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SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

ITU-T L.1500 – Overview of climate change effects and possible impacts

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ITU-T L-SERIES RECOMMENDATIONS

ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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Supplement 24 to ITU-T L-series Recommendations

ITU-T L.1500 – Overview of climate change effects and possible impacts

Summary

In light of the historic Paris Agreement to combat climate change and unleash actions and investment towards a low carbon, resilient and sustainable future agreed by 195 countries in Paris on 12 December 2015, Supplement 24 to ITU-T L-series Recommendations aims to offer a better understanding of climate change effects that could assist in the development of recommendations related to adaptation. The Paris Agreement for the first time brings all nations into a common cause based on their historic, current and future responsibilities. The universal Paris Agreement's main aim is to keep a global temperature rise this century to well below 2 degrees Celsius and to drive efforts to limit temperature increases even further to 1.5 degrees Celsius above pre-industrial levels. Additionally, the Paris Agreement aims to strengthen the ability to deal with the impacts of climate change. The Paris Agreement and the outcomes of the UN climate conference (COP21) cover all of the crucial areas identified as essential for a landmark conclusion:

- Mitigation – reducing emissions fast enough to achieve the temperature goal
- A transparency system and global stock-take – accounting for climate action
- Adaptation – strengthening the ability of countries to deal with climate impacts
- Loss and damage – strengthening ability of countries to recover from climate impacts
- Support – including finance, for countries to build clean, resilient futures

Countries will submit updated climate plans, called nationally determined contributions (NDCs), every five years, thereby steadily increasing their ambition in the long-term. Climate action will also be taken forward in the period before 2020. Countries will continue to engage in a process on mitigation opportunities and will put added focus on adaptation opportunities.

This Supplement includes information on identifying and describing climate change effects that can affect the information and communication technology (ICT) sector and other sectors. It also provides a general introduction to the identified climate change effects and describes possible impacts of climate change effects on the ICT sector, human behaviours, human health and the energy sector.

This Supplement could also be used as a reference for other relevant recommendations.

History

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Clean development mechanism (CDM), climate change, climate change adaptation, greenhouse gas (GHG), information and communication technology (ICT), global warming.

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FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

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ITU-T L.1500 – Overview of climate change effects and possible impacts

1 Scope

This Supplement aims to provide a better understanding of climate change effects and so assist in the development of recommendations related to adaptation . In addition this Supplement serves as a reference to other relevant recommendations. This Supplement includes information on identifying and describing climate change effects that can affect the ICT sector and other sectors. It also provides a general introduction to the identified climate change effects and describes possible impacts of climate change effects on the ICT sector, human behaviours, human health and the energy sector.

2 References

[ITU-T L.1500] Recommendation ITU-T L.1500 (2014), *Framework for information and communication technologies and adaptation to the effects of climate change*.

[ITU-T L.1501] Recommendation ITU-T L.1501 (2014), *Best practices on how countries can utilize ICTs to adapt to the effects of climate change*.

[ITU-T L.1502] Recommendation ITU-T L.1502 (2015), *Adapting information and communication technology infrastructure to the effects of climate change*.

3 Definitions

3.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

3.1.1 climate change [b-IPCC]: Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. The Intergovernmental Panel on Climate Change (IPCC) uses a relatively broad definition, referring to a change in the state of the climate that can be identified (e.g., using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.

3.1.2 climate change adaptation [b-IPCC]: Adaptation to climate change can be defined as the adjustment in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential harm or benefit from opportunities associated with climate change.

3.2 Terms defined in this Supplement

This Supplement defines the following terms:

3.2.1 climate change effect: The result of environmental items such as air temperature, sea temperature, wind, ice and snow in terms of the degree of their changes**.**

3.2.2 climate change impact: The influence of a climate change effect on industries and societies in terms of their behaviours, practices, structures and processes.

4 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

CCS Carbon Capture and Storage

CDM Clean Development Mechanism

ENSO El Niño-Southern Oscillation

GHG Greenhouse Gas

ICT Information and Communication Technology

IPCC Intergovernmental Panel on Climate Change

NASA National Aeronautics and Space Administration

NDC Nationally Determined Contribution

NOAA National Oceanic and Atmospheric Administration

UNFCCC United Nations Framework Convention on Climate Change

5 Conventions

None.

6 General overview of climate change adaptation

The United Nations Framework Convention on Climate Change (UNFCCC) addresses two fundamental response strategies to cope with climate change: mitigation and adaptation. While climate change mitigation aims at tackling and reducing causes of climate change, such as greenhouse gas (GHG) emissions and energy consumption, climate change adaptation aims at adjusting ecological, social or economic systems in response to actual or expected climatic stimuli and their effects (e.g., surface temperature change, sea level raise, coastal wetland migration, increases in intense rainfall and increases in tornados, heavy rain, thunder and ice ball fall). The adaptation to such effects of climate change refers to changes in processes, practices, structures and behaviours to the moderate potential harm or benefit from opportunities associated with climate change. Adaptation is realized by, for example, reducing social infrastructure damages and natural disasters and/or facilitating opportunities (for example, a flood can cause a natural disaster but can also provide a water resource supply opportunity.)

Information and communication technologies (ICTs) deliver innovative products and services which can have a role to play at different stages of climate change adaptation processes. For additional information on ICTs and climate change adaption refer to clause 6 of [ITU-T L.1501].

7 Known effects of climate change

7.1 Categories of climate change effects

This Supplement does not provide an exhaustive list of climate change effects. Climate change effects can however be classified according to the following categories which impact the ICT sector:

– Wind

– Rain

– Air temperature

– Sea temperature

– Thunder

– Snow

– Ocean acidification

– Drought

NOTE – The Intergovernmental Panel on Climate Change (IPCC) released the study report, "Climate Change 2014: Impacts, Adaptation, and Vulnerability," in March 2014. The report deals with various climate change effects, impacts, adaptation, risks and opportunity aspects. This Supplement is consistent with the IPCC study report.

7.2 Climate change effects relating to wind

7.2.1 Introduction

Global warming may cause increased average and/or extreme wind speeds which, however, may be seasonally variable and geographically different.

7.2.3 Severe tornado

The climate change situation may cause extremely high wind speeds and such extremely high wind speeds may happen more frequently. An increase in the sea surface temperature of a source region increases the atmospheric moisture content. Increased moisture can fuel an increase in severe weather and tornado activity, particularly during the cool season. Tornadoes emit on the electromagnetic spectrum. There are observed correlations between tornadoes and patterns of lightning.

7.2.4 Increase in tropical cyclone intensity

The climate change situation may increase the intensity as well as the frequency of tropical cyclones where "tropical" refers to the geographical origin of cyclones which form generally over tropical areas. Tropical cyclones with strong winds and heavy rain can generate high waves, storm surges and tornadoes. Their power weakens when they arrive over land because they can no longer derive energy from the ocean. For this reason coastal regions are particularly vulnerable to damage from tropical cyclones compared to inland regions. Heavy rains however can cause significant flooding inland and storm surges can produce extensive coastal flooding. Though their effects on human populations are often devastating, tropical cyclones can relieve drought conditions. Tropical cyclones also carry heat energy away from the tropics and transport it toward temperate latitudes, which may play an important role in modulating regional and global climate.

7.3 Climate change effects relating to rain

7.3.1 Introduction

Global warming may cause changes in rainfall patterns: heavy and frequent rainfalls in some regions and reduced rainfalls in other regions. This is because an increase in surface air temperature causes an increase in evaporation and generally higher levels of water vapour in the atmosphere. In addition, a warmer atmosphere is capable of holding more water vapour. The excess water vapour will in turn lead to more frequent heavy precipitation. Intense precipitation can result in flooding, soil erosion, landslides and damage to structures and crops.

7.3.2 Frequent and intense rainfall and flooding

According to various national authorities and their assessment reports including the 2009 United States National Climate Assessment, heavy rainfalls have increased in frequency and intensity over the last 50 years. Climate change assessment models predict that downpours will become still more and more frequent and intense as greenhouse gas emissions and the planet's temperature continue to rise. More frequent and intense rainfalls and resulting flooding are not happening everywhere but are a net overall global trend.

As there are a number of climatic and non-climatic drivers influencing flood impacts, the realization of risks depends on several factors according to the IPCC study report. Floods include river floods, flash floods, urban floods and sewer floods and can be caused by intense and/or long-lasting precipitation, snowmelt, dam breaks, or reduced conveyance due to ice jams or landslides. Floods depend on precipitation intensity, volume, timing, antecedent conditions of rivers and their drainage basins (e.g., presence of snow and ice, soil character, wetness, urbanization and existence of dikes, dams, or reservoirs). Human encroachment into flood plains and lack of flood response plans increase the damage potential.

7.3.3 Precipitation increases in high latitudes

A robust result, consistent across climate model projections, is that higher precipitation extremes in warmer climates are very likely to occur according to the IPCC study report. Precipitation intensity increases almost everywhere, but particularly at mid- and high latitudes where mean precipitation also increases. This directly affects the risk of flash flooding and urban flooding. Storm drainage systems have to be adapted to accommodate increasing rainfall intensity resulting from climate change.

7.3.4 Precipitation decreases in subtropical land regions

An increase in droughts over low latitudes and mid-latitude continental interiors in summer is likely according to the IPCC study report, this however is sensitive to model land-surface formulation. Projections for the 2090s show regions of strong wetting and drying, with a net overall global drying trend. For example, the proportion of the land surface in extreme drought, globally, is predicted to increase by a factor of 10 to 30; from 1-3 % for the present day to 30% by the 2090s. The number of extreme drought events per 100 years and mean drought duration are likely to increase by factors of two and six, respectively, by the 2090s. A decrease in summer precipitation in southern Europe, accompanied by rising temperatures, which enhance evaporative demand, would inevitably lead to reduced summer soil moisture and more frequent and more intense droughts.

7.3.5 Drought and decreased water resources

Increased temperatures will amplify the drying out of soils and vegetation due to increased evaporation in the summer. This is likely to result in more severe and widespread droughts in regions and at periods when atmospheric conditions do not favour precipitation.

As temperatures rise, the likelihood of precipitation falling as rain rather than snow increases, especially in areas with temperatures near to 0°C in autumn and spring. Snowmelt is projected to be earlier and less abundant in the melt period and this may lead to an increased risk of droughts in snowmelt-fed basins in summer and autumn, when demand is highest.

7.3.6 Frequent landslides

While the causal factors involved in landslides are complex, the key factor connecting climate change to landslides is water. That is, the more precipitation and rainfalls increase the more landslides are to be expected. Intense rainfall and flooding may cause landslides and their higher frequency will cause more frequent landslides.

7.3.7 Variable rainfall patterns

Decadal increases in temperature of between 0.1ºC and 0.3ºC have been observed across the continent of Africa, with indications that Africa is warming faster than the global average. Observed changes suggest that rainfall patterns are becoming more variable across the continent, reflecting the influence of factors such as the El Niño-Southern Oscillation (ENSO). There is also a strong hypothesis that warming in the south Atlantic and Indian Oceans has led to a weakening of monsoons, depriving the Sahel region of rainfall in recent years.

7.4 Climate change effects relating to air temperature

7.4.1 Sea level rise

The National Oceanic and Atmospheric Administration (NOAA) calculated that the current sea level rise is about 3 mm/year worldwide. According to IPCC, two main factors contribute to observed sea level rise: the first main factor is the melting of major stores of land ice such as glaciers and ice sheets due to increases in air temperature; and the second main factor is related to an increase in sea temperature as described in clause 7.5.1. A sea level rise may cause coastal erosion which can result in losses of sediment and rocks, or redistribution of coastal sediments.

7.4.2 Surface temperature change

The IPCC stated the global average surface temperature (the average of near surface air temperature over land and the sea surface temperature) increased over the 20th century since 1861 by 0.6 ± 0.2°C. Since the late 1950s (the period of adequate observations from weather balloons), the overall global temperature increases in the lowest 8 km of the atmosphere and in surface temperature have been similar at 0.1°C per decade.

Satellite data show that there are very likely to have been decreases of about 10% in the extent of snow cover since the late 1960s and ground-based observations show that there is very likely to have been a reduction of about two weeks in the annual duration of lake and river ice cover in the mid- and high latitudes of the northern hemisphere, over the course of the 20th century.

There has been a widespread retreat of mountain glaciers in non-polar regions during the 20th century.

Northern Hemisphere spring and summer sea-ice extent has decreased by about 10 to 15% since the 1950s. It is likely that there has been about a 40% decline in Arctic sea-ice thickness during late summer to early autumn in recent decades and a considerably slower decline in winter sea-ice thickness.

7.4.3 Longer, more intense heat waves

As greenhouse gases continue to accumulate in the atmosphere from the burning of fossil fuels, more heat is trapped in the lower atmosphere. This increases the likelihood that hot weather will occur and that heatwaves will become longer and more intense. Observations over the past half century confirm this physical process. For example, since 1950 the annual number of record hot days across Australia has more than doubled and the mean temperature has increased by about 0.9°C.

Heatwaves have several significant characteristics, including:

– Frequency characteristics, such as the number of heatwave days and the annual number of summer heatwave events
– Duration characteristics, such as the length of the longest heatwave in a season
– Intensity characteristics, such as the average excess temperature expected during a heatwave and the hottest day of a heatwave; and
– Timing characteristics, including the occurrence of the first heatwave event in a season

7.5 Climate change effects relating to sea temperature

7.5.1 Sea level rise

Sea level rise occurs by thermal expansion: as ocean water warms, it expands. As stated in clause 7.4.1, a sea level rise may cause coastal erosion which can result in losses of sediment and rocks, or redistribution of coastal sediments. A sea level rise may also cause more frequent coastal flooding.

Between 1870 and 2000, the sea level rose by 1.7 mm/year on average, for a total sea level rise of 221 mm and the rate of sea level rise is accelerating. Since 1993, National Aeronautics and Space Administration (NASA) satellites have shown that sea levels are rising more quickly, by about 3 mm/year, for a total sea level rise of 48 mm between 1993 and 2009. Figure 1 shows sea level changes observed by NASA.

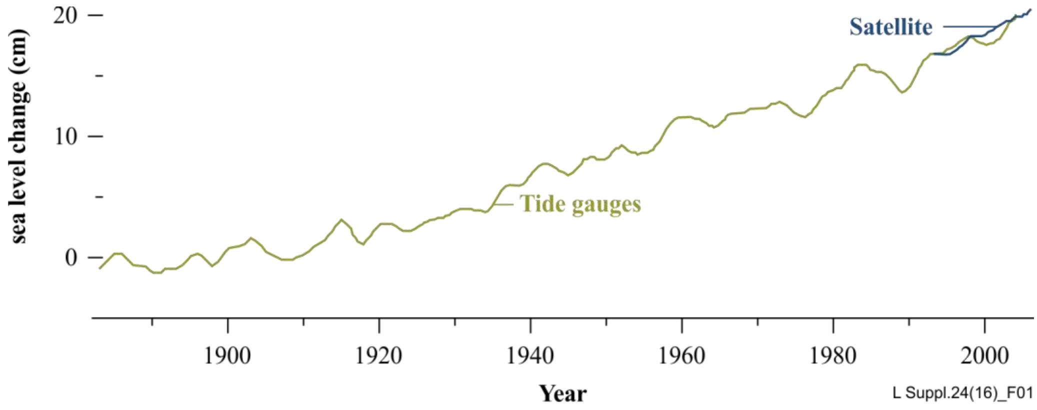

Figure 1 – Sea level change with recent satellite observations by NASA

The IPCC estimates that sea levels will rise between 0.18 and 0.59 meters by 2099 as warming sea water expands and mountain and polar glaciers melt.

7.5.2 Coastal wetland migration

Coastal wetlands include saltwater and freshwater wetlands located within coastal watersheds. Wetland types found in coastal watersheds include salt marshes, bottomland hardwood swamps, fresh marshes and mangrove swamps. As sea levels rise, river levels also will rise. Coastal watersheds can then extend many kilometres inland from the coast.

Services provided by coastal wetlands include [b-EPA]:

– Flood protection: Coastal wetlands protect upland areas, including valuable residential and commercial property, from flooding due to sea level rise and storms
– Erosion control: Coastal wetlands can prevent coastline erosion due to their ability to absorb the energy created by ocean currents which would otherwise degrade a shoreline and associated development
– Commercial fisheries: Commercial fish and shellfish species rely on coastal wetlands
– Water quality: Wetlands filter chemicals and sediment out of water before it is discharged into the ocean
– Carbon sequestration: Certain coastal wetland ecosystems (such as salt marshes and mangroves) can sequester and store large amounts of carbon due to their rapid growth rates and slow decomposition rates

Coastal wetlands, however, have been lost at many places worldwide. For example, in the coastal watersheds of the Atlantic, Pacific, the Gulf of Mexico, and the Great Lakes, wetlands were lost at an average rate of about 80 000 acres per year between 2004 and 2009. The majority of this loss occurred in freshwater wetlands.

Coastal wetlands are naturally altered by high energy events such as erosion and inundation from sea level rise and storms. If sea level increases, more wetlands will be converted to open water.

7.5.3 El Niño

The El Niño is a phenomenon of irregular warming in sea surface temperatures ranges from the equatorial central Pacific to the waters off the west coast of Peru (South America). This warming is known to be linked with the occurrence of some major unusual weather conditions in different parts of the world as depicted in Figure 2. These unusual weather conditions include drier weather in many parts of the world including India, South East Asia and Central America and wet weather in the central Pacific and in some parts of North America during the months of June to August. Alternately during northern hemisphere winters, El Niño has led to warmer weather in parts of North Asia and America and wet weather in many equatorial regions. This unusual weather impacts the affected regions through prolonged draughts, bush fires, haze, heavy downfalls and severe floods.

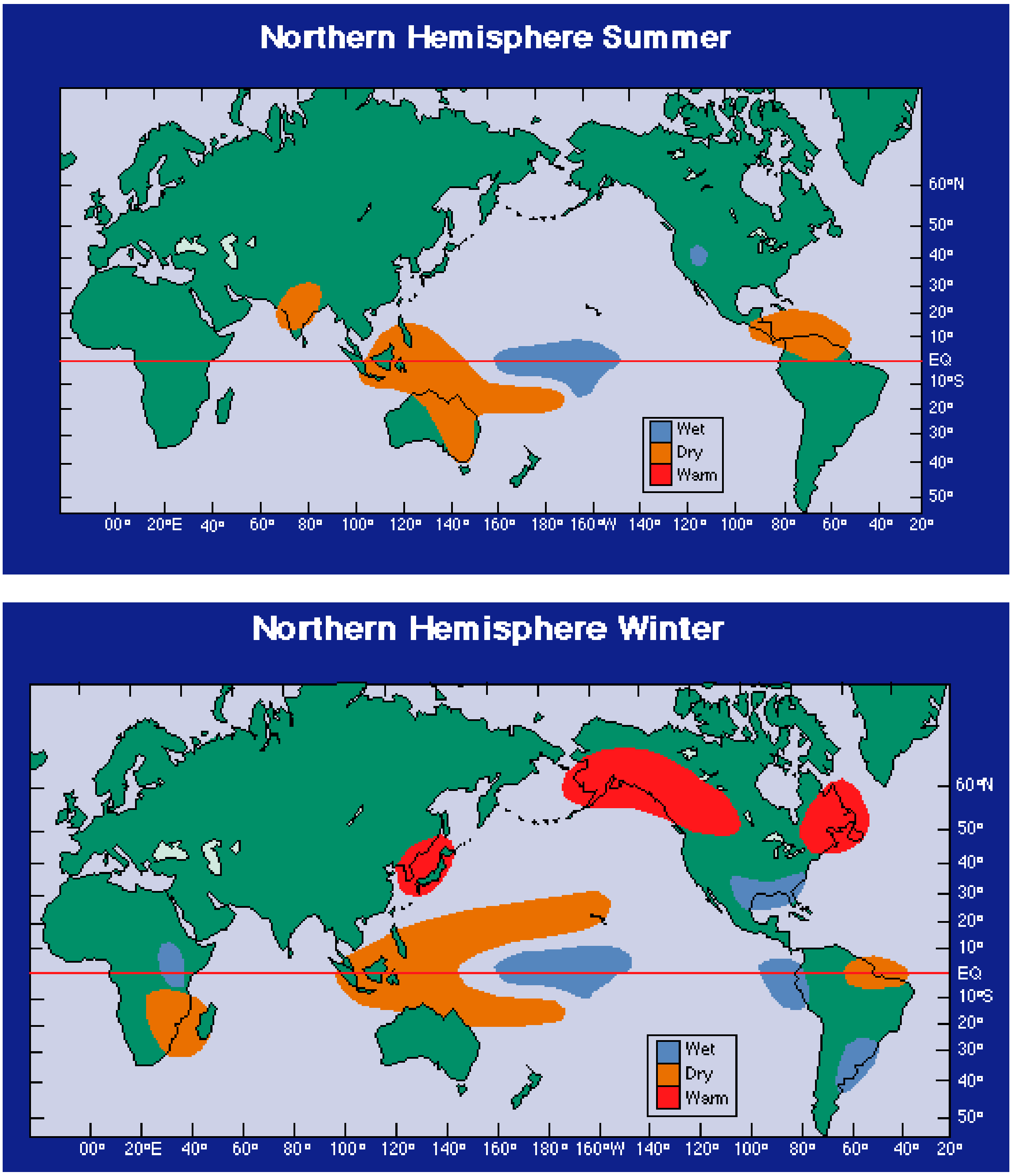

Figure 2 – El Niño phenomenon, by NOAA

7.6 Climate change effects relating to thunder

7.6.1 Frequent thunder

Thunderstorms that precipitate hail and spawn tornadoes are likely to occur more frequently as the climate changes and these may produce continuous thunder and a roaring sound. These intense storms are likely to occur with growing frequency as GHG levels continue to rise.

Severe thunderstorms typically occur when high altitude wind speeds exceed those nearer the ground and when there are also strong updrafts. As the climate changes, these two weather conditions will coincide more often.

7.6.2 Frequent forest fires

As the climate warms, moisture and precipitation levels are changing, with wet areas becoming wetter and dry areas becoming drier [b-UCSUSA]. Higher spring and summer temperatures and earlier spring snow-melt typically cause soils to be drier for longer, increasing the likelihood of drought and a longer wildfire season. These hot, dry conditions also increase the likelihood that, once wildfires are started by lightning strikes or human error, they will be more intensely and burn for longer.

7.7 Climate change effects relating to snow

Melting snow and ice are altering hydrological systems and affecting water resources in terms of quantity and quality.

7.8 Climate change effects relating to ocean acidification

When carbon dioxide (CO2) is absorbed by seawater, chemical reactions occur that reduce seawater pH, carbonate ion concentration and saturation states of biologically important calcium carbonate minerals. Calcium carbonate minerals are the building blocks for the skeletons and shells of many marine organisms. In areas where currently most life congregates in the ocean, the seawater is supersaturated with respect to calcium carbonate minerals. This means there are abundant building blocks for calcifying organisms to build their skeletons and shells. However, continued ocean acidification is causing many parts of the ocean to become under-saturated with these minerals, which is likely to affect the ability of some organisms to produce and maintain their shells [b-PMEL].

7.9 Climate change effects relating to drought

Scientists expect the amount of land affected by drought to grow by mid-century and water resources in affected areas to decline as much as 30 percent. These changes are occurring partly because of an expanding atmospheric circulation pattern known as the Hadley cell in which warm air in the tropics rises, loses moisture to tropical thunderstorms and descends in the subtropics as dry air. As jet streams continue to shift to higher latitudes and storm patterns shift along with them, semi-arid and desert areas are expected to expand [b-CHM1].

10 Possible impacts of climate change effects

10.1 Categories of impacts

As examples, the following categories of impacts caused by climate change effects are identified:

– ICT sector

– Human behaviours

– Human health

– Energy sector

10.2 Possible impacts on ICT sector

10.2.1 Sea level rise

Coastal erosion can destroy base stations near the areas (e.g., beach, cliff foot, dune, etc.) which can be affected by the sea level rise. Telecommunications ducts and conduits can be flooded.

10.2.2 Other impacts

Various climate change impacts which affect ICT infrastructure are described in [ITU-T L.1502].

10.3 Possible impacts on human behaviours

10.3.1 Frequent and intense rainfall

Frequent and intense rainfall may have a certain impact on human society due to:

– Increased risk of inland flash floods in Europe [b-CNG]
– More frequent coastal flooding and increased erosion from storms and sea level rise in Europe
– Coastal areas will be at risk due to increased flooding in Asia
– Death rate from disease associated with floods expected to rise in some regions in Asia

10.3.2 Longer, more intense heat waves

Longer, more intense heat waves may have a certain impact on human society due to:

– Increased frequency of hot extremes, heat waves and heavy precipitation
– Decreasing snowpack in the western mountains in North America
– Gradual replacement of tropical forest by savannah in eastern Amazonia of Latin America
– Risk of significant biodiversity loss through species extinction in many tropical areas in Latin America
– Glacial retreat in mountainous areas in Europe
– Reduced snow cover and winter tourism in Europe
– Reductions in crop productivity in southern Europe

10.4 Possible impacts on health

Rising temperatures will likely lead to increased air pollution, a longer and more intense allergy season, the spread of insect-borne diseases, more frequent and dangerous heat waves and heavier rainstorms and flooding. All of these changes pose serious and costly risks to public health.

High temperatures can lead to dehydration, heat exhaustion and deadly heat stroke. Very hot weather can also aggravate existing medical conditions such as diabetes, respiratory disease, kidney disease and heart disease.

Warmer temperatures and higher concentrations of carbon dioxide in the atmosphere stimulate some plants to grow faster, mature earlier, or produce more potent allergens. Common allergens such as ragweed seem to respond particularly well to higher concentrations of CO2, as do pesky plants such as poison ivy. Allergy-related diseases rank among the most common and chronic illnesses that can lead to lower productivity [b-CHM2].

Scientists expect a warmer world to bring changes in "disease vectors", the mechanisms by which some diseases are spread. Insects previously halted by cold winters are already moving to higher latitudes (toward the poles). Warmer oceans and other surface waters may also mean severe cholera outbreaks and harmful bacteria in certain types of seafood. However, changes in land use and the ability of public health systems to respond make projecting the risk of vector-borne disease particularly difficult.

10.5 Possible impacts on the energy sector

10.5.1 Increasing temperatures

Increasing temperatures may have a certain impact on the energy sector as follows:

– Increasing temperatures will likely increase electricity demand for cooling and decrease fuel oil and natural gas demand for heating
– Thawing permafrost could damage oil and gas infrastructure and force changes to existing operations in Arctic Alaska, while decreasing sea ice could generate benefits for oil and gas exploration and production in Arctic Alaska
– Increasing temperatures reduce transmission systems efficiency and could decrease available transmission capacity, while more frequent and severe wildfires also increase the risk of physical damage to transmission infrastructure
– Increasing air and water temperatures reduce the efficiency of thermoelectric power generation and could decrease available generation capacity

10.5.2 Decreasing water availability

Decreasing water availability may have a certain impact on the energy sector as follows:

– Decreasing water availability for cooling at thermoelectric facilities could reduce available generation capacity and deployment of carbon capture and storage (CCS) technologies
– Decreasing water availability could impact oil and gas production, particularly in times of drought
– Reductions in river levels could impede barge transport of crude oil, petroleum products and coal, resulting in delivery delays and increased costs
– Changes in precipitation and decreasing snowpack could decrease available hydropower generation capacity and affect the operation of facilities in some regions
– Decreasing water availability could decrease bioenergy production in some regions

10.5.3 Increasing storms, flooding and sea level rise

Increasing storms, flooding and sea level rise may have a certain impact on the energy sector as follows:

– Increasing intensity of storm events, sea level rise and storm surges put coastal and offshore oil and gas facilities at increased risk of damage or disruption
– Increasing intensity of storm events increases the risk of damage to electric transmission and distribution lines
– Increasing intensity of storm events, sea level rise and storm surges pose a risk to coastal thermoelectric facilities, while an increasing intensity and frequency of flooding poses a risk to inland thermoelectric facilities
– Increasing intensity and frequency of flooding increases the risk to rail and barge transport of crude oil, petroleum products and coal

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