G20 CLIMATE RISK ATLAS

Impacts, policy, economics

UNITED STATES OF AMERICA

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

UNITED STATES
CLIMATE

OVERVIEW

The USA has several climates due to its large size and geographical complexity, including mountains and deserts. The predominant climate is continental, with cold winters and hot summers, the duration of which varies according to latitude and distance from the sea. Other climates exist throughout the country, such as alpine in mountainous areas, subarctic in Alaska, tropical in Florida, Mediterranean along the west coast, and desert in the southwest.

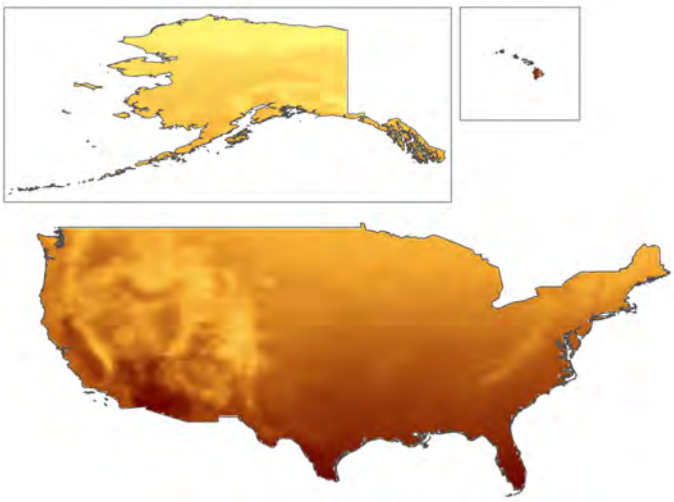
TEMPERATURE

The temperature regime in the USA varies from region to region. In general, temperatures drop from the East Coast to the West Coast depending on latitude and other climatic factors which define climate types.

MEAN TEMPERATURE

-12 25

Celsius degrees / Over 1991-2020



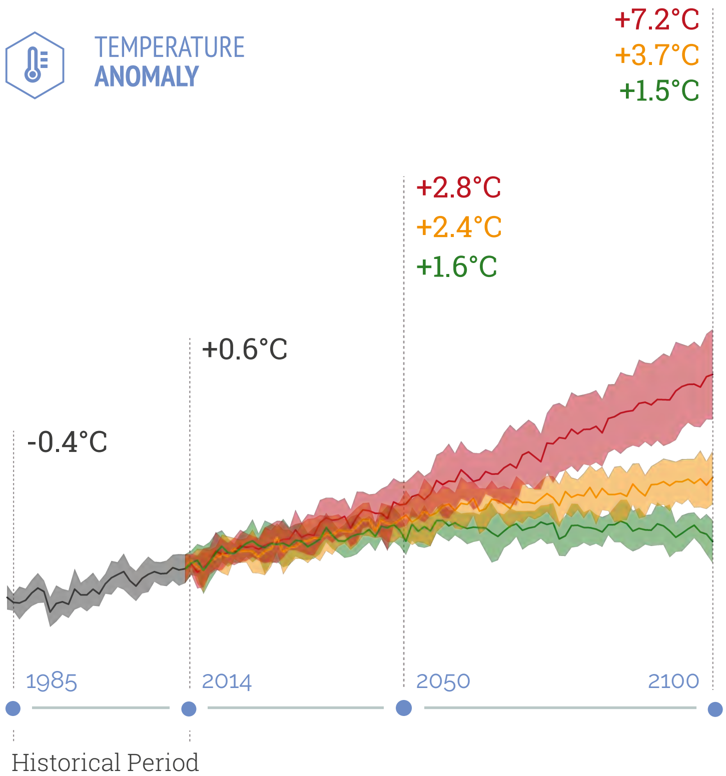
TEMPERATURE TREND

Temperature anomalies over the last 60 years with respect to the annual mean of 8°C in the United Kingdom during the 1961-1990 period

max
2.3 °C

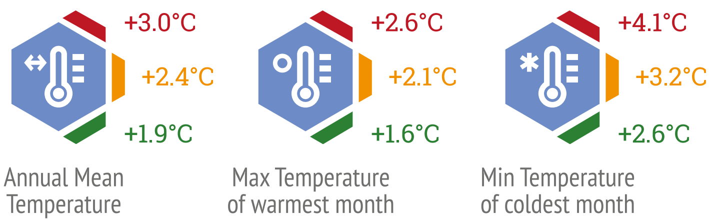
TEMPERATURE PROJECTIONS

Under a low emissions scenario projected temperature variations will remain contained at around +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.



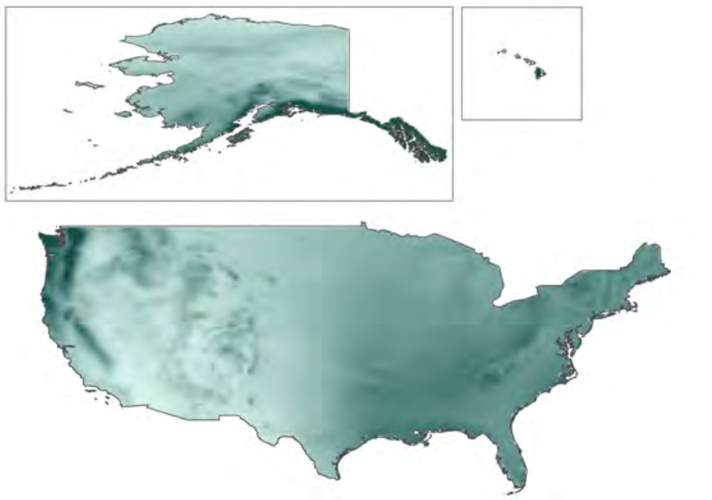
PRECIPITATION

The precipitation regime in the USA varies from region to region due to the country's size and geographical complexity.
The eastern part of the contiguous USA, east of the 98th meridian, the Pacific Northwest Mountains, the Willamette Valley, and the Sierra Nevada are the wettest parts of the country.
The driest areas are the desert Southwest, the Great Basin, the valleys of north-eastern Arizona, eastern Utah and central Wyoming. Increased warming in urban heat islands leads to increased precipitation downwind of cities.

MEAN PRECIPITATION

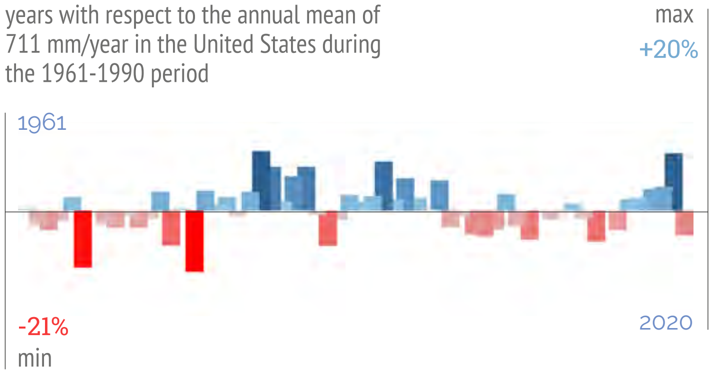
73 — 7,209

mm/year / Over 1991-2020



PRECIPITATION TREND

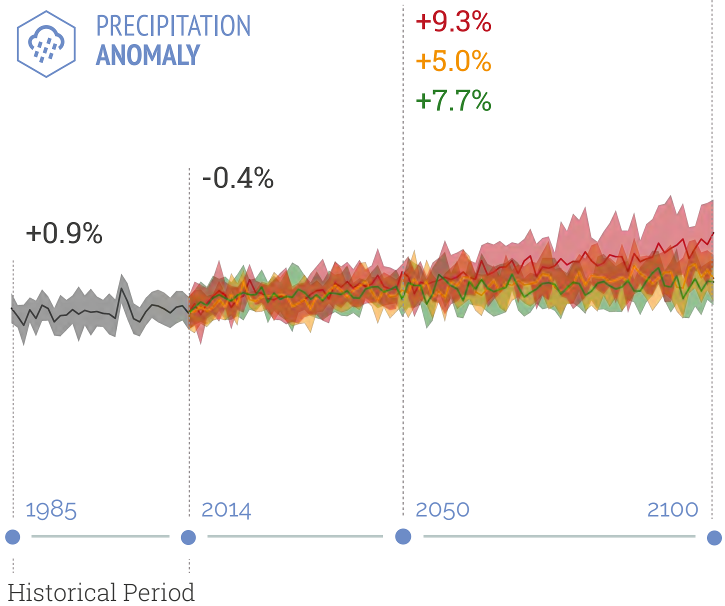
Precipiation anomalies over the last 60 years with respect to the annual mean of 711 mm/year in the United States during the 1961-1990 period



PRECIPITATION PROJECTIONS

Considering the different scenarios, precipitation trends show a general increase in annual precipitation at a country level. Higher increments are reported under a high emissions scenario even if characterized by higher variability with respect to the historical period and to the other scenarios.

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: +8.2% / +5.9% / +5.8%

Precipitation of wettest month: +8.7% / +6.9% / +6.3%

Precipitation of warmest quarter: +6.5% / +4.6% / +6.0%

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): +36% / +17% / +13%

Hydrological drought proportion of time (% of time): +21% / +12% / +10%

Heatwave duration (% of time): +2,000% / +311% / +117%

Runoff increase (% of area): +39% / +12% / +4%

Agricultural drought frequency (% of change): +67% / +36% / +27%

Hydrological drought frequency (% of change): +14% / +10% / +13%

Heatwave frequency (% of change): +91% / +40% / +22%

Runoff decrease (% of area): +16% / +5% / +2%

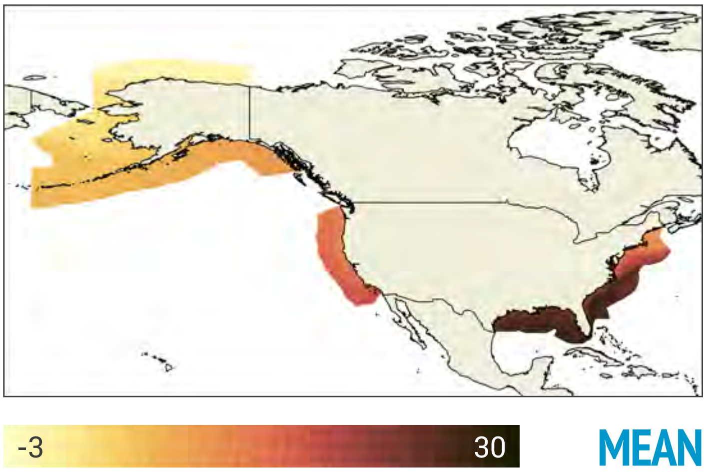
UNITED STATES
OCEAN

OCEAN IN UNITED STATES

The US marine exclusive economic zone (EEZ) comprises a wide range of environmental conditions, from the cold waters surrounding Alaska to the subtropical ecosystem of the southern coasts. Coastal systems can be divided into three main areas: Alaskan, Atlantic and Pacific marine regions.

CURRENT CLIMATE CONDITIONS

Mean sea surface temperatures reflects the different climate regimes over the wide EEZ domain.

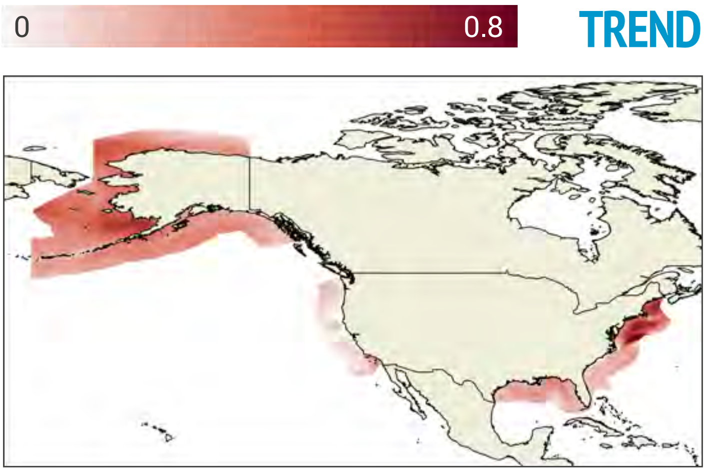


MEAN

SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

TREND

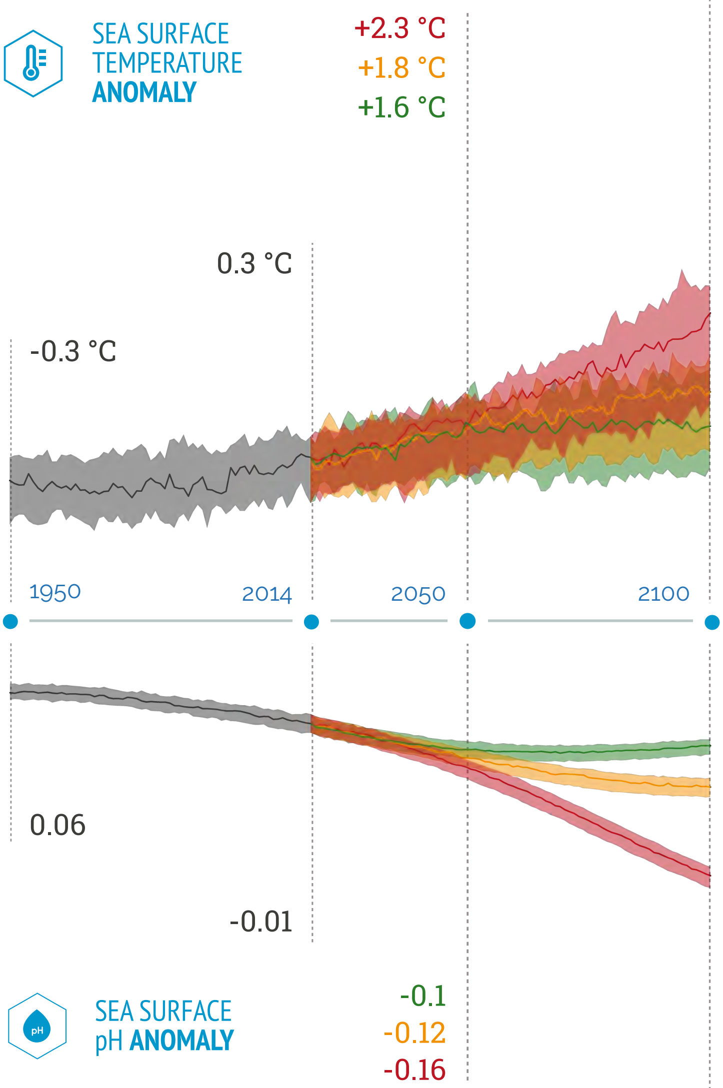


Surface temperature trend indicates high warming rates in the colder marine regions, with values up to 0.8°C/decade

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 in 2100 close to +5°C under a high emissions scenario.



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.

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).

Temperature regulates the metabolism of marine organisms determining which habitats remain suitable. Excessive warming will likely push ecosystems beyond tolerance thresholds.

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.

Oxygen is fundamental to sustain marine life and its reduction can have a large impact on coastal ecosystem services including fisheries and aquaculture.

Chlorophyll is an indicator of the biomass available at the base of the marine food web supporting all ecosystem productivity.

	Alaska	Atlantic	Pacific
Temperature	4.97°C +2.86 °C +2.24 °C +1.77 °C	23.48°C +1.97 °C +1.62 °C +1.6 °C	15.06°C +2.13 °C +1.74 °C +1.62 °C
pH	8.07 -0.17 -0.13 -0.1	8.1 -0.14 -0.11 -0.08	8.06 -0.16 -0.12 -0.09
Oxygen	322.97 mmol/m³ -4.89 % -4.29 % -3.33 %	219.33 mmol/m³ -4.22 % -3.4 % -3.35 %	260.98 mmol/m³ -3.61 % -3.12 % -2.97 %
Chlorophyll	0.62 mg/m³ -1.12 % +0.32 % -1.93 %	0.33 mg/m³ -5.49 % -1.52 % -3.96 %	0.38 mg/m³ -13.23 % -9.79 % -11.9 %

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
	-1.7%
	-0.5%

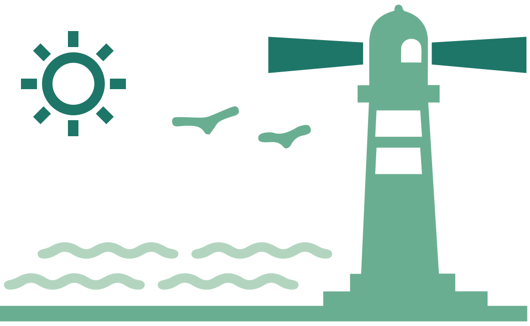
ANALYSIS DETAILS

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 tempereature 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.

UNITED STATES COASTS



OVERVIEW

The extensive coastline of the USA, one of the longest in the world with a total of over 130,000 kilometres, can be broadly split into three regions - the Atlantic, Pacific, and Gulf coasts. The Atlantic coast, home to major metropolitan hubs such as Boston, New York, and Miami, is largely low lying, with sandy beaches and even coral reefs in the Florida Keys. The western Pacific coast is largely rocky, with sandy beaches. The Gulf coast is characterized by large marshlands, deltas and lagoons.

Shoreline Length: 133,312 km

Sandy Coast Retreat at 2050: -38.8 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. Coastal hazards are becoming more of a concern for USA coastal areas as a result of the increasing impacts of climate change. Changes in the patterns of storm activity and precipitation, as well as warmer temperatures driven by high carbon emissions, are increasing the risk of rising sea levels, storm surges, and coastal inundation. These effects are likely to worsen making destructive events more frequent and leading to further risk of coastal erosion, saltwater intrusion and other negative impacts that have already been observed across the coastline of the USA.

SEA LEVEL RISE

The USA's coastal areas have already seen a noted average sea level rise in the 20th Century, reaching peaks of 1.5-2 millimetres per year, although the extent is dependent on the location. Areas along the east coast have been identified as sea level rise hotspots with an acceleration in the rate of change since the 1980s. 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

3.24 mm/year

0.23 m

0.18 m

EXTREME SEA LEVEL

Extreme sea levels are expected to rise in line with sea level rise, increasing the frequency of damaging high water level conditions. Under a medium emissions scenario, one in 100 year extreme sea level events in the USA are expected to rise from 3.69 metres at present day to 3.92 metres by 2050.

Current and projected extreme sea level at 2050

3.69 m

3.99 m

3.92 m

OBSERVED STORMS

Waves and storms present a particularly strong threat to the Atlantic coast of the USA, with large hurricanes capable of causing significant damage (such as hurricane Harvey in 2017 and Katrina in 2005). However, the potential for high energy waves to cause continuous erosion and environmental damage exists throughout the coastal regions of the country, particularly in low-lying areas such as in Florida.

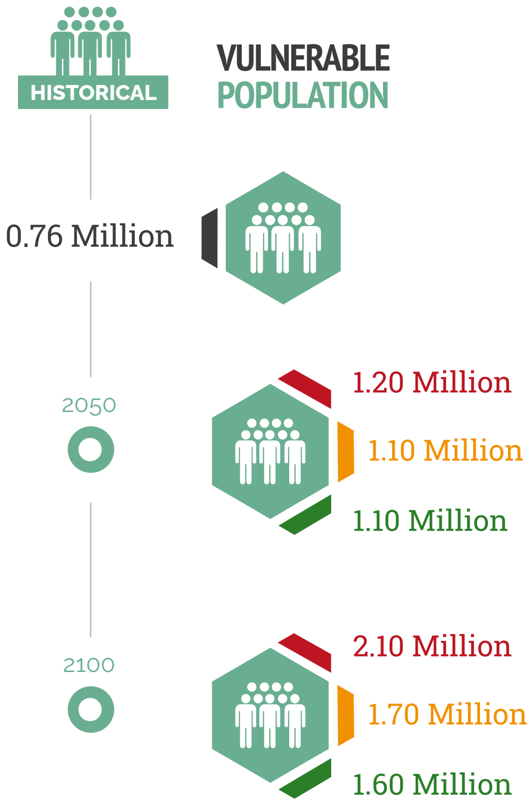
FUTURE STORMS

Global warming will likely exacerbate the issue of storm surges and high waves, both through sea level rise and an intensification in the frequency and severity of tropical storms. The balance of these two factors will depend largely on location. For example, in New York the impact of future sea level rise on the frequency of extreme water level events will have a much larger effect than any changes in the intensity of tropical storms.

VULNERABILITY AND RISK

By 2010, 39% of the USA's population was living in coastal areas, and that number is projected to continue to increase. This represents a large number of people at risk from the coastal impacts of climate change. Over 13 million people live on land that is projected to be flooded by 2100 under a high emissions scenario. Beyond the direct impacts that this would have on urbanized areas and the local population, this could also have knock-on effects by driving migration inland. Coastal biodiversity and species distribution are also prone to the negative impacts of climate change, with sea level-driven habitat loss posing a major threat.

Significant changes would be experience with sea level rise alone, not to mention the more frequent extreme flooding events and their impacts on infrastructure and the natural environment, particularly on the East Coast where the low lying land is more vulnerable to coastal inundation and erosion. The economic impacts could be severe, for example in the Houston-Galveston area which is a major economic and productive centre on the Gulf Coast and which is particularly vulnerable to storm surges and flooding events. Under a medium emissions scenario, the total population exposed to the annual coastal flood level is expected to increase from 760,000 to 1,1 million by 2050.



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

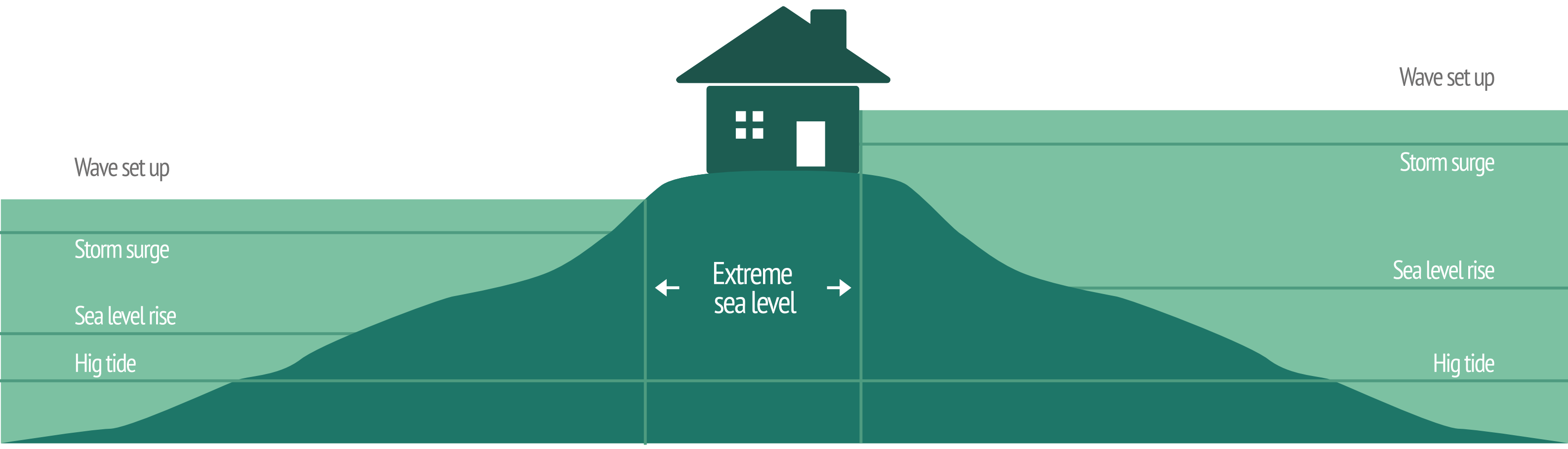
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

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.

UNITED STATES WATER

OVERVIEW

The USA is a water-rich country in terms of water resources per capita. However, it also faces problems of uneven distribution. The industrial sector uses the largest share of water, with 46% of the total, followed by agriculture with 41%, and domestic use with 13%.

Shifts in rainfall quantities during storms provide evidence that the water cycle is already changing. Over the past 50 years, the amount of rain falling during very heavy precipitation events has increased for most of the USA.

This trend has been most pronounced in the north-east, Midwest, and upper Great Plains, where the amount of rain falling during the most intense 1% of storms has increased by more than 30%.

Renewable internal freshwater resources: 2,818 billion m^3

Renewable internal freshwater resources per capita: 8,667 m^3

Many areas of the USA, and the western states in particular, face periodical water shortages. The amount of water available in these areas is limited and demand will continue to rise as population grows. Many areas in the west have experienced less rain over the past 50 years, as well as increases in the severity and length of droughts. This is causing particular concern in the south-west of the USA.

CLIMATE CHANGE HAZARDS

Climate change can affect water resources due to increasing temperatures, higher rates of evapotranspiration and altered rainfall patterns. This leads to changes in the water cycle, including decrease of snow and ice coverage, alterations in surface runoff and groundwater storage, as well as drought and flood occurrence. Projected rainfall patterns show a possible decrease in water availability mainly in the west and southwest of the country, including the Colorado River basin, and changes in snowfall and melting patterns which may affect water availability and cycles. The Great Plains and the Mississippi River, may also experience changes in water availability from snow melt and increasing intensities of rainfall events.

KEY POINT RUNOFF

Increasing temperatures, which are likely to impact the entire USA, may result in lower surface runoff as a consequence of increasing evapotranspiration in large areas, possibly counterbalancing the effects of increasing rainfall. This is likely in areas such as parts of the Colorado River basin.

On a country scale, an increase in surface runoff by an average of 7.91% under a low emissions scenario, and 8.21% under a high emissions scenario, is expected for the 2045-2055 period compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C and 4°C, then 2%, 5.4% and 16% of the country will likely experience an increase in runoff, whereas 4%, 12.3% and 39% of the country will likely experience a decrease in runoff for the same temperature changes.

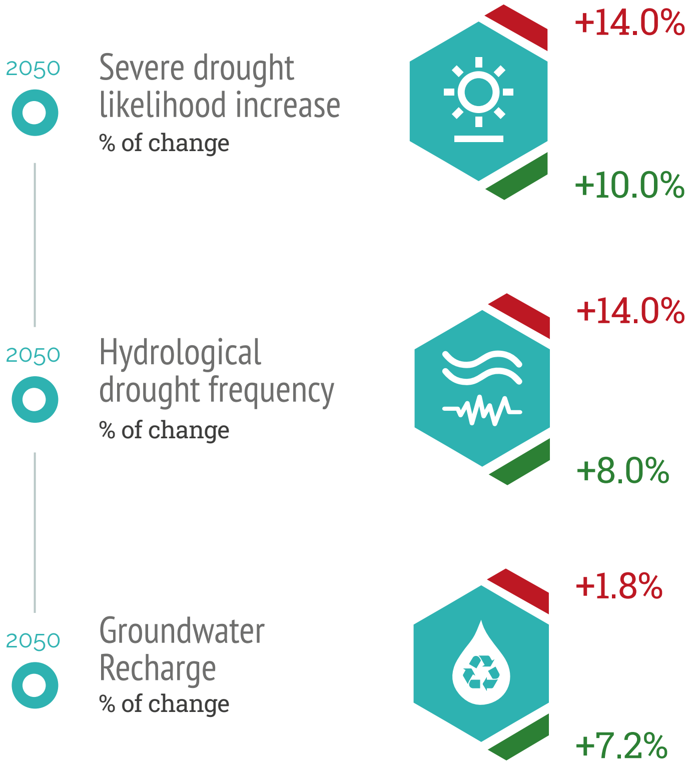
2050 — Changes in annual runoff (% of change): +8.3% / +7.9%

2050 — Runoff increase (% of area): +16.0% / +2.0%

KEY POINT DROUGHTS

Evidence shows that climate change has already led to more intense and longer meteorological droughts in some regions of the world, including the US. For example, the Southwest of the US has been identified as global drought hotspot, with very significant droughts in the 2010s. In part, the severity of these droughts has been attributed to human-induced climate change.

The recent National Climate Assessment shows that seasonal drought is expected to intensify in most US regions, and long-term drought will occur in large areas of the southwest, southern Great Plains, and southeast. This drying trend may pose a substantial threat to US food security as nearly two-thirds of the country's freshwater diversions are used for agricultural irrigation.



KEY POINT GROUNDWATER

Half of the US population relies on groundwater for domestic uses. Water use trend analysis shows that irrigated areas and groundwater withdrawals have increased over the last 30 years in humid and temperate regions, whereas the overall irrigated area has decreased in semi-arid regions. At the same time, the irrigation rate and share of irrigation from groundwater have increased everywhere, suggesting a potential shift in the preferred water source for irrigation.

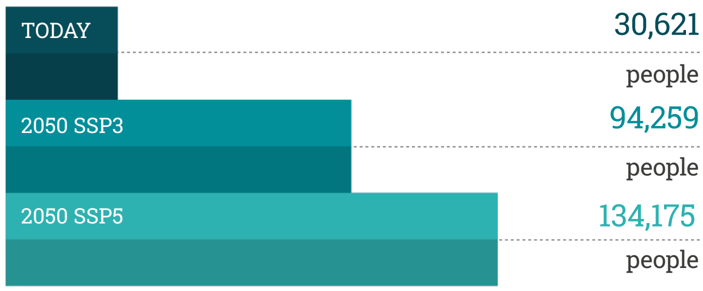
Parts of the south-west are likely to experience declines in groundwater recharge, whereas the north-west may experience slight increases to modest declines. The available estimates indicate average declines of 10-20% in total recharge across the aquifers of the southern states.

On a country level, a +3.5%, +6.4% and -11.4% change in annual groundwater recharge for the period 2045-2055 compared to 2015-2025 is expected under low, medium and high emissions scenarios respectively.

KEY POINT FLOODS

Flooding is the second deadliest climatic hazard in the US, second only to heat. Floods are caused by heavy rain, snowmelt, structural failure of protective structures, or a combination of these factors. In general, flood-related fatalities have increased over the last 25 years compared with the early-to-middle part of the twentieth century. Changing rain patterns may affect the frequency and intensity of floods and the total population exposed to floods is expected to increase from about 30,000 today to about 94,000 under SSP3 and 134.000 under SSP5 by 2050, with higher impact flood events.

POPULATION AFFECTED BY RIVER FLOODS

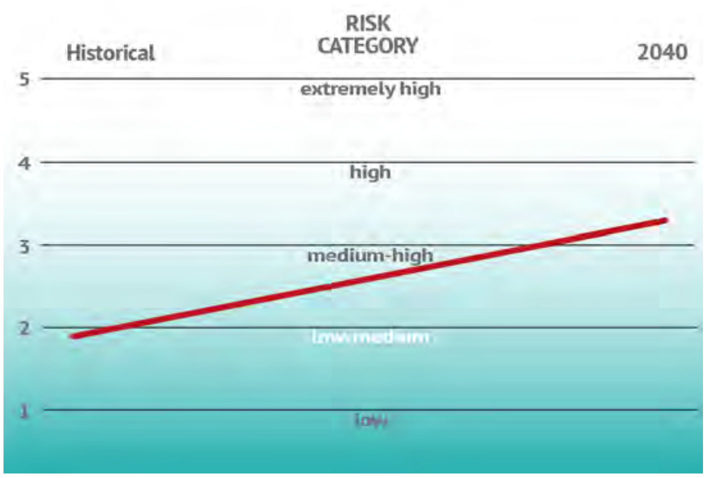


RISK INDICATORS

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

The USA's water stress level is considered low to medium for the recent past (1960 to 2014 average), although it is expected to increase for the 2030 to 2050 period based on climate change projections.



UNITED STATES
AGRICULTURE

OVERVIEW

Agriculture is a major, and highly mechanized, industry in the USA, which is a net exporter of food and currently the largest producer of maize, second for soy production and fourth for wheat.

Agricultural activity is particularly concentrated in the Great Plains, a vast expanse of flat, arable land in the center of the nation in the region west of the Great Lakes and east of the Rocky Mountains. The eastern, wetter half, is a major corn and soybean producing region known as the Corn Belt, whereas the western, drier half, is known as the Wheat Belt for its high rate of wheat production.

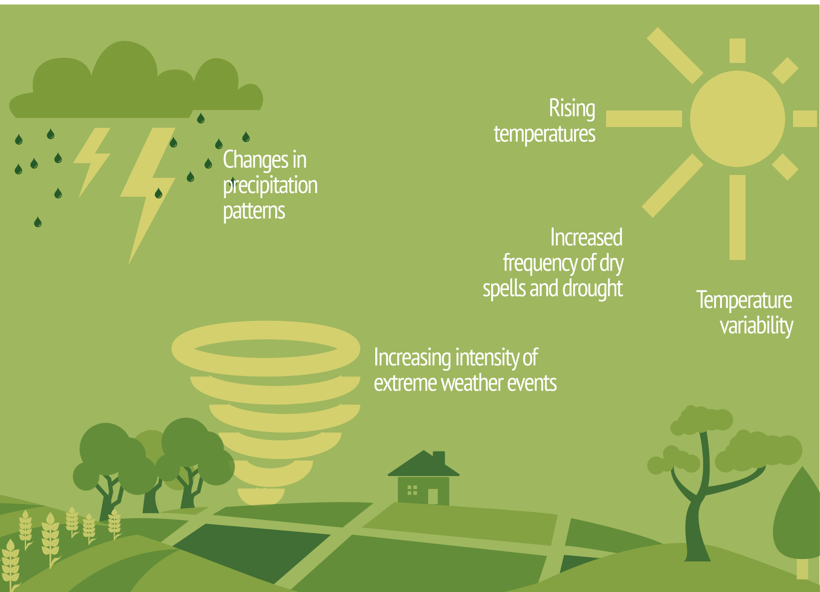
The Central Valley of California produces fruits, vegetables and nuts. The South has historically been a large producer of cotton, tobacco, and rice, although agricultural production has declined over the past century.

364.3 Mt Maize	120.5 Mt Soybeans	51.3 Mt Wheat
31.3 Mt Sugarcane	6.9 Mt Grapes	5.6 Mt Citrus

Year	Added Value of Agriculture, Forestry and Fishing	Share of Agriculture Value added in Total GDP	Agricultural land	Area Equipped for Irrigation
2000	129,483 USD Million	0.9 %	178,068 Thousand HA	27,000 Thousand HA
2018	183,901 USD Million	0.9 %	160,437 Thousand HA	26,916 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.

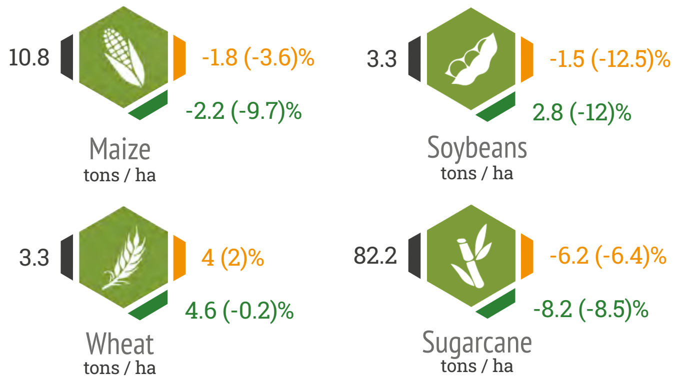


CROP PRODUCTIVITY

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.

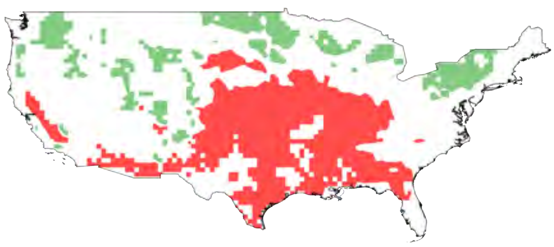


2050

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.

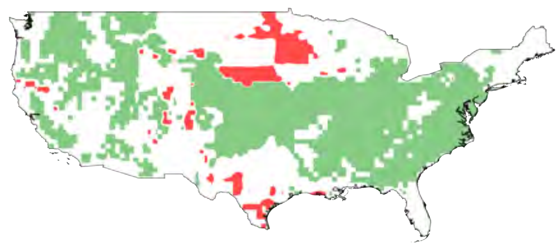
CHANGE IN MAIZE

− = +



CHANGE IN WHEAT

− = +



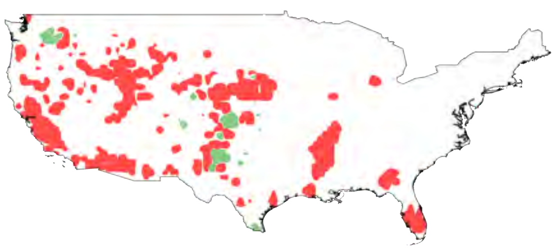
Maize and sugarcane are predicted to suffer a considerable decline in productivity, particularly in semi-arid regions where higher temperatures exceed the optimum temperature for crops. The greatest maize productivity losses are expected in the western and southern regions of United States, where large increases of consecutive dry days and number of hot nights during the grain production period lead to lower productivity and reduced quality. Wheat and soybean may on average increase their productivity. However, productivity changes can have disparities across regions following climate change patterns. Citrus productivity may increase over growing areas in Florida, Arizona, Texas and California, also because of reduced frost risks. Increases in temperatures will shift grape production to cooler climate regions, and actual production areas will require warmer climate varieties and lower quality wines. Nut trees may experience a productivity decline, where milder winters will not be able to fully satisfy chilling requirements, limiting flower emergence and viability.

ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Agriculture in the United States is a major user of both ground and surface water, with much of the irrigated land concentrated in the west and southeast. Water resources are expected to decline in the west and southwest in spring and summer, also due to earlier snowmelt and reduced snowpack. In the last decade, the United States experienced a pronounced drought with more than two-thirds of its counties declared as disaster areas and large declines in aquifer levels. Higher temperatures will generally require an increase in irrigation demand due to higher plant evapotranspiration. Water withdrawals in the Great Plains are expected to exceed renewable freshwater resources by 40%, making them particularly prone to water stress.

CHANGE IN WATER DEMAND

− = +



Agriculture
Water Demand
% of change

2050

Climate risks imply substantial increases in water demand (up to 30-35% in some areas) to maintain agriculture production, which will require adaptation practices and crop varieties enhancing water-use efficiency to limit increasing stress on water resources.

UNITED STATES FORESTS

FORESTS IN UNITED STATES

USA forests play a key role in tackling the climate emergency and can be seen as the country's most important nature-based solution. Given its vastness, the US territory hosts all the main types of existing forests, from boreal to temperate and finally tropical ones.

Of these, nearly 25% are primary forests. In large areas of Florida, a wide distribution of the very important coastal mangrove forest biome is found.

1990

303 Mln ha
Million hectares
Forested area

192 Tons/ha
Tons of Carbon per hectare
Carbon stock

2020

310 Mln ha
Million hectares
Forested area

201 Tons/ha
Tons of Carbon per hectare
Carbon stock

FORESTED AREA AND CARBON STORAGE

Forests cover almost 35% of the country. The United States Forest Service reports that they capture between 15 and 20% of domestic carbon dioxide emissions by storing approximately 800 million metric tons of carbon dioxide per year. The total amount of carbon stored in forest ecosystems to date is almost 58 gigatonnes.

2050

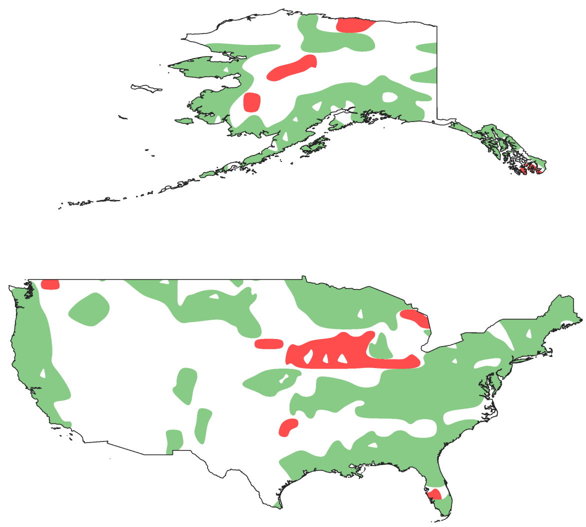
Productivity anomaly
Tons of Carbon per hectare per year

+0.46

+0.31

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.



Increase particularly pronounced for more forested areas such as on the Eastern and Western coasts

+ Fertilizing effect of CO_2, and increasing length of the growing season due to rising temperatures promote productivity, particularly in the north

Decrease in a few areas, particularly in Midwest and northeastern forests

+ Increasing risk of drought stress due to modifications in the water regime reduce productivity

KEY SPECIES UNDER CLIMATE CHANGE

LOW VULNERABILITY
OAKS
Systems dominated by oaks show low vulnerability

THREATENED
MANGROVES
Rapid sea level rise will threaten the Florida Everglades coastal mangrove forests

COMPETITIVENESS
HICKORY
Species such as hickory and pine are expected to become more competitive

HIGH VULNERABILITY
BOREAL
Northern and boreal forests will experience high vulnerability and a pronounced decline

FIRES IN UNITED STATES

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, a total of 1,300 million wildland fires occurred.

BURNING
52 MILLION HECTARES

EMITTING
28.8 TERAGRAMMES OF CARBON PER YEAR

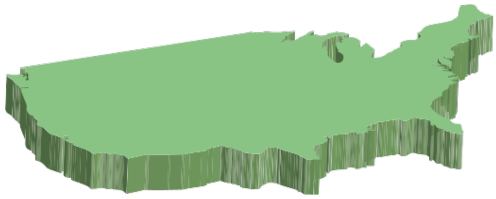
FOREST FIRE EMISSIONS CONTRIBUTED TO 62% OF TOTAL FIRE RELATED CARBON EMISSIONS

COSTING
2.9 AND 3.1 BILLION USD IN SUPPRESSION COSTS BETWEEN 2017 AND 2018

WHERE DO FIRES OCCUR?

In California, shrublands experience high-intensity fires, whereas montane mixed forests are characterized by surface fires.

In western USA forests, 30% of cool and sub-alpine environments are characterized by high severity fires shaping landscape diversity and vegetation regeneration.



Southern and western regions of the US are the most affected by fires.

In low-elevation and mid-montane forests, low severity fires are more frequent.

FUTURE BURNED AREA

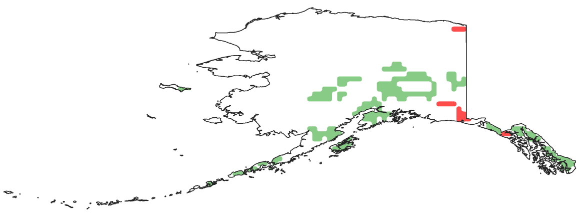
Under a low emissions scenario, models project a generalized increase in burned areas across the south-west basins and plateaus, as well as in northern California and troughout the Great Plains and northern Florida. This trend might be emphasized under a medium emissions scenario, and more pronounced in California and in the Gulf Coastal Plains.

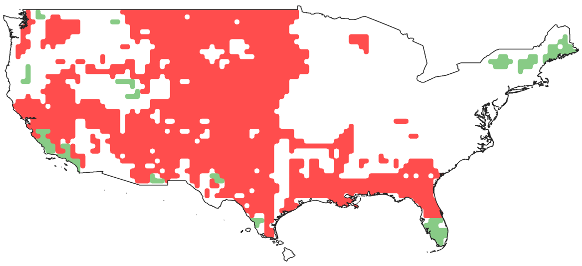
Burned Area
km² per year

2050

+3,517

+2,062





Decrease in burned areas for a low emissions scenario

Increase in burned areas for a low emissions scenario

+ Increasing length of the fire season due to increasing temperatures
+ Increasing length of drought periods and warming

VARIATION OF SPECIFIC FIRE INDICATORS

% of change
Number of weeks with large wildland fires

2031–2060

+105%

+53%

Billion US$ per year
Health economic damages attributable to wildfires

2050

26

23

cases/year
PM2.5 mortality attributable to wildfires

2050

+1600

+1300

FUTURE FIRE EMISSIONS

Fire emissions follow a similar spatial pattern to burned area. The largest projected changes are expected in the Pacific Northwest (and northern California) and from the Northern Rockies down to the Southwest - with more pronounced changes under a medium emissions scenario.

Fire Carbon emission
Teragrams of Carbon per year

2050

+30

+15

UNITED STATES
URBAN

OVERVIEW

The USA's population is projected to increase by 14% by 2050, becoming increasingly urbanized.

More than 10% of the urban population resides in the 2 largest cities - New York City and Los Angeles, while the majority of urban residents live in cities with 1 to 5 million people.

Built up areas cover 1.54% of the USA (143,238.63 square kilometers).

Population in Urban Areas

2020: 273,975,139

2050: 347,346,215v

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

Urbanization Rate

2020: 82.7%

2050: 89.2%

OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

Impacts on cities and their inhabitatns are constantly evolving as climate change increases their exposure and vulnerability to extreme weather events and sea level rise, with significant variations across the country.

Acute and chronic climate stressors and how they interact with local geographic characteristics differ regionally. Most cities are subject to multiple climate impacts that affect multiple urban sectors.

HEATWAVES AND HEAT STRESS

Cities experience higher temperatures than surrounding rural areas because of the Urban Heat Island (UHI) effect, whereby built up areas absorb solar radiation during the day and release heat at night, warming the surrounding air.

UHI is caused by factors such as less natural landscapes, the materials used for buildings, urban layouts and waste heat. Heatwaves are occurring more often than they used to in major cities, increasing from an average of two heatwaves per year during the 1960s, to six per year during the 2010s.

The duration of individual heatwaves and the heatwave season have also been increasing, along with heatwave intensity. Future scenarios of 1.5°C, 2°C and 4°C mean temperature increases indicate that heatwaves will last longer throughout the entire country.

2050 — Cooling Degree Days (% of change)

+11.6%

+42.3%

+26.2%

2050 — Heatwave frequency (% of change)

+91.2%

+40.0%

+22.4%

2050 — Heatwave duration (% of time)

+2,000%

+311%

+117%

HEAT, HEALTH AND AIR POLLUTION

Heat related health impacts from increasing air temperatures in urban areas are furthermore accentuated by air pollution. Wildfires, on the rise in the West, contribute to lower air quality in cities near the wildland–urban interface.

PM2.5 from wildfire smoke is the air pollutant of greatest concern to public health. In 2017, 3.3% of the population was exposed to levels exceeding WHO guideline values for PM2.5.

2017

Population exposed to air pollution

3.3%

COASTAL FLOODING

The cities most vulnerable to flooding in the USA are low-lying coastal areas, where the built environment is subject to storm surge, high tide flooding, and saltwater intrusion. There has been an increase in coastal flooding since the 1950s, with the rate of increase accelerating at most locations along the East and Gulf coasts; the East Coast endures the most frequent coastal flooding and has experienced the largest increases in the number of flood days.

The ongoing increase in the frequency, depth, and extent of tidal flooding due to sea level rise will cause cascading impacts on the larger economy. The increased probability of heavy precipitation events will further heighten the risk of coastal flooding in the future.

Projected sea level rise

2050

0.23 m

0.18 m

2100

0.77 m

0.38 m

EXTREME PRECIPITATION

Annual precipitation has decreased in much of the west, southwest, and southeast; and increased in most of the northern and southern plains, Midwest, and Northeast. Across most of the country, heavy precipitation events have increased in both intensity and frequency, however there are important regional differences in trends, with the largest increases occurring in the Northeast.

Seasonal average precipitation projections include a mix of increases, decreases, or little change, depending on location and season. Generally, high-latitude regions are expected to become wetter while the subtropical zone becomes drier. Precipitation extremes will increase in frequency and intensity in the future throughout the contiguous United States.

2050

Runoff increase
% of area

+16%

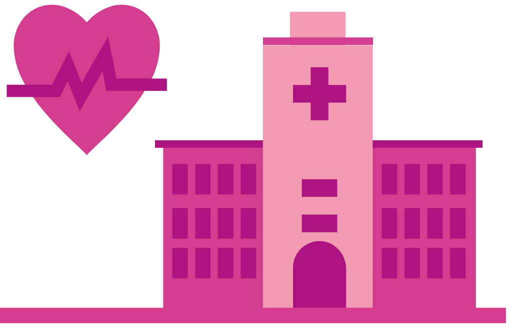
+5%

+2%

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.

UNITED STATES HEALTH



OVERVIEW

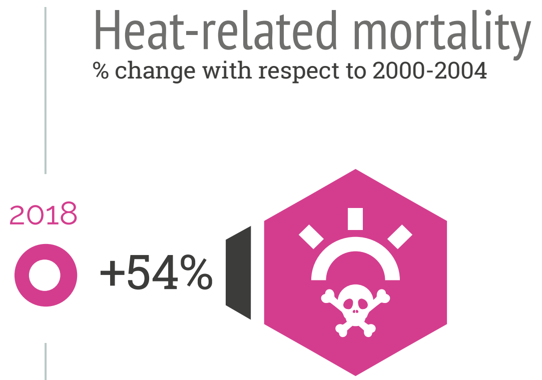
Given the USA's geographical and climatic heterogeneity, climate change poses one of the most significant environmental and human health threats. Rising sea levels, warming oceans, expected increases in the frequency and intensity of extreme weather events and changes in temperature and precipitation patterns pose direct and indirect risks to the health and well-being of the population.

Changing climate patterns will likely cause deterioration of food security, nutrition, and the emergence and reemergence of water-borne, vector-borne, and food-borne diseases. In addition, drivers of climate change, such as air pollution, will increase the risk of cardiovascular diseases, cancers, and respiratory diseases.

HEAT RELATED MORTALITY

Climate change is projected to lead to a significant increase in heat-related deaths. Under a high emissions scenario, heatwave-related excess deaths will increase by 496%, whereas mortality will increase by 309% under a medium emissions scenario.

In 2018, there was a 54% increase in heat-related deaths in the US compared to the 2000 to 2004 baseline. 34.7% of US heat-related mortality from 1991 to 2006 can be attributed to human-induced climate change.

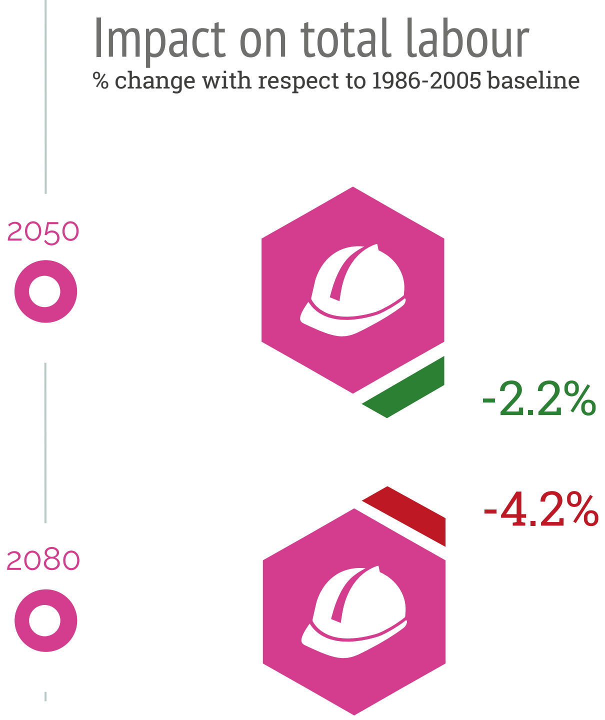


IMPACTS ON LABOUR

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 the US is expected to decline by 2.2% under a low emissions scenario, and by 4.2% 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.

Dengue suitability

% of population at risk

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

In the USA, climate change could create suitable conditions for dengue transmission year-round.

Under a medium emissions scenario, 92% of the population will be at risk of transmission-suitable mean temperature for dengue by 2050, whereas 94.6% will be at risk under a high emissions scenario. In the case of Zika, 83.8% of the population will be at risk by 2050 with medium emissions, whereas 88.2% will be at risk under a high emissions scenario.

Zika suitability

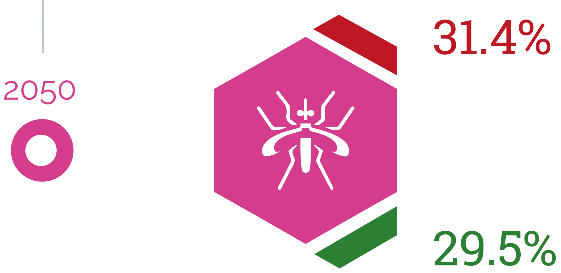
% of population at risk

CLIMATE CHANGE AND MALARIA

Malaria transmission stability will likely increase in the US due to warming. In 2050, 29.5% of the US population will be at risk of malaria under a low emissions scenario, whereas 31.4% will be at risk under a high emissions scenario.

Malaria suitability

% of population at risk



POLLUTION AND PREMATURE MORTALITY

Under a medium emissions scenario, annual premature deaths due to long-term exposure to near-surface ozone and heat will increase from 299 per million (2010) baseline, to 307 per million in 2050.

UNITED STATES ENERGY

ENERGY SYSTEM IN A NUTSHELL

Fossil fuels have dominated the USA's energy mix for the last century, although the share of renewables has been growing over the last decade. Oil and gas remain a key feature of the energy landscape, benefitting from cost reductions from drilling and fracking innovations. Energy security is the primary goal of energy policy, and the level of domestic energy production risen steadily over the last two decades.

0.11
ktoe/US$
Energy intensity

26.4%
AC Share in electricity consumption

CLIMATE CHANGE TODAY

EXTREME EVENTS

Extreme weather is the primary cause of power outages across the USA. Higher temperatures, wildfires, flooding, and storms resulted in strong disruptions to transmission lines. In the Gulf Coast, hurricanes cause heavy damage to offshore oil drilling facilities. Hurricanes Katrina and Rita caused damage to over 100 platforms and 558 pipelines.

DROUGHTS

Hydropower generation has been significantly affected by droughts and higher temperatures have forced nuclear plants to reduce generation or shut down.

HEAT

Hotter summers are boosting air conditioning use, resulting in more frequent and longer power outages. The Southwest blackout at the end of the summer of 2011 left 2.7 million people without power for 12 hours.

ENERGY SUPPLY

The USA's total primary energy supply energy mix shows a strong dependence on fossil fuels (83% of total primary energy supply in 2019) of which 36.2% is oil, used mainly for transport, 12.6% coal and 23% gas. Nuclear's contribution has remained steady at 10% since 2010. Only 8% of the total primary energy supply is currently met by renewable sources - doubling their 1990 share, whereas coal has halved.

ENERGY DEMAND

With only 5% of the world's population the USA uses nearly 17% of the world's energy. In 2018, transport claimed 40% of energy demand - mainly to fuel road transport. The industrial sector claims over 17% of energy demand, almost at par with the residential sector. The tertiary sector accounts for 13.6% of final energy demand; energy use in agriculture and forestry is negligible. Air conditioning accounts for a substantial share of final residential electricity, 26.4%.

FUTURE ENERGY DEMAND

In the USA, warmer summers are predicted to increase electricity demand, resulting in higher summer peak loads. Milder winters are expected to decrease energy demands for heating, but by a smaller scale than the increase in summer cooling needs. Overall, net energy demand is predicted to increase. Higher temperatures might affect the energy mix, reducing demand for oil and natural gas used to heat homes, and instead increasing electricity demand for cooling needs.

Net change in energy demand due to changes in DD/CDD
Billion KWh

2050

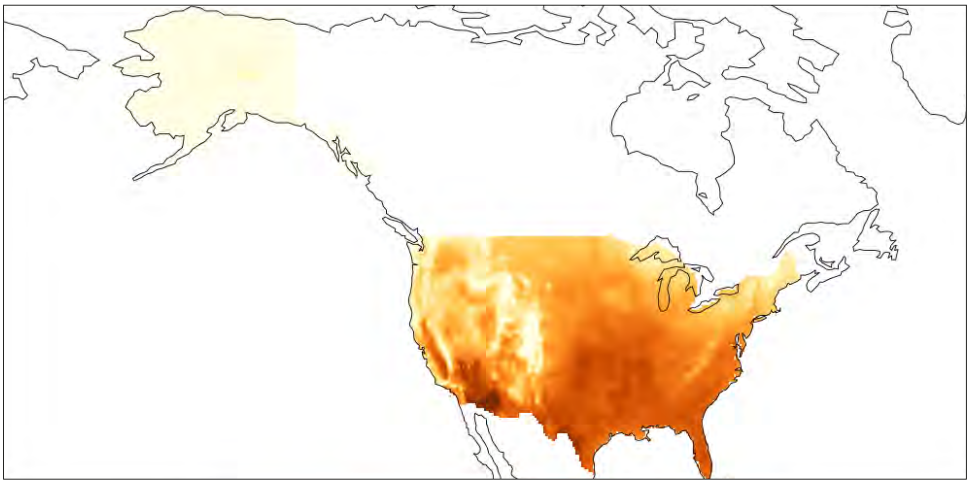
+ 5,338.09

COOLING NEEDS

Warmer and longer summers are expected to increase cooling needs across all regions of the USA. The magnitude of the effects will differ across locations but will be stronger in the southern and central states. Cooling needs are expected to increase for southern regions and exceed any savings from a reduction in heating needs.

COOLING DEGREE DAYS

0 600

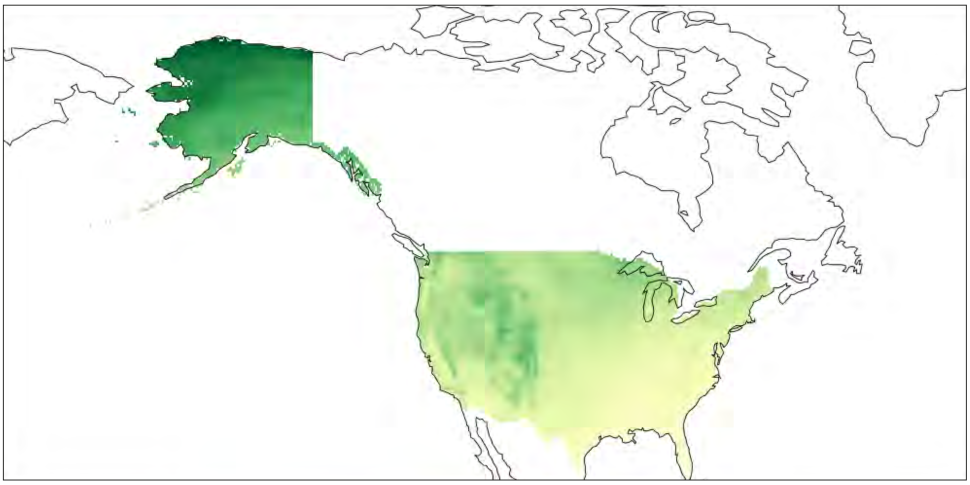


HEATING NEEDS

Heating needs are predicted to decrease across the United States as winters become milder. In the northeast, Midwest and northwest where the majority of energy demand is for heating needs, net energy consumption is predicted to decline as the decrease in heating needs exceeds the increase for summer cooling. The extreme decrease in heating degree days in Alaska is expected to be of negligible relevance in terms of energy demands, as the state has a small population.

HEATING DEGREE DAYS

-1,643 0



FUTURE ENERGY SUPPLY

The future configuration of the USA's energy mix is likely to be determined by the evolution of climate mitigation policies and hence is outside the scope of this report. The U.S. Climate Crisis Action Plan sets a target of net-zero greenhouse-gas emissions by no later than 2050. Ultimately the policy decisions and the resulting interim targets will shape the future energy supply mix in the USA. These policy targets will likely result in a marginal relevance of fossil fuels and their vulnerabilities to climate change, while carbon free sources and their vulnerabilities will prevail.

Change in Hydropower generation
% of change

2050

-4.64%

-4.84%

EXPECTED IMPACTS OF CLIMATE CHANGE

Increasing wildfire risks will threaten transmission lines across the USA. Energy infrastructure in coastal areas will face increasing risks as extreme tides and storm events increase in frequency and severity. Water shortages will affect thermal power generation. Peak loads during summer droughts might threaten the stability of the energy system.

UNITED STATES ECONOMY

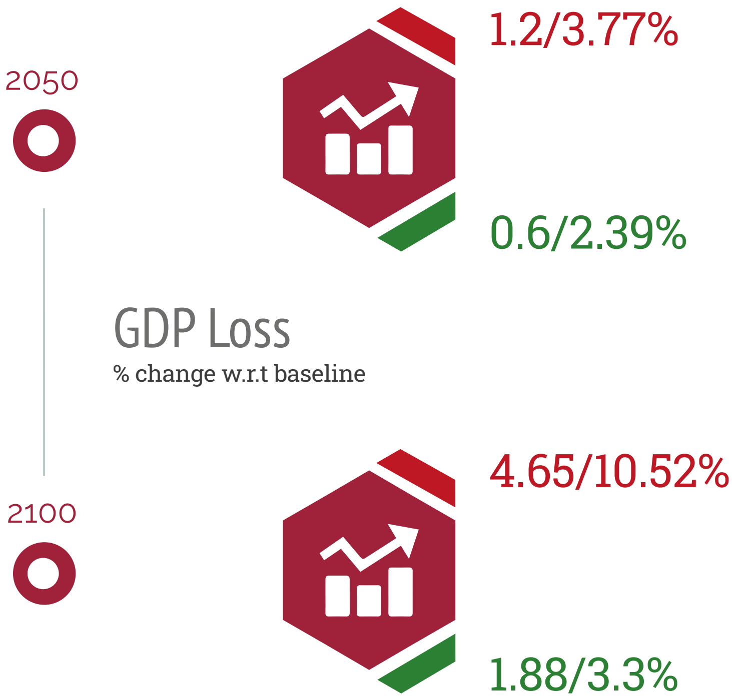
OVERVIEW

The USA has the largest economy in the world in terms of GDP. The COVID 19 pandemic reduced growth rates in 2020, whereby the USA lost 3.5% of real GDP. However, it has recovered quickly with a growth rate of 6.4% in 2021.

IMPACTS ON GDP

Climate change will have an effect on the growth rate and overall systematic economic performance of the country. National losses in GDP may be significant, reaching 2.4% of GDP or 415 billion EUR by mid century under a low emissions scenario, and drastically rising to 10.5% of GDP, or 1.8 trillion EUR, under a high emissions scenario by the end of the century. The costs of climate change are borne unequally across the US, exacerbating pre-existing inequality.

By the end of the century, under a high emissions scenario the poorest counties are likely to experience substantial damages in the range of 2-20% compared to gains exceeding 10% of county income in some regions.



SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

Sea level rise poses risks to communities, infrastructure and industry along the USA coastline. In particular the coast is crucial for the north-eastern economy, where many major cities and industries are located on the water. Much of this infrastructure is extremely vulnerable to sea level rise.

As a result of climate change, the expected damage from hurricanes is predicted to increase in the future for the USA. Probabilistic estimates of the damages caused by hurricanes and coastal storms show that there could be additional damages amounting to 108 billion USD by the end of the century. Natural disasters are already imposing significant costs on the USA, whereby in 2017 there were 300 billion USD worth of damage to homes, businesses, infrastructure and goods.

IMPACTS ON AGRICULTURE

The agricultural sector in the US is significant, producing almost 330 billion USD in agricultural commodities annually. The forestry sector is an important contributor to wealth production, providing a range of important goods and services from timber products to places of recreation. Wildfires in particular will pose a risk to the majority of the US. It is estimated that mitigation efforts could save the USA's economy between 8.6 and 11 billion USD in wildfire costs relative to a business-as-usual scenario until 2100.

Expected effects on crop yields are highly heterogeneous across crops and regions. This tendency leaves the aggregate damage estimates quite modest relative to the size of the US economy, and potentially some benefits from climate change could be experienced.

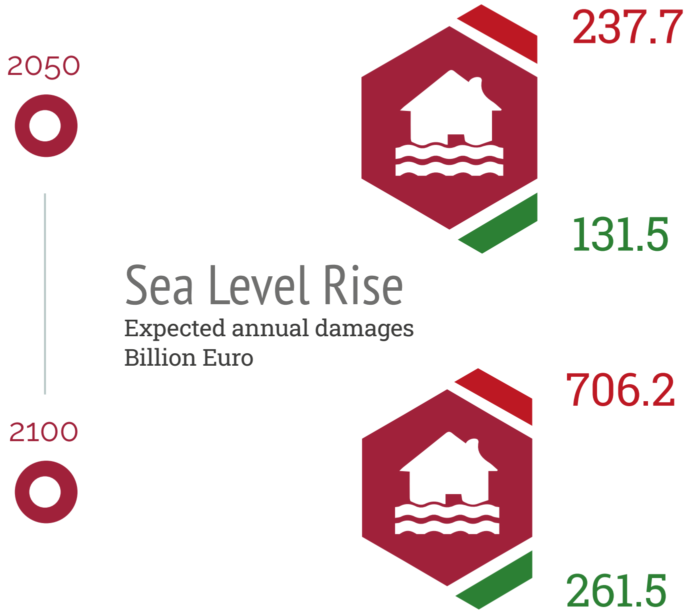
Some estimates place the damage to crop yields under a high emissions scenario in the range of -8.2 to +19 billion USD by mid century and -12 to +53 billion USD by the end of the century. More recent studies emphasize smaller potential gains.

Nevertheless, damage from extreme weather events may be substantial. The EPA estimates that greenhouse gas mitigation measures could avoid damage of up to 6.6 to 11 billion USD in the agricultural sector by 2100 compared to a business-as-usual scenario, and additionally 0.52 billion to 1.5 billion USD in the forestry sector.

SEA LEVEL RISE DAMAGES

Under the current level of coastal protection, by mid century, sea-level rise and coastal flooding could cost the country 131.5 to 237.5 billion EUR in terms of expected damage to assets low and high emissions scenarios, respectively.

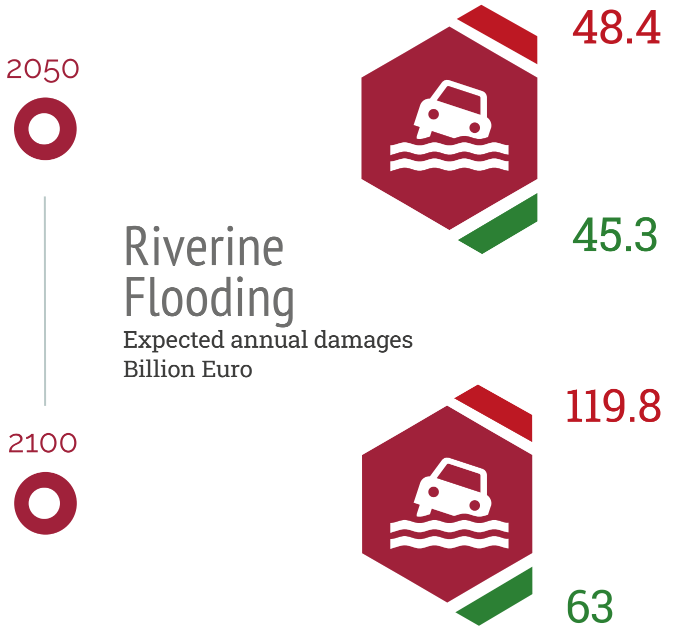
By the end of the century, expected losses may increase to 261.5 billion EUR under a low emissions scenario and to 706.2 billion EUR under a high emissions scenario. Damage to coastal properties is unevenly distributed across the country, with the largest losses occurring in the southeast and Atlantic coasts where sea level rise is expected to be higher.



RIVER FLOODING DAMAGES

River flooding can also induce severe damages. By mid century total asset losses are projected to be 45.3 to 48.4 billion EUR under low and high emissions scenarios, respectively.

By the end of the century these costs are projected to rise to 63 and 119.8 billion under low and high emissions scenarios, respectively.



IMPACTS ON FORESTRY AND FISHERY

Under a medium emissions scenario, commercial fishing revenues in the US could experience a total loss of 3.75 billion and 7.5 billion USD under the high emissions scenario by the end of the century.

IMPACTS ON ENERGY

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

Nevertheless, climate change is expected to increase electricity costs and demand. Higher temperatures will increase demand and power generation will become less efficient with the additional costs being passed on to residential and commercial ratepayers. By the end of the century under a high emissions scenario average yearly energy expenditures are projected to increase by between 26.5 and 72.1 billion EUR. There are, however, no overall estimates of the economic impact of climate change on energy infrastructure for the USA.

IMPACTS ON TOURISM

Tourists in the US, both foreign and domestic, are highly climate sensitive and hence the tourist industry depends on the climate itself and the amenities it provides. In particular, winter sports, and destinations popular for coastal and outdoor recreation will be vulnerable to changes in climate.

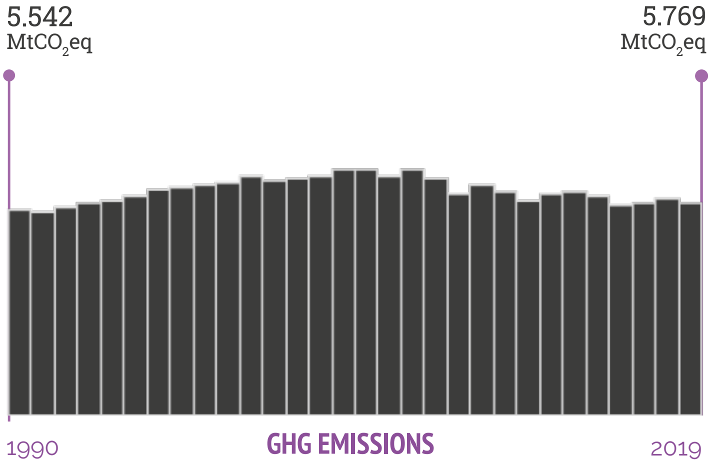
It is estimated that increased coral bleaching will cost the US approximately 18.8 billion USD (15.6 billion EUR) in losses associated with coral reef recreation and 320 million USD (265 million EUR) in recreational freshwater fishing, by the end of the century. Winter sports are a notable contributor to the tourism sector, with over three-quarters of states benefiting economically from these activities.

Winter sporting activities annually contributed 12.2 billion USD (10.1 billion EUR) to the US economy (2009-2010). Changing snowfall patterns are already taking their toll on the economy, resulting in a loss of over 1 billion USD (0.82 billion EUR) over the decade from 1999-2010. Winter temperatures are predicted to rise, exacerbating the losses already experienced by the sector.

UNITED STATES
POLICY

OVERVIEW

The USA is the world's 4th largest country and accounts for 13% of global emissions, with one of the highest rates of GHG emissions per capita. Emissions have been declining since 2004, and a net zero emissions by 2050 target has been set.



INTERNATIONAL COMMITMENTS

In its 2021 NDC update, the USA strengthened their target from a 26-28% emissions reduction below 2005 levels by 2030, to a 50-52% reduction.

CLIMATE POLICY COMMITMENTS CHRONOLOGY

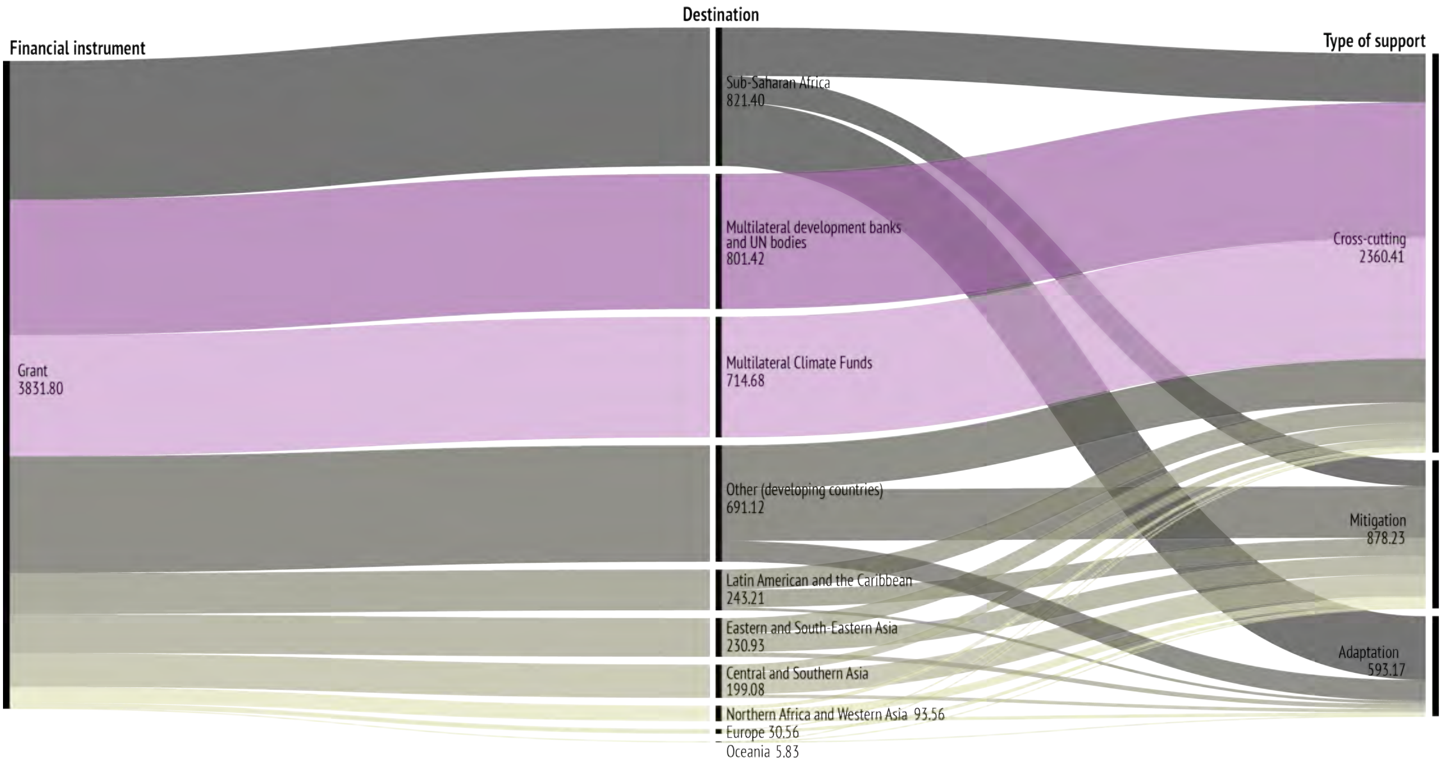
KYOTO PROTOCOL - 1ST PERIOD
The USA had a 7% GHG reduction target but eventually failed to ratify the Kyoto Protocol

2016
PARIS AGREEMENT - 1ST NDC
Between 26% and 28% GHG reduction by 2025, with reference to 2005 levels

2021
PARIS AGREEMENT - NDC UPDATE
Between 50% and 52% GHG reduction by 2030, with reference to 2005 levels

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

The diagram is based on OECD DAC climate-related development finance data for 2017-2018: the USA are providers of 3.8 billion USD, mainly devoted to cross-cutting projects. The largest share is directed to sub-Saharan Africa.



SUSTAINABLE RECOVERY POLICY

According to the Global Recovery Observatory, in 2020 the proportion of green spending out of total recovery spending was 9%.

4,526.33 billion $	122.76 billion $	10.77 billion $
Total Spending	Recovery Spending	Green Spending

DOMESTIC ADAPTATION POLICY

Through the Executive Order on Tackling the Climate Crisis at Home and Abroad, the United State President, in January 2021, directed federal agencies to develop climate action plans and established a White House Office of Domestic Climate Policy and a National Climate Task Force.

- ○ 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

International Boundary and Water Commission

International Boundary and Water Commission implements water treaties between the United States and Mexico. It explores an array of adaptive water management strategies to manage climate-related impacts on Colorado River water

NATIONAL INITIATIVES

Climate Change Response Framework (CCRF)

The CCRF is a collaborative, cross-boundary approach among scientists, managers, and landowners to incorporate climate change considerations into natural resource management

U.S. Climate Resilience Toolkit

The Toolkit provides a five-step process that communities can use to identify and assess their climate vulnerabilities. The site also provides other resources from the federal government to help communities put the process into action

SUBNATIONAL INITIATIVES

Southeast Florida Regional Climate Action Plan (RCAP)

RCAP is the Compact's guiding tool for coordinated climate action in Southeast Florida to reduce GHG emissions and build climate resilience. It provides a set of recommendations, guidelines for implementation and best practices for local entities to act in-line with the regional agenda

Climate Ready Boston - Municipal Vulnerability to Climate Change

The project forecasts climate change impacts, ranging from sea level rise to extreme weather events. The report used existing research to identify potential municipal infrastructure and other city services that are exposed to climate change

ENERGY TRANSITION

The USA shows an Energy Transition index slightly below the G20 average, positioning itself in the mid-to-low section of the ranking. This is determined in particular by the still heavy contribution of fossil fuels to the USA energy sector, and more in general to its economy and industry.

The USA, is not only the world's largest oil and gas producer, but it is also by far the biggest fossil fuel consumer at a global level. This situation is reflected also on the Renewables indicator, where the country – despite the ongoing process of transformation and massive penetration of wind and solar power – still performs below the group average (though better compared to other big fossil producing countries).

On Emissions and Electrification, the USA scores are slightly below the G20 average, showing the need to continue and strengthen the process of deployment of renewables and power grids in line with its 2050 decarbonization targets. Finally, the country is placed in the mid-to-top part of the ranking when it comes to Efficiency with further improvements expected to happen.

Indicator	G20 AVERAGE	COUNTRY
Energy Transition	58.7	55.0
Fossil Fuels	45.3	31.8
Renewables	19.7	12.7
Efficiency	84.9	89.3
Electrification	70.8	70.1
Emissions	72.9	71.3

G20 AVERAGE COUNTRY

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.