

Table 18-5 | Observed impacts of climate change reported since AR4 on mountains, snow, and ice, over the past several decades, across major world regions, with descriptors for (1) the confidence in detection of a climate change impact; (2) the relative contribution of climate change to the observed change, compared to that of non-climatic drivers; (3) the main climatic driver(s) causing the impacts; (4) the reference behavior of the system in the absence of climate change; and (5) the confidence in attribution of the impacts to climate change. References to related chapters in this report are given as well as key references to other IPCC reports and the scientific literature. Absence of climate change impacts from this table does not imply that such impacts have not occurred.

	Mountains, snow and ice	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
Africa	Retreat of tropical highland glaciers in East Africa	Mölg et al. (2008, 2012); Taylor et al. (2009)	<i>Very high</i>	Major	Warming, drying	No change	<i>High</i>
Europe	Retreat of Alpine, Scandinavian, and Icelandic glaciers	WGI AR5 Section 4.3.3; Bauder et al. (2007); Björnsson and Pálsson (2008); Paul and Haeberli (2008); WGMS (2008); Zemp et al. (2009); Andreassen et al. (2012); Marzeion et al. (2012); Gardner et al. (2013)	<i>Very high</i>	Major	Warming	No change	<i>High</i>
	Increase in rock slope failures in western Alps	Sections 18.3.1.3 and 23.3.1.4; Fischer et al. (2012); Huggel et al. (2012a)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
Asia	Permafrost degradation in Siberia, Central Asia, and the Tibetan Plateau	WGI AR5 Section 4.7.2; Section 24.4.2.2; Romanovsky et al. (2010); Yang et al. (2013)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Shrinking mountain glaciers across most of Asia	WGI AR5 Section 4.3.3; Section 24.4.1.2; Box 3-1; Bolch et al. (2012); Cogley (2012); Gardelle et al. (2012); Kääh et al. (2012); Yao et al. (2012); Gardner et al. (2013); Stokes et al. (2013)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
Australasia	Substantial reduction in ice and glacier ice volume in New Zealand	WGI AR5 Section 4.3.3; Table 25-1; Chinn et al. (2012)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Significant decline in late-season snow depth at three out of four alpine sites in Australia 1957–2002	Table 25-1; Nicholls (2006); Hennessy et al. (2008)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
North America	Shrinkage of glaciers across western and northern North America	WGI AR5 Section 4.3.3; Gardner et al. (2013)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Decreasing amount of water in spring snowpack in western North America 1960–2002	Stewart et al. (2005); Mote (2006); Barnett et al. (2008)	<i>High</i>	Major	Warming	No change	<i>High</i>
South and Central America	Shrinkage of Andean glaciers	WGI AR5 Section 4.3.3; Section 27.3.1.1; Table 27-3; Vuille et al. (2008); Bradley et al. (2009); Jomelli et al. (2009); Poveda and Pineda (2009); Marzeion et al. (2012); Gardner et al. (2013); Rabatel et al. (2013)	<i>High</i>	Major	Warming	No change	<i>High</i>
Polar regions	Decreasing Arctic sea ice cover in summer	WGI AR5 Section 4.2.2.1; ACIA (2005); AMAP (2011)	<i>Very high</i>	Major	Air and ocean warming, change in ocean circulation	No change	<i>High</i>
	Reduction in ice volume in Arctic glaciers	WGI AR5 Section 4.3.3; ACIA (2005); Nuth et al. (2010); AMAP (2011); Gardner et al. (2011, 2013); Moholdt et al. (2012)	<i>Very high</i>	Major	Warming	No change	<i>High</i>
	Decreasing snow cover across the Arctic	Section 28.2.3.1; AMAP (2011); Callaghan et al. (2011)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Widespread permafrost degradation, especially in the southern Arctic	Section 28.2.1.1; AMAP (2011); Olsen et al. (2011)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Ice mass loss along coastal Antarctica	WGI AR5 Sections 4.3.3, 4.4, and 10.5.2.1; Gardner et al. (2013); Miles et al. (2013)	<i>Medium</i>	Major	Warming	No change	<i>Medium</i>

Table 18-6 | Observed impacts of climate change reported since AR4 on rivers, lakes, and soil moisture, over the past several decades, across major world regions, with descriptors for (1) the confidence in detection of a climate change impact; (2) the relative contribution of climate change to the observed change, compared to that of non-climatic drivers; (3) the main climatic driver(s) causing the impacts; (4) the reference behavior of the system in the absence of climate change; and (5) the confidence in attribution of the impacts to climate change. References to related chapters in this report are given as well as key references to other IPCC reports and the scientific literature. Absence of climate change impacts from this table does not imply that such impacts have not occurred.

	Rivers, lakes, and soil moisture	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
Africa	Reduced discharge in West African rivers	d'Orgeval and Polcher (2008); Dai et al. (2009); Di Baldassarre et al. (2010)	Medium	Major	Reduced precipitation	No change	Low
	Lake surface warming and water column stratification increases in the Great Lakes and Lake Kariba	Section 22.3.2.2; Tierney et al. (2010); Ndebele-Murisa et al. (2011); Powers et al. (2011)	High	Major	Warming	No change	High
	Increased soil moisture drought in the Sahel since 1970, partially wetter conditions since 1990	Section 22.2.2.1; Hoerling et al. (2006); Giannini et al. (2008); Greene et al. (2009); Seneviratne et al. (2012)	Medium	Major	Change in precipitation	No change	Medium
Europe	Changes in the occurrence of extreme river discharges and floods	Section 23.2.3; Schmockler-Fackel and Naef (2010); Beniston et al. (2011); Cutter et al. (2012); Vorogushyn and Merz (2012); Kundzewicz et al. (2013)	Low	Minor	Change in precipitation; change in extreme precipitation	No change	Very low
Asia	Changes in water availability in many Chinese rivers	Table SM24-4; Zhang et al. (2007); Zhang, S. et al. (2008)	High	Minor	Change in precipitation	Changes due to land use	Low
	Increased flow in several rivers in China due to shrinking glaciers	Casassa et al. (2009); Li et al. (2010); Zhang, Y. et al. (2008)	High	Major	Warming	No change	High
	Earlier timing of maximum spring flood in Russian rivers	Section 28.2.1.1; Shiklomanov et al. (2007); Tan et al. (2011)	High	Major	Warming	No change	Medium
	Reduced soil moisture in North Central and Northeast China 1950–2006	Sections 24.3.1 and 24.4.1.2; Sheffield and Wood (2007); Wang, A. et al. (2011); Seneviratne et al. (2012)	Medium	Major	Warming; change in precipitation	No change	Medium
	Surface water degradation in parts of Asia	Section 24.4.1.2; Prathumratana et al. (2008); Delpla et al. (2009); Huang et al. (2009)	Medium	Minor	Warming; change in precipitation	Changes due to land use	Medium
Australasia	Intensification of hydrological drought due to regional warming in Southeast Australia	Table 25-1; Nicholls (2006); Cai et al. (2009)	Low	Minor	Warming	No change	Low
	Reduced inflow in river systems in southwestern Australia (since the mid-1970s)	Table 25-1; Section 25.5.1; Cai and Cowan (2006); Nicholls (2010)	High	Major	Change in precipitation; warming	No change	High
North America	Shift to earlier peak flow in snow dominated rivers in western North America	Barnett et al. (2008)	High	Major	Warming; change in snow	No change	High
	Runoff increases in the midwestern and northeastern USA	Georgakakos et al. (2013)	High	Minor	Change in precipitation; warming	No change	Medium
South and Central America	Changes in extreme flows in Amazon River	Section 27.3.1.1; Butt et al. (2011); Wang, G. et al. (2011); Espinoza et al. (2013)	High	Major	Change in precipitation; change in extreme precipitation	No change	Medium
	Changing discharge patterns in rivers in the Western Andes; for major river basins in Colombia discharge has decreased during the last 30–40 years	Section 27.3.1.1; Table 27-3; Vuille et al. (2008); Casassa et al. (2009); Poveda and Pineda (2009); Baraer et al. (2012); Rabatel et al. (2013)	Medium	Major	Warming	No change	Medium
	Increased streamflow in sub-basins of the La Plata River	Section 27.3.1.1; Pasquini and Depetris (2007); Krepper et al. (2008); Saurral et al. (2008); Conway and Mahé (2009); Krepper and Zucarelli (2010); Doyle and Barros (2011)	High	Major	Change in precipitation	Increase due to land use	High
Polar regions	Increased river discharge for large circumpolar rivers (1997–2007)	Section 28.2.1.1; Overeem and Syvitsky, (2010)	High	Major	Warming; change in precipitation; change in snow cover	No change	Low
	Winter minimum river flow increase in most sectors of the Arctic	Section 28.2.1.1; Tan et al. (2011)	High	Major	Warming; change in snow cover	No change	Medium
	Increasing lake water temperatures 1985–2009, prolonged ice-free seasons	Section 28.2.1.1; Callaghan et al. (2010); Schneider and Hook (2010)	Medium	Major	Warming	No change	Medium
	Thermokarst lakes disappear due to permafrost degradation in the low Arctic, new ones created in areas of formerly frozen peat	Section 28.2.1.1; Riordan et al. (2006); Marsh et al. (2008); Prowse and Brown (2010)	High	Major	Warming	No change	High
Small islands	Increased water scarcity in Jamaica	Gamble et al. (2010); Jury and Winter (2010)	Low	Minor	Change in precipitation	Increase due to water use	Very low

Table 18-7 | Observed impacts of climate change reported since AR4 on terrestrial ecosystems, over the past several decades, across major world regions, with descriptors for: (1) the confidence in detection of a climate change impact; (2) the relative contribution of climate change to the observed change, compared to that of non-climatic drivers; (3) the main climatic driver(s) causing the impacts; (4) the reference behavior of the system in the absence of climate change; and (5) the confidence in attribution of the impacts to climate change. References to related chapters in this report are given as well as key references to other IPCC reports and the scientific literature. Absence of climate change impacts from this table does not imply that such impacts have not occurred.

	Terrestrial ecosystems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
Africa	Tree density decreases in Western Sahel and semi-arid Morocco	Section 22.3.2.1; Gonzalez et al. (2012); Le Polain de Waroux and Lambin (2012)	Medium	Major	Change in precipitation	Changes due to land use	Medium
	Range shifts of several southern plants and animals: South African bird species polewards; Madagascar reptiles and amphibians upwards; Namib aloe contracting ranges	Table 22-3; Foden et al. (2007); Raxworthy et al. (2008); Hockey and Midgley (2009); Hockey et al. (2011)	High	Major	Warming	Changes due to land use	Medium
	Wildfires increase on Mt. Kilimanjaro	Table 22-3; Hemp (2005)	Medium	Major	Warming; drying	No change	Low
Europe	Earlier greening, earlier leaf emergence and fruiting in temperate and boreal trees	Section 4.3.2.1; Menzel et al. (2006)	High	Major	Warming	No change	High
	Increased colonization of alien plant species in Europe	Section 4.2.4.6; Table 23-6; Walther et al. (2009)	Medium	Major	Warming	Some invasion	Medium
	Earlier arrival of migratory birds in Europe since 1970	Section 4.2.4.6; Table 23-6; Møller et al. (2008)	Medium	Major	Warming	No change	Medium
	Upward shift in tree line in Europe	Section 18.3.2.3; Table 23-6; Gehrig-Fasel et al. (2007); Lenoir et al. (2008)	Medium	Major	Warming	Changes due to land use	Low
	Increasing burnt forest areas during recent decades in Portugal and Greece	Table 23-6; Camia and Amatulli (2009); Hoinka et al. (2009); Costa et al. (2011); Koutsias et al. (2012)	High	Major	Warming; change in precipitation	Some increase due to land use	High
Asia	Changes in plant phenology and growth in many parts of Asia (earlier greening), particularly in the north and the east	Sections 4.3.2.1 and 24.4.2.2; Figure 4-4; Ma and Zhou (2012); Panday and Ghimire (2012); Shrestha et al. (2012); Ogawa-Onishi and Berry (2013)	High	Major	Warming	No change	Medium
	Distribution shifts in many plant and animal species, particularly in the north of Asia, upwards in elevation or polewards	Sections 4.3.2.5 and 24.4.2.2; Figure 4-4; Moiseev et al. (2010); Chen et al. (2011); Jump et al. (2012); Ogawa-Onishi and Berry (2013)	High	Major	Warming	No change	Medium
	Invasion of Siberian larch forests by pine and spruce during recent decades	Section 24.4.2.2; Kharuk et al. (2010); Lloyd et al. (2011)	Medium	Major	Warming	No change	Low
	Advance of shrubs into the Siberian tundra	Sections 4.3.3.4, 24.4.2.2, and 28.2.3.1; Henry and Elmendorf (2010); Blok et al. (2011)	High	Major	Warming	No change	High
Australasia	Changes in genetics, growth, distribution, and phenology of many species, in particular birds, butterflies and plants in Australia	Table 25-3; Chambers (2008); Chessman (2009); Green (2010); Kearney et al. (2010); Keatley and Hudson (2012); Chambers et al. (2013b)	High	Major	Warming	Fluctuations due to variable local climates, land use, pollution, invasive species	High
	Expansion of some wetlands and contraction of adjacent woodlands in southeast Australia	Table 25-3; Keith et al. (2010)	Medium	Major	Change in precipitation; warming	No change	Low
	Expansion of monsoon rainforest at expense of savannah and grasslands in north Australia	Table 25-3; Banfai and Bowman (2007); Bowman et al. (2010)	Medium	Major	Change in precipitation; increased CO ₂	No change	Medium
	Migration of glass eels advanced by several weeks in Waikato River, New Zealand	Table 25-3; Jellyman et al. (2009)	Medium	Major	Warming	No change	Low

Table 18-7 (continued)

	Terrestrial ecosystems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
North America	Phenology changes and species distribution shifts upward in elevation and northward across multiple taxa	Section 26.4.1; Parmesan and Galbraith (2004); Parmesan (2006); Kelly and Goulden (2008); Moritz et al. (2008); Tingley et al. (2009)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Increased wildfire frequency in subarctic conifer forests and tundra	Section 28.2.3.1; Mack et al. (2011); Mann et al. (2012)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Regional increases in tree mortality and insect infestations in forests	Section 26.4.2.1; Van Mantgem et al. (2009); Peng et al. (2011)	<i>Medium</i>	Minor	Warming	No change	<i>Low</i>
	Increase in wildfire activity, fire frequency and duration, and burnt area in forests of the western US and boreal forests in Canada	Box 26-2; Gillett et al. (2004); Westerling et al. (2006); Girardin et al. (2013)	<i>High</i>	Minor	Warming; change in precipitation	Changes due to land use and fire management	<i>Medium</i>
South and Central America	Increased tree mortality and forest fire in the Amazon	Section 4.3.3.1.3; Phillips et al. (2009)	<i>Medium</i>	Minor	Warming	No change	<i>Low</i>
	Degrading and receding rainforest in the Amazon	Sections 18.3.2.4, 27.2.2.1, and 27.3.2.1; Etter et al. (2006); Nepstad et al. (2006); Oliveira et al. (2007); Wassenaar et al. (2007); Killeen et al. (2008); Nepstad and Stickler (2008)	<i>Low</i>	Minor	Warming	Deforestation and land degradation	<i>Low</i>
Polar regions	Increase in shrub cover in tundra in North America and Eurasia	Section 28.2.3.1.2; Tape et al. (2006); Walker et al. (2006); Henry and Elmendorf (2010); Blok et al. (2011); Elmendorf et al. (2012); Tape et al. (2012)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Advance of Arctic tree-line in latitude and altitude	Section 28.2.3.1.2; AMAP (2011); Hedenäs et al. (2011); Van Bogaert et al. (2011)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Loss of snow-bed ecosystems and tussock tundra	Section 28.2.3.1.2; Björk and Molau (2007); Molau (2010a); Hedenäs et al. (2011); Callaghan et al. (2013)	<i>High</i>	Major	Warming; change in precipitation	No change	<i>High</i>
	Impacts on tundra animals from increased ice layers in snow pack, following rain-on-snow events	Section 28.2.3.1.3; Callaghan et al. (2011); Hansen et al. (2013)	<i>Medium</i>	Major	Change in precipitation; warming	No change	<i>Medium</i>
	Changes in breeding area and population size of subarctic birds, due to snowbed reduction and/or tundra shrub encroachment	Molau (2010b); Callaghan et al. (2013)	<i>High</i>	Major	Warming	No change	<i>Medium</i>
	Increase in plant species ranges in the West Antarctic Peninsula and nearby islands over the past 50 years	Section 28.2.3.2; Fowbert and Smith (1994); Parnikoza et al. (2009)	<i>High</i>	Major	Warming	No change	<i>High</i>
	Increasing phytoplankton productivity in Signy Island lake waters	Quayle et al. (2002); Laybourn-Parry (2003)	<i>High</i>	Major	Warming	No change	<i>High</i>
Small islands	Changes in tropical bird populations in Mauritius	Section 29.3.2; Senapathi et al. (2011)	<i>Medium</i>	Major	Change in precipitation	No change	<i>Medium</i>
	Decline of an endemic plant in Hawai'i	Krushelnicky et al. (2013)	<i>Medium</i>	Major	Warming; change in precipitation	No change	<i>Medium</i>
	Upward trend in tree lines and associated fauna on high-elevation islands	Section 29.3.2; Benning et al. (2002); Jump et al. (2006)	<i>Low</i>	Minor	Warming	No change	<i>Low</i>

Table 18-8 | Observed impacts of climate change reported since AR4 on coastal and marine ecosystems, over the past several decades, across major world regions, with descriptors for (1) the confidence in detection of a climate change impact; (2) the relative contribution of climate change to the observed change, compared to that of non-climatic drivers; (3) the main climatic driver(s) causing the impacts; (4) the reference behavior of the system in the absence of climate change; and (5) the confidence in attribution of the impacts to climate change. References to related chapters in this report are given as well as key references to other IPCC reports and the scientific literature. Absence of climate change impacts from this table does not imply that such impacts have not occurred.

	Coastal and marine ecosystems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
Africa	Decline in coral reefs in tropical African waters	Sections 30.5.3.1.2 and 30.5.4.1.5; Baker et al. (2008); Carpenter et al. (2008); Ateweberhan et al. (2011)	High	Major	Ocean warming	Decline due to human impacts	High
Europe	Northward shifts in the distributions of zooplankton, fish, seabirds, and benthic invertebrates in the northeast Atlantic	Box 6-1; Table 6-2; Sections 6.3.1, 23.6.5, and 30.5.1.1; Beaugrand et al. (2009); Philippart et al. (2011)	High	Major	Ocean warming	No change	High
	Northward and depth shift in distribution of many fish species across European seas	Sections 6.3.1, 23.6.4, 23.6.5, and 30.5.3.1; Table 6-2; Perry et al. (2005); Pörtner et al. (2008); Beaugrand et al. (2009, 2010); Beaugrand and Kirby (2010); Hermant et al. (2010); Philippart et al. (2011)	High	Major	Ocean warming	No change	Medium
	Phenology changes in plankton in the northeast Atlantic	Box 6-1; Sections 6.3.1, 23.6.5, and 30.5.1.1; Beaugrand et al. (2002, 2009); Edwards and Richardson (2004); Philippart et al. (2011)	Medium	Major	Ocean warming	No change	Medium
	Spread of warm water species into the Mediterranean	Sections 23.6.5 and 30.5.3.1.5; Boero et al. (2008); Lasram and Mouillot (2009); Raitsos et al. (2010)	High	Major	Ocean warming	Changes due to invasive species and human impacts	Medium
Asia	Decline in coral reefs in tropical Asian waters	Sections 24.4.3.2 and 30.5.1.4.3; McLeod et al. (2010); Krishnan et al. (2011); Coles and Riegl (2012)	High	Major	Ocean warming	Decline due to human impacts	High
	Northward range extension of coral in the East China Sea and western Pacific, and a predatory fish in the Sea of Japan	Section 24.4.3.2; Yamano et al. (2011); Tian et al. (2012); Ogawa-Onishi and Berry (2013)	Medium	Major	Ocean warming	No change	Medium
	Shift from sardines to anchovies in the western North Pacific	Sections 6.3.1 and 6.3.6; Table 6-2; Takasuka et al. (2007, 2008)	Medium	Major	Ocean warming	Fluctuations due to fisheries	Low
	Increased coastal erosion in Arctic Asia	Section 24.4.3.2; Razumov (2010); Forbes (2011); Lantuit et al. (2011)	Medium	Major	Permafrost degradation, ocean warming, change in sea ice	No change	Low
Australasia	Southward shifts in the distribution of marine species near Australia	Table 25-3; Ling et al. (2009b); Pitt et al. (2010); Neuheimer et al. (2011); Wernberg et al. (2011b)	High	Major	Ocean warming	Changes due to short-term environmental fluctuations; fishing and pollution	Medium
	Change in timing of migration of seabirds in Australia	Section 25.6.2.1; Chambers et al. (2011, 2013a)	Medium	Major	Air and ocean warming	No change	Low
	Increase in coral bleaching in the Great Barrier Reef and Western Australian Reefs	Sections 6.3.1.4, 6.3.1.5, and 25.6.2.1; Table 25-3; Cooper et al. (2008); De'ath et al. (2009, 2012); Moore et al. (2012)	High	Major	Ocean warming	Pollution; physical disturbance	High
	Changes in coral disease patterns at Great Barrier Reef	Section 25.6.2.1; Table 25-3; Bruno et al. (2007); Sato et al. (2009); Dalton et al. (2010)	Medium	Major	Ocean warming	Pollution	Medium
North America	Northward shifts in the distributions of northwest Atlantic fish species	Section 30.5.1.1; Nye et al. (2009, 2011); Lucey and Nye (2010)	High	Major	Ocean warming	No change	High
	Changes in mussel beds along the west coast of the USA	Smith et al. (2006); Menge et al. (2008); Harley (2011)	High	Major	Ocean warming	No change	High
	Changes in migration and survival of salmon in the northeast Pacific	Table 6-2; Eliason et al. (2011); Kovach et al. (2012)	High	Major	Ocean warming	No change	High
	Increased coastal erosion in Alaska and Canada	Sections 18.3.1.1 and 18.3.3.1; Mars and Houseknecht (2007); Forbes (2011); Lantuit et al. (2011)	High	Major	Permafrost degradation; ocean warming, change in sea ice	No change	Medium

Table 18-8 (continued)

	Coastal and marine ecosystems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
South and Central America	Increase in coral bleaching in the western Caribbean	Section 27.3.3.1; Guzman et al. (2008); Manzello et al. (2008); Carilli et al. (2009); Eakin et al. (2010)	<i>High</i>	Major	Ocean warming	Pollution; physical disturbance	<i>High</i>
	Mangrove degradation on north coast of South America	Section 27.3.3.1; Alongi (2008); Lampis (2010); Polidoro et al. (2010); Giri et al. (2011)	<i>Low</i>	Minor	Ocean warming	Degradation due to pollution and land use	<i>Low</i>
Polar regions	Increased coastal erosion across the Arctic	Sections 18.3.1.1, 18.3.3.1, 28.2.4.2, and 28.3.4; Mars and Houseknecht (2007); Razumov (2010); Forbes (2011); Lantuit et al. (2011)	<i>Medium</i>	Major	Permafrost degradation; ocean warming, change in sea ice	No change	<i>Medium</i>
	Negative effects on non-migratory Arctic species	Section 28.2.2.1; Laidre et al. (2008); Amstrup et al. (2010); McIntyre et al. (2011)	<i>High</i>	Major	Atmospheric and ocean warming; circulation change; change in sea ice	No change	<i>High</i>
	Decreased reproductive success in Arctic seabirds	Section 28.2.2.1.2; Gaston et al. (2009); Grémillet and Boulinier (2009)	<i>Medium</i>	Major	Air and ocean warming; change in ocean circulation; change in sea ice	No change	<i>Medium</i>
	Decline in Southern Ocean seals and seabirds	Section 28.2.2.2; Croxall et al. (2002); Patterson et al. (2003); Jenouvrier et al. (2005); Véran et al. (2007); Forcada et al. (2008); Trathan et al. (2011); Chambers et al. (2013a)	<i>High</i>	Major	Ocean warming	No change	<i>Medium</i>
	Reduced thickness of foraminiferal shells in the Southern Ocean	Sections 6.3.2 and 28.2.2.2; Moy et al. (2009)	<i>Medium</i>	Major	Ocean acidification	No change	<i>Medium</i>
	Reduced density of krill in the Scotia Sea	Atkinson et al. (2004); Trivelpiece et al. (2011)	<i>Medium</i>	Major	Ocean warming; change in ocean circulation; change in sea ice	No change	<i>Medium</i>
Small islands	Increased coral bleaching near many tropical small islands	Section 29.3.1.2; Alling et al. (2007); Bruno and Selig (2007); Oxenford et al. (2008); Sandin et al. (2008)	<i>High</i>	Major	Ocean warming	Degradation due to fishing and pollution	<i>High</i>
	Degradation of mangroves, wetlands, and seagrass around small islands	Section 29.3.1.2; McKee et al. (2007); Gilman et al. (2008); Schlepupner (2008); Krauss et al. (2010); Marbà and Duarte (2010); Rankey (2011)	<i>Low</i>	Minor	Sea level rise; atmospheric and ocean warming	Degradation due to other disturbances	<i>Very low</i>
	Increasing flooding and erosion	Section 29.3.1.1; Webb (2006); Webb (2007); Yamano et al. (2007); Cambers (2009); Novelo-Casanova and Suarez (2010); Storey and Hunter (2010); Ballu et al. (2011); Rankey (2011); Ford (2012); Romine et al. (2013)	<i>Low</i>	Minor	Sea level rise	Erosion due to human activities, natural erosion, and accretion	<i>Low</i>
	Degradation of groundwater and freshwater ecosystems due to saline intrusion	Section 29.3.2; White et al. (2007a,b); Ross et al. (2009); Carreira et al. (2010); Terry and Falkland (2010); White and Falkland (2010); Goodman et al. (2012)	<i>Low</i>	Minor	Sea level rise	Degradation due to pollution and groundwater pumping	<i>Low</i>

Table 18-9 | Observed impacts of climate change reported since AR4 on human and managed systems, over the past several decades, across major world regions, with descriptors for (1) the confidence in detection of a climate change impact; (2) the relative contribution of climate change to the observed change, compared to that of non-climatic drivers; (3) the main climatic driver(s) causing the impacts; (4) the reference behavior of the system in the absence of climate change; and (5) the confidence in attribution of the impacts to climate change. References to related chapters in this report are given as well as key references to other IPCC reports and the scientific literature. Absence of climate change impacts from this table does not imply that such impacts have not occurred.

	Human and managed systems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
Africa	Adaptative responses to changing rainfall by South African farmers	Section 13.2.1.2; Thomas et al. (2007)	<i>Low</i>	Major	Change in precipitation	Changes due to economic conditions	<i>Very low</i>
	Decline in fruit-bearing trees in Sahel	Wezel and Lykke (2006); Maranz (2009)	<i>Medium</i>	Major	Change in precipitation	No change	<i>Low</i>
	Malaria increases in Kenyan highlands	Section 11.5.1.1; O'Meara et al. (2010); Alonso et al. (2011); Stern et al. (2011)	<i>Low</i>	Minor	Warming	Changes due to vaccination, drug resistance, demography, and livelihoods	<i>Low</i>
	Reduced fisheries productivity of Great Lakes and Lake Kariba	Sections 7.2.1.2, 13.2.1.1, and 22.3.2.2; Descy and Sarmento (2008); Hecky et al. (2010); Ndebele-Murisa et al. (2011); Marshall (2012)	<i>Low</i>	Minor	Warming	Changes due to fisheries management and land use	<i>Low</i>
Europe	Shift from cold-related mortality to heat-related mortality in England and Wales	Sections 18.4.4 and 23.5.1; Christidis et al. (2010)	<i>Medium</i>	Major	Warming	Changes due to exposure and health care	<i>Low</i>
	Impacts on livelihoods of Sámi people in northern Europe	Eira (2012); Mathiesen et al. (2013)	<i>Medium</i>	Major	Warming	Economic and sociopolitical changes	<i>Medium</i>
	Stagnation of wheat yields in some countries in recent decades	Section 23.4.1; Brisson et al. (2010); Kristensen et al. (2011)	<i>High</i>	Minor	Warming	Increase due to improved technology	<i>Medium</i>
	Positive yield impacts for some crops, mainly in northern Europe	Figure 7-2; Section 23.4.1; Jaggard et al. (2007); Supit et al. (2010); Gregory and Marshall (2012)	<i>High</i>	Minor	Warming	Increase due to improved technology	<i>Medium</i>
	Spread of bluetongue virus in sheep, and of ticks across parts of Europe	Section 23.4.2; Arzt et al. (2010); Randolph and Rogers (2010); Van Dijk et al. (2010); Guis et al. (2012); Petney et al. (2012)	<i>High</i>	Minor	Warming	No change	<i>Medium</i>
Asia	Impacts on livelihoods of indigenous groups in Arctic Russia	Sections 13.2.1.2, 18.4.6, and 28.2.4.2; Table 18-4; Crate (2013)	<i>Medium</i>	Major	Warming; change in snow cover; change in sea ice	Economic and sociopolitical changes	<i>Low</i>
	Negative impacts on aggregate wheat yields in South Asia	Section 7.2.1; Figure 7-2; Pathak et al. (2003)	<i>Medium</i>	Minor	Warming; change in precipitation	Increase due to improved technology	<i>Medium</i>
	Negative impacts on aggregate wheat and maize yields in China	Section 7.2.1; Figure 7-2; Tao et al. (2006, 2008, 2012); You et al. (2009); Chen et al. (2010)	<i>Low</i>	Minor	Warming	Increase due to improved technology	<i>Low</i>
	Increases in a water-borne disease in Israel	Paz et al. (2007)	<i>Low</i>	Minor	Warming	No change	<i>Low</i>
Australasia	Advance timing of wine-grape maturation in recent decades	Table 25-3; Webb et al. (2012)	<i>High</i>	Major	Warming	Advance due to improved management	<i>Medium</i>
	Shift in winter versus summer human mortality in Australia	Sections 11.4.1, 18.4.4, and 25.8.1.1; Bennett et al. (2013)	<i>Medium</i>	Major	Warming	Changes due to exposure and health care	<i>Low</i>
	Relocation or diversification of agricultural activities in Australia	Section 25.7.2; Box 25-5; Gaydon et al. (2010); Howden et al. (2010); Park et al. (2012); Thorburn et al. (2012)	<i>Medium</i>	Minor	Warming	Changes due to policy, markets, and short-term climate variability	<i>Low</i>
Central and South America	More vulnerable livelihood trajectories for indigenous Aymara farmers in Bolivia, due to water shortage	Section 13.1.4; McDowell and Hess (2012)	<i>Medium</i>	Major	Warming	Increasing social and economic stress	<i>Medium</i>
	Increase in agricultural yields and expansion of agricultural areas in southeastern South America	Section 27.3.4.1; Magrin et al. (2007); Barros (2010); Hoyos et al. (2013)	<i>Medium</i>	Major	Precipitation increase	Increase due to improved technology	<i>Medium</i>

Table 18-9 (continued)

	Human and managed systems	References	Confidence in detection	Role of climate	Climate driver	Reference behavior	Confidence in attribution
North America	Impacts on livelihoods of indigenous groups in the Canadian Arctic	Sections 18.4.6 and 28.2.4.2; Table 18-4; Hovelsrud et al. (2008); Ford et al. (2009); Beaumier and Ford (2010); Pearce et al. (2010); Brubaker et al. (2011)	<i>Medium</i>	Major	Warming; change in snow cover; change in sea ice	Economic and sociopolitical changes	<i>Medium</i>
Polar regions	Impact on livelihoods of Arctic indigenous peoples	Sections 18.4.6 and 28.2.4.2; Table 18-4; Hovelsrud et al. (2008); Ford et al. (2009); Beaumier and Ford (2010); Pearce et al. (2010); Eira (2012); Crate (2013); Mathiesen et al. (2013)	<i>Medium</i>	Major	Warming; change in snow cover; change in sea ice	Economic and sociopolitical changes	<i>Medium</i>
	Increase of shipping traffic across the Bering Strait	Section 28.2.6.1.3; Figure 28-4; Robards (2013)	<i>Medium</i>	Major	Warming; change in sea ice	No change	<i>Medium</i>
Small islands	Increased degradation of coastal fisheries due to direct effects and effects of increased coral reef bleaching	Box CC-CR; Sections 18.3.3.3, 18.4.1.2, 29.3.1.2, and 30.6.2.1	<i>Low</i>	Minor	Ocean warming	Coastal fisheries degraded by overfishing and pollution	<i>Low</i>