

Index

Note: Page numbers in bold indicate page spans for entire chapters. Page numbers in italics denote tables, figures and boxed material.

A

Adaptation, 4, 48-51

- autonomous, 48, 63
- examples, 50
- limits on, 49
- mitigation, potential conflicts with, 124
- planned, 48-49, 63
- supply-side and demand-side options, 48, 49
- sustainable development implications, 130
- vulnerability reduction by, 49
- See also* Mitigation

Adaptation, vulnerability and sustainable development, 125-131

- Africa, 50, 85
- agriculture, 63-67
- Asia, 88-90
- Australia and New Zealand, 50, 92-93, 92
- economy, insurance, tourism, industry and transportation, 75
- Europe, 50, 95-96
- human health, 69
- Latin America, 50, 100-102, 101
- North America, 50, 104-106
- polar regions, 50, 109
- settlements and infrastructure, 74
- small islands, 50, 110, 111-113
- water supply and sanitation, 71-73

Aerosol processes, 15

Afforestation, 4, 59, 118, 120-121

Africa, 79-85, 128-129

- adaptation and vulnerability, 50, 85
- current observations, 79-81, 79-80
- forest ecosystems, 60
- Kilimanjaro, Mt., 82
- lakes and rivers, 36, 129
- pastoralist coping strategies, 64
- precipitation, 16, 25, 59

projected changes, 81-85, 128-129

runoff, 21-22, 35

vulnerabilities, 66, 128

Agriculture, 59-67, 128

- adaptation, vulnerability and sustainable development, 63-67
- biotechnology and, 65, 65
- cropland drainage, 123, 123
- cropland management (reduced tillage), 118, 120, 122-123
- cropland management (water), 118, 120
- crops, 61-62
- fertiliser use, 10, 120
- intensification of, 120
- irrigation water requirements, 4, 10, 61, 62, 128
- mitigation measures and water, 118, 120
- modelling, 59
- observations, 60, 61
- projections, 60-63, 128
- residue return, 122-123, 123
- water management and GHG emissions, 123
- water quality, effects on, 10
- See also* Agriculture: regional aspects; Irrigation

Agriculture: regional aspects

- Africa, 81, 83, 84
- Asia, 87, 88
- Australia and New Zealand, 91
- Europe, 95
- Latin America, 97, 100
- North America, 103-104
- small islands, 111

Agro-forestry, 119

Algal blooms, 56, 68, 71

Alpine ecosystems, 58

Amphibians, 55, 58, 98

Annular Modes, 22-23, 31

Aquaculture, 66

Arid and semi-arid areas

- observed changes, 38
- projected changes, 62, 127, 128
- vulnerability, 3, 127
- See also* Droughts

Asia, 85-90, 129

- adaptation and vulnerability, 50, 88-89
- floods, 37, 86
- glaciers, 86, 86, 129
- lakes and rivers, 36
- observed impacts, 85-87
- precipitation, 16, 25
- projected impacts and vulnerabilities, 87-88, 129
- runoff, 20, 29, 45-46
- water supply, 43, 129

Attribution for climate change, 15, 16-17**Australia and New Zealand, 90-94, 129**

- adaptation and vulnerability, 50, 92-93, 92
- droughts, 38, 66
- groundwater, 36
- infrastructure, 129
- observed changes, 90-91, 90
- precipitation, 16, 59
- projected changes, 91-92, 129

B**Bio-energy crops, 4, 117-119, 118****Biodiversity, 55, 128**

- Africa, 81, 84-85, 84
- Asia, 87
- Australia and New Zealand, 91-92
- Europe, 95
- Latin America, 97-98, 100
- North America, 104
- polar regions, 108
- small islands, 111

Biofuels, 66**Biogeochemical feedbacks, 24****Biomass electricity, 118, 119****Biotechnology, 65, 65****Buildings, 74, 118, 119****C****Campylobacteriosis, 68****Carbon cycle, feedbacks, 24****Carbon dioxide and water dynamics, 60**

- See also* Greenhouse gas (GHG) emissions

Carbon dioxide capture and storage (CCS), 117-

123, 118

Carbon dioxide fertilisation, 58**Carbon sinks, 24****Caribbean, 25, 110**

- See also* Small islands

Chacaltaya Glacier, 35, 99**Climate**

- complexity of response, 15
- feedbacks with hydrological cycle, 15, 23-24
- models (*see* Climate models)
- observed changes, 15-23
- projected changes, 24-31
- variability, large-scale patterns of, 22-23, 31

Climate change, 13-31

- aggravation of other stresses by, 4, 130
- attribution for, 15, 16-17
- impacts on sustainable development, 47, **125-131**
- impacts on water resources, 35-47, 47, **125-131**
- mitigation measures (*see* Mitigation)
- See also* Linking of climate change and water resources

Climate change and water, 5-11

- background, scope and context, 7-11
- climate-related drivers of freshwater systems, 24-31, 38-43
- linking climate change to water resources, **33-51**
- negative impacts vs. benefits, global, 3, 127
- observed changes, 8-9, 35-38
- projected changes, 38-48
- projected impacts by regions, **77-113**, 128-130
- projected impacts by sectors, 59-74, 127-128
- projected impacts by systems, 55-58
- summary, **1-4**

Climate models, 3, 24-31, 48, 179

- multi-model probabilistic approaches, 26-27, 48
- observational needs, 135
- projections from, 24-31, 135-136
- scenarios/storylines, 9-10, 10, 24

Coastal areas

- future impacts, 43, 57-58, 128
- human settlements and infrastructure, 73, 74

Colorado River Basin, 51, 51, 105**Columbia River Basin, 106****Confidence levels. *See* Uncertainty****Costs and socio-economic aspects, 45-47, 74-75****Cryosphere**

- observed changes, 3, 19-20, 19-20, 35
- projected changes, 27-28

- Cryptosporidiosis**, 68, 71
- Cyclones, tropical**
observed changes, 17-18
projected changes, 27, 31, 41, 103
- D**
- Dams**
construction and decommissioning, 9-10, 136
greenhouse gas emissions from, 4, 122, 123, 130
water storage by, 10
- Deforestation**, 23, 59, 61
avoided/reduced, 118, 121
- Deltas, projected impacts**, 57, 99, 128
- Desalination**, 10, 46, 72, 130
greenhouse gas emissions from, 123, 124
- Drinking water quality**, 45, 67-68, 72
- Droughts**
frequency of 100-year droughts, projected, 42
human health and, 68
observed changes, 37, 38, 39
projected changes, 26-27, 41-42, 42-43, 127
See also specific regions
- Dry areas.** *See* Arid and semi-arid areas
- Dust storms**, 68
- E**
- Economic growth, water use and**, 9
- Economy**, 74-75
- Ecosystems**, 55-58, 127-128
- Egypt, agriculture in**, 83, 84
- El Niño-Southern Oscillation (ENSO)**, 22, 31, 85
- Energy**
Africa, 80, 82
Asia, 88
Australia and New Zealand, 91
Europe, 95
infrastructure, 74
Latin America, 96, 98
mitigation measures and water, 118
North America, 103
small islands, 111
water management and GHG emissions, 123
- ENSO.** *See* El Niño-Southern Oscillation
- Erosion, soil**, 43, 57
- Europe**, 93-96, 129
adaptation and vulnerability, 50, 95-96
droughts, 38, 94-95, 94
flooding, damage estimates, 46
heatwave of 2003, 38
mountain ecosystems, 58
observed changes, 93, 93
precipitation, 25, 42, 59
projected changes, 29, 42, 93-95, 129
runoff, 21-22, 29, 35, 45, 129
water-stressed areas, 129
- Evapotranspiration**
feedbacks, 23
observed changes, 20-21
projected changes, 25-26, 27, 29
- Extinctions**, 55, 56-57, 84, 91, 98, 128
See also Biodiversity
- F**
- Feedbacks of climate and hydrological cycle**, 23-24
emissions and sinks, 24
land surface effects, 23
ocean circulation, 24
- Fisheries**, 62-63, 66, 130
adaptation strategies, 64
Mekong river example, 63
- Floods**
costs of future impacts, 46, 75
in Europe, 94-95, 94
frequency of 100-year floods, projected, 41
human health and, 68
impacts on transportation and infrastructure, 73-74
insurance and, 75
observed changes, 37-38, 37
projected changes, 26, 41-42, 41, 127
- Food availability/security**, 3, 59, 60-63, 65-66
- Forests/forestry**, 59-60, 60, 128
adaptation strategies, 64-65
agro-forestry, 119
biotechnology and, 65, 65
conversion to cropland, 117
ecosystems, 58
mitigation measures and water, 118
- Frozen ground**
observed changes, 19, 19, 35, 107
projected changes, 27-28, 43, 108, 130
- Future research needs**, 4, 133-137
- G**
- Gangotri Glacier**, 86, 86
- Gaps in knowledge**, 4, 133-137
- Geothermal energy**, 118, 119
greenhouse gas emissions from, 123, 124

Glacial lake outburst floods (GLOFs), 20, 35, 68
prevention projects, 88, 89

Glaciers

Asia, 45, 86, 86, 129
Chacaltaya Glacier, 35, 99

Europe, 129

Latin America, 35, 97, 99, 129-130

observed changes, 19-20, 19-20, 35, 97

projected changes, 28, 43, 129

Grasslands, 58, 62

Greenhouse gas (GHG) emissions

from hydropower dams, 4, 122, 123, 130

water management policies and, 122-124, 123

Groundwater

mitigation measures and, 118

observed changes, 9, 35-36

projected changes, 38-41, 40

salinisation of, 3, 43

H

Health. *See* Human health

Heatwaves

European (2003), 38

observed changes, 15, 38, 60

projected changes, 24, 26, 95

Helminthiasis, 66, 69

Human health, 67-69

adaptation, vulnerability and sustainable
development, 69

Africa, 80-81, 83

Australia and New Zealand, 91

Europe, 95

Latin America, 96-97, 98-100

North America, 103

observations, 69

projections, 69, 128

small islands, 111

water quality and, 66

Human settlements, 73-74, 128

Hunger, 59

See also Food availability/security

Hydrological cycle

assumptions from past experience, 4

feedbacks with climate, 15, 23-24

projected changes, 3-4, 25-31, 38-48

uncertainties and, 24-25

variability in, 15

See also Hydrology; *water entries*

Hydrology

observed changes, 35-36

projected changes, 38-47

projected impacts on ecosystems and
biodiversity, 55-58

Hydropower, 46, 118, 119, 136

Africa, 82

Europe, 46, 129

greenhouse gas emissions from, 4, 122, 123, 130

infrastructure, 74

North America, 47

See also Dams; Energy

I

Ice

observed changes, 3, 19-20, 19-20

projected changes, 27-28, 130

Ice sheets

contribution to sea-level rise, 20, 24, 28-29

observed changes, 35

Industry, 74-75, 118, 128

Infrastructure, 4, 73-74, 128

Insurance, 74-75, 105

**Integrated water resources management
(IWRM)**, 44, 51, 124

Irrigation

adaptation practices, 63-65, 122, 123, 128

area of irrigated land, 9, 10

greenhouse gas emissions and, 122, 123

water use, observed changes, 8-9

water use, projected changes, 4, 10, 44, 61, 62,
128

K

Kilimanjaro, Mt., 82

L

Lakes

anoxia and algal blooms, 56

chemistry, 36

erosion and sediment, 37

observed changes, 36-37

projected changes, 43, 55-56, 129

thermal structure, 36, 56

Land surface effects, 23-24

Land use, 59-60

adaptation, 64

bio-energy crops and, 117

- Land-use change and management**, 118, 119-120
- Latin America**, 96-102, 129-130
 adaptation and vulnerability, 50, 100-102, 101
 glaciers, 35, 97, 99, 129-130
 observed changes, 96-98, 97
 pre-Colombian adaptations, 101
 precipitation, 16, 97-98
 projected changes, 98-100, 129-130
 runoff, 21-22, 30, 35
 water-stress, 96, 98, 100, 129
- Leptospirosis**, 97
- Linking of climate change and water resources, 33-51**
 adaptation to climate change, water-related, 48-51
 future water changes due to climate change, 38-48
 observed climate change impacts, 35-38
See also specific aspects of change and water resources
- Livestock**, 62, 64
- M**
- Malaria**, 80-81, 100
- Mekong river**, 63
- Meningitis**, 68
- Meridional overturning circulation (MOC)**, 24
- Methane**
 hydrodams and, 122
 landfill/wastewater, 123
 sources and sinks, 24, 130
- Millennium Development Goals, water sector and**, 131
- Mitigation, 115-124**, 130
 afforestation/reforestation, 118, 120-121
 avoided/reduced deforestation, 118, 121
 benefits vs. negative side effects of, 4, 67, 130
 bio-energy crops, 117-119, 118
 biomass electricity, 118, 119
 buildings, energy use in, 118, 119
 carbon dioxide capture and storage (CCS), 117, 118
 cropland drainage, 123, 123
 cropland management, 118, 120
 desalination, 123, 124
 future data needs, 136-137
 geothermal energy, 118, 119, 123, 124
 greenhouse gas (GHG) emissions and, 122-124, 123
 hydrodams, 122, 123
 hydropower, 118, 119
 irrigation, 122, 123
 land-use change and management, 118, 119-120
 policy implications, 130
 relationship with water, 117
 residue return, 122-123, 123
 synergies with adaptation, 67
 unconventional oil, 118, 122
 waste/wastewater management, 118, 121, 123-124, 123
 water management policies and, 122-124, 123, 130
See also Adaptation
- Models.** *See* Climate models
- Monsoon regimes**, 25
- Mountain ecosystems**, 58
- N**
- Nasca system of water cropping**, 101
- New Zealand.** *See* Australia and New Zealand
- Nile River**, 79, 84
- Nitrogen fertiliser use**, 10, 120
- Non-climatic drivers of water resources**, 8, 10, 43-44
- North America**, 102-106, 130
 adaptation, 50, 104-106
 case studies of climate change impacts, 104, 105-106
 droughts, 38, 66
 lakes and rivers, thermal structure of, 36
 observed change, 102
 precipitation, 16
 projected change and consequences, 102-104, 102, 130
 runoff, 21-22
- North Atlantic Oscillation (NAO)**, 15, 22, 31
- O**
- Observed changes**
 in climate, 15-23
 impacts on water resources, 8-9, 35-38
 summary, 3-4
See also specific regions and sectors
- Oceans**
 circulation, climate feedbacks through, 24
 salinity, 15, 24
See also Sea-level rise
- Oil, unconventional**, 118, 122
- P**
- Pastoralist coping strategies**, 64
- Permafrost.** *See* Frozen ground; Ice
- Phenology**, 60

Polar regions, 106-109, 130

- adaptation and vulnerability, 50, 109
- observed changes, 107, 108
- projected changes, 108-109, 130

Policies

- climate change implications for, **125-131**
- water management, 122-124, 123
- See also* Adaptation, vulnerability and sustainable development

Population growth

- in coastal areas, 73, 74
- water demand and, 4, 8, 9
- in water-stressed areas, 45, 45

Precipitation, 15-19, 25-27

- anthropogenic contribution to, 16-17
- extremes, 26-27, 28
- heavy precipitation events, 3, 16-17, 18, 41, 41
- heavy precipitation events, costs to agriculture, 61
- heavy precipitation events, human health and, 70-71, 128
- mean, 25-26
- monsoon regimes, 25
- observed changes, 3, 15-19, 16-18
- projected changes, 3, 25-27, 26-27, 41-42, 41, 127
- variability in, 3, 15
- See also* Cyclones, tropical; Drought

Projected changes

- in climate, 9, 24-31
- summary, 3-4
- in water resources, 9-10, 38-48
- See also specific regions and sectors*

R**Rangelands**, 62

- See also* Grasslands

Reforestation, 4, 59, 118, 120-121**Regional impacts**, 77-113, 128-129

- See also specific regions*

Residue return, 122-123, 123**Rivers**, 36, 55-56

- projected impacts, 56, 57-58
- river discharge, 45-46, 57-58
- See also* Runoff

Runoff

- mitigation measures and, 118
- observed changes, 3, 21-22, 35-36, 37
- planning for use of, 71
- projected changes, 3, 27, 29-30, 30, 61, 61, 127

S**Salinisation**

- of coastal waters, 57
- of groundwater, 3, 43, 71
- See also* Desalinisation

Sanitation. *See* Human health**Savannas**, 58**Scenarios**, 9-10, 10

- See also* Climate models

Schistosomiasis, 68-69, 97**Sea-level rise**

- contributions to, 20, 28-29
- observed changes, 20
- projected changes and impacts, 3, 28-29, 43
- water quality and, 10, 43

Semi-arid areas. *See* Arid and semi-arid areas**Settlements and infrastructure**, 73-74, 128**Small islands**, 109-113, 130

- adaptation, 50, 110, 111-113
- observed changes and projections, 109-111, 112, 130
- water stress, 130

Snow cover

- feedbacks on climate, 23-24
- observed changes, 3, 19, 19-20, 35
- projected changes, 27-28

Socio-economic aspects of freshwater, 45-47, 74-75**Soil erosion**, 43, 57**Soil moisture**

- feedbacks, 23
- observed changes, 21
- projected changes, 27, 29

South America. *See* Latin America**SRES scenarios**, 9, 10, 24**Storylines**, 9, 10**Sustainable development**, **125-131**

- future climate change impacts threatening, 47, 130
- Millennium Development Goals, water sector, 131
- rural communities and water conflicts, 66
- See also* Adaptation, vulnerability and sustainable development

T**Tar sands**, 118, 122**Teleconnections**, 22**Temperature**

- observed changes, 15
- projected changes, 24, 31

Thermokarst development, 57

Tourism, 35, 74-75
Transportation, 73-75
Tropical cyclones. *See* Cyclones, tropical
Tsho Rolpa Risk Reduction Project, 89

U

Uncertainty, 11, 11
See also Gaps in knowledge

V

Variability, large-scale patterns of, 22-23, 31
Vector-borne diseases, 68-69
Vulnerabilities: water resources, 3-4, 9, 47, 47
See also Adaptation, vulnerability and sustainable development; Water stress

W

Waste, 118, 121, 123
Wastewater reuse, 10
Wastewater treatment, 9, 72
 greenhouse gas emissions and, 123-124, 123
 mitigation measures and, 118, 121
 water quality and, 10
Water availability
 mitigation measures and, 118
 observations, 69, 70
 projections, 44, 70-71
Water-borne diseases, 68, 70, 81, 103
Water chemistry, 36, 37
Water demand
 for irrigation, projected, 4, 10, 61, 62, 128
 population and, 4, 8, 9
 projected changes, 4, 38-47, 44-45
Water management
 adaptation practices, 48-51, 49-50
 adaptive management, 51
 in agriculture, 63-67
 assumptions from past experience, 4
 climate change and, 4, 43-44, 127
 greenhouse gas emissions and, 117
 impacts on other areas, 4, 43-44, 47
 integrated water resources management (IWRM), 44, 51, 124
 policies, effects on GHG emissions and mitigation, 122-124, 123
 scenario-based approach, 51
See also Adaptation
Water quality

adaptation and, 71-72
 drinking water, 45, 67-68, 72
 flow variation and, 70-71
 micro-pollutants, 10
 mitigation measures and, 118
 observed changes, 9, 36-37
 projected changes, 3, 10, 43, 66, 70-72
 temperature and, 71

Water resources

adaptation, overview, 48-51, 49-50
 administration of, 72, 127
 climate-related drivers, 24-31, 38-43
 conflicts, potential, 124
 feedbacks with climate, 23-24
 highly vulnerable areas and sectors, 47, 47
 importance of, 7
 linking to climate change, 33-51
 mitigation measures and (*see* Mitigation)
 non-climatic drivers, 8, 10, 43-44
 observed impacts of climate change, 35-38
 projected impacts of climate change, 38-47
 summary, 3-4
 uncertainties in projected impacts, 47-48
See also Vulnerabilities; Water resources:
 regional aspects; *and specific water resources*

Water resources: regional aspects

Africa, 80, 81-82
 Asia, 85-88
 Australia and New Zealand, 91
 Europe, 93-95
 Latin America, 96, 98
 North America, 102-104, 102
 small islands, 110, 110

Water storage

behind dams, 10
 in glaciers and snow cover, 3

Water stress

Africa, 83, 129
 definition of, 8
 Europe, 129
 future impacts of climate change on, 45, 45
 Latin America, 96, 98, 100, 129
 map of, 9
 in small islands, 130
 vulnerability and, 8

Water supply and sanitation, 69-73

adaptation, vulnerability and sustainable development, 4, 71-73

observations, 69, 70

projections, 70-71

Water temperature

mitigation measures and, 118

observed changes, 36, 37

projected changes, 127

Water use

observed changes, 8-9

projected changes, 43-44, 62

Water vapour

observed changes, 16, 18-19

projected changes, 25-26, 29

Watershed management, 66-67

Wetlands, 56-57, 119