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Climate Change Impacts on APEC Countries

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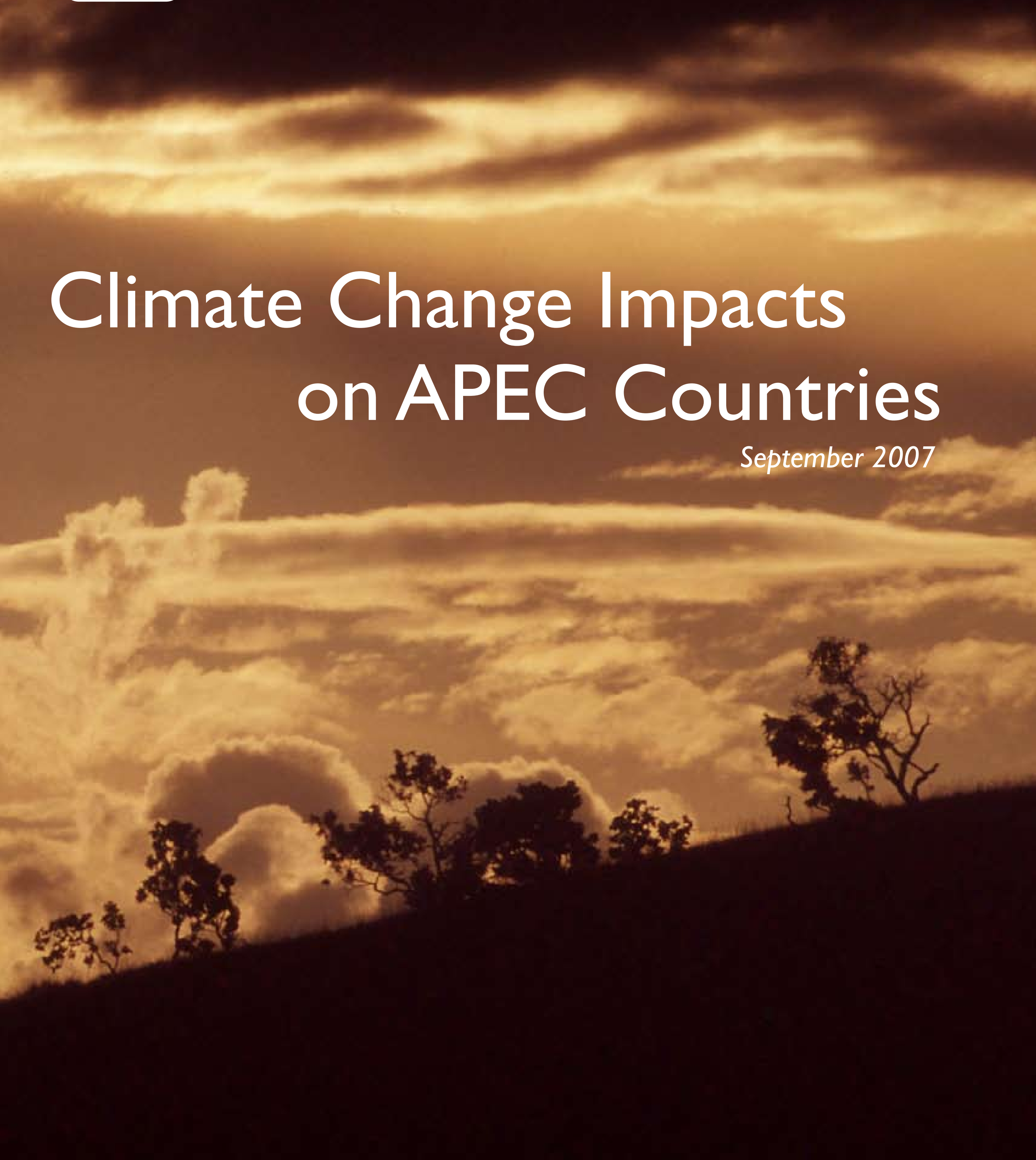

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introduction

Climate change will affect the countries of Asia Pacific in many different ways. The latest science as reported by the Intergovernmental Panel on Climate Change (IPCC, 2007) has defined the impacts on specific countries, in much more detail than previously available.

This document shows that the countries of APEC will be at the front line of climate change impacts and they therefore have a strong imperative to act decisively to avoid dangerous levels of warming and causing irreversible damage to ecosystems. This requires that global warming be limited to well below 2ºC above pre-industrial levels,

The APEC region will also determine whether the worst impacts of dangerous climate change will be avoided. Energy generated or derived from coal, oil and other fossil fuels, and deforestation are the two main sources of global greenhouse gas emissions. APEC economies presently account for approximately 60% of the world's energy generation and use – mostly sourced from coal and oil – and this is projected to rise significantly in coming decades because of the growing populations and technological and manufacturing capacity of APEC economies.[1]

WWF proposes that APEC and ABAC delegates resolve:

1. That climate change is a grave threat to the economies, societies and the natural environment of the Asia-Pacific region;

2. That the global objective of climate change policy should be to avoid a warming of 2°C above pre-industrial levels because this should avoid the worst impacts of climate change;

3. That in order to avoid a warming of 2°C above pre-industrial levels long-term greenhouse gas concentrations in the atmosphere need to be stabilised at about 400 parts per million carbon dioxide equivalent and to achieve stabilisation at this level global greenhouse gas emissions need to start to fall by 2015 and be reduced by about 50% of 1990 levels by 2050;

4. That achieving emission reductions of this magnitude in an equitable manner will require a global framework of emission reduction targets, timelines, policies and measures – including measures to assist developing countries to pursue a highly efficient, low emission pathway to development – to be in place by 2012;

5. That business in the Asia-Pacific region would benefit from the early adoption of emission reduction targets.

[1] *APEC Energy Working Group, 2007 http://www.apecsec.org.sg/apec/apec_groups/working_groups/energy.html*

It is important for all decision makers to recognise that the cost of not acting to prevent dangerous climate change severely outweighs the costs of action. The Stern review of the economics of climate change has put the cost of inaction as high as 20% of global GDP. To this end the following document summarises the latest science as reported by the IPCC, for each of the APEC countries (where available). We would invite you to learn more about your own country's very real vulnerabilities, by referring to your respective section in the following pages.

All references, unless noted otherwise, are from:

Parry M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., 2007, Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, 1000pp.

The contents of this document contains material from the IPCC Working Group II Fourth Assessment Report that relate to climate change impacts for APEC countries. The square brackets at the end of each sentence refer to the sections where the quote can be found within the report.

impacts
by country

1.1. Australia

As reported by the IPCC 4th Assessment Report

• Eight mass bleaching events on the Great Barrier Reef since 1979, triggered by unusually high sea surface temperatures, with no serious events known prior to 1979 [Table 11.1]

• 58 to 81% of the Great Barrier Reef could experience bleaching every year by 2030. Potentially catastrophic mortality of coral species annually by 2080 with 95% decrease in distribution species [Table 11.6].

• Predictions of a phase switch to algal dominance on hard coral reefs in 2030 (After bleaching, algae quickly colonise dead corals, possibly inhibiting later coral recruitment) [Table 11.6].

• Floods, landslides, droughts and storm surges are very likely to become more frequent. Heatwaves and fires are virtually certain to increase in intensity and frequency (high confidence) [11.3.1].

• By 2050, 3,200 to 5,200 more heat-related deaths/yr, and 0.6 to 1.4 million more people exposed to dengue fever (projections incl. NZ). Large cities identified as hotspots [Table 11.7].

• In south-east Australia, the frequency of very high and extreme fire danger days is likely to rise 4-25% by 2020 and 15-70% by 2050 [11.3.1].

• Reduced crop, pastoral and rangeland production over much of southern and eastern Australia. Reduced grain and grape quality. A southward shift of pests and disease vectors. Increased fire risk for forests [Table 11.7].

• Water security: Murray-Darling Basin streamflow drop 10-25% and salinity changes -8 to +19% by 2050. Agricultural costs US$0.6 to 0.9 billion by 2100 (SRES scenarios B1 & A1) [Table 11.5].

• The droughts of 1982-1983, 1991-1995 and 2002-2003 cost US$2.3 billion, US$3.8 billion and US$7.6 billion, respectively [Box 11.1].

• The frequency of bird-breeding events in the Macquarie Marshes (Murray-Darling Basin) is predicted to decrease with reduced streamflow, as breeding requires a certain minimum annual flow [3.5.1].

• Coastal inundation and erosion increasing, especially in regions exposed to cyclones and storm surges. Coastal development is exacerbating the climate risks [Table 11.7].

• Saltwater intrusion into freshwater swamps since 1950s in the Northern Territory has been accelerating since 1980s, possibly associated with sea level and precipitation changes [Table 11.1].

• Extensive loss/conversion of habitat in Kakadu wetland due to sea-level rise and saltwater intrusion with 2.8°C increase above pre-industrial levels [Table 4.1]. 80% loss of habitat in Kakadu wetland for a projected 30cm sea level rise by 2050 [Table 11.6].

• 7-14% of reptiles, 8-18% of frogs, 7-10% of birds and 10-15% of mammals committed to extinction as 47% of appropriate habitat in Queensland lost with 1.9°C increase above pre-industrial levels [Table 4.1].

• In alpine zones, reductions in duration and depth of snow cover are likely to alter distributions of communities, favouring an expansion of woody vegetation into herbfields. More fires are likely in alpine peatlands. Alpine vertebrates dependent on snow cover for hibernation are likely to be at risk of extinction [11.4.2].

1.2. Brunei Darussalam, Malaysia and Singapore

As reported by the IPCC 4th Assessment Report

- Decreasing precipitation trend, increase in hot days and warm nights and decrease in cold days and nights from 1961to 1998 [Table 10.2 & 10.3].
- Rising temperatures and rainfall variability has lead to increased frequency of occurrence of climate-induced diseases and heat stress in central, east, south and south-east Asia [10.2.3, 10.2.4].
- Projected sea-level rise is very likely to result in significant losses of coastal ecosystems and a million or so people along the coasts of south and south-east Asia will likely be at risk from flooding (high confidence) [10.4.3.1].
- Increase in endemic morbidity and mortality due to diarrhoeal disease associated with floods and droughts [10.4.5]
- In south-east Asia extreme weather events associated with El- Niño were reported to be more frequent and intense in the past 20 years [10.4.3].
- Over 34% of the coral reefs of Asia that are of immense ecological and economic importance to the region, particularly in south, south-east and east Asia were lost in 1998, largely due to coral bleaching induced by the 1997/98 El Niño event [10.2.4.3].
- Large-scale conversions of coastal mangrove forests to shrimp aquaculture have occurred during the past three decades along the coastlines of Malaysia. The additional stressors associated with climate change could lead to further declines in mangroves forests and their biodiversity [6.4.2.5].
- Increase in occurrence of extreme weather events including heat wave and intense precipitation events [10.3.1].
- Increase in the inter-annual variability of daily precipitation in the Asian summer monsoon [10.3.1].
- Increase of 10-20% in tropical cyclone intensities for a rise in sea surface temperature of 2- 4°C relative to the current threshold temperature [10.3.1].
- Possibility of substantial losses in rain-fed wheat [10.4.1].
- Reduction of primary production of fish stocks – both from aquaculture and capture – due to changes in oceanic circulation, increased frequency of El Niño events, inundation and coastal erosion [10.4.1.3].
- Grasslands, livestock and water resources in marginal areas likely to be vulnerable to climate change [10.4.1.4].
- Expansion of areas under severe water stress, and associated increase in number of people living under water stress – up to 1.2 billion people in south and south-east Asia by 2050, depending on the scenario [10.4.2.3].
- Observations from the past 20 years show that the increasing intensity and spread of forest fires in the region were largely related to temperature rise and precipitation decline, in combination with increasing intensity of land uses [10.4.4].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].
- The annual cost of protecting Singapore's coast is estimated to be between US$0.3 and $5.7 million by 2050 and between US$0.9 and $16.8 million by 2100 [6.5.3].

1.3. Canada

As reported by the IPCC 4th Assessment Report

- Rising temperatures will diminish snowpack and increase evaporation, affecting seasonal availability of water [14.2.1, 14.4.1, 14.4.6, Boxes 14.2, 14.3] .

- 1 to 2 week earlier peak river flow due to earlier warming-driven snowmelt 1936- 2000 [1.3.1.1].
- Polar bears will face a high risk of extinction with warming of 2.8°C above pre-industrial. Western Hudson Bay population has declined from 1200 bears in 1987 to fewer than 950 in 2004. Break-up of the sea ice on the western Hudson Bay, already occurs about 3 weeks earlier than in the early 1970s, resulting in polar bears in this area coming ashore earlier with reduced fat reserves (a 15% decline in body condition), fasting for longer periods of time and having reduced productivity. [Box 4.3].
- Temperature in the Fraser River in British Columbia for longer river sections reach a temperature over 20°C, which is considered a threshold for degrading salmon habitat [3.2].
- Arctic coast already experiencing adverse effects of temperature rise [Table 6.8].
- All four Atlantic cod populations show substantial decreases to the present, and suggest that they are now vulnerable to future changes in both climate and exploitation [Box 15.1].
- Earlier spring snowmelt has led to longer growing seasons and drought, especially at higher elevations, where the increase in wildfire activity has been greatest. Warmer May-August temperatures of 0.8°C since 1970 are highly correlated with area burned [Box 14.1].
- Drought has been more frequent and intense in the west [14.2.1].
- Warmer summer temperatures are expected to extend the annual window of high fire ignition risk by 10-30%, and could result in increased area burned of 74-118% in Canada by 2100 [14.4.4].
- Observations from satellite imagery (1982-2003) document a decline for a substantial portion of northern forest, possibly related to warmer and longer summers, whereas tundra productivity is continuing to increase [1.3.6.1].
- The vegetation growing season has increased an average of 2 days/decade since 1950, with most of the increase resulting from earlier spring [14.2].
- Mountain pine beetle has expanded its range in British Columbia into areas previously too cold. Susceptibility of the trees to insects is increased when multi-year droughts degrade the trees' ability to generate defensive chemicals [Box 14.1].
- Changes in coastal processes and shoreline erosion:
    - ▶ 19% of studied shoreline in the Manitounuk Strait is retreating, in spite of land uplift, due to thawing of permafrost (1950-1995) [Table 1.4].
    - ▶ Increased thermokarst erosion at the Arctic Ocean & Beaufort Sea coasts due to climate warming (1970-2000 relative to 1954-1970) [Table 1.4].
- Arctic and sub-arctic ecosystems (particularly ombrotrophic bog communities-a form of wetland) above permafrost may turn Arctic regions from a net carbon sink to a net source [4.4.6].
- Over the 21st century, pressure for species to shift north and to higher elevations will fundamentally rearrange North American ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will alter ecosystem structure, function and services [14.2.4, 14.2.2, 14.4.2, Box 14.1].
- Residents of northern Canada and Alaska are likely to experience the most disruptive impacts of climate change, including shifts in the range or abundance of wild species crucial to the livelihoods and well-being of indigenous peoples (high confidence) [14.4.6].

1.4. Chile

As reported by the IPCC 4th Assessment Report

- Over the last 50 years Chile has experienced a 50% reduction of precipitation [Table 13.2].
- Sea-level rise is very likely to affect the location of fish stocks in the south-east Pacific (e.g., in Peru and Chile) [13.4.4].
- Most of the South American glaciers from Colombia to Chile and Argentina (up to 25°S) are drastically

reducing their volume at an accelerated rate [13.2.4.1].

- Climate change is likely to lead to salinisation and desertification of agricultural lands in northern and central Chile [13.4.2].
- Decreased precipitation may lead to hydroelectricity vulnerability [13.2.2].
- Potential damage to water supply and sanitation services in coastal cities, as well as groundwater contamination by saline intrusion [13.4.3].
- The number of people in Latin America experiencing increased water stress under the SRES scenarios is estimated to range from 12 to 81 million in the 2020s, and from 79 to 178 million in the 2050s [13.4.3].

1.5. The People's Republic of China and Hong Kong, China

As reported by the IPCC 4th Assessment Report

- Northwest China 0.7°C increase in mean annual temperature from 1961 to 2000. Between 22% and 33% increase in rainfall [Table 10.2]. Increase in frequency of short duration heatwaves in recent decade, increasing warmer days and nights in recent decades [Table 10.3].
- Increasing frequency of extreme rains in western and southern parts including Changjiang River, and decrease in northern regions; more floods in Changjiang River in past decade; more frequent floods in north-east China since 1990s; More intense summer rains in east China; severe flood in 1999; seven-fold increase in frequency of floods since 1950s [Table 10.3].
- In east Asia, for 1°C rise in surface air temperature expected by 2020s, water demand for agricultural irrigation would increase by 6 - 10% or more [Figure 10.4].
- North China, irrigation from surface and groundwater sources will meet only 70% of the water requirement for agricultural production, due to the effects of climate change and increasing demand [10.4.2.1].
- Studies suggest that a 2°C increase in mean air temperature decreases rain-fed rice yield by 5 to 12% in China [10.4.1.1].
- Northward shift of agricultural zones: Studies suggest that by the middle of this century in northern China, tri-planting boundary will likely shift by 500 km from Changjiang valley to Huanghe basin, and double planting regions will move towards the existing single planting areas, while single planting areas will shrink by 23% [10.4.1.2].
- The rain-fed crops in the plains of north and north-east China could face water-related challenges in coming decades, due to increases in water demands and soil-moisture deficit associated with projected decline in precipitation. Agricultural irrigation demand in arid and semi-arid regions of Asia is estimated to increase by at least 10% for an increase in temperature of 1°C [10.4.1.2].
- The entire Himalayan Hindu Kush ice mass has decreased in the last two decades and the ratio of melt accelerates. Water supply in areas fed by HHK glacier melt, on which hundreds of millions of people in China and India depend, will be negatively affected [3.4.3].
- Tibetan Plateau glaciers of < 4 km in length are projected to disappear with 3°C temperature rise and no change in precipitation. If current warming rates are maintained, glaciers located over Tibetan Plateau are likely to shrink at very rapid rates from 500,000 km^2 in 1995 to 100,000 km^2 by the 2030s. [10.4.4.3,10.6.2].
- Freshwater availability in central, south, east and south-east Asia, particularly in large river basins, is projected to decrease due to climate change which, along with population growth and increasing demand arising from higher standards of living, could adversely affect more than a billion people by the 2050s [10.4].
- Coastal areas, especially heavily-populated megadelta regions in south,east and south-east Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers [10.4].

- The projected relative sea level rise, including that due to thermal expansion, tectonic movement, ground subsidence and the trends of rising river water level are 70-90, 50-70 and 40-60 cm in the Huanghe, Changjiang and in the Zhujiang deltas respectively by the year 2050 [10.4.3.1].
- A 30 cm rise in sea level will increase coastal flooding areas by five or six times in both the 'with' and 'without protection' scenarios in the Changjiang and Zhujiang deltas [10.4.3.1].
- The adverse impacts of salt-water intrusion on water supply in the Changjiang delta and Zhujiang delta, mangrove forests, agriculture production and freshwater fish catch, resulting in a loss of US$125x$10^6$ per annum in the Indus delta could also be aggravated by climate change [10.6.1].
- Observed decreased rates of deltaic wetland progradation (seaward build up of sediments) in the on the Yangtze River delta due to reduced sediment supply from dam construction (1960s-2003) [Table 1.4].
- Warmer climate, precipitation decline and droughts in most delta regions of China have resulted in drying up of wetlands and severe degradation of ecosystems [10.2.4.4].
- Observed decrease in the frost period in northern China by 10 days [1.3.6.2].
- Observed increase in animal (livestock) production related to warming in summer and annual temperature in Tibet (1978-2002) [Table 1.1].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.6. Indonesia

As reported by the IPCC 4th Assessment Report

- Observed decline in rainfall in southern and increase in northern region [Table 10.2].
- Observed changes: Droughts normally associated with ENSO years in Myanmar, Laos, Philippines, Indonesia and Vietnam; droughts in 1997 to 98 caused massive crop failures and water shortages and forest fires in various parts of Philippines, Laos and Indonesia [Table 10.3].
- Fires in peatlands of Indonesia during the 1997-98 El Niño dry season affected over 2 million ha and emitted an estimated 0.81 to 2.57 Gt Carbon to the atmosphere. The 1997/98 ENSO event in Indonesia triggered forest and brush fires in 9.7 million hectares, with serious domestic and trans-boundary pollution consequences [10.2.4.4].
- Projected severe flood risk with rising sea levels [10.4.3.1].
- Increases in endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected in east, south and south-east Asia [10.2.4.6].
- Around 30% of Asia's coral reefs are likely to be lost in the next 30 years due to multiple stresses and climate change [10.4.3.2].
- Even under the most conservative scenario, sea level will be about 40 cm higher than today by the end of 21st century and this is projected to increase the annual number of people flooded in coastal populations from 13 million to 94 million. About 20% will occur in south-east Asia, specifically from Thailand to Vietnam including Indonesia and the Philippines [10.4.3.1].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.7. Japan

As reported by the IPCC 4th Assessment Report

- About 1.0°C temperature rise in 20th century with 2-3°C rise in large cities [Table 10.2].
- In east Asia, for 1°C rise in surface air temperature expected by 2020s, water demand for agricultural irrigation would increase by 6 - 10% or more [Figure 10.4].
- Observed increasing incidences of daily maximum temperature >35°C and decrease in extremely low temperature [Table 10.3]. Heatwave conditions over Japan are likely to be enhanced in the future [10.3.1].
- Decreasing trends in annual mean rainfall are observed in some parts of Japan, overall no significant trend in the 20th century [10.2.2 & Table 10.2].
- Summer precipitation and mean winter precipitation will likely increase in east Asia [10.3.1].
- Extreme daily precipitation, including that associated with typhoon, would be further enhanced over Japan due to the increase in atmospheric moisture availability [10.3.1].
- An increase of 10 to 20% in tropical cyclone intensities for a rise in sea-surface temperature of 2 to 4°C relative to the current threshold temperature is projected in east Asia [10.3.1].
- Changes in length of growing season, based on observations. *Gingko biloba* (a deciduous Chinese tree) have leaf-unfolding and leaf-fall 2.6 days/decade longer (1953-2000) [Table 1.7].
- Studies (also: Asia, Europe) find that various birds and mammals exhibit trends towards larger body size, probably due to increasing food availability, with regionally increasing temperatures [1.3.5.4].
- Rice yield is projected to decrease up to 40% in irrigated lowland area of central and southern Japan under doubled CO_2 atmosphere [10.4.1.1].
- Annual insured losses from hurricanes in United States, typhoons in Japan and windstorms in Europe are projected to increase by two-thirds to US$27 billion by the 2080s. The projected increase in insured losses due to the most extreme storms (with current return periods of 100 to 250 years) by the 2080s would be more than twice the reported losses of the 2004 typhoon season, the costliest in terms of damage during the past 100 years [10.4.6.5].

1.8. Republic of Korea

As reported by the IPCC 4th Assessment Report

- Korea has seen a temperature increase of 0.23°C per decade [Table 10.2].
- Recent past has seen Korea experience more frequent heavy rain [Table 10.2]. Summer precipitation and mean winter precipitation will likely increase in east Asia [10.3.1].
- Increasing frequency of extreme maximum temperatures with higher values in 1980s and 1990s; decrease in frequency of record low temperatures during 1958 to 2001 [Table 10.3].
- Rice yield is estimated to decrease by 10% for every 1°C increase in growing-season minimum temperature. A decline in potentially good agricultural land in east Asia has been reported [10.2.4.1].
- In east Asia, for 1°C rise in surface air temperature expected by 2020s, water demand for agricultural irrigation would increase by 6 - 10% or more [Figure 10.4].
- Freshwater availability in central, south, east and south-east Asia, particularly in large river basins, is projected to decrease due to climate change which, along with population growth and increasing demand arising from higher standards of living, could adversely affect more than a billion people by the 2050s [10.4].
- Coastal areas, especially heavily-populated megadelta regions in south, east and south-east Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers [10.4].
- An increase of 10 to 20% in tropical cyclone intensities for a rise in sea-surface temperature of 2 to 4°C relative to the current threshold temperature is projected in east Asia [10.3.1].

- A one metre sea level rise will see inundation of 1.2% of the Korean peninsula (2643 km^2) [10.4.3.1].
- Climate change is projected to contribute to a 20 – 35% decrease in Korean broad-leaved pine forest coverage [10.4.4.1].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.9. Mexico

As reported by the IPCC 4th Assessment Report

- Replacement of tropical forest by savannas is expected in the tropical forests of central and southern Mexico, along with replacement of semi-arid by arid vegetation in most of central and northern Mexico due to synergistic effects of both land use and climate changes (medium confidence) [13.4.1].
- In tropical forests, species extinctions are likely [13.4].
- Grain yield reductions could reach up to 30% by 2080 under the warmer scenario [13.4.2].
- 73% to 78% reduction in coffee production by 2050 in Veracruz [Table 13.5].
- By 2050, desertification and salinisation will affect 50% of agricultural lands in Latin America and the Caribbean zone [13.4.2]
- In some coastal areas of the Gulf of Mexico, an increase in sea surface temperature, minimum temperature and precipitation was associated with an increase in dengue transmission cycles [13.2.2]. Projected sea surface temperature of 1-3°C by the 2080s [Table 13.7].
- Models project a substantial increase in the number of people at risk of dengue due to changes in the geographical limits of transmission [13.4.5].
- Projected impacts of climate change include 2-18% of the mammals, 2-8% of the birds and 1-11% of the butterflies committed to extinction with temperature increase of 1.3-3°C above pre-industrial levels [Table 4.1].
- Coastal vegetated wetlands are sensitive to climate change and long-term sea-level change. Regional losses would be most severe on the Atlantic and Gulf of Mexico coasts of North and Central America, the Caribbean, the Mediterranean, the Baltic and most small island regions due to their low tidal range [6.4.1.4].
- Sea level rise and sea surface temperature increases are very likely to affect buildings, tourism and the Mesoamerican coral reefs [13.4.4].
- Mesoamerican coral reef and mangroves from Gulf of Mexico are expected to be threatened, with consequences for a number of endangered species; e.g. the green, hawksbill and loggerhead turtles, the West Indian manatee and the American and Motelet's species of crocodile with the projected 1-3 °C warmer sea surface temperature by the 2080s [Table 13.7].
- Mangrove forests located in low-lying coastal areas are particularly vulnerable to sea-level rise, increased mean temperatures, and hurricane frequency and intensity [13.2.2]
- Since the third assessment report, several highly unusual extreme weather events have been reported in Latin America, such as Hurricane Wilma and Stan (Oct. 2005) and Hurricane Emily (Jul. 2005). H. Wilma made several landfalls, mainly in the Yucatán Peninsula. Losses of US$1,881 million. 95% of the tourist infrastructure seriously damaged [13.2.2 & Table 13.1].
- The impacts of Hurricanes Katrina, Rita and Wilma in 2005 and Ivan in 2004 demonstrated that the Gulf of Mexico offshore oil and natural gas platforms and pipelines, petroleum refineries, and supporting infrastructure can be seriously harmed by major hurricanes, which can produce national-level impacts, and require recovery times stretching to months or longer [14.2.8].

1.10. New Zealand

As reported by the IPCC 4th Assessment Report

- Mean air temperatures have risen 1.0°C from 1855-2004, and 0.4°C since 1950 [11.2.1]. There have been more heatwaves, fewer frosts, more rain in the south-west, less rain in the north-east and a rise in sea level of about 70 mm [11.2.1].
- Floods, landslides, droughts and storm surges are very likely to become more frequent and intense, and snow and frost are likely to become less frequent (high confidence) [11.3.1].
- The 1997-1998 and 1998-1999 droughts had agricultural losses of US$800 million [Box 11.1].
- Coastal inundation and erosion, especially in regions exposed to cyclones and storm surges. Coastal development is exacerbating the climate risks (from the Bay of Plenty to Northland) [Table 11.7].
- Eastern New Zealand is likely to have less soil moisture, although the western part is likely to receive more rain (medium confidence) [11.3].
- Ice volume of glaciers decreased from 100 km^3 to 53 km^3 over past century. Losses of at least a quarter of glacier mass since 1950. Mass balance of Franz Josef glacier decreased 0.02m/year from 1894-2005 [Table 11.1].
- In alpine zones, reductions in duration and depth of snow cover are likely to alter distributions of communities, for example favouring an expansion of woody vegetation into herb fields.
- More fires are likely in alpine peatlands and alpine vertebrates dependent on snow cover for hibernation are likely to be at risk of extinction [11.4.2]. Tree line has shifted to higher altitudes due to increased temperature [Table 1.9].
- Westward shift of Chilean jack mackerel in the Pacific and subsequent invasion into New Zealand waters in the mid-1980s associated with increasing El Niño frequency [11.4.6].
- Earlier egg laying in Welcome Swallow [Table 11.1].
- Production of current kiwifruit varieties is likely to become uneconomic in Northland by 2050 because of a lack of winter chilling [11.4.3.2].
- Water security: reduction in water supply for irrigation, cities, industry and riverine environment in those areas where stream flow declines (e.g. Northland and eastern lowlands) [Table 11.7].

1.11. Papua New Guinea

As reported by the IPCC 4th Assessment Report

- Sea-level rise and increased sea water temperature will cause accelerated beach erosion, degradation of coral reefs, and bleaching [16.4.6].
- A loss of cultural heritage from inundation and flooding reduces the amenity value for coastal users [16.4.6].
- Internal migration from the Cartaret Islands in Papua New Guinea to Bougainville as a consequence of inundation from high water levels and storms [16.5.4.4].
- Warmer climate could reduce the number of people visiting small islands in low latitudes (it could have the reverse effect in mid- and high-latitude islands) [16.4.6].
- Water shortages and increased incidence of vector-borne diseases may deter tourists [16.4.6].
- A modelling study showed significant large-scale changes of skipjack tuna habitat in the equatorial Pacific under projected warming scenarios. The tuna catch of east Asia and south-east Asia is nearly one-fourth of the world's total [10.4.1.3].
- Clear evidence exists that the number of storms reaching categories 4 and 5 globally has increased since 1970. The largest increase of total number of cyclones and cyclone days was in the north Pacific, Indian and south-west Pacific oceans. The global view of tropical storm activity highlights the important role

of ENSO in all basins [16.2.2.2].

- Even under the most conservative scenario, sea level will be about 40 cm higher than today by the end of 21st century and this is projected to increase the annual number of people flooded in coastal populations from 13 million to 94 million. About 20% will occur in south-east Asia, specifically from Thailand to Vietnam including Indonesia and the Philippines [10.4.3.1].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.12. Peru

As reported by the IPCC 4th Assessment Report

- Glacial retreat has already reached critical conditions, with a 22% reduction of total glacial area over the past 35 years [Table 13.3].
- Highly strained impact of freshwater supplies from 2015-2025 (12% reduction in the coastal zone where more than half of the people live) [13.4.3].
- Southern Peru has seen reduced precipitation over recent decades while north-west Peru has experienced an increase [13.2.4.1].
- Hydropower is vulnerable to large-scale and persistent rainfall anomalies due to El Niño and La Niña [13.2.2].
- Over the next decades Andean inter-tropical glaciers are very likely to disappear, affecting water availability and hydropower generation (high confidence) [13.2.4.1].
- Recent shortening of cotton and mango growing cycles on the northern coast of Peru during El Niño because of increases in temperature and several fungal diseases in maize, potato, wheat and beans [13.2.2].
- Climate change is likely to lead to salinisation and desertification of agricultural lands on the Peruvian coast. By 2050, desertification and salinisation will affect 50% of agricultural lands in Latin America and the Caribbean zone [13.4.2].
- El Niño has been associated with some dermatological diseases, related to an increase in summer temperature, hyperthermia with no infectious cause has also been related to heatwaves, and sea surface temperature has been associated with the incidence of Carrion's disease [13.2.2].
- Projected increase in the number of people exposed to vector borne diseases, such as dengue [13.4.5].
- Sea-level rise is very likely to affect the location of fish stocks in the south-east Pacific (e.g., in Peru and Chile) [13.4.4].

1.13. Philippines

As reported by the IPCC 4th Assessment Report

- Increase in mean annual, maximum and minimum temperatures by 0.14°C from 1971-2000. Increase in annual mean rainfall since 1980s and in number of rainy days since 1990s [Table 10.2].
- Observed changes in extreme events and severe climate anomalies: increased occurrence of landslides and floods in 1990 and 2004 [Table 10. 3].
- Observed changes: droughts normally associated with ENSO years in Myanmar, Laos, Philippines, Indonesia and Vietnam; droughts in 1997 to 98 caused massive crop failures and water shortages and forest fires in various parts of Philippines, Laos and Indonesia [Table 10.3].
- On an average 20 cyclones cross the Philippines Area of Responsibility (PAR) with about 8-9 land fall

each year; with an increase of 4.2 in the frequency of cyclones entering PAR during the period 1990-2003 [Table 10. 3].

- Decrease of rice yield associated with increase of temperature (0.35 °C and 1.13°C for maximum and minimum respectively during 1979-2003) [Table 1.10].
- Even under the most conservative scenario, sea level will be about 40 cm higher than today by the end of 21st century and this is projected to increase the annual number of people flooded in coastal populations from 13 million to 94 million. About 20% will occur in south-east Asia, specifically from Thailand to Vietnam including Indonesia and the Philippines [10.4.3.1].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.14. Russian Federation

As reported by the IPCC 4th Assessment Report

- Observed climate trends of 2-3°C temperature rise in past 90 years, more pronounced in spring and winter [Table 10.2].
- Observed changes in extreme events and severe climate anomalies:
  - ▶ Heatwaves exceeded 22-year record in May 2005 [Table 10. 3].
  - ▶ Increase in heavy rains in western Russia and decrease in Siberia; increase in number of days with more than 10 mm rain; 50-70% increase in surface runoff in Siberia [Table10. 3].
- Decreasing rain and increasing temperature by over 1°C have caused droughts; 27 major droughts in 20th century have been reported [Table 10.3].
- Dramatic increase of fires in Siberian peatlands (of which 20 million ha were burnt in 2003) linked to increased human activities combined with changing climate conditions, particularly the increase in temperature [10.2.4.4].
- An average temperature increase of 1°C, the duration of wild fire season in north Asia could increase by 30% [10.4.4.1].
- Serious problems are connected with the impact of air pollution due to Siberian forest fires on human health [10.4.5].
- Warming leads to changes in the seasonality of river flows where much winter precipitation currently falls as snow in the entire Russian territory. The effect is greatest at lower elevations (where snowfall is more marginal), and in many cases peak flow would occur at least a month earlier. Winter flows increase and summer flows decrease [3.4.1].
- Annual flow increase of 5%, including a winter increase of 25-90%, increase in winter base flow due to increased melt and thawing permafrost, demonstrated from 1935 to 1999 in the Arctic Drainage Basin: Ob, Lena, Yenisey [Table 1.3].
- Russian Arctic rivers: increasing frequency of catastrophic floods (0.5-1%) in recent years due to earlier break-up of river-ice and heavy rain [Table 1.3.].
- A recent major ecosystem shift in the northern Bering Sea has been attributed to regional climate warming and trends in the Arctic Oscillation [1.3.4.2].
- Increasing winter temperature considerably changes the ice regime of water bodies in the northern regions. Comparing the horizon of 2010-2015 with the control period 1950-1979 shows that ice cover duration on the rivers in Siberia would be shorter by 15-27 days and maximum ice cover would be thinner by 20-40% [3.4].
- In some parts of Russia, climate change could significantly alter the variability of river runoff such that

extremely low runoff events may occur much more frequently in the crop growing regions of the south west [10.4.2.1].

- Globally there will be major gains in potential agricultural land by 2080, particularly in North America (20-50%) and the Russian Federation (40-70%), but losses of up to 9% in sub-Saharan Africa [5.6.4].
- Climate change could make it more difficult than it is already to step up the agricultural production to meet the growing demands in Russia and other developing countries in Asia [10.2.4.1].
- In several northern hemisphere mountain systems, tree lines have markedly shifted to higher elevations during the 20th century such as in the Urals [1.3.5.2].
- Soil subsidence caused by the melting of permafrost is a risk to gas and oil pipelines, electrical transmission towers, nuclear-power plants and natural gas processing plants in the Arctic region [7.4.2.1].
- In northern regions, mean annual temperature of frozen soil and rocks and the depth of seasonal thawing will increase in 2020 by as much as 4°C for the depth of 0.8 m and by at most 2.2°C for the depth of 1.6 m [10.4.4.3].
- The change in the rock and soil temperatures will result in a change in the strength characteristics, bearing capacity, and compressibility of the frozen rocks and soils, thaw settlement strains, frozen ground exploitability in the course of excavation and mining, generation of thermokarst, thermal erosion and some other geocryological processes [10.4.4.3].
- Arctic and sub-arctic ecosystems (particularly ombrotrophic bog communities- a form of wetland) above permafrost were considered likely to be most vulnerable to climatic changes, since impacts may turn Arctic regions from a net carbon sink to a net source [4.4.6].
- Current estimates of northern wetland methane emissions increase by 10–63% based on northern Siberian estimates alone. This methane source comprises a positive feedback to climate change, as thaw lakes and mires are expanding in response to warming [4.4.6].
- Loss of summer sea ice will bring an increasingly navigable Northwest Passage, and the Northern Sea Route will create new opportunities for cruise shipping. Projections suggest that by 2050, the Northern Sea Route will have 125 days/yr with less than 75% sea-ice cover, which represents favourable conditions for navigation by ice-strengthened cargo ships [15.7.1].
- The approximately 10% of the circumpolar population that is indigenous is particularly vulnerable to climate change. Factors contributing to their vulnerability include their close relationship with the land, location of communities in coastal regions, reliance on the local environment for aspects of their diet and economy, and socio-economic and other factors [8.4.2.6].
- Polar bears will face a high risk of extinction with warming of 2.8°C above pre-industrial [Box 4.3].

1.15. Chinese Taipei

As reported by the IPCC 4th Assessment Report

- Summer precipitation and mean winter precipitation will likely increase in east Asia [10.3.1].
- An increase of 10 to 20% in tropical cyclone intensities for a rise in sea-surface temperature of 2 to 4°C relative to the current threshold temperature is projected in east Asia [10.3.1].
- In east Asia, for 1°C rise in surface air temperature expected by 2020s, water demand for agricultural irrigation would increase by 6 - 10% or more [Figure 10.4].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.16. Thailand

As reported by the IPCC 4th Assessment Report

- Loss of land due to a sea-level rise of between 50 cm and 100 cm could decrease national GDP by 0.36% to 0.69% (US$300 to 600 million) per year, respectively [6.5.3].
- Projected severe flood risk with sea level rise [10.4.3.1]. The population exposed to flooding by storm surges will increase over the 21st century. Asia dominates the global exposure with its large coastal population: Bangladesh, China, Japan, Vietnam and Thailand having serious coastal flooding problems [6.4.2.3]
- The decline in annual flow of the Red River by 13-19% and that of Mekong River by 16-24% by the end of 21st century will contribute to increasing water stress [10.4.2.3].
- The poor, particularly in urban and urbanizing cities of Asia are highly vulnerable to climate change because of their limited access to profitable livelihood opportunities and limited access to areas that are fit for safe and healthy habitation. Consequently the poor sector will likely be exposed to more risks from floods and other climate related hazards in areas they are forced to stay in. This also includes the rural poor who live in the lower Mekong countries and dependent on fisheries as their major livelihood along with those living in coastal areas who are likely to suffer heavy losses without appropriate protection [10.4.6.6].
- Even under the most conservative scenario, sea level will be about 40 cm higher than today by the end of 21st century and this is projected to increase the annual number of people flooded in coastal populations from 13 million to 94 million. About 20% will occur in south-east Asia, specifically from Thailand to Vietnam including Indonesia and the Philippines [10.4.3.1].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

1.17. United States

As reported by the IPCC 4th Assessment Report

- Over the past several decades, economic damage from severe weather has increased dramatically, due largely to increased value of the infrastructure at risk. Annual costs to North America have now reached tens of billions of dollars in damaged property and economic productivity, as well as lives disrupted and lost [14.2.3, 14.2.6, 14.2.7, 14.2.8].
- Annual insured losses from hurricanes in United States, typhoons in Japan and windstorms in Europe are projected to increase by two-thirds to US$27 billion by the 2080s. The projected increase in insured losses due to the most extreme storms (with current return periods of 100 to 250 years) by the 2080s would be more than twice the reported losses of the 2004 typhoon season, the costliest in terms of damage during the past 100 years [10.4.6.5].
- Increases in the number of intense hurricanes in 2005 created record catastrophic losses, principally in the Gulf Coast US and in Florida, when a record four Saffir Simpson severe (Cat. 3-5) hurricanes made landfall causing more than US$100 billion in damages with almost 2000 fatalities [1.3.8.3].
- The impacts of Hurricanes Katrina, Rita and Wilma in 2005 and Ivan in 2004 demonstrated that the Gulf of Mexico offshore oil and natural gas platforms and pipelines, petroleum refineries, and supporting infrastructure can be seriously harmed by major hurricanes, which can produce national-level impacts, and require recovery times stretching to months or longer [14.2.8].
- Annual-mean precipitation is projected to decrease in the south-west of the U.S. but increase over the rest of the continent and [14.3.1].

- In the south-western U.S., fire activity is correlated with El Niño-Southern Oscillation (ENSO) positive phases, and higher Palmer Drought Severity Indices [Box 14.1].
- Observed droughts due to dry and unusually warm summers related to warming of western tropical Pacific and Indian Oceans in recent years (1998- 2004) in western United States [1.3.2.1 & 14.2.1]. Semi-arid and arid areas in the west will suffer a decrease of water resources due to climate change [3.4, 3.7].
- Since 1980, an average of 22,000 km^2/yr has burned in U.S. wildfires, almost twice the 1920 to 1980 average of 13,000 km^2/yr. Human vulnerability to wildfires has increased, with a rising population in the wildland-urban interface [Box 14.1].
- A warming climate encourages wildfires through a longer summer period that dries fuels, promoting easier ignition and faster spread. In response to a spring- summer warming of 0.87°C the wildfire season in the western U.S. has increased by 78 days, and burn durations of fires >1000 ha in area have increased from 7.5 to 37.1 days in the last three decades [Box 14.1].
- Wildfires in Colorado (2002) and British Columbia (2003) caused tens of millions of dollars in tourism losses by reducing visitation and destroying infrastructure [14.2.7].
- Nutritional stresses related to longer ice-free seasons in the Beaufort Sea (Alaska) may be inducing declining survival rates, smaller size, and cannibalism among polar bears [1.3.1.1].
- The Pika, a small mammal in US western mountains, has been extirpated (become locally extinct) from many mountain slopes (climate-driven extinction) [1.3.5.3].
- A landward migration of mangroves into adjacent wetland communities has been recorded in the Florida Everglades during the past 50 years, apparently responding to sea-level rise over that period [1.3.3.1 & 6.4.1.4].
- Regional losses of coastal vegetated wetlands expected to be most severe on the Atlantic and Gulf of Mexico coasts of North and Central America [6.4.1.4]. Present rates of coastal wetland loss are projected to increase with accelerated sea level rise (in part due to structures preventing landward migration) [14.4.3].
- Wetland changes: decreases in salt marsh area due to regional sea level rise and human impacts (1920s-1999) Long Island, NY; Connecticut, Landward migration of cord grass (*Spartina alterniflora*) due to sea level rise and excess nitrogen in late 20th century on Rhode Island [Table 1.4].
- Tree lines have markedly shifted to higher elevations during the 20th century in Alaska [1.3.5.2]. Arctic-alpine species have declined in Montana at the southern margin of range (due to increased temperature) [1.3.5.2].
- A recent major ecosystem shift in the northern Bering Sea has been attributed to regional climate warming and trends in the Arctic Oscillation [1.3.4.2].
- Stream flow peaks in the snowmelt-dominated western mountains occurred 1-4 weeks earlier in 2002 than in 1948 [14.2.1]. Number of ski areas has decreased from 58 to 17 in New Hampshire (1975-2002) [Table 1.2]. Projected warming in the western mountains by the mid 21st Century is very likely to cause: large decreases in snowpack, earlier snowmelt, more winter rain events, increased peak winter flows and flooding, and reduced summer flows [14.4.1].
- Projected Columbia River seasonal flows shift markedly towards larger winter and spring flows and smaller summer and fall flows. A 2°C warming in the 2040s would increase demand for water in Portland, Oregon by 5.7 million m^3/yr, with an additional demand of 20.8 million m^3/yr due to population growth, while decreasing the supply by 4.9 million m3/yr [Box 14.2].
- Net primary production (NPP) in the continental U.S. increased nearly 10% from 1982-1998. Overall forest growth in North America will likely increase modestly (10-20%) as a result of extended growing seasons and elevated CO_2 over the next century. In the mid latitudes changes in NPP are depending on whether there is sufficient enhancement of precipitation to offset increased evapotranspiration in a warmer climate [14.2.2].
- While there have been attempts to realistically model the dynamics of adaptation to climate change,

understanding of agriculture's current sensitivity to climate variability and its capacity to cope with climate change remains limited [14.2.4].

1.18. Vietnam

As reported by the IPCC 4th Assessment Report

- An increase in occurrence of extreme weather events including heatwave and intense precipitation events is also projected in south Asia, east Asia, and south-east Asia along with an increase in the interannual variability of daily precipitation in the Asian summer monsoon [10.3.1].
- Increased occurrence of extreme rains causing flash floods in Vietnam; landslides and floods in 1990 and 2004 in the Philippines, and floods in Cambodia in 2000 [Table 10. 3].
- Projected sea-level rise could flood the residence of millions of people living in the low lying areas of south, south-east and east Asia such as in Vietnam, Bangladesh, India and China [10.4.3.1].
- The damage caused by intense cyclones has risen significantly in the affected countries, particularly India, China, Philippines, Cambodia, Iran and Tibetan Plateau [10.2.3].
- The population exposed to flooding by storm surges will increase over the 21st century. Asia dominates the global exposure with its large coastal population: Bangladesh, China, Japan, Vietnam and Thailand having serious coastal flooding problems [6.4.2.3].
- In the Mekong delta more than 1 million people will be directly affected by 2050 from risk through coastal erosion and land loss, primarily as a result of the decreased sediment delivery by the rivers, but also through the accentuated rates of sea-level rise [Box 6.3].
- The decline in annual flow of the Red River by 13-19% and that of Mekong River by 16-24% by the end of 21st century will contribute to increasing water stress [10.4.2.3].
- Grasslands, livestock and water resources in marginal areas of central Asia and south-east Asia are likely to be vulnerable to climate change. Food insecurity and loss of livelihood are likely to be further exacerbated by the loss of cultivated land and nursery areas for fisheries by inundation and coastal erosion in low-lying areas of the tropical Asia [10.4.1.4].
- Observed changes: Droughts normally associated with ENSO years in Myanmar, Laos, Philippines, Indonesia and Vietnam [Table 10.3].
- Even under the most conservative scenario, sea level will be about 40 cm higher than today by the end of 21st century and this is projected to increase the annual number of people flooded in coastal populations from 13 million to 94 million. About 20% will occur in south-east Asia, specifically from Thailand to Vietnam including Indonesia and the Philippines [10.4.3.1].
- Large-scale conversions of coastal mangrove forests to shrimp aquaculture have occurred during the past three decades along the coastlines of Vietnam, Bangladesh and India, Hong Kong, the Philippines, Mexico, Thailand and Malaysia. The additional stressors associated with climate change could lead to further declines in mangroves forests and their biodiversity [6.4.2.5].
- The cost of direct damage in Asia caused by tropical cyclones has increased more than five times in the 1980s as compared with those in the 1970s and about 35 times more in the early 1990s than in 1970s. Flood-related damages also increased by about three times and eight times respectively in the 1990s, relative to those in the 1980s and 1970s. These trends are likely to persist in the future [10.4.6.5].

This document and further information on climate change and the APEC region can be found online at www.panda.org/climate/apec

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