, 596, 603, 791 case studies. 604-605 Chacaltaya glacier, Bolivia, 87 climate, 53, 583, 585-587, 588-589, 593-594 climate, possibility of rapid changes, 596 climate variability, 54, 583, 586, 591 coasts, 54, 584, 586, 593, 599, 600, 602-603 current sensitivity/vulnerability, 584-593 deforestation, 53, 583, 590, 594-595, 604, 606 dengue fever, 404, 586, 591, 593, 599 development, 595-596 distinctions of, 584-585 droughts, 400, 586 ecosystems, natural, 583, 584, 586, 592, 596, 601 El Niño/ENSO in, 585, 586, 591 extreme weather events, 53, 583, 585, 594 fires, 53, 596, 600 fisheries, 281, 584, 587, 590, 603 floods, 398, 586, 588 food security, 602 forests/forestry, 106, 584, 592, 594-595, 602 future impacts and vulnerabilities, 53-55, 61, 242-244, 596-600, 788, 791, 825, 829 glaciers, 87, 584, 589, 598 HIV/AIDS in, 587 hotspots, 604, 606 human health, 395, 403, 405, 408, 583, 584, 586-588, 599-601, 603-604 human population, 587, 595 hydropower generation, 586, 589, 591, 597-598 introduction, 583-584 land-use changes, 53, 583, 590, 594-595, 606 livestock, 54, 583, 586, 602 malaria, 408, 584, 586, 591, 593, 599 migration, 587, 595 non-climatic stresses, 587-588 observed changes, 30, 87, 106, 115-116, 588-591 past and current trends, 588-591 pollution, 587-588 pre-Columbian communities, adaptation practices, 605 precipitation, 53, 151, 583, 588, 589, 593-594 schistosomiasis in, 405 sea-level rise, 54, 346, 584, 586, 589, 791 socio-economic factors, 590-591 summary of knowledge in TAR, 584 sustainable development, 55, 299, 584, 606-607

temperature, 53-54, 150, 583, 589, 593-594, 606 tourism, 587, 599 uncertainties and research priorities, 607 urban indicators, 363 urbanisation, 587, 590 vulnerability/risk, 53-54, 596-600, 788, 791 water resources, 586, 592-593, 597-599, 602, 605 water stress, 54, 583, 597-598 weather and climate forecasting, 591-592, 604 weather and climate stresses, 585-587 See also specific countries Leaching\*, 52, 228, 294, 542, 543, 545 Leaf area index (LAI)\*, 220, 227, 240 Lebanon, water resources, 483 Legumes\*, 54, 106, 287, 583, 590, 607 Leishmaniasis, 403, 557, 587, 593, 599 Lemmings, 658, 666 Lentic (still-water) systems, 664 Leptospirosis, 404, 587, 588, 701 Lianas, 104 Likelihood\*, 27, 786, 799 See also Confidence; Uncertainty Linkages/linkage systems, 43, 359, 362, 365, 366, 374, 382 Littoral zone\*, 599 Livestock adaptation, 295, 721 in Africa, 278, 287, 447, 448 in Asia, 287, 482, 483 in Australia/New Zealand region, 283, 520 diseases, 447, 555 drought mortality, 278 in Europe, 555, 565 forage production for, 277, 277, 480, 486, 555 heat stress mortality, 555, 586 insect pests and, 283, 520 in Latin America, 54, 583, 586, 602 observed changes, 105, 106 production, 285-288 projected changes, 38 summary of impacts, 301, 302 vulnerability/risk, 790 Low-lying areas. See Coastal systems and low-lying areas Lyme disease, 108, 410, 557, 619, 625, 632

# M

Madden-Julian Oscillation (MJO), 691
Mainstreaming, 471, 513, 637-638, 639, 732, 768

adaptation into planning/development decisions, 55, 65,
818, 832-836
barriers to, 835-836
definition, 749

Maize, 106, 297, 448, 452, 480, 597

projected crop yields, 54
sensitivity to climate change, 39
temperature and, 286

Malaria\*, 394, 400, 404, 557, 689, 701

adaptation/mitigation decisions and, 755
in Africa, 48, 108-109, 400, 404, 406, 408, 409, 437-439,

446 in Asia, 408, 478, 487 avian. 700 climate change impacts on, 408, 409-410, 418 climate-related factors and, 48, 478 distribution, transmission and seasonality of, 393, 404, 435, 437-439, 446, 487 epidemic areas in Africa, 438, 446 future risks, 406, 407-408 geographic range of, 393, 400, 403, 404, 437-439 in Latin America, 408, 584, 586, 591, 593, 599 observed changes, 108-109 See also Diseases; Human health Maldives, 694, 703-705, 708 Malnutrition, 393, 394, 399-400, 407 projections, 48, 298, 299, 418 in small islands, 701 **Mammals** in Africa, 435, 449 in Australia/New Zealand region, 512 marine, 56, 236, 565, 668-669, 696 migration corridors, 525 observed changes, 100, 103 in polar regions, 660, 666 See also specific mammals Management. See Governance/government; Technology Managed systems, 31, 51, 71 definition, 82 observed changes in, 79-131 See also Agriculture; Observed changes and responses Manatees, 449 Mangrove forests, 92, 317, 329, 696 in Africa, 449 in Asia, 49, 471, 472, 477, 481, 485, 492 conservation of, 492, 495 in Latin America, 586, 590 observed changes, 816 Marine ecosystems, 213-214, 234-236 adaptation, 295, 719 globalisation and, 719, 730 observed changes, 28, 81, 94-96, 115-116 in polar regions, 655, 658-660, 668-671 projected changes, 38, 49 resilience of, 719 vulnerability/risk, 74, 788 See also Coastal systems; Fisheries; Oceans Marine fisheries. See Fisheries Marine mammals, 56, 236, 565, 668-669, 696 See also specific mammals Market impacts\*, 74, 75, 137, 781, 782, 787, 790-791, 796, 798 Mediterranean islands. 691. 696 See also Small islands Mediterranean region. See Europe Mediterranean-type ecosystems (MTEs), 214, 226-227 Megadeltas, 40, 41 in Asia, 40, 64, 279, 327, 484-485, 493, 496 in polar regions (Arctic), 674

sea-level rise impacts, 484-485 vulnerabilities, 41, 64, 377 See also Ganges-Brahmaputra delta Mekong River/delta, 279, 327, 483, 485, 489, 496 See also Deltas; Megadeltas Meloidogyne incognita, 597 Meningitis\*, 399-400, 438, 439 Mental disorders, as impact of disasters, 399 Meridional overturning circulation (MOC). See Thermohaline circulation (THC) Meta-analysis, 112-116 Methane release from methane hydrates, 662, 793 release from permafrost, 38, 88, 213, 231, 662, 667, 793 social cost of, 822 warming influence of, vs. carbon dioxide, 655, 662 See also Greenhouse gases (GHGs) Methane hydrates, 662, 793 Methods. See Assessment methods Mexico adaptation, 722, 734 agriculture, 586, 592 See also Latin America Microclimate\*, 84, 101, 102, 439 Mid-latitude islands, 689, 695 See also Small islands Migration. 237 of African ungulates, 226 of birds, 100, 223-224, 230, 239, 403, 449, 625, 666, 696 climate change impacts on, 237, 239, 509 drought and, 399 environmental, 365, 368 of fish, 98, 333 habitat fragmentation and, 783 impacts of polar region changes on, 662, 666 of wetland species, 234 See also Migration, human Migration corridors. See Ecological corridors Migration, human, 365, 728, 736 as adaptation strategy, 452, 492, 728, 736 in Africa, 452 in Asia, 488, 491-492 in Latin America, 587, 595 rural-to-urban, 488, 492 from small islands, 697, 708, 736 vulnerability/risk, 787 Millennium Development Goals (MDGs)\*, 75-76, 813, 819, 826-827, 834-835 targets, likelihood of meeting, 75-76, 813, 826-827 in coastal systems, 345 food security, 456 impacts of climate change on, 458 indicators used in, 834-835 list of. 826 water sector contribution to, 175, 200 See also Development; Sustainable development Millennium Ecosystem Assessment (MA), 139, 147, 816 alternate development pathways, 818

nitrogen fertiliser use, 182 water use, 182 See also Biodiversity; Ecosystems Millet, 49, 452, 482, 726 Mining industry, 522 Mires\*. See Bogs Mississippi River/delta, 326, 332, 333, 377 See also Deltas; Megadeltas Mitigation\*, 70-73, 76, 798-803 adaptive capacity and, 827-832 capacity, 763 costs and benefits, 749, 756-757, 802 crop production and, 284 damages avoided, 756-757 definitions, 749, 750, 763 differences, similarities and complementarities, 750 global vulnerability projections with and without mitigation, 830-831 implementation, 747, 766-770 indigenous knowledge and, 456-457, 832, 833 inter-relationships with adaptation (See Adaptation and mitigation inter-relationships) introduction, 748-750 methods in mitigation assessment, 798-803 regions and sectors, 757-760 response capacity and development pathways, 747, 763-766,767 risk management assessment and, 139-141 risk reduction by, 782 risks of delay in, 782, 802, 804 scales, 747, 749, 753-754, 767-769 scenarios, 35, 139-141, 158-160, 799-803, 813, 830-831 substitutability for adaptation, 749, 753-754, 766-767 synergies, 72, 747, 754-756, 762-763, 813, 827-832 trade-offs, 747, 754-756, 762 See also Adaptation; Adaptation and mitigation interrelationships; Carbon dioxide; Greenhouse gases (GHGs); Overshoot scenarios Mixed layer\*, 91 MOC (meridional overturning circulation). See Thermohaline circulation (THC) Models. See Climate models Modes of climate variability, 794-795 See also Climate variability; El Niño Southern Oscillation (ENSO); Indian Ocean Dipole (IOD); Interdecadal Pacific Oscillation (IPO); North Atlantic Oscillation (NAO): Northern Annular Mode: Pacific Decadal Oscillation (PDO); Southern Annular Mode Molluscs, 236, 243, 291, 292 See also Pteropods Mongolia, 486, 487 See also Asia Monsoons\* in Asia, 472, 484 in Latin America, 585 projected changes, 795 Montane\* ecosystems/species, 227, 230, 232, 243, 244

Montreal Protocol, 495

Morbidity\* diarrhoeal diseases, 50, 471, 478, 481 extreme events and, 701 temperature extremes and, 625 Morphology\*, 103 Mortality\*, 43, 393 child mortality, 394, 401 cold-related, 51, 108, 393, 407, 408, 411, 418, 557 diarrhoeal diseases, 50, 471, 478, 481 extreme weather events and, 620, 626, 701 global climate-related, 43, 791 global climate-related, costs of, 415 heat-related, 108, 396-398, 487, 519, 524, 525, 557, 625, 733 risk areas in Africa, 438 See also Diseases; Heat stress; Heatwaves; Human health Mosquito-borne diseases, 400, 524, 625 See also Dengue fever; Malaria Mosquitoes, 403, 487 Anopheles spp., 108, 416, 439 Culex, 625 pitcher plant, 104 Stegomyia aegypti (formerly Aedes aegypti), 403-404, 524 Wyeomyia smithii, 403 Mountain regions, 228, 232-233 adaptation, 52, 559 adaption option limits/limitations, 52, 543, 559 adaptive capacity, 52 in Africa, 48, 439, 440, 449 biodiversity, 48, 52 in Europe, 52, 543, 551-552, 559, 565 human health, 414 observed changes, 102-103 vulnerability/risk, 52, 788 Mountain Wheatear, 224 Mouse (Mus musculus), 103 Multilateral Environmental Agreements, 72, 495 Multinucleated sphere X (MSX) disease, 292 Multiple stresses, 78, 361, 372, 373, 813, 816-819 adaptation, 359, 384, 816-819 adaptive capacity and, 719, 729 in Africa, 48, 69, 435, 436, 440, 442, 454, 457 in Asia, 50, 471, 492 catalogue of, 816 in coastal systems, 40, 317, 336 in ecosystems, 37, 213, 215, 241, 246-247 in food, fibre and forest products, 277-278, 279, 290 in India, 71 in industry, settlement and society, 359, 361, 372, 373, 374-376, 377 in North America, 623, 624 uncertainties caused by, 783 vulnerability and, 75 Musk oxen, 666, 667

#### Ν

Narwhal (*Monodon monoceros*), 236, 669 Nasca civilization, 605

National Adaptation Programmes (Plans) of Action (NAPAs), 69, 719, 731-732 Natural systems interaction of with human sub-systems, 318 observed changes in, 79-131 See also Observed changes and responses; specific systems and regions Navigation International Convention for the Prevention of Pollution from Ships, 495 in North America, 56, 619, 628, 635 in polar regions, 88, 676 NDVI. See Normalised Difference Vegetation Index Nepal Tsho Rolpa project, 719, 721, 723 water resources, 477 See also Asia Net biome production (NBP)\*, 221 Net ecosystem production (NEP)\*, 228 Net primary production (NPP)\* in Asia, 481 estimated changes (1982-1999), 106 in Europe, 552 global, 213, 220, 234 in lakes and rivers, 234 in North America, 621, 622, 629-630 observed changes, 106 The Netherlands adaptation, 547, 719, 722, 724 cost of nature conservation, 247 human health, 395, 414 See also Europe New Zealand. See Australia/New Zealand region Nile River/delta, 143, 339, 445, 485 See also Deltas; Megadeltas Nipah virus, 404 Nitrogen, 153, 221, 816 leaching, 52, 294, 542, 543, 545 Nitrogen fertiliser use, 182 Nitrogen oxides (NO<sub>x</sub>)\*, 278 No regrets policy\*, 246, 472, 633 Non-climate drivers of change, 26-28, 84-85, 135 Non-linearity\*, 141, 148, 215, 216, 219 Non-market impacts\*, 790-791 Normalised Difference Vegetation Index (NDVI)\*, 657 North America, 55-56, 61-62, 617-652 adaptation, 619, 620, 623, 633, 635-638, 722 agriculture, 620, 623-624, 627, 631, 636 assumptions about future trends, 626-627 case studies, 623, 628, 633, 639 cities, integration of impacts, 633 climate trends, 626-627 coastal regions, 55, 619, 621, 622-623, 626, 630 construction, 379, 635 costs of extreme weather events, 332, 338, 619, 621, 626, 630 current sensitivity/vulnerability, 620-626 droughts, 619, 622, 623, 624, 625, 626

ecosystems, 619, 620, 621, 622, 629-630, 635 El Niño Southern Oscillation (ENSO), 623, 627, 630 energy, industry and transportation, 626, 630, 633, 634-635,636 extreme weather events, 55, 619, 621, 625-626, 632-633 fires, 31, 56, 619, 620, 621, 623, 631, 636 fisheries, 620, 624, 631-632 floods, 55, 620, 626, 630, 633 forestry, 218, 620, 622, 624, 630, 636 freshwater resources, 619, 621-622, 627-629, 628 future impacts and vulnerabilities, 55-56, 61-62, 242-245, 619, 627-635, 825, 829 Great Lakes, 56, 619, 627-629, 628, 634 heatwaves, 619, 620, 632, 733 human health, 55, 619, 620, 625, 632, 635 human settlement, 620, 625-626, 632-633, 633 hurricanes, 92, 369, 399, 621, 625-626, 627 (See also specific hurricanes) indigenous peoples, 55, 619, 625, 639, 730-731 infrastructure, 55, 619, 625-626, 632, 633, 635, 636, 638 interacting impacts, 635 introduction, 619-620 multiple stresses, 623, 624 observed changes, 30, 115-116 phenology, 99-100, 621, 622, 631 precipitation, 151, 621-622, 621, 627 resources. 620 sea-level rise, 346, 619, 620, 621, 623, 630 social, economic and institutional context, 627 soil erosion, 190 sustainable development, 639 temperature, 55, 150, 619, 620, 621, 626-627 tourism and recreation, 626, 627, 634 uncertainties and research priorities, 639-640 urban indicators, 363 vulnerabilities, 619, 620-626, 627-635 water resources, 55-56, 629, 633 wetlands, 620, 630 wildlife, 622 See also Canada; United States North American Free Trade Agreement, 731 North Atlantic Oscillation (NAO)\*, 292, 319, 550, 551 marine ecosystems and, 96, 101 projected changes, 794 See also Modes of climate variability North Atlantic Sub-tropical High (NAH), 691 Northern Annular Mode, 794 See also Modes of climate variability Northern Hemisphere temperature (NHT), 96 Nutrition, 399-400 See also Malnutrition; Undernutrition

# 0

**Observed changes and responses**, 26-31, **79-131**, 781 adaptation, regional, 111-112 agriculture and forestry, 81-82, 104-107 attribution to temperature, 81, 112-116 biological systems, 83, 94-107, *115-116* 

climate and non-climate drivers, 83-85 coastal processes and zones, 81, 92-94, 115 confidence. 85 cryosphere, 81, 85-90, 115 disasters and hazards, 109-111 geographic locations and associated temperatures, 115-116 geographical balance in data, lack of/need for, 82, 117 human health, 82, 107-109 hydrology and water resources, 81, 90-92 introduction, 82-83 larger-scale aggregation and joint attribution, 82, 83, 112-116 learning from, 117 linking climate-change causes with, 29 locations of significant changes in, 30 marine and freshwater biological systems, 81, 94-98, 115-116 meta-analysis studies, 112-116 methods of detection and attribution, 83-85 no change, evidence of, 85 physical systems, 83, 85-92, 115-116 socio-economic indicators, 82, 111-112 terrestrial biological systems, 81, 98-104, 115-116 vulnerability, adaptation and research needs, 117 See also specific systems and regions **Occupational health**, 405 Ocean acidification\*, 28-31, 38, 81, 234, 236, 320, 793 in Australia/New Zealand region, 517, 527 coral bleaching and, 330 coral calcification and, 38, 94, 235 in polar regions, 655, 658 projections, 37, 45, 235 Oceans, 213, 234-237 carbon buffering, 38 carbon stocks, 38, 213, 214 circulation, 662 (See also Thermohaline circulation) food webs, 658, 669-670 freshening of, 88, 662 mixed layer, 91 observed changes, 81, 88 primary production decline, 94 projected changes, 662 warming, 656 water chemistry, 658 See also Marine ecosystems; Ocean acidification; Southern Ocean OECD. See Organisation for Economic Co-operation and Development Okanagan, Canada, 195 Ombrotrophic bog\*, 230 Oncomelania, 487 **Opportunity costs**\*, 763, 826 **Optimality**, 749 **Organisation for Economic Co-operation and** Development (OECD), 755, 768 Overshoot scenarios, 801-802, 804 See also Mitigation **Oxygen deficiency** 

in fish-spawning habitats, 665 in oceans and coastal areas, 235 **Oysters**, 292, 400 **Ozone\***, 401-402, 413 effects on crop yields, 276, 278 future scenarios, 153, 372 ground-level, health impacts of, 393, 401-402, 408-411, 412, 588, 619, 632 interaction in carbon dioxide effects, 40, 276, 278 stratospheric, impacts of loss of, 600-601 tropospheric, warming associated with, 480

## P

Pacific Decadal Oscillation (PDO), 95, 101, 292, 319 See also Modes of climate variability PAGE2002 model, 821-823 See also Integrated assessment models (IAMs) Pakistan human population, 488 migration, human, 488 water resources, 477 See also Asia Palm products industry, 333, 450 Paludification\*, 229, 231 Participatory processes, 813, 832-834 Particulates\*, 394, 402, 588 Pastoralists, 39, 279, 281-282, 657 coping/adaptation strategies, 293, 457 Patagonian toothfish (Dissostichus eleginoides), 669, 676 Peat/peatlands\*, 234, 239, 477-478, 543, 558, 792, 795 **Pelagic communities**\*, 94, 95, 234, 236 in polar regions, 658, 659 range shifts in, 659 See also Fish; Fisheries; Pelagic fisheries **Pelagic fisheries** in Australia/New Zealand region, 521 observed changes, 97 See also Fish; Fisheries; Pelagic communities Penguins, 660 Perkinsus marinus, 292 Permafrost\*, 49, 214, 221, 486-487, 655, 660-661, 663 adaptation to melting of, 719, 722 in Asia, 49, 472, 477, 486-487 carbon stocks, 214, 221, 231 in Europe, 51, 52, 543, 551, 558, 559, 565 infrastructure and, 632, 635, 661, 675 interactions/feedbacks, 249, 661 lake formation and drainage, 90, 91 methane release from, 38, 88, 213, 231, 662, 793 in North Americas, 632, 635 observed changes, 28, 81, 83, 88, 177, 655 projected changes, 40, 49, 486-487, 663 temperatures, 477 thawing, 221, 237, 551, 558, 655, 656, 663, 675 vulnerability, 660-661 See also Polar regions Pesticides, 175, 182, 188 pH, oceanic projected, 37, 45, 235

See also Ocean acidification Phenology\*, 31, 97, 99-100, 101 agricultural impacts, 31, 81, 105 in Asia, 100, 478 in Australia/New Zealand region, 100 COST725 project, 112, 113 in Europe, 51-52, 99-100, 101, 113, 546, 551, 552, 553, 558 insect pest activity and, 283 in North America, 99-100, 283, 621, 622, 631 observed changes, 28, 81, 83, 96, 98, 99-101, 113-114 pelagic communities, 95, 97 See also Growing season Phosphorus, 816 Photochemical smog\*, 487, 557-558 Photosynthesis\*, 104, 329 See also Growing season Physical systems, 26, 28 linking climate-change with observed effects, 29 locations of significant changes in, 30 See also Detection and attribution; Joint attribution; Observed changes and responses Phytoplankton\*, 56, 234, 236, 414, 793 observed changes, 91, 96 in polar regions, 56, 659 productivity in lakes, 91 sea surface temperature and, 487 See also Algal blooms; Zooplankton Pied flycatchers (Ficedula hypoleuca), 101, 103, 696 Pika (Ochotona princeps), 103 Pine and spruce beetles, 107, 228, 283, 623, 624, 631, 667 See also Disturbance regimes; Insect pests; Insects Pinnipeds, 236 Pitcher plant mosquito, 104 Plankton\*, 213, 234, 295, 517 communities, 234, 236 ocean acidification and, 38 poleward shift of, 28 See also Algal blooms; Phytoplankton; Zooplankton Planned adaptation, 65, 719, 731-733, 781 in Australia/New Zealand region, 509, 513, 524-525 barriers to, 525-526, 732-733 definition, 294 ecosystem management, 246-248 in Europe, 547 evaluation of, 815-816 food, fibre and forest products, 295-296 human health, 43 international and national actions, 43, 416-417, 731-733 in Latin America, 591-593 in small islands, 706 Plant functional type (PFT)\*, 219, 226, 240 Plasmodium falciparum, 400, 406, 407, 408 Plasmodium vivax, 408, 413 Polar bears (Ursus maritimus), 88, 231, 236, 237, 668-669, 734,792 endangerment status, 231 habitat reduction, 213

reproductive success, 103 vulnerability/risk, 230, 231, 240, 668-669 Polar regions (Arctic and Antarctic), 56, 62-63, 653-685 acidification of oceans/seas, 655, 658 adaptation, 82, 655, 660, 672-673 adaptive capacity, 658-660, 661 albedo, 655, 656, 661 Antarctic Peninsula case study, 674-675 aquatic productivity and biodiversity, 665 assumptions about future trends, 661-663 biodiversity, 667, 792 carbon storage/flux, 662, 665, 667-668 case studies, 673-675 climate, environment and socio-economic state, 655, 656-658 climate projections, 150, 151, 656-657 coastal zone and small islands, 92, 320, 672 current sensitivity/vulnerability, 656-661 economies/socio-economic systems, 56, 655, 657, 661, 665-666, 668, 676 ecosystems, 56, 665-671 (See also Sea-ice biome) feedbacks to global climate systems, 655, 660, 661-662, 667-668 fish/fisheries, 49, 291, 655, 665, 669, 676 freshwater systems, 655, 660, 663-666 future impacts and vulnerabilities, 56, 62-63, 663-672, 788, 791, 792, 829 glaciers, 656, 657, 661, 674 "greening of," 88, 655 human health, 414-415, 657, 671-672 human population, 657, 661 human settlement, 56, 376, 656, 657, 661, 791 hydrology, 655, 662, 664-665 ice habitats, 96 ice sheets, 64, 73, 655, 656, 661-662, 663, 781, 789, 793-794.800 ice shelves, 86, 674-675 indigenous peoples, 31, 56, 82, 657, 659, 661, 673-675, 730-731 infrastructure, 376, 655, 661, 675 introduction, 655-656 marine ecosystems and services, 56, 655, 658-660, 668-671 Marion Island, 230 megadeltas, 674 observed changes, 30, 56, 96, 115-116 permafrost, 655, 656, 657, 660-661, 662, 663, 675 precipitation, 151, 657, 662 projected changes, 62-63, 150, 151, 656-657, 662-663 sea ice, 56, 655-656, 657, 658, 659, 662, 668-669, 792 sustainable development, 675-676 temperature, 150, 230, 656, 656-658, 662, 674 terrestrial ecosystems and services, 655, 656, 658-660, 666-668 tourism, 673, 676 traditional ecological knowledge (TEK), 666, 673-674 traditional economies/livelihoods, 655, 661, 665-666, 668 transportation/navigation, 88, 676

uncertainties and research priorities, 676-677 vegetation, 231, 657, 658-660, 666-668 vulnerability/risk, 64, 230, 658-661, 663-672, 788, 791, 792 wetlands, 88, 655, 665 See also Permafrost; Tundra Policy-base adaptation. See Planned adaptation Policy-based assessment, 136 Policy, climate. See Climate policy Pollen, 31, 103, 108, 109, 393, 558, 619, 632 ragweed (Ambrosia artemisiifolia), 402-403 See also Human health; Phenology Pollock (Theragra chalcogramma), 669 Pollution direct and indirect effects of, 84 in Latin America, 587-588 See also Air pollution; Water pollution Polynyas\*, 669 **Population.** See Human population **Population systems**\*, 242-245 Portfolio, 749 Post-traumatic stress disorder, 399 Potential production\*, 297 **Poverty**, 364, 494 adaptation measures for, 275, 299 adaptive capacity and, 492, 720 in Africa, 48-49 in Asia, 489, 492, 494 disproportionate impacts associated with, 55, 359, 362, 363, 373-374, 399, 625, 720 extreme event impacts, 585, 625-626 human health and, 43, 393, 406, 478 informal settlements, 373-374 sustainable development and, 494 vulnerability and, 74, 399, 489 Prairies. See Grasslands **Pre-industrial temperatures**, 783 probability of exceeding 2°C above, 801 Precipitation extremes, 187, 547 observed trends, 177 projected impacts and interactions, 42, 375, 795 projections, regional worldwide, 33, 149, 151 See also Droughts; Floods; specific regions and countries **Primary production\***, 288, 291-292 carbon dioxide effects on, 282, 284-285 in lakes, 97 in oceans, 94, 234 See also Net primary production (NPP) Probabilistic analyses, 141, 799, 800-801, 803 Probabilistic futures, 35, 135, 145, 160-161 **Projections\*** climate projection, 31-35, 133-171 climate variability and extremes, 152 definition, 145 temperature and precipitation, regionally, 149-150 Property rights, 816 Protozoan parasites, 292, 487

**Psychological research**, 735-736 **Pteropods\***, 213, 234, 658 **Pure rate of time preference\***, 822, 823

#### Q

Qinghai-Tibet Railway, 724

#### R

**Rabies.** 671 Radiation. See Ultraviolet (UV)-B radiation **Radiative forcing\*** methane emissions and, 662, 667 scenario analysis and stabilisation targets, 799-802 Ragweed (Ambrosia artemisiifolia), 402-403 Rainfall. See Precipitation Range shifts of vegetation and wildlife, 28, 213, 216, 217, 229, 232, 237, 546, 553, 622 in Africa, 449 in Asia, 471, 478 observed changes, 56, 81, 83, 102 in pelagic communities, 659 in polar regions, 56, 667 See also Extinction; Vulnerability hotspots Rangelands\*, 285-288 in Asia, 486 in Australia/New Zealand region, 513, 519-520 See also Grasslands; Savannas; Tundra 'Reasons for concern'. See Climate change Recalcitrant\* carbon stocks, 221 Recreation in Australia/New Zealand region, 523 in Europe, 336, 556-557, 561 fisheries, 624 in North America, 626, 634 See also Tourism Red tides. 485 Reference scenario. See Baseline/reference climate Reforestation\*, 491, 758, 759, 769 **Regional climate change** distribution of impacts, 796 key vulnerabilities, 788, 791-792 observed changes related to, 85-116 projected impacts, 48-63, 824, 825, 829 synthesis of changes and temperatures, 114-116 temperature and precipitation, 33, 783 See also specific regions Reid's paradox\*, 229 Reindeer, 666, 667, 668 Reinsurance\*, 110, 369, 370, 376 Relative sea level. See Sea-level rise Reproduction, terrestrial organisms, 103 Reptiles, 52, 224, 243, 543, 554, 565 Research priorities/needs, adaptation practices, options, constraints and capacity, 737 Africa, 458 Asia, 497 Australia/New Zealand, 529-531 CCIAV assessment, 161

climate change and sustainability, 836 coastal systems and low-lying areas, 345-346 ecosystems, their properties, goods and services, 249 Europe, 564-565 food, fibre and forest products, 301-302 freshwater resources and their management, 201 human health, 419 industry, settlement and society, 385 inter-relationships between adaptation and mitigation, 770 key vulnerabilities and the risk from climate change, 804 Latin America, 607 North America, 639 observed changes and responses, 117 Polar regions, 676 Small islands, 711 **Reservoirs\*** of carbon, 220, 234 of disease, 401, 403, 404, 405, 413 microbial load in, 401 sedimentation of, 179 water storage, 90, 176, 179, 180, 326, 401 Resilience\*, 76, 673, 674 adaptation and, 721, 733-734 in Africa, 48-49, 452, 453 of Arctic indigenous peoples, 655, 673, 674 of ecosystems, exceedence projections, 37 seasonal forecasts and, 416 in small islands, 698 of subsistence/smallholder livelihood systems, 281-282 thresholds, 733-734 **Resource-dependent communities**, 625 Respiration\*, 220, 221, 225, 226 Respiratory disorders, 372, 393, 400, 402, 523 in Asia, 487 in Latin America, 588, 600 in North America, 55, 619, 620, 632 in polar regions, 671 in small islands, 689, 701 See also Air pollution; Pollen Response capacity, 747, 763-766, 767 **Response strategies**, 69, 70, 781-782, 797-804 Retail and commercial services, 368 Rhine River, 184, 193, 198-199 Rice observed crop yields, 106, 475 projected crop yields, 54, 297, 480, 481, 583 temperature and, 286 **Rift Valley Fever, 447** Riparian\* systems, 56, 178, 234, 491 Risk, 753, 781 adaptation and, 781 assessment (See Risk assessment) climate change, compendium of projected risks, 37, 240 communication, 143-144, 380, 735 criteria, 141, 785-786 definition, 753, 782, 786 high-risk regions, vulnerability of, 781 high-risk settlements, 359, 364

perceptions of, 735-736, 737 risk-sharing, 707, 813 temperature and, 787-789 timing and, 345, 785, 801-802 uncertainty and, 781 See also Insurance; Vulnerabilities Risk assessment, 771, 779-810 health and disease, 407-412 tools, 723 use of vulnerability assessment framework, 782 See also Vulnerability assessment Risk management, 31, 53, 135, 139-141, 361, 724 disaster risk management/reduction, 820-821 global warming approaches, synthesis, 140 sustainable development and, 384, 819-820 Tsho Rolpa project, Nepal, 719, 721, 723 for water sector, 36 **River basins** in Africa, 48 in Asia, 471, 483, 493 human population in, 35 in Latin America, 586, 592-593 in North America, 193-194, 197, 627, 628, 633, 634, 818-819 trans-boundary, 767-769 water stress, 36, 179, 193-194 River discharge\*, 28, 182-184, 183-184 See also Runoff Rivers. 233-234 acidification, 189 Arctic, 663-665 dams on (See Dams) extreme floods, 109 observed changes, 28, 81, 91 river ice, 83, 88-89, 664 trans-basin diversions, 193-194, 197, 602 See also Freshwater resources and management; Runoff; specific rivers Runoff\*, 175, 177, 182-184 in Africa, 446 in Asia, 49, 472, 483 in Europe, 52, 549-550, 554 in Latin America, 596, 598-599 observed changes, 81, 83, 89, 90 in polar regions, 655, 663-665 projected changes, 36, 280, 792 relation to temperature rise, 90 **Rural settlements** adaptive capacity, 383 agriculture, 282 development, 492 human health, 413 in North America, 625 rural-urban migration, 491-492 **Russia–East of the Urals** glacial melt impacts, 484 Lena delta, 496 permafrost degradation, 487

See also Asia

#### S

Salinisation\*, 35, 186, 189 in coastal regions, 35, 179, 599 of groundwater, 35, 175, 179, 189, 483, 693 of inland waters, 553, 558 secondary, 189 Salmon, 192-193, 275, 291, 624 Salmonella, 487 See also Food poisoning Salmonellosis, 108, 400, 557, 701 Salps, 56, 88, 660, 675 Saltmarshes, 317, 329 biodiversity in, 630 in United States, 619, 623, 630 Saltwater intrusion/encroachment\*, 35, 175, 179, 186, 189 adaptation, 722 in Asia, 49, 471, 477, 483 in Australia/New Zealand region, 512, 517 projected impacts and interactions, 375 See also Freshwater resources and management; Groundwater Sanitation and urban drainage, 371 See also Wastewater Savannas\*, 214, 224-226 in Africa, 451 forest replacement by, 583, 596 in Latin America, 596 See also Grasslands; Rangelands Scale, 359, 360, 366 of adaptation and mitigation, 749 ecosystem responses, 214, 215, 547 human health, adaptation approaches, 416-417 Large Scale Biosphere-Atmosphere Experiment, 604 in mitigation, 747, 749, 753-754, 767-769 Scenarios\*, 31, 76, 77, 146-160 adaptation, 156-158, 719, 724 analysis, 799-802 atmospheric composition, 152-153 baseline, 782 carbon dioxide concentration, 34-35 climate, 32-33, 148-152, 149-151, 155 climate change, global-scale impacts, 821-825 climate scenarios assumed in this report, 149-151 definition, 145 emissions, 155, 529, 758 extreme weather events, 148-152 geographical resolution, 135 global and aggregate impacts, 821-825 Global Scenarios Group set of, 364 governance, 364 integration, 160 land use, 155-156 mitigation, 35, 139-141, 158-160, 799-803, 813, 830-831 non-climate, 34-35 overshoot, 801-802, 804 sea-level, 153-154

socio-economic, 154, 155 stabilisation, 35, 71, 529, 758, 765, 799-802, 828 statistical downscaling, 148 "Techno Garden," 818 technology, 156, 364 See also SRES scenarios Schistosomiasis, 405, 487, 689, 701 Sea grasses, 328-330 Sea ice, 56, 655, 668-669, 734 Antarctic, 658 Arctic, 56, 655, 658, 659, 668 ecosystem impacts of decrease in, 88, 213, 231, 236, 668-669 observed changes, 28, 81, 83, 88, 657, 658, 659 projected changes, 40, 236, 656, 659, 662, 792 Sea-ice biome\*, 56, 81, 231, 236, 655, 668-669, 792 Sea-level rise\*, 40, 41, 49 adaptation, 798 adaptation costs and benefits, 345, 435, 724-725 adaptation examples, 722 adaptation limits, 734 coastal area impacts, 40, 41, 49, 317, 322-324, 325, 326, 336, 339 costs for developing vs. developed countries, 339, 339 extreme water levels and, 93, 325 geographic variability in, 484 glacial melt and, 663 ice sheet deglaciation and, 64, 75, 317, 346, 793, 793-794 inertia of, 41, 317, 346 long-term impacts (beyond 2100), 346 observed changes, 92, 479 (See also specific regions and *countries*) projected changes, 40, 41 (See also specific regions and countries) projected impacts, 42, 51, 54, 346, 375, 484-485, 793, 828 rapid, 734 regional scenarios, 154, 346 salt water intrusion and, 175, 186, 189 scenarios, 35, 153-154, 154, 322-324, 346, 696 storm surge scenarios/interactions, 154, 725 timing and risk, 345, 798 unavoidability of, 41, 317 See also specific regions and countries Sea surface temperature (SST) in Australia/New Zealand region, 510, 512, 522, 527 coral bleaching and, 320, 321-322 cyclones and, 479, 795 marine ecosystems and, 236 phytoplankton blooms and, 487 Sea turtles, 236, 449, 696 Sea urchins, 730 **Sea wall\***, *343* Seabirds, 95-96, 521, 527, 696 Seals, 96, 236, 660, 668, 669, 671 Seasonal climate forecasting, 416, 721, 727-728 Seasons. See Phenology Sediment transport, 179, 189-190, 320, 485 dams and, 319, 326

deltas and, 493 Semi-arid regions\* afforestation in, 758 in Africa, 435, 439 freshwater resources and management, 36, 175, 176, 193-194, 331 replacement with arid vegetation, 54, 583 Sensitivity\* in Africa, 435, 436-443, 451 in Asia, 472-478 in Australia/New Zealand region, 510-514, 525 coastal systems, 318-322 ecosystems, 215-218 energy production systems, 362 in Europe, 544, 545-547 food, fibre and forest products, 277-280 freshwater resources, 176-180 human health, 396-405 industry, settlement and society, 361-363, 375 in Latin America, 584-593 in North America, 620-626, 627 in polar regions, 656-661 in small islands, 690-694 See also Climate sensitivity Sensitivity analysis, 32, 145, 146 Sequestration. See Carbon sequestration Services adaptation, 379-381 ecosystem goods and services, 213, 215, 245-246 future impacts and vulnerabilities, 367 Settlement. See Human settlements See also Industry, settlement and society; Urban settlements Shellfish poisoning, 400 See also Food poisoning Shrimp, 669 Shrublands, 238, 552-553, 565 Silviculture\*. See Forestry Sinks\*. See Carbon sinks Ski industry, 28, 557, 558, 561, 634, 636, 734, 790 adaptation, 492, 721 in Asia, 489 effects of decreased snow, 86 snow-making, 557, 719, 721, 734 See also Europe, European Alps Skin cancer, 601 Small islands, 57-58, 63, 687-716 adaptation, 694, 703-709, 728 adaptive capacity, 706-709 agriculture, fisheries and food security, 57-58, 689, 698-700 assumptions about future trends, 694-695 atolls, 40, 697-698, 705, 707 biodiversity, 58, 689, 700 capacity building, 708-709, 710 characteristics of, 57, 690-691 climate and weather, 691-692, 694 coastal systems and resources, 690, 693, 697-698

coral reefs, 57-58, 330, 699 current sensitivity/vulnerability, 690-694 drivers of change, 704 economic, financial and socio-cultural impacts, 57, 695, 698,701-702 ecosystems, 693, 696, 706 El Niño Southern Oscillation (ENSO), 689, 690, 691, 692 emigration and resettlement, 697, 708 energy, 702 extreme events, 695 future impacts and vulnerabilities, 57-58, 63, 689, 695-703, 696, 704, 788, 791-792, 829 globalisation, 693, 707 human health, 58, 689-690, 701 human settlement, 689, 690, 693, 695, 700-701 infrastructure and transportation, 57, 689, 690, 702-703 interactions of human and physical stresses, 693 introduction, 690 market impacts, 791 migration, 697, 708, 736 non-climate-change threats, 699 observed changes, 92, 93, 689, 691-692 precipitation, 151, 691-692, 694, 695-697 resilience in, 698 risk-sharing and insurance, 690, 707 salinisation of groundwater, 186, 189 sea level/sea-level rise, 57, 317, 689, 692, 694, 696, 705-706 socio-economic stresses, 692-693 sub-Antarctic islands, 672 sustainable development, 709-711, 791-792 temperature, 150, 691, 694 tourism, 58, 689, 690, 698, 701-702 traditional knowledge and culture, 690, 695, 728 tropical and extra-tropical cyclones, 689, 691-692, 695, 700 uncertainties and research priorities, 711-712 vulnerability/risk, 40, 57, 58, 74, 695-703, 788, 791-792 water resources, 57, 689, 693, 695-697, 703-705 See also Caribbean region; Fiji; Mediterranean islands Snow cover. 28 albedo and, 231 in Asia, 484 in Europe, 544, 551, 558, 565 on Mt. Kilimanjaro, 48, 440 observed changes, 28, 83, 86, 88, 115, 177 projected changes, 662-663 See also Snowpack Snow water equivalent\*, 621 Snowmelt, 83, 187, 193-194, 627 Snowpack\*, 39, 55, 99 in Europe, 551 in North America, 55, 619, 623, 624, 627, 628 See also Snow cover Social capital, 453, 492, 816 Social cost of carbon (SCC)\*, 65, 756, 771, 813, 821-824 Social cost of methane, 822 Social issues

adaptation, 382-383, 729, 736-737 future impacts and vulnerabilities, 373-374 Social systems adaptive capacity, 782, 798, 804 key vulnerabilities, 74, 787, 790-791 Socio-economic factors, 26-28, 84-85 in Asia. 474 in North America, 627 Socio-economic impacts, 41-43, 46-47 in Africa, 48-49, 297, 444 in Asia, 50, 479, 487-489 in Australia/New Zealand region, 521-522 coastal systems, 317, 322, 323, 330-339, 331 in Europe, 52-53, 543-544, 545, 548 food, fibre and forest products, 291, 296-299 forestry, 291, 297 freshwater resources/management, 190-196 human health and, 394 industry, settlement and society, 362, 373-374, 376-379 in Latin America, 590-591 methods and tools for characterising, 337 net negative impact of climate change, 338-339 in North America, 55, 632-635 observed changes, 82, 84-85, 111-112 in polar regions, 56, 655, 657, 661, 665-666, 668, 676 in small islands, 57, 58, 695, 698, 701-702 See also specific systems and regions Socio-economic scenarios\*, 154, 155 Soil carbon stocks, 221 erosion, 179, 189-190, 558 nitrogen, 221 water balance/moisture, 50, 225 Solar resources, 634 Sorghum, 49, 288, 295, 452, 482, 555 South America. See Latin America South Atlantic Convergence Zone (SACZ), 584 South-east Asia. See Asia South Pacific Convergence Zone (SPCZ), 691 Southern Annular Mode, 675, 794 See also Modes of climate variability Southern Ocean carbon flux, 662 ecosystems, 244, 669-671 projected circulation changes, 521 vulnerabilities, 234 warming, observed, 95-96 See also Polar regions Southern Oscillation. See El Niño Southern Oscillation Soybeans, 54, 106, 583, 590, 607 Spatial analysis, 29 Spatially-explicit methods, 824-825, 836 Sphagnum moss, 660 Springtails (Collembola spp.), 103 Spruce budworm, 218, 623 SRES scenarios\*, 32, 147, 147 carbon dioxide stabilisation, 159

climate scenarios assumed in this report, 149-151

970

climate variability/extremes, 152 downscaling methods, 135 food demand and supply, 38, 284 global economic growth projections, 364 global storylines and scenarios, 147 land-use and land-cover, 157 nutrition/hunger, 275, 298, 299, 300 sea-level, 153, 694, 696 socio-economic characterisations. 155 terrestrial ecosystem changes by 2100, 213, 238 tourism, 369 water stress, 36 See also Scenarios Stabilisation scenarios, 35, 71, 529, 758, 765, 799-802, 828 Stakeholders\*, 31, 747, 753-754, 770 assessment inputs, 31-32, 135, 141-142 participation ladder, 142 vulnerability assessment and, 782 Stegomyia aegypti (formerly Aedes aegypti), 403-404, 524 Stochastic modelling, 337 Stock. See Carbon stocks Storm surges, 317, 319-320, 334, 398 adaptation, 722, 724 in Europe, 550-551 in Latin America, 586 in North America, 55, 630 observed changes, 92-93 projected impacts and interactions, 375, 725, 795 scenarios, 154 in small islands, 57, 695 See also Extra-tropical cyclones; Hurricanes; Tropical cyclones; Waves Storylines, 32, 145, 146, 147 Stratosphere\*, 600-601 Streamflow\*, 175, 176, 179, 189 in Africa, 446 in North America, 621-622 observed changes, 89, 114, 177 projections, 36, 185, 193-194 Sturgeon, 275, 291 Sub-alpine\* regions forests, 232, 620, 624 lakes, 91 vegetation and mammals, 512 Sub-Antarctic islands, 50, 672 See also Small islands Sub-arctic regions in Europe, 543, 551-552, 559, 565 productivity, 659 **Sub-tropical regions** ecosystems, 213-214, 229, 236 human health, 689, 701 See also Tropical regions Subsistence livelihoods, 43, 49, 248-249, 275, 279, 281-282, 293-294,657 Succulents\*, 223, 243, 449, 792 Sulfur dioxide, 153 Surface air temperature

in polar regions, 230, 656-657 in small islands, 694 Surface runoff\*, 90 See also Runoff Surprises, ecological, 38, 242 Sustainable development\*, 55, 75-76, 384, 811-841 adaptation and development communities, bringing together, 76, 834-836 adaptation and mitigation links, 747, 751, 765-766, 827-832 adaptive capacity and, 76, 817-819 in Africa, 457 in Asia, 494-495 in Australia/New Zealand region, 528-529 barriers to, 299 coastal systems, 345 definition, 494, 814 ecosystems, 248-249 environmental quality, 819-820, 835 equity issues, 813, 826-827, 835 in Europe, 546-547, 563-564 food, fibre, forestry and fisheries, 276, 299 freshwater resources, 36, 200-201 global and aggregate impacts, 821-825 indigenous knowledge and, 832, 833 industry, settlement and society, 380, 384 introduction, 814 in Latin America, 55, 299, 584, 606-607 linkages with climate change/adaptation, 817-819 multiple stresses and, 359, 384, 813, 816-819 in North America, 639 opportunities, co-benefits and challenges for adaptation, 832-836 overview schematic, 815 participatory processes, 813, 832-834 pillars of, 814, 815 in polar regions, 675-676 regional, sub-regional, local and sectoral development, 826-832 risk, hazard and disaster management and, 820-821 in small islands, 709-711, 791-792 supporting factors, 813, 816-817, 836 synergies in, 813, 827-832, 835, 836, 837 synthesis of new knowledge, 814-816 'three pillars' of, 766 thresholds. 361 uncertainties, unknowns and priorities for research, 78, 836-837 See also Development; Millennium Development Goals Switchgrass (Panicum virgatum L.), 288 Synergies, 72, 747, 754-756, 762-763, 813, 835 definition. 749 geographic distribution of, 827, 830-831 of mitigation and enhanced adaptive capacity, 72, 827-832, 837

in Asian regions, 480

Taiga\*, 229, 230, 485 Tajikistan, hydropower generation, 483 Technology access to, 441, 791, 813, 816, 826-827 adaptation and, 554-555, 727-728, 734 biotechnology, 296, 452, 555-556 limits, 734 scenarios, 156, 364 Temperature adaptation examples, 721, 722 agricultural impacts, 275, 282-283, 284-285, 286, 287-288, 300, 301 alert plans/early warning systems, 53, 417, 491, 544, 563, 721 attribution of observed changes to, 81, 112-116 in Australia/New Zealand region, 509, 510-511 extreme events, 789, 795 (See also Heatwaves) fisheries and. 291 impacts (See Temperature impacts) observed changes correlated with, 85-112, 114-116 (See also Observed changes and responses) observed changes in, 81, 115-116 (See also specific regions and countries) projected impacts (See Temperature impacts) reference for temperature levels, 783 regional changes in, attribution for, 112-113 relationship with vulnerability/risk, 787-789 sea surface (SST) (See Sea surface temperature) surface air (See Surface air temperature) thresholds, 802, 803 See also Heatwaves; Temperature impacts; Temperature projections; specific regions and countries **Temperature impacts**, 31, 37, 42, 73 compendium of risks for additional degrees of warming, 37 damage estimates for additional degrees of warming, 822 global/aggregate impacts, 64, 66, 73, 821-825, 827, 828-829 key vulnerabilities exacerbated by, 73, 781, 786-797, 803-804 linking of observed effects with temperature, 29 potential vulnerabilities with additional degrees or warming, 787-789, 792, 804 projected global impacts with additional degrees of warming, 828-829 projected impacts of 2-3°C rise, 38, 65, 781, 792 projected impacts of 4°C rise, 65, 781, 822 regional impacts, 33, 67, 827, 829 See also Extreme weather events; Temperature **Temperature projections** carbon dioxide stabilisation and, 158-159 global, by 2080, 824 global damage estimates, 822 global, mean change above 1990-2000 levels, 781, 783, 792,804 impacts of delay in addressing, 782, 802, 804 overshoot scenarios, 801-802, 804 probability of exceeding 2°C above pre-industrial level, 801 regional, summarised, 33, 149-150

Terrestrial ecosystems, 38 adaptive capacity, 658-660 carbon exchange, 38, 222, 792 as carbon source in future, 38, 213, 222, 792 climate-linked extinctions and invasions, 103 in coastal areas, 319-320 morphology/reproduction changes, 103 observed changes, 28-31, 81, 98-104, 115-116 phenology, 28, 99-101 in polar regions, 655, 656, 658-660, 666-668 projected changes, 38, 213, 238, 792 species community changes, 103-104 species distribution/abundance, 101-103 species evolutionary processes, 104 vulnerability/risk, 74, 788 Thailand, flooding in, 484 Thermal expansion\*, 41, 318, 324, 346, 484 See also Lakes Thermal stratification, 81, 91, 234, 235 See also Lakes Thermal stress. See Heat stress Thermocline\*, 91, 553 See also Thermal stratification Thermohaline circulation (THC; also called Meridional Overturning Circulation)\*, 275, 292, 563, 655, 664 impacts of potential changes in, 64, 563, 794, 802-803 observed condition of, 88 vulnerability/risk, 74, 789, 794, 802 Thermokarst\*, 88, 89, 231, 486 Thresholds\*, 78, 141, 359, 361, 365 adaptation limits, 733-734 climate, 781, 784-785, 802-803 coastal systems, 320, 321-322 coral bleaching, 321-322 crop responses, 277 dangerous anthropogenic interference (DAI), 801-802 ecosystems, 215 ice sheet deglaciation, 73, 793, 797, 800 temperature, 802 Tibetan Plateau, 106, 472, 724 glaciers, 477, 481, 487, 493, 494 vegetation changes, 486 See also Asia Tick-borne diseases, 108, 403, 557, 619, 620, 671 Lyme disease, 557, 619, 625, 632 tick-borne encephalitis (TBE), 108, 403, 410, 487, 671 Ticks in Australia/New Zealand region, 283, 520 cattle tick (Boophilus microplus), 283, 520 in Europe, 403, 410, 557 Ixodes scapularis, 625, 632 in North America, 620, 632 Timber industry. See Forestry Timor Lest (East Timor), 706 Tolerable Windows Approach (TWA), 754-755, 802 Top-down assessment approaches, 136, 748-749 Top-down risk reduction approach, 820

#### Tourism

adaptation, 380 in Africa, 435, 439, 449, 450, 459 in Asia, 489, 492 in Australia/New Zealand region, 523, 527, 529 coastal area impacts, 320, 335-336 direct and indirect effects, 368-369 in Europe, 53, 336, 543-544, 556-557, 561, 565 future impacts and vulnerabilities, 362, 368-369, 790 infrastructures to protect tourists, 492 in Latin America, 587, 599 in North America, 626, 634 observed changes, 111 in polar regions, 673, 676 sensitivity to climate effects, 363 in small islands, 58, 689, 690, 698, 701-702 vulnerability/risk, 362, 368-369, 790 See also Recreation Toxic algal blooms. See Harmful algal blooms (HABs) Trade adaptation, 379, 730 agreements, 731 food, fibre and forest products, 40, 276, 284, 297, 300 future impacts and vulnerabilities, 367-368 international, climate change effects on, 368 See also Globalisation Trade-offs, 72, 747, 749, 751, 754-756, 762, 771 in coastal systems, 342-344, 795 Traditional ecological knowledge, 456-457, 523, 605, 666, 673-674,833 Transpiration\*, 220 See also Evapotranspiration **Transportation** adaptation costs and benefits, 725, 726 in Europe, 556, 561, 565 extreme weather events and, 362, 366 future impacts and vulnerabilities, 368 linkage systems, 362 in North America, 627, 628, 630, 635, 636 in polar regions, 88, 676 in small islands, 689, 702-703 See also Infrastructure Tree line\*, 229, 232, 233, 546, 551, 565 polar and altitudinal changes, 666 in polar regions, 655, 666 Trophic level\*, 96-97 Trophic relationships\*, 56, 667 Tropical cyclones, 317, 338 in Africa, 444 in Asia, 473, 476, 479, 489 in Australia/New Zealand region, 511 cost of damage, Asia, 489 deaths, worldwide, 40, 338 observed changes, 110 projected impacts/vulnerabilities, 42, 74, 317, 375, 781, 789,795 range of impacts, 338 in small islands, 689, 691-692, 695, 700 wind speed projections, 695

See also Extra-tropical cyclones; Hurricanes Tropical forests, 54, 106, 220-221, 584, 596 deforestation, 53, 583, 594-595 replacement by savanna, 583, 596 **Tropical regions** fires in, 218 forest replacement by savanna, 583, 596 See also specific regions and countries Troposphere\*, ozone in, 153, 480 Trout, 291, 665 See also Fisheries Trypanosomiasis, 447 Tsetse fly, 447 Tsho Rolpa project, Nepal, 719, 721, 723 See also Adaptation Tsunamis\*, 319-320 Tularemia, 671 Tuna, 292, 482, 700 Tundra\*, 38, 214, 230-232, 485, 666-668 adaptation limits/limitations, 52, 543 "greening" trend, 88 projected changes, 52, 792 See also Permafrost; Polar regions Typhoid, 398, 701

# U

Ultraviolet (UV)-B radiation, 234, 278, 405, 558, 600-601 Uncertainty\*, 27, 143-144, 799 adaptation procedures planned for, 201-202 in future projections, 378 managing, 141 multiple stresses/factors and, 783 See also Risk; specific systems and regions Undernutrition\*, 38, 394, 399-400, 438 See also Hunger; Malnutrition Ungulates\*, 226 Unique and threatened systems, 73, 795-796 United Kingdom (UK) adaptation, 381, 722, 724, 820 adaptation/mitigation inter-relationships, 769-770 Climate Change Programme, 769-770 coastal retreat, 92 energy use/demand, 111 fires, 107 flood defences, 65, 381, 722 forage quality, 287 human health, 395, 409-412 marine ecosystems, 94 opportunities from climate change, 381 participatory processes, 834 phenology, 100 water supply/management, 199-200, 371 See also Europe United Nations Development Programme (UNDP), 732-733 **United Nations Framework Convention on Climate Change** (UNFCCC)\*, 383, 731, 748, 753, 766-767 Article 2, 73, 766, 781, 782, 783, 784 compliance with/governance of, 495

Global Environmental Facility (GEF), 836 policy focus on adaptation, 817-818 United States adaptation, 633, 722, 815, 820 agriculture, 623-624, 631 cities, climate change impacts in, 633 coastal areas, 92, 622-623, 719 Colorado River basin, 193-194, 197, 627, 634 Columbia River basin, 627, 628, 633, 818-819 costs of weather-related disasters, 332, 338, 369, 377, 621, 626 Deer Island sewage facility, 724 ecosystem impacts, 242-245 energy, 626, 634-2527, 760 fisheries, 281 forestry, 624, 630 freshwater resources, 621-622, 627-629 heatwaves, 111, 411 human health, 372, 625 hurricanes, 92, 369, 399, 621, 625-626, 627 (See also Hurricanes, Hurricane Katrina) Mississippi River/delta, 326, 332, 333, 377 net primary production (NPP), 622 phenology, 100, 283, 622 precipitation, 621-622 protectorates (See Small islands) storm surges, 92-93 temperature, 620, 621 tourism and recreation, 336, 626, 634 transportation, 366 See also North America Upwelling region\*, 91, 96, 235 Urban heat islands. See Heat islands Urban planning, 761 **Urban settlements** future impacts, 372 high-risk areas, 361 sanitation and drainage, 371 summary of indicators, 363 See also Construction; Human settlements; Industry, settlement and society; Infrastructure Urbanisation\*, 359 in Asia, 488-489, 491, 494-495 in Europe, 549, 550 human health and, 412-413 in Latin America, 587, 590 Utilities, 370, 381

### V

Vagile\* animals, 237 Valley Fever, 625 Vascular plants\*, 667 *See also* Vegetation Vector(s)\*, 82, 108, 393, 400, 403, *418*, 435, 599 changes in transmission seasons/areal range, 31, 43, 50, 403-405, 471, 487 possible pesticide resistance, 487 Vector-borne diseases\*, 372, 394, 403-405, 418, 555

in Asia, 50, 471, 472, 487 in Europe, 51, 543, 557 in North America, 619, 620, 625, 632 observed changes, 108, 403-405 See also Diseases; specific diseases Vegetation Arctic region, current and projected, 57 carbon dioxide effects on, 220, 276, 282-283, 285-287, 290.300 Dynamic Global Vegetation Models (DGVMs), 219, 220, 222 herbaceous vs. woody growth, 225-226, 552 poleward/altitudinal shift in ranges of, 57, 83, 102-103, 659 See also Ecosystems; specific systems and regions Vernalisation\*. See Phenology Vibrio cholerae, 401 Vibrio parahaemolyticus, 400 Vibrio vulnificus, 400 Vietnam, 473, 484 See also Mekong River/delta Visceral leishmaniasis, 403, 557, 587 Vulnerabilities\*, 73-75, 117, 138-139 in Africa, 40, 48, 48-49, 64, 280, 435, 436-443, 444-450, 451, 788, 791 in Asia, 64, 472-478, 479-489 assessment of (See Vulnerability assessment) in Australia/New Zealand region, 50-51, 242-245, 509, 510-514, 516-524, 525, 528, 529, 530 coastal systems, 40-41, 317, 318-322, 324-336 context/scale and, 43, 138-139, 359, 360, 366 definition, 27, 138, 781, 782 distribution, variations in, 781, 784, 796 ecosystems, 213-214, 219-245 in Europe, 545-547, 549-558, 565-566 food, fibre and forest products, 74, 277-280, 282-294, 297-299 freshwater resources, 176-180, 182-190, 193-194, 233-234 global distribution in 2050, 77, 830 global distribution in 2100, 831 globalisation and, 731 hotspots (See Vulnerability hotspots) human health, 396-405, 406-415 industry, settlement and society, 41, 359, 361-363, 364-376 'key' vulnerabilities, 73-75, 781, 783-797 (See also Vulnerability assessment) in Latin America, 53-54, 584-593, 596-600 multiple stresses and, 75, 813 national vulnerability index, 827, 830-831 in North America, 242-245, 619, 620-626, 627-635 perceptions of, 735-736 in polar regions, 64, 230, 658-661, 663-672 in small islands, 57, 58, 64, 74, 689, 690-694, 695-703, 696 of special populations, 43, 64, 78, 393, 399, 557, 791, 796 See also Coping ranges; Risk; specific systems and countries Vulnerability assessment, 64, 73-75, 138-139, 779-810 as bottom-up approach, 136

characteristics summarised, 137 critical levels and thresholds, 784-785 dangerous anthropogenic interference (DAI), 73, 781, 782, 784, 798, 799, 801-802, 804 distribution and aggregation of impacts, 75, 781, 784, 786, 796-797 equity issues, 784, 786 extreme events, 64, 68, 73-74, 781, 789, 795, 796 geophysical systems, 74, 782, 789, 792-795 global biological systems, 74, 782, 788-789, 792 global social systems, 74, 782, 787, 790-791 introduction, 782-785 key vulnerabilities, 73-75, 783-784, 786-797 key vulnerability criteria, 73, 781, 785-787 methods, 798-804 mitigation strategies, 798-803 'reasons for concern' update, 73-76, 781, 795-797, 800 regional systems, 74, 788, 791-792 research needs, 804 response strategies, 781-782, 797-804 scenario analysis, 799-802 scientific assessment and value judgments, 784, 786, 799 stabilisation targets, 799-802 synthesis, 803-804 uncertainties in, 782, 799 UNFCCC Article 2, 781, 783, 784 See also CCIAV assessment **Vulnerability hotspots** in Africa, 438 Amazonia. 604 in Asia, 481

in Australia/New Zealand region, 51, 509, 529, 530 in coastal systems, 40, 41, 317, 327, 336, 337 in Latin America, 604, 606 megadeltas, 41, 64, 377

#### W

Walrus (Odobenus rosmarus), 669, 792 Warming. See Global warming Wastewater management, Australia/New Zealand region, 517 re-use for irrigation, 418, 491 sanitation and urban drainage, 371 use, 181-182, 189, 490-491 Water chemistry, 89, 91, 658 groundwater (See Groundwater) water-climate interface, 201-202 See also Freshwater resources and management; Hydrological systems Water-borne diseases, 178-179, 189, 400-401 in Asia, 50, 471, 487 in Australia/New Zealand region, 524 in Latin America, 599 in North America, 625 observed changes, 108, 109 in small islands, 701 Water consumption\*, 179, 191, 200, 370

Water demand/use, 36, 175, 191-194, 196-200, 197, 816 in Asia, 284, 481, 482, 483-484 in Australia/New Zealand region, 511-512, 528 in Europe, 550 Water pollution, 36, 175, 182, 188-189 Water productivity\*, 192, 194 Water quality, 178-179, 188-189, 791 in Africa, 441-442 in Asia, 483, 487 in Australia/New Zealand region, 517, 525 in Europe, 545, 549-550, 557 human health and, 400-401, 413, 487 in lakes, 233 in North America, 629 in small islands, 693, 703-705 Water resources adaptation and mitigation decisions, 758-759 adaptation costs and benefits, 300, 725, 726, 727 in Africa, 48, 284, 370, 377, 435, 437, 441-442, 444-446, 451, 458-459 in Asia, 49, 471, 471-472, 477, 481, 483-484, 490-491 in Australia/New Zealand region, 50, 511-512, 514, 526, 528 in Europe, 52, 545, 549-550 infrastructure, 36, 175, 189, 191 in Latin America, 586, 592-593, 597-599, 602, 605 in North America, 55-56, 627-629, 633 observed changes, 90-92 projected changes, 35-37, 828 in small islands, 57, 689, 693, 695-697, 703-705 vulnerability/risk, 787, 791, 824 See also Freshwater resources and management; Groundwater; Runoff Water stress\*, 36, 179, 193-194, 284, 365, 791 in Africa, 48, 435, 437, 444, 445, 451 in Asia, 471, 472, 484 in Europe, 52, 543, 550, 552, 559, 565 in Latin America, 54, 583, 597-598, 791 projections, 795, 813, 825 in small islands, 689, 697 Water supply future impacts and vulnerabilities, 370-371, 726 human health and, 401 infrastructure, 36, 175, 189, 191 regional planning, 382 Water use efficiency\*, 283, 284, 331, 490-491 Waves, 93, 110, 317, 319 See also Storm surges Weeds, 103, 283, 483, 520 Welfare\*, 814, 821 coast impacts and, 40 West Nile virus, 619, 625 Wetlands\*, 40, 233-234 in Africa, 449 Arctic, 88, 655, 665 in Asia, 471, 478, 485 in Australia/New Zealand region, 509, 517, 530 biodiversity, 234

coastal, 40, 92, 93, 317, 328-330 in Europe, 551, 553, 560, 565 methane emissions from, 793 in North America, 620, 630 observed changes, 92 tundra, 230-231 wastewater re-use and, 491 Whales, 236, 669, 671 Wheat, 277, 452, 480 Fusarium in, 586, 590 observed changes, 106 projected crop yields, 54, 297, 586 sensitivity to climate change, 39 temperature and, 39, 286 Wildfires. See Fires Wildlife ranges, 83, 230-231, 622 See also Range shifts of vegetation and wildlife Wind adaptation options, 70 flooding and, 398 (See also Storm surge)

resources, 634 speed, in tropical cyclones, 695 windstorms in Europe, 489, 547-548, 557 See also Extra-tropical cyclones; Hurricanes; Tropical cyclones Wine production, 104, 105, 624, 631, 731 Women. See Gender Woodlands. See Forests World Bank, carbon offset funds, 753 World Trade Organization (WTO), 767 Wyeomyia smithii, 403

# Y

Yedoma\*, 213, 214, 221, 231 Yields. See Crop yields

# Z

Zoonoses (zoonotic diseases)\*, 625, 671 Zooplankton\*, 28, 56, 88, 94-96, 97, 556 *See also* Algal blooms; Phytoplankton