G20 CLIMATE RISK ATLAS

Impacts, policy, economics

cmcc

MEXICO

With the scientific contribution of Enel Foundation

How to read the Atlas: graphs, colours and scenarios.

The maps used in this Atlas are taken from **The World Bank Official Boundaries** - ***https://datacatalog.worldbank.org/search/dataset/0038272*** (accessed on May 28, 2021). For the section Energy, the maps are based on Panoply Data Viewer ***https://www.giss.nasa.gov/tools/panoply/credits.html***

Each sector of this Atlas contains data and information on various climate scenarios.

When reported in graphs, the **colour black** indicates data and information referring to the current state, the past or the baseline.

When the authors refer to **RCP (Representative Concentration Pathways)**, the 3 colours used across the factsheet refer to 3 scenarios, which are 3 different development options with different levels of greenhouse gas emissions, **respectively low emissions (green), medium emissions (orange), and high emissions (red)**. The same colour code is used when RCPs are associated with Shared Socioeconomic Pathways (SSP).

In some cases, the authors refer to global warming scenarios. In these cases, the 3 colours used refer to a temperature rise of **1.5°C (green), 2°C (dark green), and 4°C (red)**.

When the authors refer exclusively to **Shared Socioeconomic Pathways - SSPs** (Population affected by river floods in the section: "Water"), data related to **SSP3** - that encompasses, among other things, slow economic growth, material-intensive consumption, and persisting or worsening inequalities – **are reported in a lighter shade**; **SSP5** – which refers to social and economic development that is coupled with an energy-intensive lifestyle and the abundant exploitation of fossil fuel resources – is shown using a **middle shade of the colour**, whereas data related to **the present** conditions **are represented in a dark shade**.

Further details on scenarios, methodologies, and the full list of references are available at: **www.g20climaterisks.org**

Concept and graphic design by element6.eu

MEXICO
CLIMATE

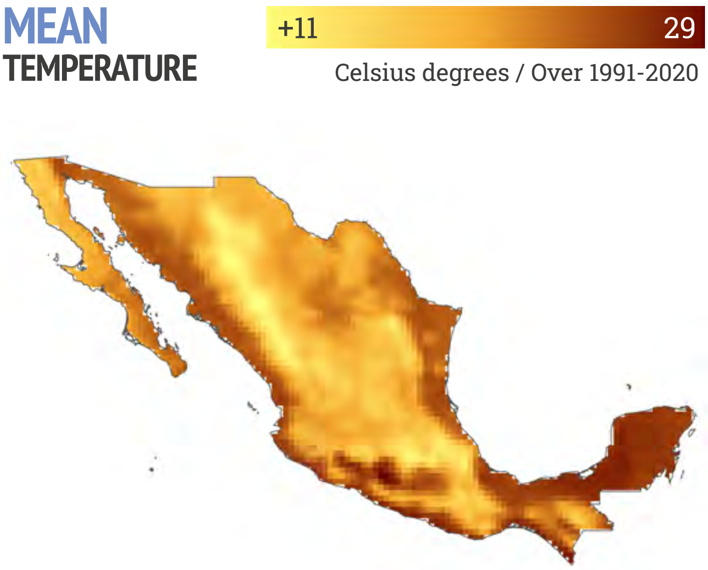
OVERVIEW

Mexico has different climates due to its wide latitudinal extent and the presence of the Northern Atlantic and Northeast Pacific Oceans' subtropical high-pressure systems. Two distinct climate zones may be identified through the Tropic of Cancer: the temperate one, generally arid or moderately rainy with mild to warm summers and cool to cold winters; and the tropical one, which is usually rainy and hot.

TEMPERATURE

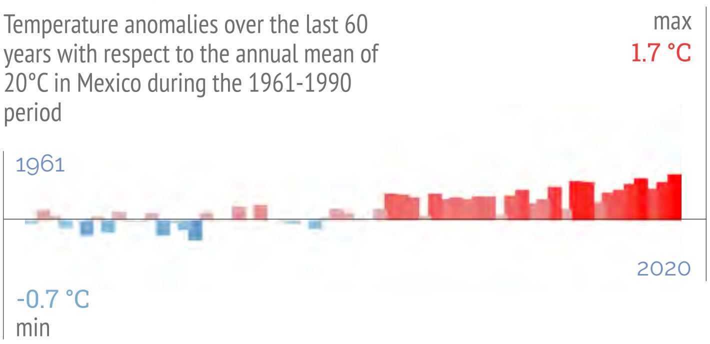
The temperature regime in Mexico varies from north to south. In the northern part, temperatures lower from coastal to inner areas, whereas in the southern part they are generally higher and influenced mainly by elevation.

MEAN TEMPERATURE



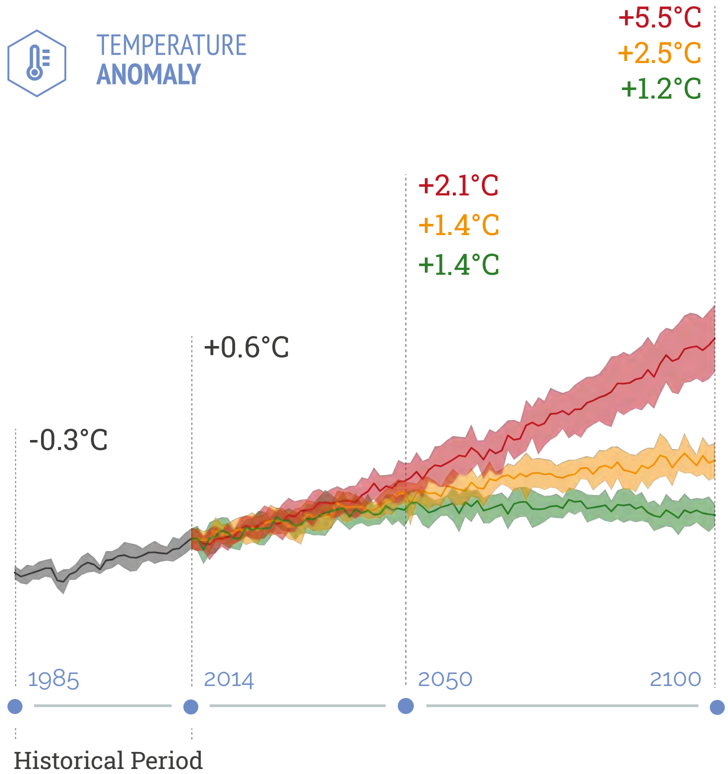
TEMPERATURE TREND

Temperature anomalies over the last 60 years with respect to the annual mean of 20°C in Mexico during the 1961-1990 period



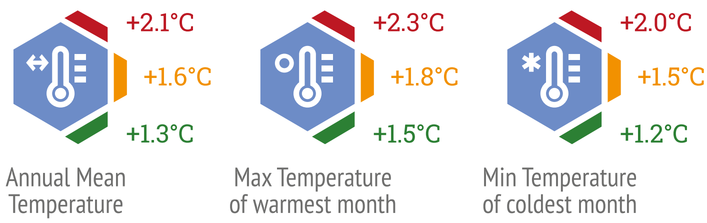
TEMPERATURE PROJECTIONS

Under a low emissions scenario projected temperature variations will remain contained under +1.5°C, both by 2050 and 2100.
Under a high emissions scenario, with no reduction in GHG emissions, much greater temperature anomalies are expected by both 2050 and 2100.



EXPECTED VARIATION FOR TEMPERATURE AT 2050

The indicators show variations in selected temperature characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.



PRECIPITATION

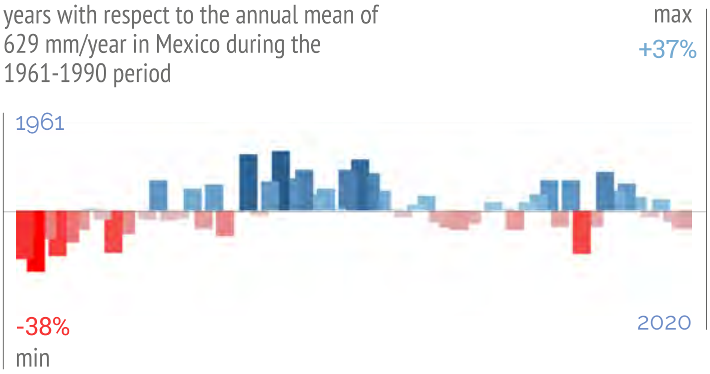
The precipitation regime in Mexico changes greatly depending on time of the year and location. Specifically, precipitation processes are mainly determined by rainfall in the rainy season, which spans from June to November. Snowfall is mainly observed in northern states during winter and at the top of mountains and volcanos in central Mexico.
The northern part of the country usually receives scarce precipitation in comparison with the southern part.

MEAN PRECIPITATION

59 – 4,377
mm/year / Over 1991-2020

PRECIPITATION TREND

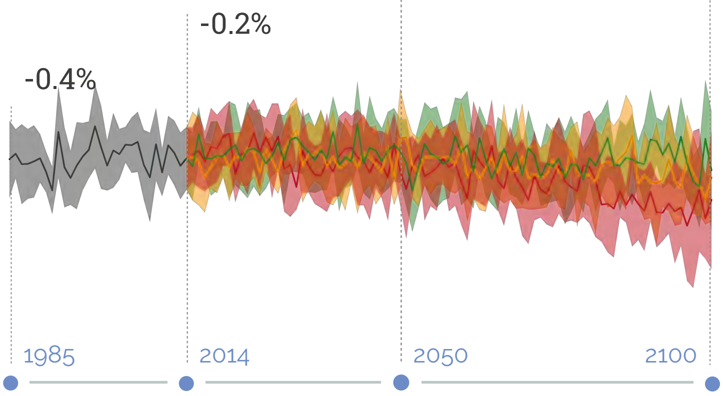
Precipiation anomalies over the last 60 years with respect to the annual mean of 629 mm/year in Mexico during the 1961-1990 period



PRECIPITATION PROJECTIONS

Precipitation trends show a very complex signal, under all emissions scenarios, with a very large variability among climate models. Trends show a however a reduction in precipitation under a high emissions scenario.

PRECIPITATION ANOMALY



EXPECTED VARIATION FOR PRECIPITATION AT 2050

The indicators show variations in selected precipitation characteristics for a thirty-year period centred on 2050 (2036-2065) with respect to the reference period 1985-2014.

- Annual total precipitation: -2.2%, -0.9%, +0.6%
- Precipitation of wettest month: +1.5%, +2.8%, +3.3%
- Precipitation of warmest quarter: -5.6%, -4.7%, -0.9%

VARIATION OF SPECIFIC CLIMATE INDICATORS

Climate indicators variation showing impacts of climate change on sectors such as agriculture, health and water. Analysis considers 3 threshold average temperature increase: **+1.5°C**, **+2°C**, **+4°C**.

- Agricultural drought proportion of time (% of time): +34%, +18%, +13%
- Hydrological drought proportion of time (% of time): +29%, +16%, +13%
- Heatwave duration (% of time): +4,005%, +538%, +195%
- Runoff increase (% of area): +52%, +31%, +22%
- Agricultural drought frequency (% of change): +72%, +37%, +24%
- Hydrological drought frequency (% of change): +15%, +12%, +13%
- Heatwave frequency (% of change): +98%, +55%, +30%
- Runoff decrease (% of area): +4%, +1%, +0%

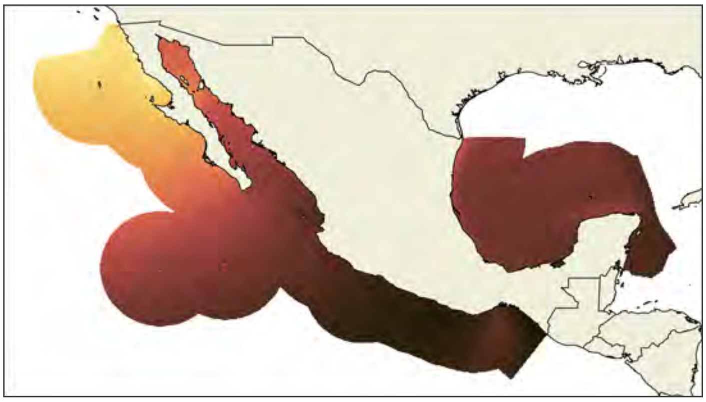
MEXICO OCEAN

OCEAN IN MEXICO

Mexico's marine exclusive economic zone (EEZ) is mainly characterized by subtropical coastal waters, which host a large variety of ecosystems such as seagrass meadows, coral reefs, and mangroves. The country's coastal systems are naturally diveded into two areas: the Pacific region and the Gulf of Mexico.

CURRENT CLIMATE CONDITIONS

Mean sea surface temperature reflects the subtropical climate regime, with colder waters located in the northern Pacific area and warmer ones along the coasts in the south.

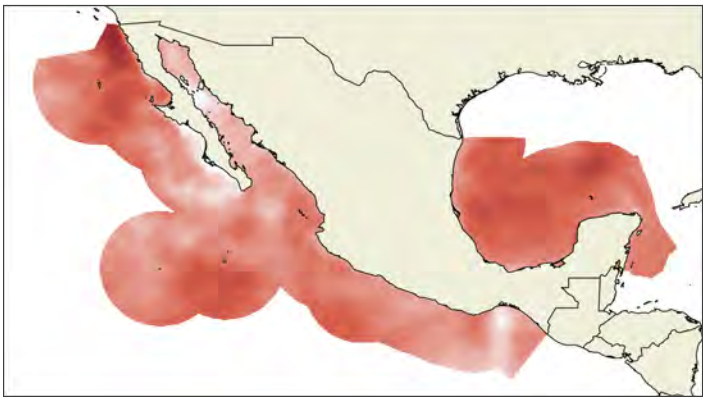


15 30 **MEAN**

SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

0 0.4 **TREND**



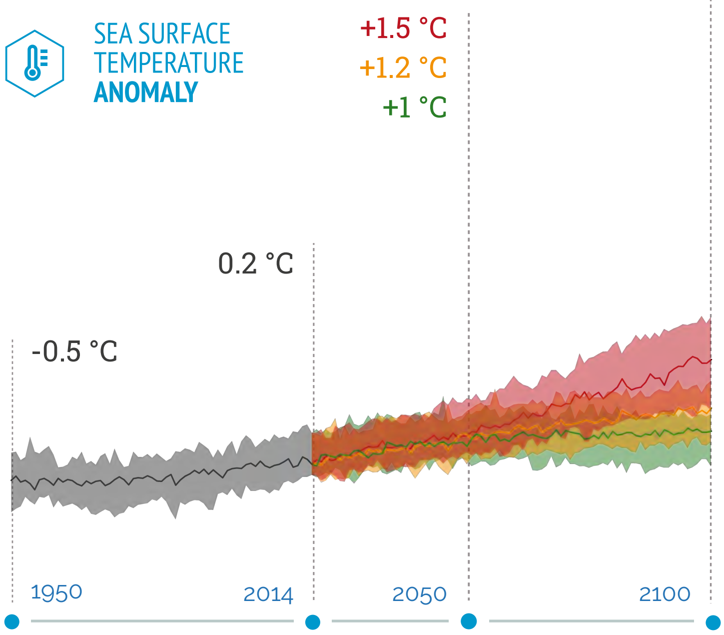
Surface temperature trends indicate a general warming of 0.2°C per decade in all marine areas, with increased gains in the northern Pacific area.

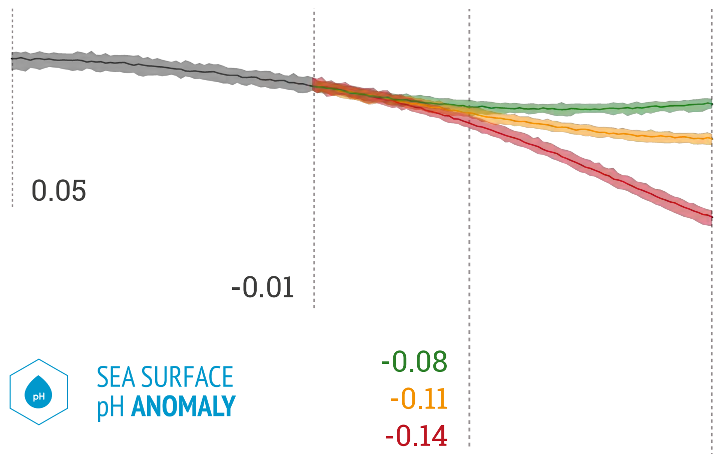
FUTURE PROJECTIONS

Projected annual changes within the marine EEZ for the two most significant marine indicators of climate change: sea surface water temperatures and pH.

Seawater temperature changes are in line with the definitions of each scenario, with maximum values above +3°C in 2100 under a high emissions scenario.

+3.6 °C
+2 °C
+1.3 °C





Seawater surface pH becomes more acidic in all scenarios, closely reflecting rising atmospheric CO_2 concentrations, and only a low emissions scenario leads to a stable condition by 2100.

-0.08
-0.17
-0.36

ECOSYSTEM INDICATORS AT 2050

Regional changes in key marine ecosystem indicators under projected future scenarios by mid-century (2036-2065) with respect to present climate conditions (1985-2014).

	Gulf of Mexico	Pacific
Temperature regulates the metabolism of marine organisms determining which habitats remain suitable. Excessive warming will likely push ecosystems beyond tolerance thresholds.	26.89°C +1.89 °C +1.55 °C +1.22 °C	25.86°C +1.46 °C +1.08 °C +0.92 °C
pH represents the acid/base status of marine waters, where a decreasing pH reflects the acidification of the ocean due to increased absorption of atmospheric CO_2.	8.08 -0.14 -0.1 -0.08	8.04 -0.14 -0.1 -0.08
Oxygen is fundamental to sustain marine life and its reduction can have a large impact on coastal ecosystem services including fisheries and aquaculture.	203.97 mmol/m³ -2.8 % -2.24 % -2.07 %	213.5 mmol/m³ -2.71 % -2.32 % -2.02 %
Chlorophyll is an indicator of the biomass available at the base of the marine food web supporting all ecosystem productivity.	0.13 mg/m³ +0.78 % -2.34 % +2.34 %	0.18 mg/m³ +6.25 % -7.39 % +12.5 %

FISH CATCH POTENTIAL

Fish catch potential is an estimate of the maximum fish catch achievable given the marine resources available over a sustained period. It is linked to the concept of maximum sustainable yield, meaning the maximum amount of fish that can be extracted from a system without causing a collapse in fish populations.

It is a characteristic of the natural system, which is substantially different from realized catch, and a direct result of the fishery policy in place.

Fish catch percentage change

2050

-17.0%

-6.8%

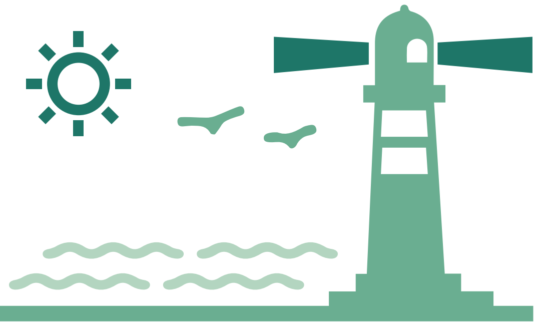
ANALYSIS DETAILS

All datasets were analysed using only data from within the marine EEZ and therefore excluding overseas territories, detached islands and any disputed or joint territories with other nations. In the assessment of current climate conditions, seawater surface tempererature data was obtained using satellite observations distributed in the framework of ESA Climate Change Initiative.

Future projections of marine indicators are represented by the combined analysis of results from 15 different Earth System models participating in the Coupled Model Intercomparison Project Phase 6 (CMIP6). These models include new and better representations of physical and biogeochemical processes, compared to previous IPCC assessment reports.

Fish catch potential data was obtained using the FAO's technical report and refers to the best and worst case climate scenarios from the Fifth IPCC Assessment Report. These mean estimates are subject to substantial uncertainties as discussed in the original work.

MEXICO COASTS



OVERVIEW

Mexico has three distinct coastal regions: the Gulf of Mexico, the Pacific coast and the Gulf of California. Each of these regions is thousands of kilometres long and presents very different environments with unique management challenges.

Whereas the eastern coastline of the Gulf of Mexico is low lying and features numerous sandy beaches and islands, the Pacific coast has many more rocky cliff faces, and the Gulf of California is home to many river basins making it an important area for local biodiversity.

Shoreline Length — 23,761 km

Sandy Coast Retreat at 2050 — -52.9 m

CLIMATE CHANGE HAZARDS

Coastal hazards such as erosion, storm tide inundation and permanent flooding, can have strong adverse impacts on coastal regions, with loss of sandy shores, damage to settlements, infrastructure and ecosystems. Climate change can exacerbate these impacts due to rising sea levels and increasing impacts of waves and storms. Climate change is affecting the Mexican coastline, particularly in the more vulnerable Gulf of Mexico where sea level rise threatens low lying shoreline areas with erosion and flooding of sandy shores, as well as saltwater intrusion. Also affected by climate change are weather patterns such as precipitation and storms, which will become more irregular and more extreme along the Mexican shoreline.

SEA LEVEL RISE

Relative sea level rise has been at or above the global average for the last 100 years. However, the rate has been accelerated, reaching over 3 millimetres per year since 1990. The latest IPCC projections indicate that, by 2050, global sea levels may rise between 0.18 metres, under a low emissions scenario, and 0.23 metres, under a high emissions scenario.

Observed and projected sea level rise at 2050

3.13 mm/year

0.23 m

0.18 m

EXTREME SEA LEVEL

On average, one in 100 extreme sea level events are expected to rise from 1.85 metres at present day to 2.09 metres by 2050 under a medium emissions scenario.

Current and projected extreme sea level at 2050

1.85 m

2.15 m

2.09 m

OBSERVED STORMS

Both the east and west coasts of Mexico are exposed to the damaging effects of high water levels and extreme tropical storms, particularly in the Gulf of Mexico. In general, hurricanes have the most significant impact on extreme water levels, whereas the mean wave climate is largely controlled by cold winter fronts. Storm surges and waves represent the main cause of damage to coastal infrastructure.

FUTURE STORMS

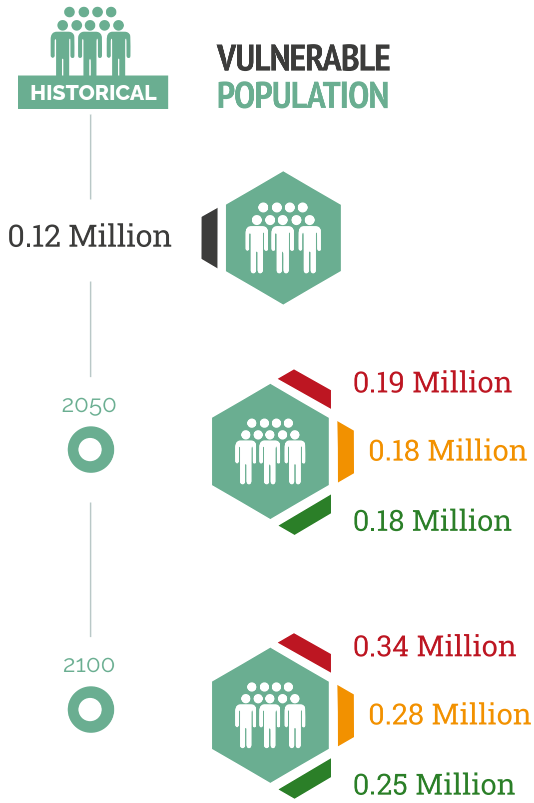
Sea level rise will increase both the frequency and the severity of extreme wave events, raising the wave climate's baseline level. For example, a strong cold front event in the Isla del Carmen area would see the flooded area increase by 31% when considering a sea level rise of 25 centimetres, and 229% for a 75 centimetre increase. As these events occur annually, they present challenges for the management and adaptation of shoreline erosion and habitat degradation.

VULNERABILITY AND RISK

Mexico's coastline is home to a significant share of the overall population. By 2015, over half of the country's 102 million people lived in coastal areas, including important cities such as Tijuana and Cancún. Coastal populations are projected to continue to increase throughout the coming decades, putting more people and urbanized areas at risk.

Sea level rise and the development of human infrastructure is leading to a coastal squeeze phenomenon, whereby local habitats are eroded and lose their ability to adapt and survive, particularly those that are susceptible to damage from flooding and salinity. In turn, this leaves these same areas more exposed to extreme storm events.

There is also significant touristic value in the at-risk coastal zones, as well as environmental value in the coastal reefs and dunes that are being degraded by climate change. Under a medium emissions scenario, the population exposed to the annual coastal flood level is expected to increase from 120,000 to 180,000 by 2050.



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

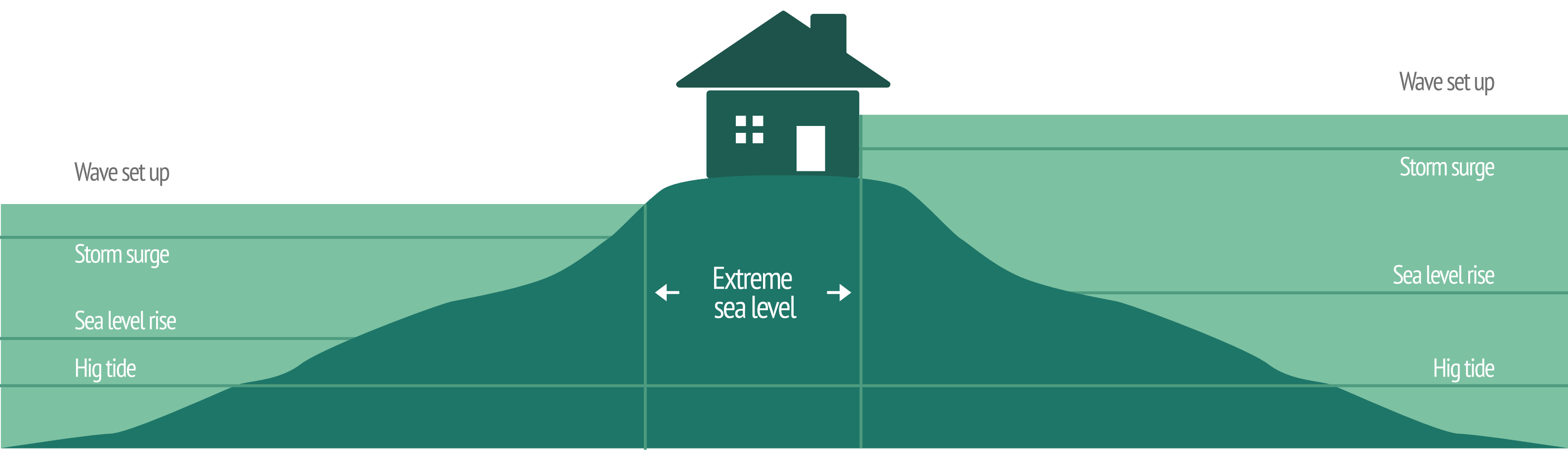
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

The extreme sea levels reported here are based on the 100-year storm surge + wave set up + sea level rise + high tide indicators. The first two parameters (storm surge + wave set up) are based on the 100-year value for the event; sea level rise is its projected value at 2050; and high tide is the absolute value of the highest tide calculated for a given locality, which won't be influenced by climate change.

+ **Wave set up** refers to the accumulation of water near the shore due to the presence of breaking waves.

+ **Storm surge** is an occasional increase in sea level driven by shoreward wind-driven water circulation and atmospheric pressure.

+ **High tide** is usually the highest tide reached in a given location based on tide records.



Present sea levels have risen globally by approximately 20 centimetres over the past century.

Future sea level rise is a projection based on different global warming scenarios, at approximately 100 centimetres by the end of 2100, with consequent inundation during extreme sea level events.

MEXICO WATER

OVERVIEW

Mexico's average annual renewable freshwater is about 0.2% of the world's total volume. Although Mexico receives about 1.4 billion cubic metres of rain per year, 67% of this falls between June and September and precipitation distribution is extremely unequal across the country. It is also estimated that 73% of this rainfall is lost to evapotranspiration.

In Mexico, in 2016, reported water-use distribution was as follows: 76.3% agriculture, 14.6% drinking water distribution, 4.8% thermoelectric, and 4.3% for industrial use.

Renewable internal freshwater resources: 409 billion m³

Renewable internal freshwater resources per capita: 3,277 m³

Mexico has a diverse climate and high spatial and temporal variability in water resource availability across different geographical regions. 77% of the population lives in the north and central regions where only 33% of the water resources are found, which leads to overexploitation of basins and aquifers.

CLIMATE CHANGE HAZARDS

Climate change can affect water resources through increasing tempe-ratures, higher rates of evapotranspiration and altered rainfall patterns. This leads to changes in the water cycle, including alterations of surface runoff and groundwater storage, as well as drought and flood occurrence. Mexico is likely to be heavily affected by climate change impacts, due to its complex climate and geography. Vast areas in central and northern Mexico already present conditions of very low water availability, especially in the Valley of Mexico. Due to population growth, regional economic development and urbanisation, it is expected that by 2030 several hydrological regions of great importance and extension will have extremely low availability, such as the Rio Grande basin.

KEY POINT RUNOFF

About 22% of the total annual precipitation in Mexico becomes runoff to surface-water bodies. The Lerma-Chapala basin, for instance, is particularly relevant because the largest water body in Mexico is located at its outlet. The long-term rate of change in surface runoff has been estimated considering the variation in future precipitation from climate models, showing a decrease in surface runoff of up to 29% in the northern part of the basin.

In some regions of Mexico, the decrease in surface runoff will be close to 20% by the end of the 21st century. At a country scale, an average change in surface runoff by approximately 13% and -4.4% is expected respectively under low and high emissions scenarios for the 2045-2055 period compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C or 4°C, 0%, 0.8% or 4% of the area of the country will likely experience an increase in runoff, while 22%, 31.4% or 52% of the surface of the country will likely experience a decrease in runoff, respectively.

2050

Changes in annual runoff
% of change

-4.4%

+13.3%

2050

Runoff increase
% of area

+4.0%

0%

KEY POINT DROUGHTS

Drought has been an inevitable natural disaster throughout Mexican history and the northern and northwestern parts of Mexico, where the mean annual precipitation is less than 500 millimetres per year. A recent three-year (2010-2012) drought in Mexico resulted in a huge amount of economic damages, including losses of 450,000 head of cattle, and a reduction in crop yields. The immediate consequence of these damages was the rising price of agricultural products, predominantly affecting the poorest sectors of society. The northern regions suffer a drought on average every 4.1 years with a mean duration of 2.2 years and an intensity of 143 millimetres per year (24.2% below the average). More recurrent and intense droughts are expected as a consequence of climate change and the decrease in precipitation expected in arid and semi-arid areas of the country.

2050
Severe drought likelihood increase
% of change
+29.1%
+13.4%

2050
Hydrological drought frequency
% of change
+15.0%
+10.0%

2050
Groundwater Recharge
% of change
-4.7%
-3.3%

KEY POINT GROUNDWATER

6% of the total annual precipitation in Mexico infiltrates groundwater. Groundwater constitutes an essential reserve for Mexico's socioeconomic development because more than half of its territory is arid or semi-arid, and the water supply depends heavily on groundwater resources, in fact, about one-third of the total consumption comes from aquifers. These are used to irrigate more than two million hectares of land (i.e., one-third of the total irrigated land), to supply about 70% of water requirements for the public-urban sector and to provide water for most of the industrial facilities and almost the entire water demand of the rural population (20 million people).

About 105 regional aquifers are subject to intensive exploitation, which has caused serious environmental impacts during the past four decades and the mining of 11 cubic kilometres per year of the underground water reserve. In response, programs have been initiated for managed aquifer recharge and extraction of brackish groundwater for desalination.

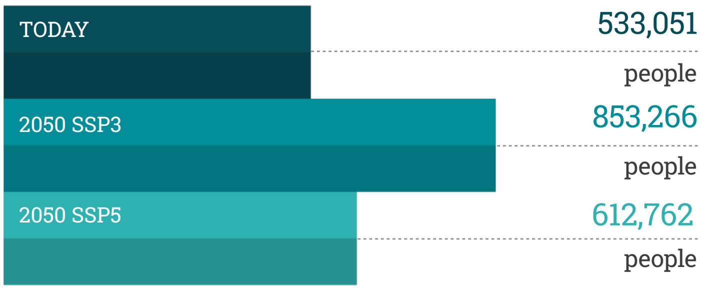
At the country level, a -3.5%, -4% and -4.7% decrease of the annual groundwater recharge for the period 2040-2060 compared to the timeframe 2010-2030 is expected respectively under low, medium and high emissions scenarios.

KEY POINT FLOODS

Local areas in Mexico are flooded basically every year because of tropical hurricanes or other extreme precipitation events. The number of events is already increasing with respect to the first 70-80 years of the last century. Urban developments in flood plains are common in Mexico: the Tabasquena Plain and the lower basin of Bravo River (Tamaulipas), Panuco River (Tamaulipas and Veracruz), Coatzacoalcos River (Veracruz), Papaloapan River (Veracruz), the Coast of Chiapas, the Atoyac, Jamapa, Tecolutla, Nautla and Antigua Rivers (Veracruz) and Tulancingo River (Hidalgo) are clear examples of areas where frequent flooding can be expected.

Heavier rains and increased extreme events are also expected to occur, making some watersheds in Mexico's southeast all the more vulnerable to floods. Changes in the population exposed to floods are expected, with an increase from about 533,000 in the present day to 853,000 under SSP3 and 613,000 under SSP5 by 2050. As such, potential impacts related to river floods might increase.

POPULATION AFFECTED BY RIVER FLOODS

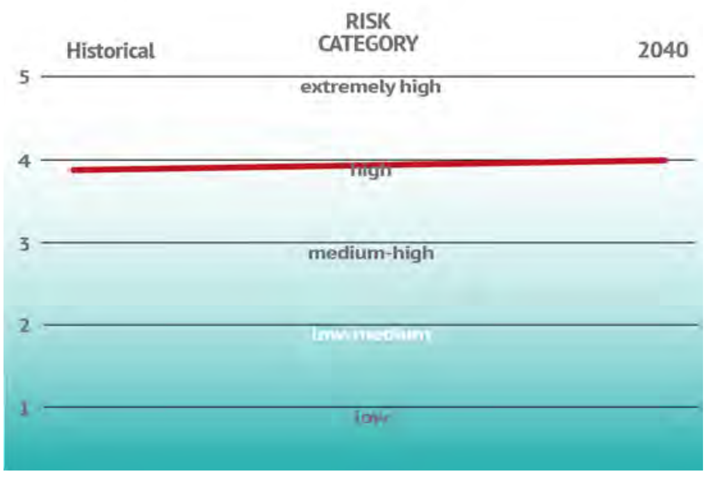


RISK INDICATORS

The water stress index summarises current and future water related vulnerabilities and risks at the global level. Scores are based on the ratio of total water withdrawals, including agriculture, industrial and human consumption, to available renewable surface and groundwater supplies.

WATER STRESS

Mexico's water stress level is considered high for the recent past (1960-2014 average), and it is expected to increase in the near future (2030-2050) based on climate change projections. In fact, the increase might be noticeable enough to place Mexico in the extremely-high risk category.



MEXICO AGRICULTURE

OVERVIEW

Mexico is the tenth most populated country in the world. Although agriculture only represents 3% of the country's GDP, 13% of the active population is employed the sector. Smallholders represent 85% of agricultural producers, generating over 60% of agricultural employment. Nevertheless, 42% of the population still lives in poverty.

Maize is the most important crop in Mexico, occupying 33% of the total cultivated area, followed by beans, sorghum, sugarcane, wheat, cattle pastures, coffee and fruit trees (oranges, lemons, avocados and mango).

Irrigated areas, though limited to specific regions, contribute significantly to agricultural production. However, they also accounted for up to 76% of total water withdrawal in 2017. Many areas of the country are under significant water stress (32.9%).

56.8 Mt
Sugarcane

8.6 Mt
Citrus

27.2 Mt
Maize

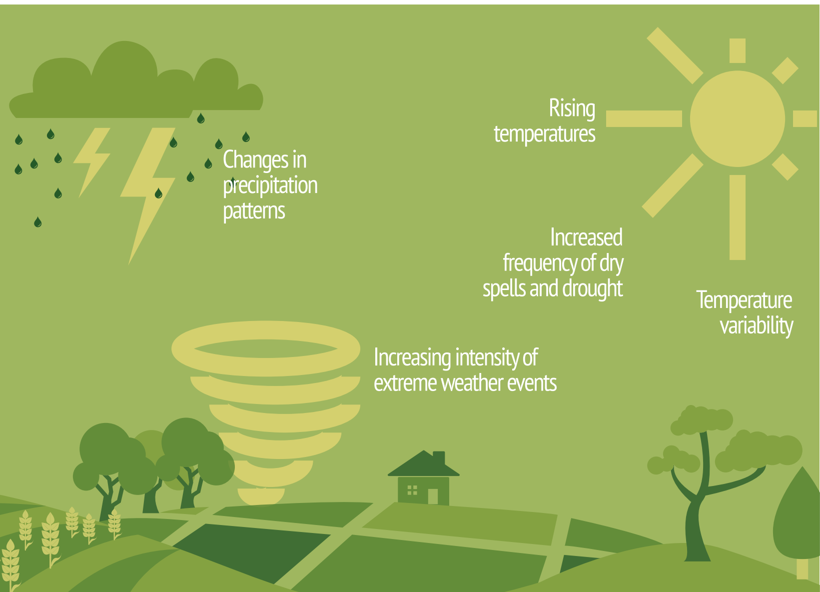
2.9 Mt
Wheat

2.2 Mt
Mango

	Added Value of Agriculture, Forestry and Fishing	Share of Agriculture Value added in Total GDP	Agricultural land	Area Equipped for Irrigation
2000	28,413 USD Million	3.2 %	25,378 Thousand HA	6,300 Thousand HA
2018	40,392 USD Million	3.2 %	26,612 Thousand HA	6,811 Thousand HA

EXPECTED IMPACTS ON AGRICULTURE PRODUCTIVITY

Rising temperatures, reduction in average annual precipitation, and intensification of extreme events such as heat waves and drought, affect production variability with a tendency towards yield reduction for many cultivated species, accompanied by a probable decrease in food quality. Crops respond to increases in temperatures with changes in duration of the growing season, early appearance of phenological phases and potential shifts of cultivation areas toward higher latitudes and altitudes for better growing conditions. However, impacts vary significantly depending on the geographical area and specific crops in question.

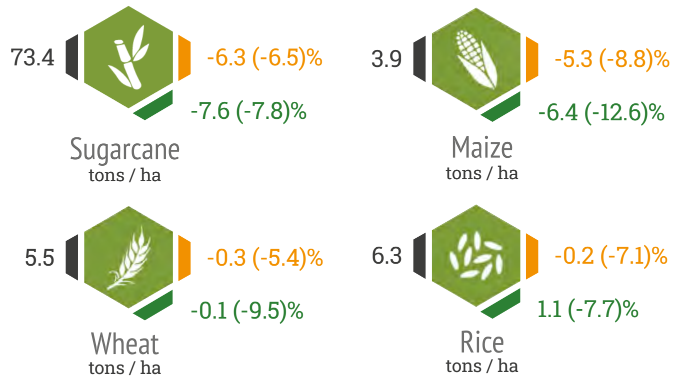


CROP PRODUCTIVITY

Crop productivity refers to the harvested yield of a crop per unit of land area. It is strongly influenced by climate and other environmental and management factors.

Climate change is expected to have an impact on the productivity of several major crops, although this may in part be offset by the fertilizing effect of higher CO_2.

Impacts are estimated using a range of model projections based on low to high emission scenarios and reported as percentage changes between the 30-year average around the historical period and the 30-year average around 2050.

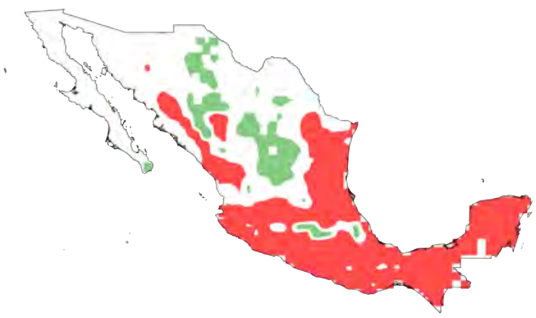


2050

Productivity change with (without) the CO_2 fertilization effect. Estimates assume sufficient water and nutrient supplies, and do not include impacts of pests, diseases, or extreme events.

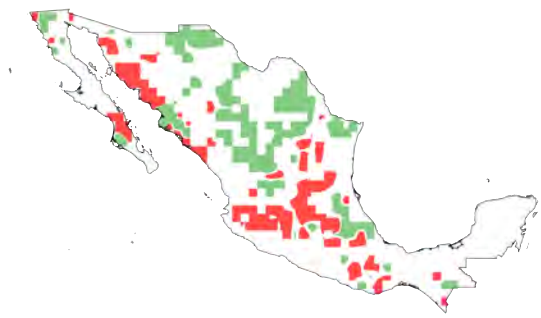
CHANGE IN MAIZE

− = +



CHANGE IN WHEAT

− = +



Projected changes in crop productivity predict a significant fall in yields for most cereals. A general and significant decline of productivity is projected for maize and sugarcane throughout most of their growing regions. A higher stability of maize yields is expected for irrigated areas, whereas more significant yield losses are projected for rainfed conditions. Wheat productivity is expected to decline slightly, although positive effects may be observed for irrigated areas in western regions and for rainfed conditions in southernmost regions. Commercial agriculture could see increased vulnerability to pests and diseases, with more than 20% of commercial tomato cultivation becoming less suitable in Mexico. Changes in fruit tree productivity will be critically linked with more frequent climate extremes and water stress.

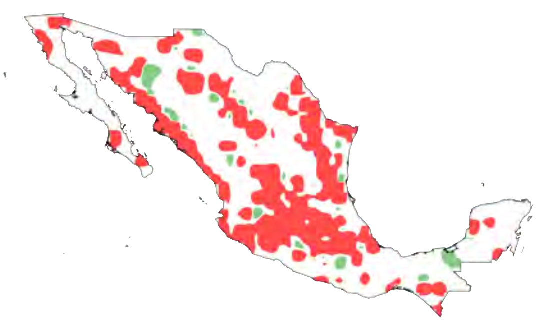
ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Climate change is enhancing risks and acting as a threat multiplier, particularly with regards to the availability of water. Overall, higher temperatures will lead to more demand for water due to increased plant evapotranspiration.

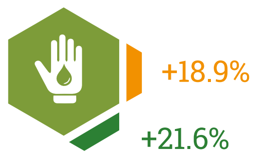
Therefore, to maintain agricultural production and ensure food security additional water resources are needed, increasing potential future water stress. For example, intensive production of high cash tree crops may be hampered in large production areas, such as Michoacán, due to water depletion and more frequent droughts.

CHANGE IN WATER DEMAND

− = +



Agriculture
Water Demand
% of change



2050

Water use efficiency will prove to be a key factor in future agricultural productivity. It will require adaptation strategies ranging from water-saving irrigation, to adoption of new crop varieties, and sustainable water management in general.

MEXICO FORESTS

FORESTS IN MEXICO

Given its topography and climatic conditions Mexican forests are extremely rich in variety and biodiversity. Half of Mexico's forest areas are primary forests and can be divided into two types: 1/3 tropical and 2/3 temperate forests of conifers and oaks. Mangrove forests grow on almost the entire Atlantic and Pacific coastline.

FORESTED AREA AND CARBON STORAGE

Although deforestation has led to a decreasing trend in recent decades, forested territories amount to almost 35% of the total land surface. Total carbon stored in the aboveground live biomass of forests in Mexico is approximately 1.7 gigatonnes and mangrove forests alone store nearly 240 million tons of organic carbon (blue carbon).

	Forested area	Carbon stock
1990	27 Mln ha Million hectares	71 Tons/ha Tons of Carbon per hectare
2020	79 Mln ha Million hectares	66 Tons/ha Tons of Carbon per hectare

FOREST PRODUCTIVITY

Forest productivity or Net Primary Production is the net carbon captured by plants. It is the difference between the carbon gained by Gross Primary Production - net photosynthesis measured at the ecosystem scale - and carbon released by plants' respiration. It is expressed per unit land area.

2050

Productivity anomaly
Tons of Carbon per hectare per year

+0.27

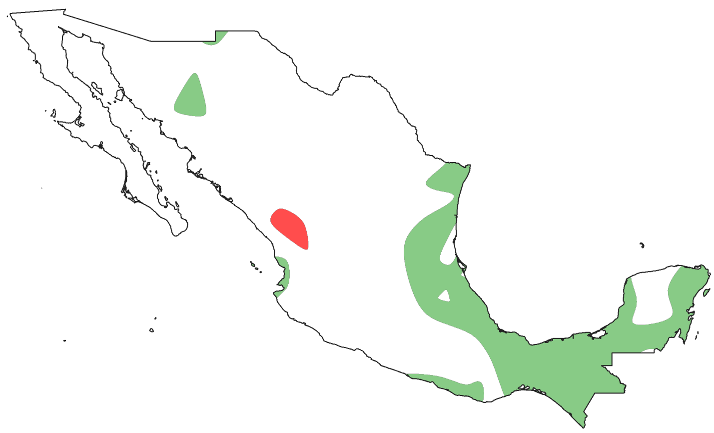
+0.19

Weak increase in southern Mexico and the Yucatan peninsula's tropical forests

+ Fertilizing effect of increasing atmospheric CO_2 and rising temperatures promote productivity

Alarming decrease expected in the central Pacific coast area

+ Increasing length of the dry season reduces productivity



KEY SPECIES UNDER CLIMATE CHANGE

REDUCTION
TROPICAL DRY
Heavy reduction of suitable areas for tropical dry forests in lower mountain ranges

LOW VULNERABILITY
SHRUBLAND
Lower vulnerability for chaparral shrubland ecosystems

SHIFT
CLOUD FORESTS
Cloud forests and tropical dry forests are expected to move to higher elevations

VULNERABILITY
MANGROVES
Rapid sea level rise will pose a significant threat to coastal Mangrove forests in the Gulf of Mexico

FIRES IN MEXICO

Fire is a structural ecological process that provides several types of ecosystem services and impacts on socio-ecological systems, including human health, carbon budgets, and climate change. Changes in global fire activity are influenced by multiple factors such as land-cover change, policies, and climatic conditions. Fire also releases large quantities of greenhouse gases into the atmosphere, contributing to a vicious cycle.

During the last two decades the total land area affected by fires was 5.3 million hectares, of which 2 million hectares were forests.

BURNING
5.3 MILLION HECTARES

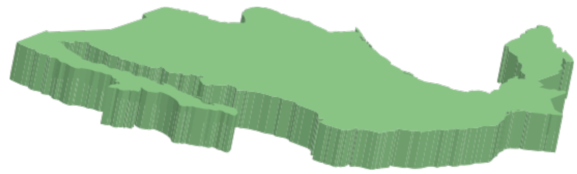
EMITTING
22 TERAGRAMMES OF CARBON PER YEAR

FOREST FIRE EMISSIONS CONTRIBUTED TO 40% OF TOTAL FIRE RELATED CARBON EMISSIONS

WHERE DO FIRES OCCUR?

Tropical Humid Forests found in Veracruz, Oaxaca and Tabasco are the most significant contributors to total fire emissions.

In 2006, fire emissions from biomass combustion had a significant impact on air quality in Mexico City contributing to more than half of the aerosol emissions and one third of the overall increase in harmful gas emissions.

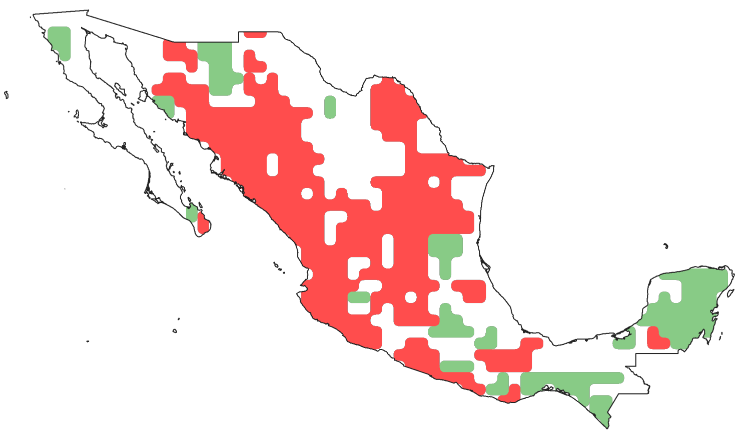


Wildfires mostly affect the states of Oaxaca, Tlaxcala, Puebla, Mexico City, Morelos, Coahuila, Hidalgo, Jalisco and Chiapas.

FUTURE BURNED AREA

Under a low emissions scenario, burned area might increase significantly in the temperate sierras and tropical dry forests, particularly in the Sonoran and Sinaloan dry forests and in the Sierra Madre Occidental pine-oak forests. Under a medium emissions scenario, the increase might be even more pronounced and widespread, affecting the central part of Mexico and the Oxaca region.

Burned Area
km^2 per year



Decrease in burned areas for a low emissions scenario

Increase in burned areas for a low emissions scenario
+ Prolonged and more intense warm and dry periods will impact water availability and induce water stress
+ Generalized increase in fire weather days and a prolonged fire season
+ More frequent El Niño conditions over central Mexico, which may lead to larger and more damaging wildfires

CASE STUDY: AIR QUALITY

In Mexico two main determinants of fire probability were identified: climate anomalies, which are more significant in northern areas and intertwined with climate change impacts; and human activities which are the most important driver in central and southern areas.

In 2019 and 2021, heat and drought conditions created an environment that was highly conducive to fires leading to impacts on air quality and public health, and affecting the homes and communities of those living in the Wildland urban interface (WUI). In 2019, Mexico City declared an environmental emergency as fire smoke contributed to unsafe levels of air pollution.

FUTURE FIRE EMISSIONS

Fire emissions follow a similar spatial pattern to burned area. Central areas and the Yucatan peninsula show greater projected changes under both low and medium emissions scenarios.

Fire Carbon emission
Teragrams of Carbon per year

MEXICO
URBAN

OVERVIEW

With an urbanization rate of 80%, Mexican cities are the most important living environments in the country and will become even more important in the near future, with 88% of people living in cities by 2050.

This growth will mainly be absorbed by cities with 1 to 5 million inhabitants, which are expected to increase in number and host 25% of the population by 2035, whereas Mexico city is expected to keep its share of approximately 20% of the urban population.

Built up areas cover 1% of Mexico (19,538.95 square kilometers).

Population in Urban Areas

2020: 108,074,410

2050: 144,909,934

Graphs refer to data provided by United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization

Urbanization Rate

2020: 80.7%

2050: 88.2%

OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

Mexican cities are most vulnerable to heat, heatwaves and flooding.

HEATWAVES AND HEAT STRESS

Many Mexican cities have experienced an increase in heatwave days. In particular, night time temperatures in cities tend to be much higher than in the sourrounding areas.

Urban areas are particularly affected by high temperatures and the urban heat island effect due to high building densities, a high degree of soil sealing, low percentage of green areas, and additional heat from anthropogenic sources such as motor vehicles and air conditioning.

The mortality risk from high temperatures for those that are 65 or older has risen by 3.22%. Heat mortality is also related to air pollution and falls to 1.3% if air pollution is factored in. Rising temperatures will lead to more frequent, prolonged and intense heatwaves.

Cooling Degree Days (% of change), 2050: +68.2% / +26.8% / +16.9%

Heatwave frequency (% of change), 2050: +4,004.8% / +538.1% / +195.2%

Heatwave duration (% of time), 2050: +4,005% / +538% / +195%

INTENSE SOIL SEALING

Urban areas built up environments accumulate high amounts of energy from the sun and release this energy during the night. In contrast vegetation transforms solar radiation energy and cools the surrounding environment. In Mexico City and other cities, this effect is particularly pronounced during night-times when built up environments release heat keeping temperatures high compared to the outskirts, which cool down quickly.

In Mexico City, the most pronounced heat island effects are observed at night during the dry season with city temperatures up to 7.8°C higher than surrounding areas. The difference in temperature between urban and rural areas were positive throughout the year, varying from 5°C at daybreak in the dry season to 1° to 3°C around noon during the wet months. Air pollution in Mexican cities is high, with 99% of urban residents exposed to unsafe levels of air pollution which exceed WHO thresholds.

COASTAL FLOODING

Many tourism centered areas are situated along the coasts and hence exposed to risks associated with climate change. For instance, the city of Cancun is exposed to hurricanes and sea level rise. In these areas wealthy hotel and tourism spots are often provided with appropriate protection, services and resources for recovery, whereas the residential areas lack adequate protection and access to recovery measures.

FLOODING

For Mexico City, annual rainfall quantities and the number of flash flood events have increased in recent decades, the latter of which reached 7 annual events during the first decade of the 21th century with respect to previous values. Research indicates that increasing urban temperatures may also have contributed to a change in precipitation patterns. During the 20th century, annual rainfall in Mexico City increased from 600 millimetres to over 900 millimetres. On 2 August 2006, 50.4 millimetres of rain fell in only 36 minutes, causing severe flooding in the southern and western parts of the city. Despite overall precipitation decreasing throughout the year, the frequency of intense precipitation events in cities such as Mexico City may continue to increase.

2017

Population exposed to air pollution

99.7%

2050

0.23 m

0.18 m

Projected sea level rise

2100

0.77 m

0.38 m

2050

Runoff increase

% of area

+4%

+1%

0%

SURFACE SEALING AND FLOODS

Heavy precipitation in cities is problematic due to the high level of sealed surfaces. Soil sealing increases run off and reduces the amount of water absorbed by soil. Where there are large amounts of impervious ground cover, short duration extreme rainfall events can lead to increased flooding, even resulting in flash floods.

SOIL SEALING **AND FLASH FLOODS**

In densely built urban areas, intense precipitation events cause flash floods where surfaces are impermeabilized and drainage systems are unable to deal with the high amounts of rainwater. These floods threaten local populations and property.

In Mexico City these risks are exacerbated by subsidence, poorly maintained drainage and sanitation systems that cause contamination. Informal settlements are particularly at risk as they are often built in areas that are exposed to flooding and landslides.

2010

% of urban population

Population living in slums

16.0%

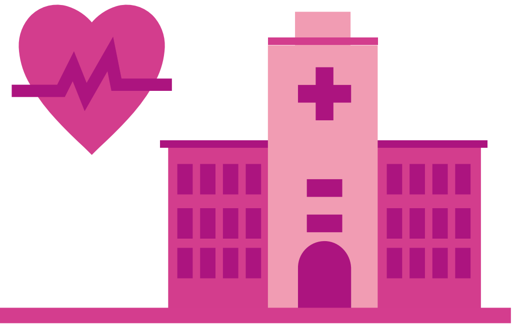
2018

% of total population

Urban population living in areas where elevation is below 5 meters

0.8%

MEXICO HEALTH



OVERVIEW

Increased temperatures, more variable precipitation pattern, and increased frequency and intensity of extreme events such as floods and hurricanes due to climate change may lead to increased heat and vector-borne mortality and morbidity in Mexico. At particular risk are relatively low-income and indigenous communities.

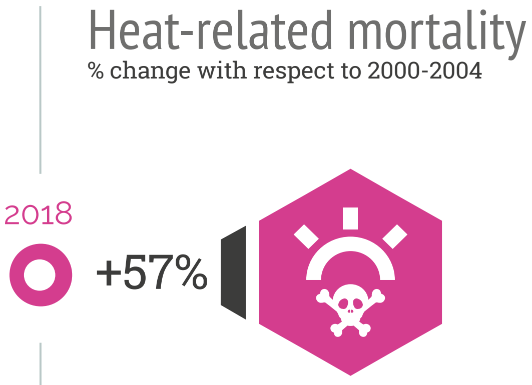
The five most populated cities in Mexico had annual mean PM2.5 levels above the WHO guideline value of 10 µg/m3. 20% of around 4,000 child deaths due to acute lower respiratory infections were attributable to household air pollution.

HEAT RELATED MORTALITY

Climate change may lead to increased temperatures and more variable precipitation patterns. Extreme events, such as floods and hurricanes, may lead to increased mortality and morbidity.

Under a high emissions scenario, heat-related deaths in the elderly (65+ years) are projected to increase to 54 deaths per 100,000 by 2080 and 11 deaths per 100,000 under a low emissions scenario; compared to a baseline of less than 3 deaths per 100,000 per year during the 1961 to 1990 period.

In 2018, there was a 57% increase in heat-related deaths in Mexico, compared to the 2000 to 2004 baseline. 44.2% of Mexico's heat-related mortality from 1998 to 2014 can be attributed to human-induced climate change.

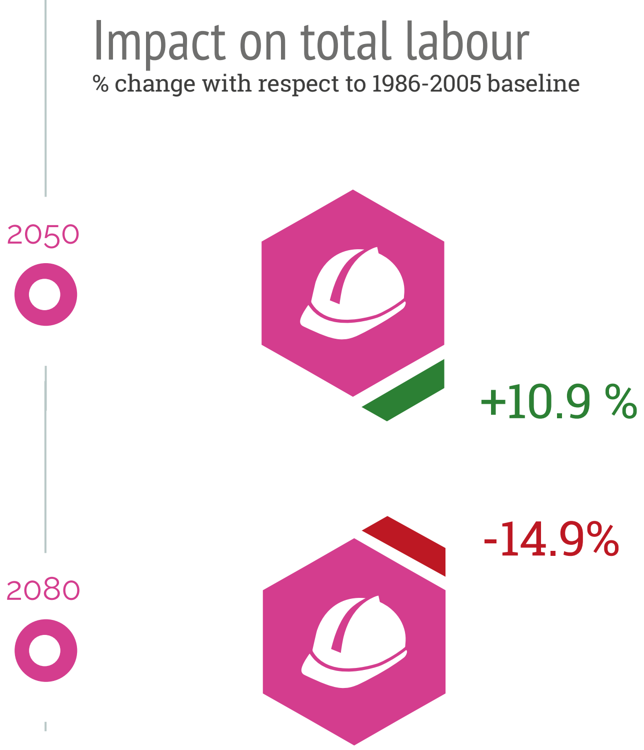


IMPACTS ON LABOUR

Labour is directly affected by changes in environmental conditions. Warming affects both the number of hours worked (labour supply) and on the productivity of workers during their working hours (labour productivity). Both labour supply and productivity are projected to decrease under future climate change in most parts of the world, and particularly in tropical regions.

Parts of sub-Saharan Africa, south Asia, and southeast Asia are at highest risk under future warming scenarios. Future climate change will reduce global total labour in the low-exposure sectors by 18 percentage points and by24.8 percentage points in the high-exposure sectors under a 3.0°C warming scenario

Total labour in Mexico is expected to decline by 8.2% under a low emissions scenario, and by 14.9% under a medium emissions scenario.



CLIMATE CHANGE AND DENGUE

Dengue has spread throughout the tropical world over the past 60 years and now affects over half the world's population. Globally, vectorial capacity for both dengue vectors (A. aegypti and A. albopictus) has been rising steadily since the 1980s, with nine of the ten highest years occurring since 2000.

Climatic stressors are one important driver of the current distribution and incidence of dengue. Climate change is likely to expand the geographical distribution and suitability of several vector-borne human infectious diseases including dengue. The risk of dengue transmission is increased by warming climates, as the growth and development of mosquitoes are significantly influenced by temperature, precipitation, and humidity.

CLIMATE CHANGE AND ZIKA

Zika virus has spread to at least 49 countries and territories since 2013. Climate change impacts on transmission suitability risk have increased over the years and future warming over 1.3 billion additional people could face suitable transmission temperatures for Zika by 2050.

DENGUE AND ZIKA: POPULATION AT RISK

Under a medium emissions scenario, 74% of the population will be at risk of transmission-suitable mean temperature for dengue by 2050, whereas 73.3% will be at risk under a high emissions scenario. In the case of Zika, 51.7% of the population will be at risk by 2050 under a medium emissions scenario, whereas 52.5% will be at risk under a high emissions scenario.

CLIMATE CHANGE AND MALARIA

53.8% of Mexicans will be at risk of malaria under a low emissions scenario in 2050, whereas 57% will be at risk under a high emissions scenario.

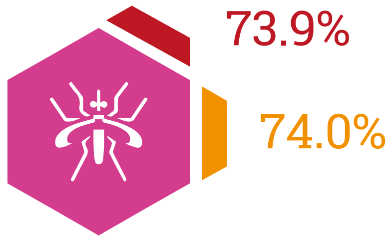
POLLUTION AND PREMATURE MORTALITY

The air pollution disease burden is substantial in Mexico. According to the World Bank, air pollution kills nearly 33,000 Mexicans every year. Nearly 20,000 of these deaths are due to outdoor air pollution, mainly in towns and cities. By 2060, 268 deaths per year per million people will be caused by outdoor air pollution, compared to 122 in 2010.

Dengue suitability

% of population at risk

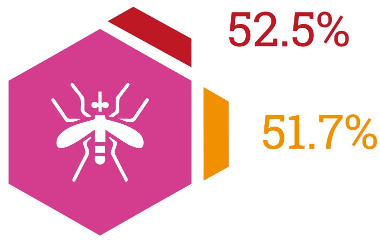
2050



Zika suitability

% of population at risk

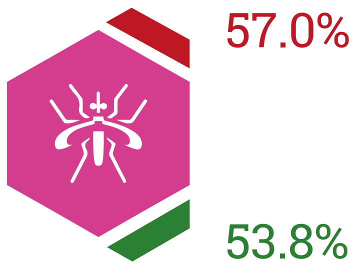
2050



Malaria suitability

% of population at risk

2050



MEXICO ENERGY

ENERGY SYSTEM IN A NUTSHELL

Mexico's energy mix is dominated by oil and gas. However, Mexico has one of the lowest energy intensities in the world. Traditionally a net energy exporter, since 2014 Mexico has turned into a net energy importer mainly due to its rising demand for oil products and natural gas. Demographic trends and economic growth are driving energy demand towards a sustained increase.

0.07
ktoe/US$
Energy intensity

16.2%
AC Share in electricity consumption

22.8%
Import dependence ratio

CLIMATE CHANGE TODAY

INCREASING TEMPERATURES

Average temperatures have risen by 0.85°C since the 1960s, resulting in electricity demand for cooling needs in 2016 increasing 5-fold (7 to 37 terawatts per hour) compared to 1990 levels.

DECREASING PRECIPITATIONS

The south-east of the country has seen decreasing precipitations, resulting in lower water availiability for hydropower and cooling of thermal plants.

EXTREME EVENTS - HURRICANES

The increasing frequency of extreme events such as hurricanes is posing a serious threat to the Mexican energy infrastructure, in particular oil extraction in the Mexican Gulf.

ENERGY SUPPLY

Mexico's energy mix is strongly dominated by fossil fuels (45.2% oil, 37.8% natural gas, 6.4% coal, for a total of 89.5% of total primary energy supply in 2018). Renewables claim 9% and there is a residual nuclear power generation (1.6% of total primary energy supply). In 2016, Mexico became a net importer; while still exporting oil, it imports oil products due to limited refining capacity, and natural gas, to cope with the fast growth in electricity demand which has doubled since 1997.

ENERGY DEMAND

In Mexico, energy is used mainly by the transport sector (43% of final demand in 2018) and industrial uses (34%, including 4% of total demand for non-energy uses), followed by residential demand (14.5%), whereas agriculture and commercial use claim smaller shares (3.3% and 3.6%). Air conditioning's contribution to residential electricity demand was about 16% in 2017.

FUTURE ENERGY DEMAND

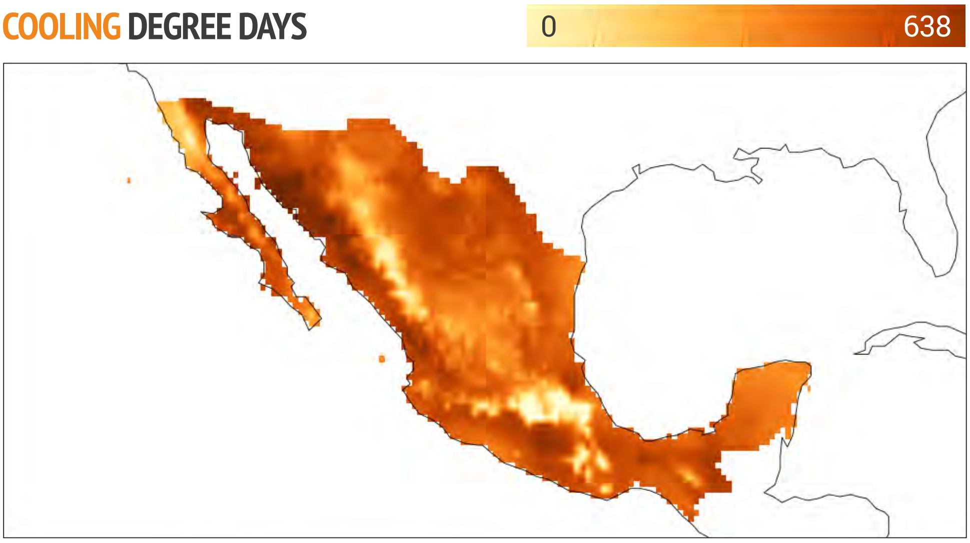
In Mexico, electricity demand for cooling is expected to increase substantially in the coming decades, due to the strong increase in cooling degree days coupled with increasing household incomes.

By 2020, an 8-fold increase in AC units is projected, from 16 million in 2016 to 126 million in 2050.

COOLING NEEDS

Marked increases in cooling needs are expected over most of the country, including mountain areas, excluding the highest elevations. Highest increases esxpected in the northwest.

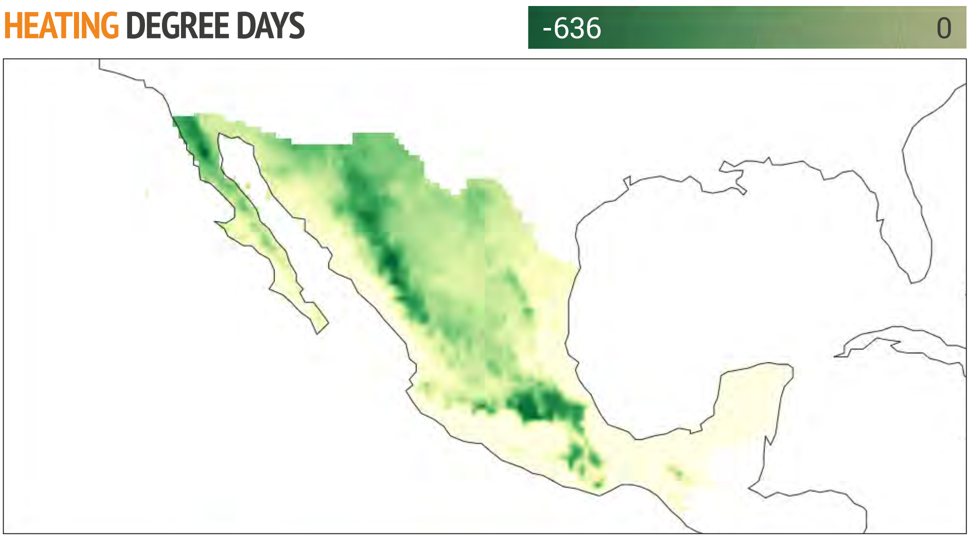
COOLING DEGREE DAYS



HEATING NEEDS

Marked decreases in heating needs are expected only at high elevations. This matters in terms of energy demand for mountain cities, as there are more than 15 cities with over 100,000 inhabitants above 2000 meters, including Mexico City (9 million).

HEATING DEGREE DAYS

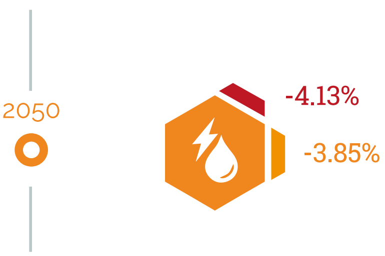


FUTURE ENERGY SUPPLY

The future configuration of the Mexican energy mix is likely to be determined by the evolution of climate mitigation policies and hence is outside the scope of this report. Mexico has a long-term commitment to halving its carbon emissions compared to 2000 levels by 2050.

However, in the wake of the COVID crisis, stimulus programs have given priority to the development of fossil fuel extraction and thermal plants, implying that the vulnerabilities of oil and gas extraction and electricity generation will be prevalent at least until mid-century.

Change in
Hydropower generation
% of change



EXPECTED IMPACTS OF CLIMATE CHANGE

There is a lack of quantitative estimates of impacts on the energy infrastructure; however, both an increase in the threat posed by hurricanes and coastal floods to oil industry infrastructure in the Gulf of Mexico, and a decrease in water availability for hydropower and cooling of thermal plants, is expected.

MEXICO ECONOMY

OVERVIEW

The Mexican economy contracted by 8.3% of GDP in 2020 due to the COVID 19 pandemic. After enduring one of the most severe economic slumps in the G20, it is poised to grow at an estimated high of 5% in 2021, spurred by the growing value of exports.

IMPACTS ON GDP

Climate change will have an effect on the growth rate and overall economic performance of the country. Under less severe climate change scenarios, climate change may have a small positive effect on GDP.

By mid century projections are in the range of a 1.87 billion EUR gain, or 0.21% of GDP, to damages of 17.6 billion EUR or 1.97% of GDP.

By the end of the century estimated aggregate damages could reach 49 billion EUR, or 5.54% of GDP under a high emissions scenario.

2050

1.7/1.97%

-0.21/1.1%

GDP Loss

% change w.r.t baseline

2100

5.54%

-0.23%

SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

Mexico's extensive coastline spanning two oceans and covering 11,000 kilometres, coupled with its unique topography, make it highly vulnerable to the damages of tropical cyclones and floods. Transport, power and water infrastructure are thus threatened, particularly in coastal areas.

IMPACTS ON AGRICULTURE

Agriculture is a small percentage of overall GDP, accounting for only 3.3%, but it is the third most important economic activity . It remains a key sector of the economy, employing 13.3% of the labour force. Mexico is the leading world producer of avocados, lemons and limes.

The agricultural sector is predicted to be the most badly affected by climate impacts: 80% of weather-related financial losses since 1990 were attributed to agriculture.

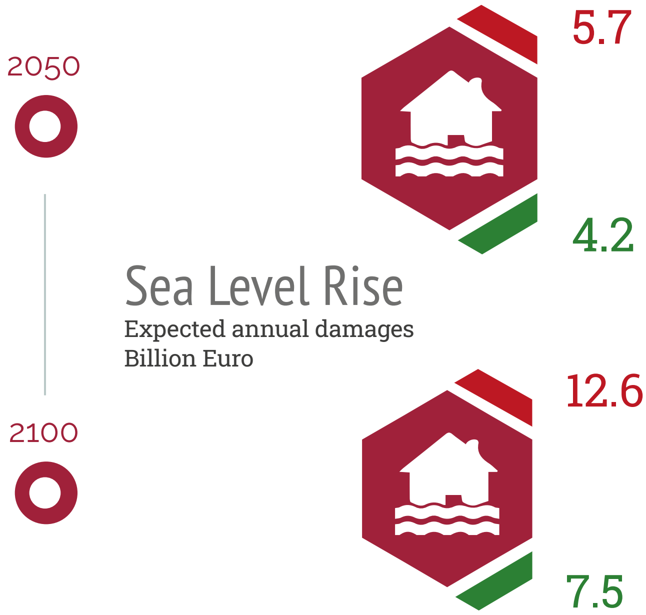
By 2050, depending on the assumptions made, the impacts of climate change on the agricultural sector could be between 8.92 and 24.98 billion EUR (1% to 2.8% of GDP) under a high emissions scenario, and between 1.22 and 1.96 billion EUR (1.37% and 2.2% of GDP) under a medium emissions scenario.

By 2100, the estimated damages under a medium emissions scenario are between 1.2 and 6.727 billion EUR (1.35% and 7.54% of GDP), and under a high emissions scenario between 1.7 and 99 billion EUR (1.91% and 11.15% of GDP).

SEA LEVEL RISE DAMAGES

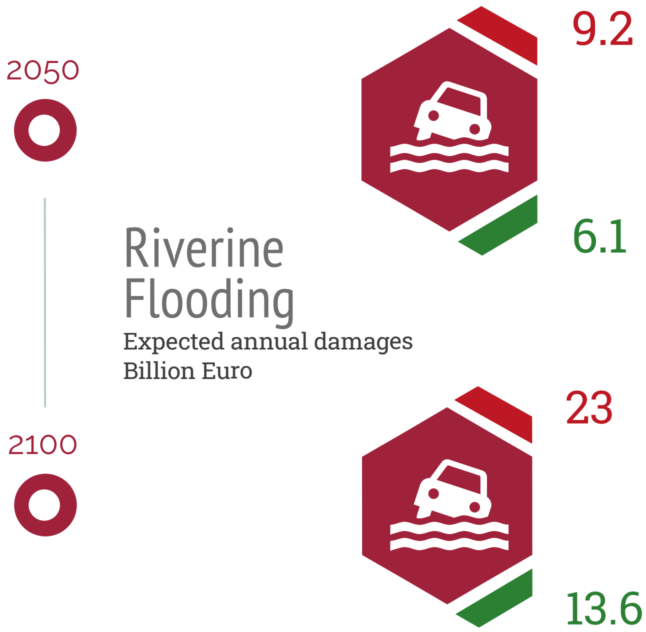
The expected annual damages from sea level rise and riverine flooding as a result of climate change are substantial. By mid century, sea level rise is projected to cause economic losses of 4.2 billion EUR under a low emissions scenario and 5.7 billion EUR under a high emissions scenario in terms of expected damages to assets.

By the end of the century, the costs rise to 7.5 billion EUR under a low emissions scenario and 12.6 billion EUR under a high emissions scenario.



RIVER FLOODING DAMAGES

Riverine floods are also expected to result in economic losses. By mid century, the expected annual damages to assets are between 6.1 billion and 9.2 billion EUR under the low and high emissions scenarios, respectively. By the end of the century, the costs rise to annual damages of 13.6 billion EUR under a low emissions scenario and rise to 23 billion EUR under a high emissions scenario.



IMPACTS ON ENERGY

As with all other economic sectors, energy supply and energy networks in Mexico will undergo more intense stress from extreme weather events.

Economic impacts of shifts in household and firm energy demand (see chapter on energy) are difficult to predict and will mostly imply redistribution effects.

In the case of Mexico, the magnitude of the increase in demand for cooling is expected to exceed by far the (tiny) decrease in heating demand, hence a significant increase in energy bills is expected.

IMPACTS ON TOURISM

Tourism is a key sector of the Mexican economy, contributing 8.7% of GDP in 2018. Coastal areas are a major tourist destination, and are highly vulnerable to climate impacts. The rich marine ecosystems are also at risk of severe weather events and temperature increases.

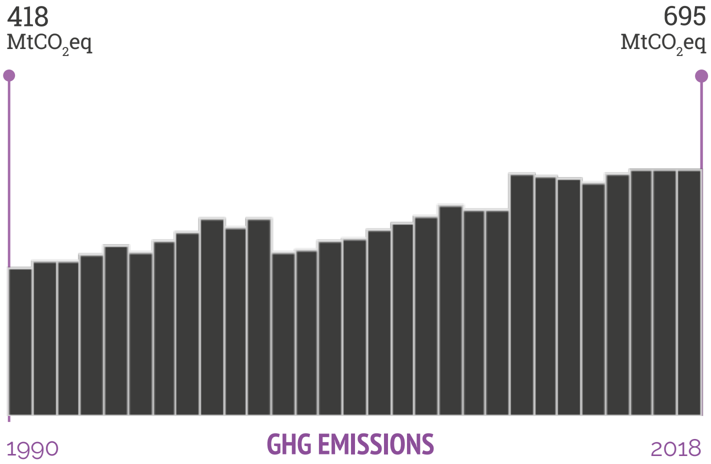
Tourist destinations in Mexico are highly sensitive to climate conditions, so it is expected to be highly impacted by climate change. Hotels located in coastal zones are constantly at risk from the effects of tropical cyclones, and the costs of disaster prevention increase every year.

It is estimated that by 2050, climate impacts on foreign tourism could result in a loss of 89 million EUR or 0.01% of GDP, under both medium and high emissions scenarios.

MEXICO POLICY

OVERVIEW

Mexico is the world's 11th largest emitter in absolute terms. Nevertheless, it is one of the countries with the lowest per capita emissions of the G20. Although Mexico has committed to the Paris Agreement, emissions continue to grow.



INTERNATIONAL COMMITMENTS

Mexico ratified the Paris Agreement in 2016. In its NDC, Mexico commits to reduce emissions by 22% in 2030, with reference to a business-as-usual scenario. The NDC also includes a commitment for the reduction of black carbon (-51% by 2030 with reference to a business-as-usual scenario).

CLIMATE POLICY COMMITMENTS CHRONOLOGY

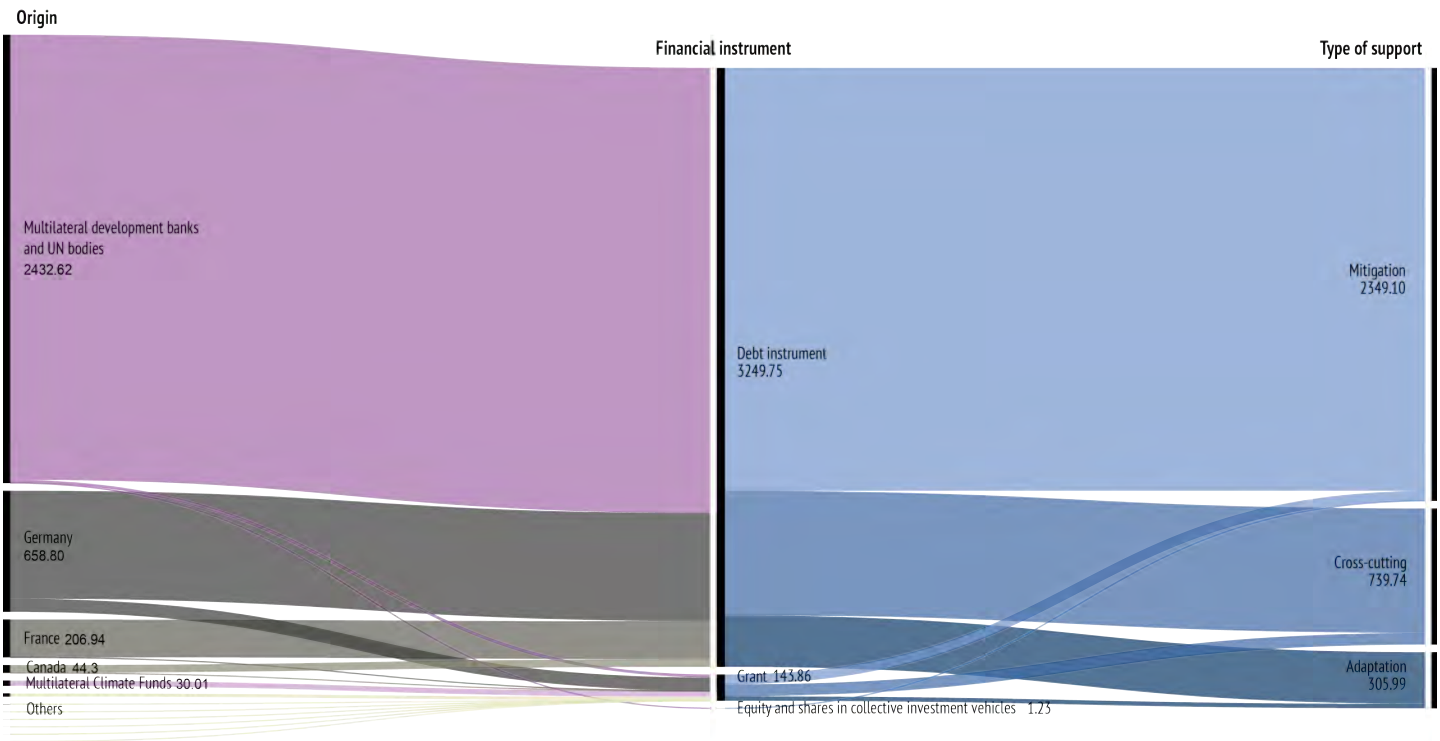
2000 — **KYOTO PROTOCOL - 1ST PERIOD**
No target

2016 — **PARIS AGREEMENT - 1ST NDC**
22% of GHG reduction by 2030, with reference to a specific business-as-usual scenario. 51% reduction in black carbon by 2030, with reference to a specific business-as-usual scenario

2020 — **PARIS AGREEMENT - NDC UPDATE**
Submitted. Commitments unchanged

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

The diagram shows the climate-related development finance received by Mexico in 2017-2018 and reported to the OECD DAC. The total amount is 3,4 billion USD. The majority comes from multilateral institutions in the form of debt instruments.



SUSTAINABLE RECOVERY POLICY

In 2020, Mexico designated 22.3 billion USD to recovery from the healthcare crisis. In the Global Recovery Observatory, no sustainable recovery measures are reported.

34.41 billion $	22.31 billion $	0 billion $
Total Spending	Recovery Spending	Green Spending

DOMESTIC ADAPTATION POLICY

Mexico has included adaptation in its NDC. To achieve its NDCs, Mexico adopted an integrated mitigation and adaptation plan. This policy foresees that sub-national administrations are responsible for the development of adaptation plans.

○ Domestic Adaptation Policy
- ● Inclusion of Adaptation in NDCs
- ● Integrated Adaptation & Mitigation Policy
- ○ Dedicated Adaptation Strategy
- ○ Dedicated Adaptation Plan

○ Subordinate Adaptation Policies
- ○ Sectoral Adaptation Plans
- ● Subnational Adaptation Plans

○ Policy not in place ● Active policy

ADAPTATION POLICY HIGHLIGHTS

TRANSNATIONAL INITIATIVES

Selva Maya Natural Resources Protection Project

The project aims to maintain the ecosystem functions and cultural values of the Selva Maya that promotes the welfare of its people and provides environmental services of global importance

Canada-Mexico Partnership Environment Working Group

The Canada-Mexico Partnership is a key mechanism for bilateral cooperation between Canada and Mexico on environmental issues, including climate change

NATIONAL INITIATIVES

National Atlas of Vulnerability to Climate Change (ANVCC)

ANVCC provides a structured and systematic set of nationwide maps that show territorial vulnerability to climate change and guide the implementation of adaptation strategies

Climate Change and Biodiversity Explorer (ECCBio)

The tool allows an interactive visualisation of past temperature and precipitation patterns, as well as different future climate change scenarios for the periods 2015-2039, 2045-2069 and 2075-2099

SUBNATIONAL INITIATIVES

Mexico City's Climate Action Program (PACCM)

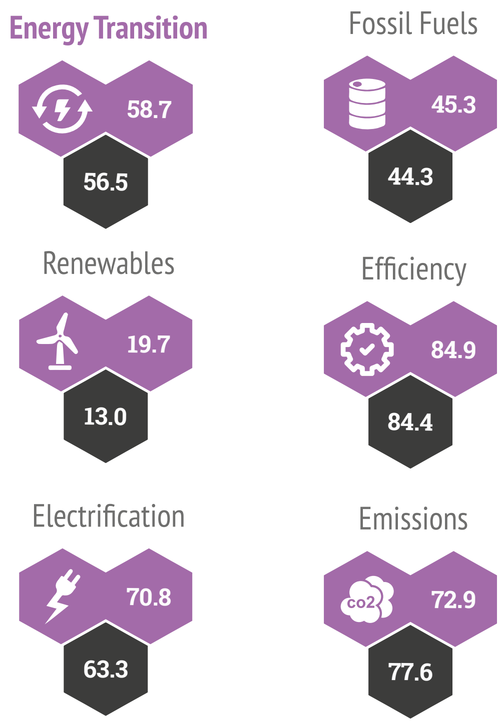
PACCM targets a wide range of challenges, such as increasing energy efficiency, containing urban sprawl, managing natural resources and preserving biodiversity and increasing research and development

Adaptation to Climate Change Impacts on the Coastal Wetlands in the Gulf of Mexico

The project focused on actions that contribute to local populations' adaptation to floods, lack of clean water, food insecurity and to mangrove conservation

ENERGY TRANSITION

Mexico is performing slightly below the G20 average in the overall Energy Transition indicator and in all domains, with the exception of Emissions where the country is performing much better. In particular, the ongoing digitalization of the electric grid should speed up and increase the level of electrification of energy consumption patterns in the country that will rise over the next few decades thanks to the expected increase in population and wealth: as a consequence, investments in electricity can also improve efficiency. Finally, Mexico should grab much more the opportunities offered by renewable energy sources, as increasing their penetration can also decrease the usage of fossil fuels.



Only actively pursuing an energy transition based on decarbonization and electrification – from policy and regulation, to health and education – will enable countries to benefit the most from future opportunities and fight climate change whilst ensuring an equitable distribution of wealth.

The Energy Transition indicators were developed by Enel Foundation in cooperation with SACE, and provide a retrospective analysis based on historical data.