G20 CLIMATE RISK ATLAS

Impacts, policy, economics

cmcc

INDONESIA

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

INDONESIA CLIMATE

OVERVIEW

Indonesia is almost entirely dominated by a tropical climate which is largely hot and humid, with rainfall occurring mainly in low-lying areas and mountainous regions that experience cooler temperatures. Indonesia sees drier conditions during El Niño events and wetter conditions during La Niña events. The wet season occurs between November and April, leaving May and October typically dry. Relative humidity varies between 70% and 90% and cooler temperatures prevail at higher altitudes.

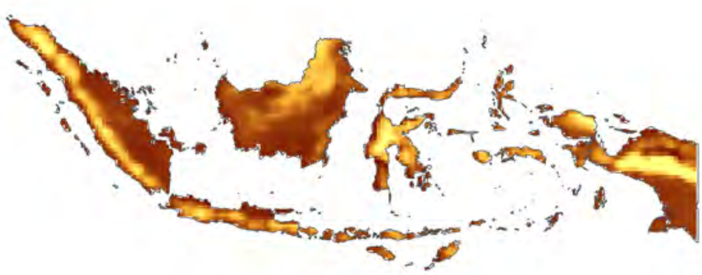
TEMPERATURE

The temperature regime in Indonesia is mainly regulated by the uniformly warm waters surrounding approximately 81% of the country. Higher temperatures are found on the coastal plains and lower ones in the mountainous areas. Seasonal variations in temperature are not so significant.

MEAN TEMPERATURE

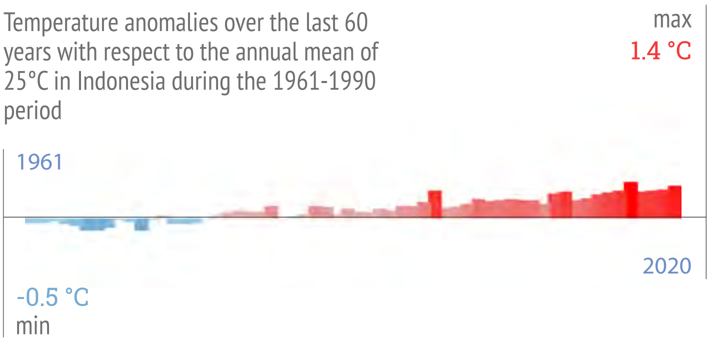
+11 28

Celsius degrees / Over 1991-2020



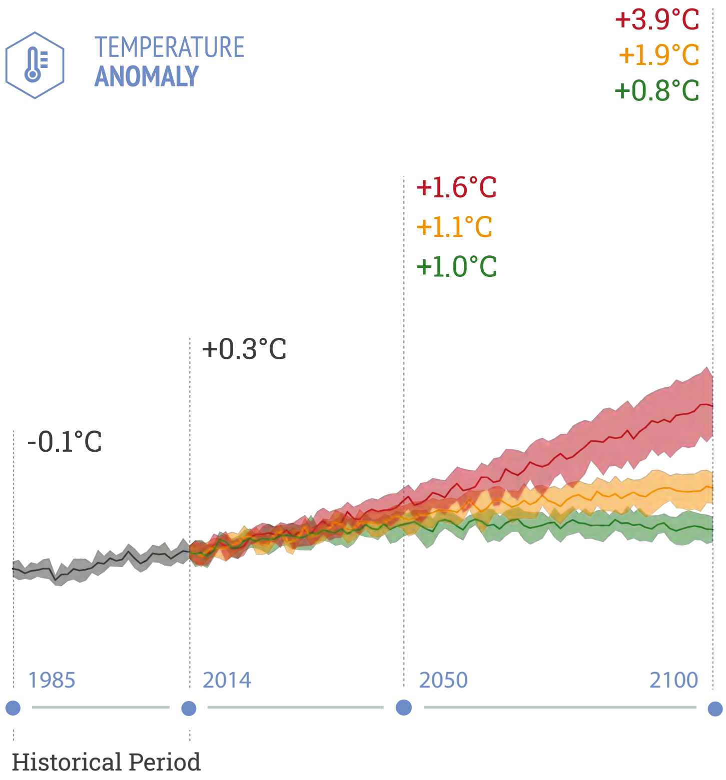
TEMPERATURE TREND

Temperature anomalies over the last 60 years with respect to the annual mean of 25°C in Indonesia during the 1961-1990 period



TEMPERATURE PROJECTIONS

Under a low emissions scenario projected temperature variations will remain contained under +1°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.

Indicator			
Annual Mean Temperature	+1.5°C	+1.2°C	+0.9°C
Max Temperature of warmest month	+1.5°C	+1.2°C	+0.9°C
Min Temperature of coldest month	+1.5°C	+1.2°C	+0.9°C

PRECIPITATION

The precipitation regime in Indonesia is variable, especially during the wet and dry seasons. The main variation in average annual precipitation occurs in the southern regions (although this includes increases in wet season precipitation), whereas variations in precipitation in the northern regions is accompanied by a decrease in dry season precipitation.

In general, precipitation in lowland areas averages 1,800-3,200 millimetres per year, increasing with altitude to an average of 6,100 millimetres in some mountainous areas. In the lowlands of Sumatra and Kalimantan, the precipitation range is 3,050-3,700 millimetres. The amount decreases towards the south, in proximity to the desert of north-western Australia.

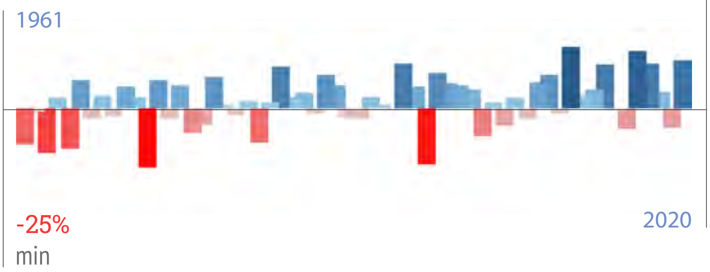
MEAN PRECIPITATION

905 — 15,200

mm/year / Over 1991-2020

PRECIPITATION TREND

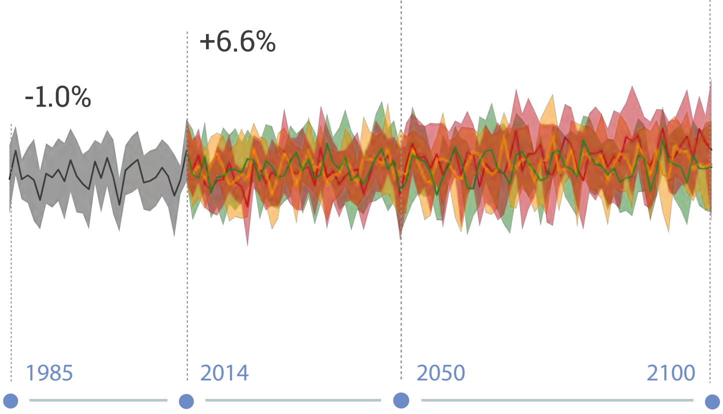
Precipiation anomalies over the last 60 years with respect to the annual mean of 2,792 mm/year in Indonesia during the 1961-1990 period



PRECIPITATION PROJECTIONS

Precipitation trends show a very complex signal, under all emissions scenarios, with a very large variability among climate models. This can be explained considering the complexity of the precipitation regime and dynamics requiring more detailed spatial and temporal analysis.

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.

Indicator	+4°C	+2°C	+1.5°C
Annual total precipitation	+2.3%	+2.2%	+2.1%
Precipitation of wettest month	+2.9%	+2.3%	+2.4%
Precipitation of warmest quarter	+0.4%	+1.9%	+0.6%

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**.

Indicator	Unit	+4°C	+2°C	+1.5°C
Agricultural drought proportion of time	% of time	+15%	+10%	+8%
Hydrological drought proportion of time	% of time	+13%	+8%	+8%
Heatwave duration	% of time	+7,933%	+911%	+328%
Runoff increase	% of area	+25%	+11%	+5%
Agricultural drought frequency	% of change	+32%	+17%	+14%
Hydrological drought frequency	% of change	+9%	+8%	+8%
Heatwave frequency	% of change	+98%	+60%	+34%
Runoff decrease	% of area	+35%	+18%	+9%

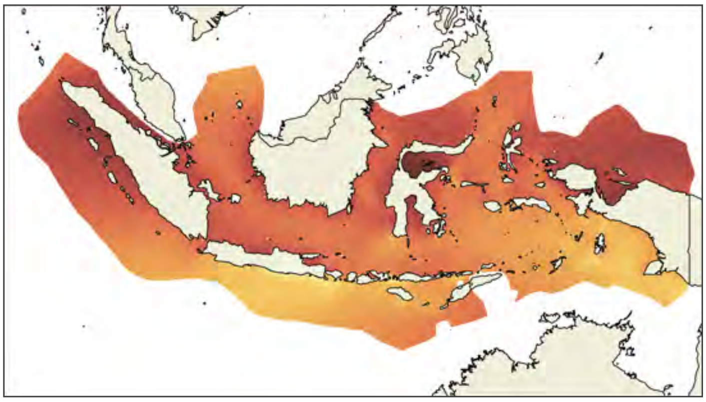
INDONESIA OCEAN

OCEAN IN INDONESIA

Indonesia's marine exclusive economic zone (EEZ) is almost entirely tropical with warm water temperatures and a wide ensemble of ecosystems such as coral reefs, seagrass meadows, algal beds, and mangroves. Indonesian coastal systems can be divided into three main areas: the Java Sea, the Banda Arc and the southern Indian region.

CURRENT CLIMATE CONDITIONS

Mean sea surface temperature reflects the Tropical climate of the region, with values ranging between 27°C and 31°C.

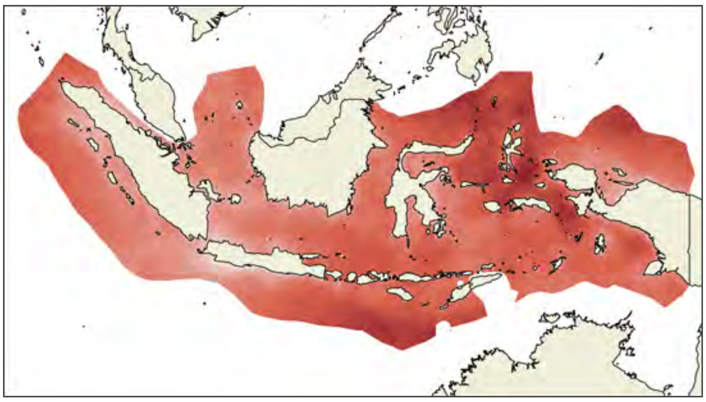


27 — 31 **MEAN**

SEA SURFACE TEMPERATURE

Celsius degrees / Over 1991-2020

0 — 0.3 **TREND**



Surface temperature trends indicate a general warming of 0.2°C per decade in all marine areas, with increased gains in the Banda Sea and the Indian oceanic region.

FUTURE PROJECTIONS

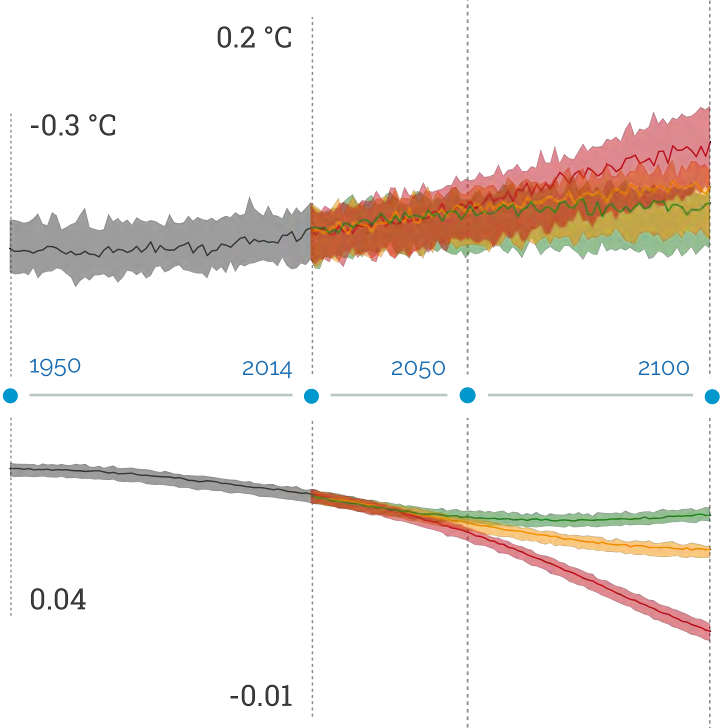
Projected annual changes within the marine EEZ for the two most significant marine indicators of climate change: sea surface water temperatures and pH.

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

+3.3 °C
+2 °C
+1.3 °C

SEA SURFACE TEMPERATURE **ANOMALY**

+1.5 °C
+1.2 °C
+1.1 °C



SEA SURFACE pH **ANOMALY**

-0.09
-0.11
-0.14

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
-0.37

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.

	Banda Arc		Indian		Java Sea	
Temperature	29.30°C	+1.61 °C +1.35 °C +1.18 °C	29.02°C	+1.48 °C +1.22 °C +1.03 °C	29.17°C	+1.67 °C +1.44 °C +1.31 °C
pH	8.06	-0.14 -0.11 -0.09	8.06	-0.14 -0.11 -0.09	8.06	-0.15 -0.11 -0.09
Oxygen	200.72 mmol/m³	-1.78 % -1.37 % -0.99 %	201.75 mmol/m³	-2.2 % -1.71 % -1.18 %	202.03 mmol/m³	-2.05 % -1.62 % -1.16 %
Chlorophyll	0.26 mg/m³	-14.12 % -17.56 % -9.92 %	0.2 mg/m³	+2.96 % +2.96 % +0.49 %	0.26 mg/m³	-0.76 % -5.7 % -11.41 %

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

-20.3%

-5.8%

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.

INDONESIA COASTS

OVERVIEW

Indonesia is a densely populated archipelago of more than 17,000 islands and 95,000 kilometres of shorelines. The country's coast hosts important ecosystems and is rich in biodiversity and natural resources which are used for fishing, recreation, waste disposal, power generation, water supply, sands extraction, forestry, farming, residential and industrial purposes. The islands of Java and Sumatra are home to most of the population, including the large coastal cities of Jakarta, Surabaya and Palembang.

Shoreline Length 95,181 km

Sandy Coast Retreat at 2050 -39.7 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 impacts on the coastal zones of Indonesia are mainly driven by rising sea levels and possible changes in storm intensity and direction, which can exacerbate erosion issues and drive flooding in low lying areas along the coast. In addition, changes in rainfall patterns can further exacerbate flooding risks for low lying coastal areas. Land subsidence is a major concern for the capital city Jakarta, which is losing land to the sea and is expecting major impacts from future sea level rise.

SEA LEVEL RISE

Relative sea level rise has been observed over the past century with a yearly average increase of approximately 4.97 millimetres per year since the 1990s. This high value reflects land subsidence in some parts of the country. 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

4.97 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 1.34 metres at present day to 1.55 metres by 2050 under a medium emissions scenario.

Current and projected extreme sea level at 2050

1.34 m

1.62 m

1.55 m

OBSERVED STORMS

The Indonesian coast is exposed to waves from the Indian Ocean, the Pacific Ocean and internal seas. In general, a general trend of increasing wave height has been observed at different locations.

FUTURE STORMS

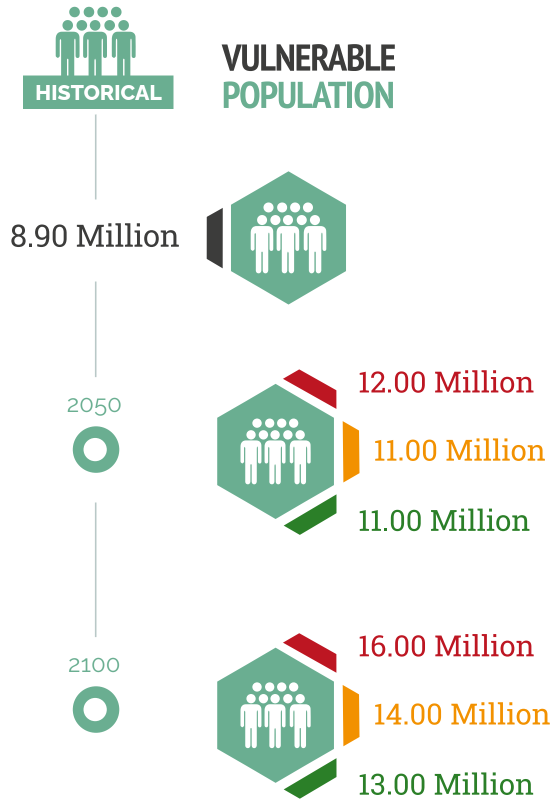
Waves and storms around the Indonesian coast are expected to change in the future. However, trends and patterns are quite unclear and heterogeneous given the size and diversity in wave climate and exposure of the Indonesian archipelago. More intense tropical cyclone activity is expected in response to warming ocean surfaces on both the Indian Ocean and Pacific Ocean side of the vast archipelago. Rising sea levels will also increase the frequency of extreme sea level events, such as the one in 100 year water level.

VULNERABILITY AND RISK

Sea level rise in Indonesia is expected to impact all areas where population is concentrated and in particular the capital city of Jakarta, which is home to more than 10 million people.

In Jakarta, the impact of sea level rise is compounded by one of the highest rates of land subsidence in the world, which is threatening the livelihoods of poorer and marginalised parts of the population in particular. Other areas of Indonesia are expected to suffer from increasing erosion which may impact economic activities.

The shoreline of the island of Bali, the main tourist destination in Indonesia, is subject to severe coastal erosion. In addition, densely populated parts of Java and Sumatra are exposed to sea level rise risk. Under a medium emissions scenario the population exposed to the one in 100 annual coastal flood level is expected to increase from 8.9 million to 11 million by 2050.



INFLUENCE OF SEA LEVEL RISE ON EXTREME SEA LEVEL

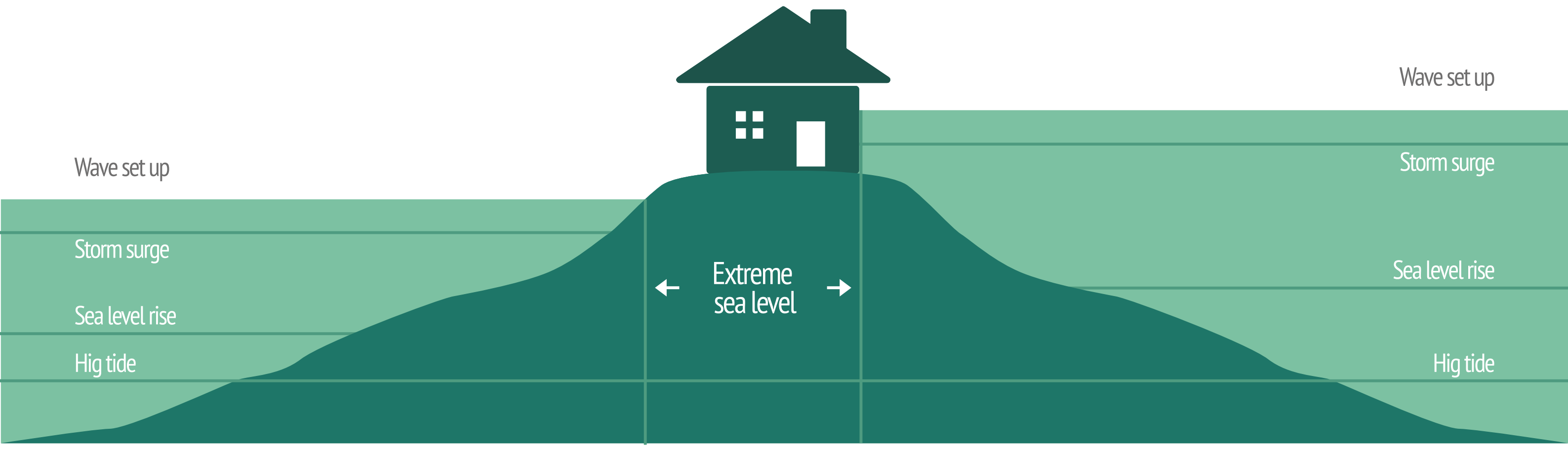
Present and future sea level rise are a consequence of carbon induced global warming causing melting ice and ocean expansion due to heat accumulation.

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.

INDONESIA
WATER

OVERVIEW

Indonesia has abundant water resources, however they are unevenly distributed throughout the archipelago. Rain measurement data for the country indicates that it has abundant rainfall, though in certain areas occasional water shortages or droughts take place.

When combining groundwater and surface runoff, Indonesia has a potential average water availability of about 2,100 millimetres per year. Significant impacts of land-use changes and environmental degradation are now believed to have changed the natural carbon, nutrient and water cycles.

Renewable internal freshwater resources: 2,019 billion m³

Renewable internal freshwater resources per capita: 7,628 m³

Even though Indonesia is a humid tropical country with high annual average rainfall, the archipelago has to cope with several water-related problems, such as rising water demand, lack of upland/upstream land management, erosion-related degradation, population growth, inefficient irrigation water management, extreme climatic change and over-pumping of groundwater.

CLIMATE CHANGE HAZARDS

Climate change can affect water resources through 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 of surface runoff and groundwater storage, as well as drought and flood occurrence. In Java, Indonesia's most populated island, rainfall has seen a marked decrease compared to the previous century, particularly during dry seasons which are becoming longer. Furthermore, the current trend in seasonal rainfall changes also implies a proportional reduction in monthly discharge for Java's major rivers. Significant decline in rainfall has threatened Indonesia's water resources due to depletion of forest resources and global climate change.

KEY POINT RUNOFF

Deterioration of watersheds damages the environment and leads to negative consequences downstream, including massive sedimentation of reservoirs, and possibly a change in the runoff pattern, leading to higher peak flows and reduced dry season flows on the archipelago. This effect will possibly be aggravated by the impacts of climate change.

At a country scale, an average change in surface runoff by approximately -11% and +32% is expected respectively under low and medium emissions scenarios for the 2045-2055 period compared to 2015-2025.

If temperatures rise by 1.5°C, 2°C or 4°C, 17%, 33.4% or 43% of the country will likely experience an increase in runoff, while 3%, 6.4% or 17% of the surface of the country will likely experience a decrease in runoff, respectively.

2050

Changes in annual runoff
% of change

+31.6%

-11.3%

2050

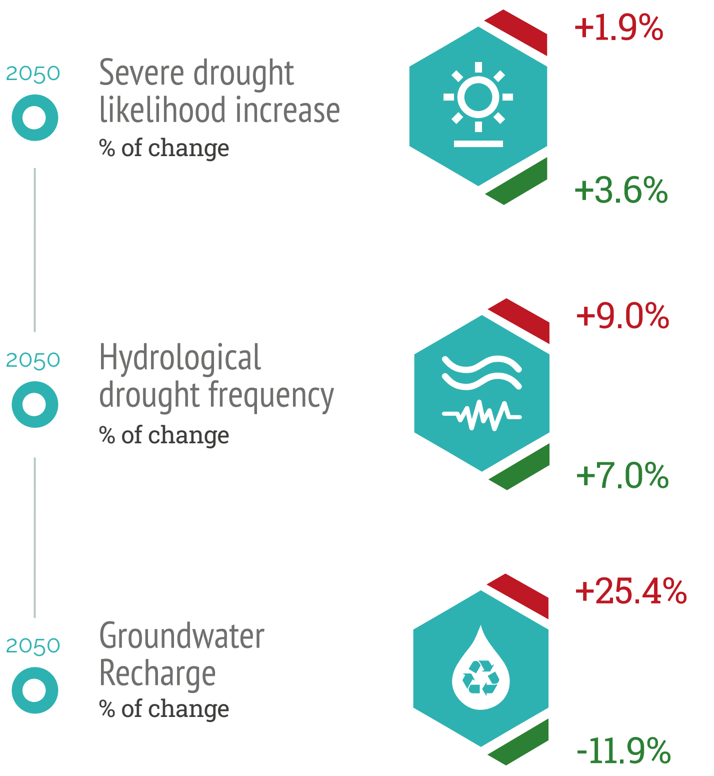
Runoff increase
% of area

+35.0%

+9.0%

KEY POINT DROUGHTS

The Indonesian climate is naturally variable from year to year and, at times, drought may occur. Most recorded droughts can be related to "warm" El Niño episodes: in these cases, the normal patterns of tropical precipitation and atmospheric circulation become disrupted and rainfall is reduced over Indonesia, Malaysia, and northern Australia. A similar correlation is found when a strong Indian summer monsoon generates easterly wind that eventually causes drought in Java–Sumatra. The droughts are most notable in the period from August to December, resulting in a late and reduced onset of the rainy season. According to recent studies, Indonesia will experience drier conditions during the boreal summer due to the effect of the global warming. Impacts include the potential for wide-spread forest fires over the archipelago, particularly in Sumatra and Borneo.



KEY POINT GROUNDWATER

The average annual rainfall in Indonesia is of 2,700 millimetres: of which, only an average of 278 millimetres (10%) infiltrates into groundwater. The most relevant groundwater basins can be found in the north of Java and Sumatra, and in the south of Kalimantan and Sulawesi. Deep groundwater is overexploited in most urbanized areas. Low coverage or poor performance of water supply companies, combined with lack of permit enforcement, leads to many industries and housing estates using deep groundwater. The deep aquifers from which groundwater is drawn are usually not replenished and, as a consequence, they are gradually depleted. This causes rapid drawdown of the groundwater table and land subsidence. Serious impacts are felt in north Jakarta, Bandung, and Semarang. Coastal groundwater may be susceptible to changes in salinity because of saltwater intrusion, associated with sea level rise, and overexploitation of groundwater may increment in the next decades, leading to a further depletion of the basins. At the country level, a -12%, +2.5% and +25% change of the annual groundwater recharge for the period 2045-2055 compared to the timeframe 2015-2025 is expected respectively under under low, medium and high emissions scenarios.

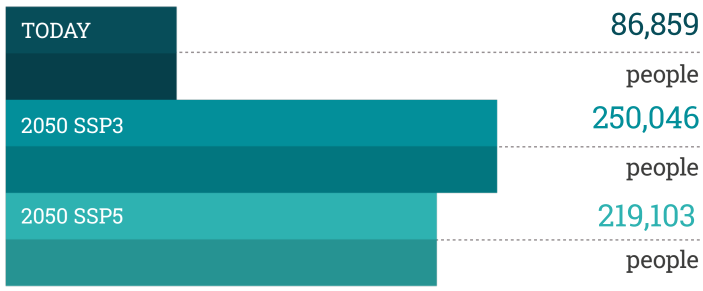
KEY POINT FLOODS

With a climate characterized by high rainfall, frequent intense storms and high runoff, floods are a natural phenomenon in Indonesia. Their impacts are, however, gradually increasing due to settlement and economic development in flood-prone areas.

Flooding has become a major problem in Indonesia, particularly in Java where a large and expanding population combined with past lapses in spatial planning and land management has permitted substantial development in flood-prone areas.

Between 1970 and 2011, 3,980 flood events in Indonesia damaged an estimated 1.1 million hectares of cropland and 65,000 kilometres of roads. By 2050 a slight increase in the number of days with intense precipitation (more than 50 millimetres of rain) is expected, with 0.26 days under a low emissions scenario and 0.41 days under a medium emissions scenario.

POPULATION AFFECTED BY RIVER FLOODS

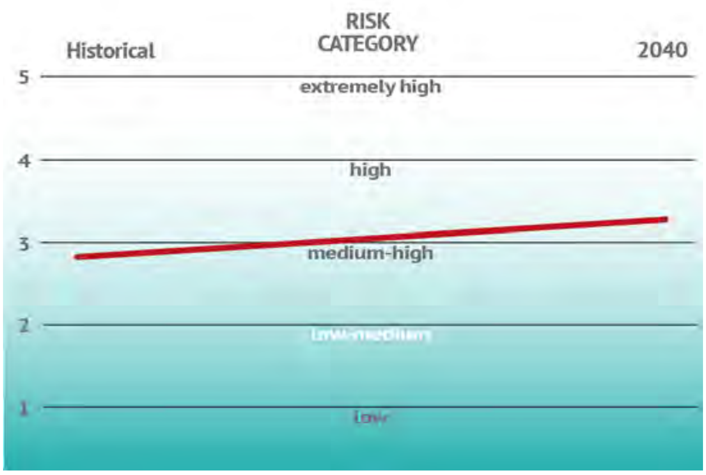


RISK INDICATORS

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

Indonesia's water stress level is considered medium-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.



INDONESIA AGRICULTURE

OVERVIEW

Indonesia is one of the world's largest producers and exporters of agricultural products, supplying important commodities such as palm oil, natural rubber, cocoa, coffee, rice, and spices to the rest of the world.

Large plantations dedicated to export cover about 15% of the total agricultural area. However, the majority of farmers are smallholders operating on less than one hectare. The country is a net importer of grains, horticulture and livestock produce. Wetlands play a very important role in food production, including rice and secondary crops (maize, cassava, soybean, sweet potatoes, peanut).

Besides food crops, Indonesia also produces a large number of perennial crops, including rubber, coconut, palm oil, coffee, cocoa, and tea, which are currently exported.

240.9 Mt
Oli Palm

30.3 Mt
Maize

59.2 Mt
Rice

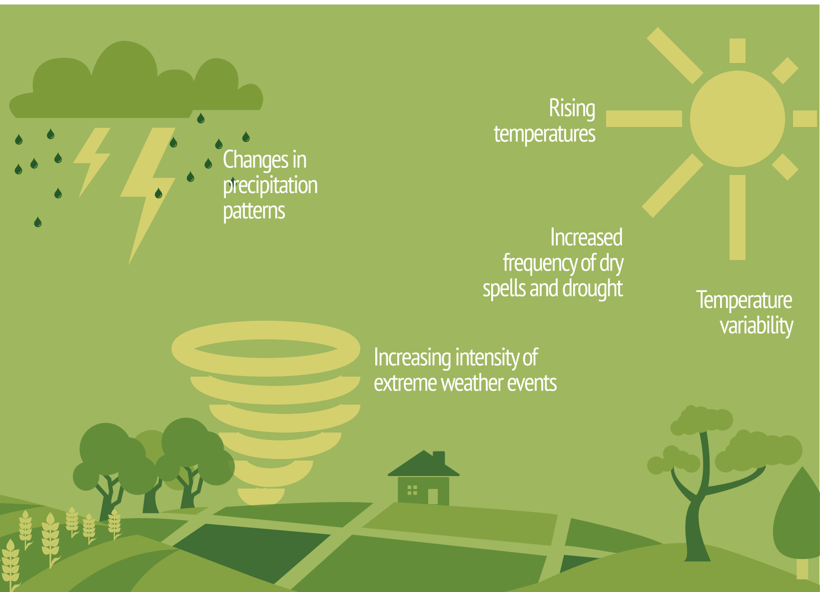
29.5 Mt
Sugarcane

16.1 Mt
Cassava

	Added Value of Agriculture, Forestry and Fishing	Share of Agriculture Value added in Total GDP	Agricultural land	Area Equipped for Irrigation
2000	67,446 USD Million	17.1 %	36,000 Thousand HA	5,500 Thousand HA
2018	129,595 USD Million	13 %	51,300 Thousand HA	6,722 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.

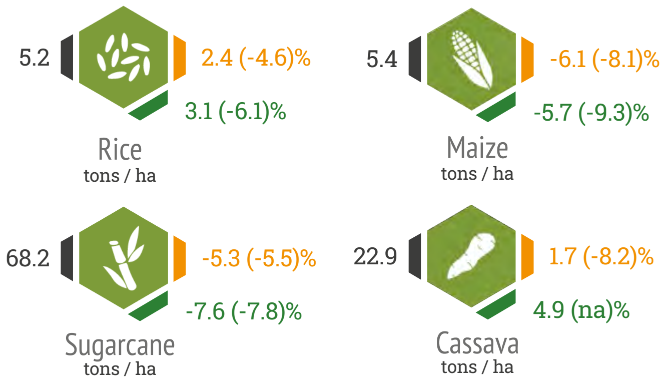


CROP PRODUCTIVITY

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.

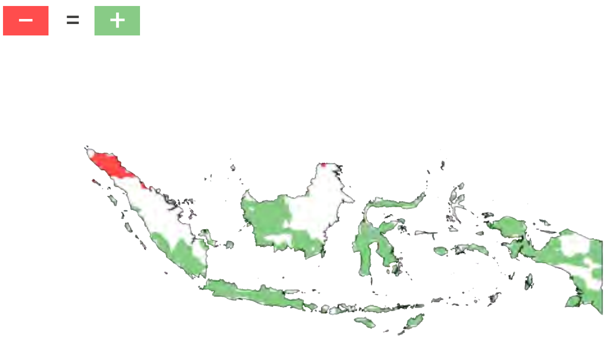
Impacts are estimated using a range of model projections based on low to high emission scenarios and reported as percentage changes between the 30-year average around the historical period and the 30-year average around 2050.



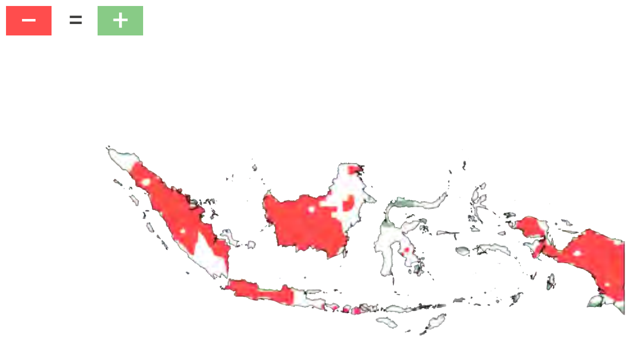
2050

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 RICE



CHANGE IN MAIZE

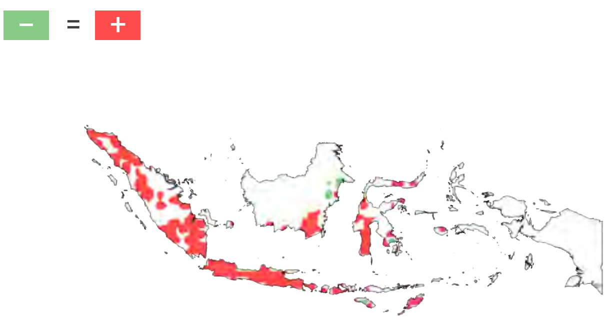


Rice production in the highlands is expected to see higher future yields compared to the lowlands. Furthermore, lowlands along the coasts may also be affected by sea level rise. Sugarcane productivity may suffer from increasing temperatures, as cool winters are needed to facilitate sucrose storage. Sugarcane production is extremely vulnerable to climate change and extreme climate events, such as drought, heat, and flooding. Maize production may also be affected by increasing temperatures, and in particular when water availability is low during El Niño events. Over half of medicinal plant species may lose up to 80% of their growing areas due to climate change. Habitat losses will be aggravated by deforestation and sea level rise. Climate change will affect palm oil production severely, especially after 2050. According to recent studies, palm oil production may decrease from 10% to 41% if temperatures rise from 1 to 4°C.

ADAPTATION IN AGRICULTURE AND WATER RESOURCES

Climate change may have some positive effects on some of the most widely used crops. However, higher temperatures will generally require an increase in irrigation demand due to higher plant evapotranspiration. Total rainfall is expected to increase by an average of 10% from April through June, but decrease by 10 to 25% from July through September. A substantial increase in water demand (45-55%) is foreseen to support irrigation needs. More than 50% of irrigated areas have damaged irrigation infrastructure. Adaptive strategies and appropriate water management will become increasingly necessary to ensure stability and availability of food.

CHANGE IN WATER DEMAND



2050

Coping with climate risks will require a substantial improvement in water infrastructure and adaptation practices, such as crop varieties that enhance water-use efficiency, to limit stress on freshwater resources.

INDONESIA FORESTS

FORESTS IN INDONESIA

Tropical Indonesian rainforests are, by extension, the third largest in the world and nearly half of which are primary forests. Furthermore, the total area of mangrove forest in Indonesia is estimated at about 3.2 million hectares, amounting to 20% of the world's mangrove forest area.

Unfortunately, the rate of primary forest loss due to deforestation is one of the highest in the tropics.

FORESTED AREA AND CARBON STORAGE

Although forests still cover half of Indonesia there has been a sharp decline inrecent decades. Indonesian forests are among the most carbon-dense in the world, mainly due to the presence of mangrove forests. Unfortunately deforestation is reducing this stock and could affect government emission reduction policies.

1990

119 Mln ha
Million hectares
Forested area

94 Tons/ha
Tons of Carbon per hectare
Carbon stock

2020

92 Mln ha
Million hectares
Forested area

104 Tons/ha
Tons of Carbon per hectare
Carbon stock

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

+1.38

+0.92

Marked increase expected throughout the archipelago, particularly under a medium emissions scenario

+ Fertilizing effect of increasing atmospheric CO_2 and nitrogen deposition
+ Rising temperatures promote productivity

No areas with an expected decrease in forest primary production

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

KEY SPECIES UNDER CLIMATE CHANGE

REDUCTION
STYRAX
Suitable habitats of Styrax sumatrana are likely to be reduced under future climate scenarios

REDUCTION
PALAQUIUM
Palaquium species biomass will decrease significantly

REDUCTION
DIPTEROCARP
Dipterocarpus species biomass will decrease significantly

VULNERABILITY
MANGROVES
Rapid sea level rise will threaten coastal Mangrove forests significantly

FIRES IN INDONESIA

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.

Over the last two decades, the total forest area affected by fires was approximately 3.37 million hectares.

BURNING
3.37 MILLION HECTARES

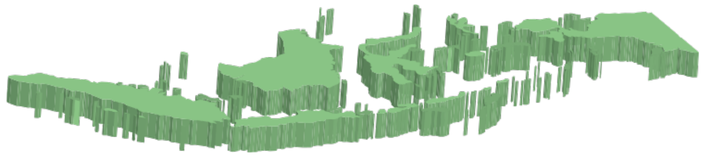
EMITTING
139 TERAGRAMMES OF CARBON PER YEAR

FOREST FIRE EMISSIONS CONTRIBUTED TO 42% OF TOTAL FIRE RELATED CARBON EMISSIONS

COSTING
16.1 BILLION USD IN DAMAGES AND LOSSES (2015 FIRE SEASON)

WHERE DO FIRES OCCUR?

Peatland fires, which mainly occur on the island of Sumatra, are a cause of major concern due to the large amount of emissions released.



Most affected areas are Central and West Kalimantan, South Sumatra, Riau and Jambi provinces.

FUTURE BURNED AREA

Under a low emission scenario, models project that the total burned area might decrease. Although, in some localized areas in Central and Southern Papua, burned area might increase affecting lowland reainforests and freshwater swamp forests.

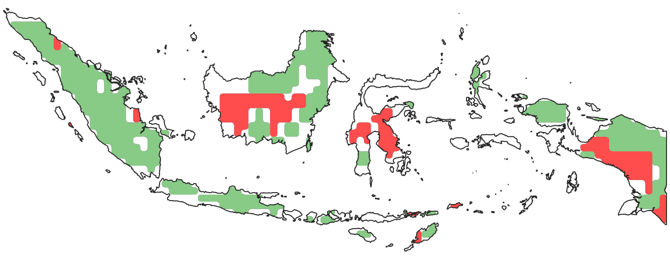
Central areas of Kalimantan and Sulawesi might also experience a slight increase in burned area. Under a medium emissions scenario, burned area projections might project a similar distribution, although Papua will be less affected.

Burned Area
km² per year

2050

-7,080

-5,437



Decrease in burned areas for a low emissions scenario

Increase in burned areas for a low emissions scenario
+ Slight increase in terms of fire season length over Sumatra and Java

VARIATION OF SPECIFIC FIRE INDICATORS

% of change
Extreme fire danger days per year, East Kalimantan

2070-2100

+297%

+209%

% of change
Extreme fire danger days per year, East Sumatra

2070-2100

+275%

+230%

FUTURE FIRE EMISSIONS

Fire emissions follow a similar spatial pattern as burned area. Papua, Kalimantan and Sulawesi show greater projected changes over both low and medium emissions scenarios.

Fire Carbon emission
Teragrams of Carbon per year

2050

-21.03

-13.4

INDONESIA URBAN

OVERVIEW

In 2020, slightly more than half of the population (56.5%) lived in urban areas, which represents a steep increase from 14.5% in 1960. By 2050, this rate is expected to reach 73%.

Urbanization in Indonesia mainly concerns the island of Java, and few other coastal urban areas. Less than 20% of the urban population lives in the capital Jakarta, and another 20% live in the 20 major cities with 1 to 5 milion inhabitants. Therefore the majority of Indonesians lives in minor urban centres with less than 300,000 inhabitants.

Although built up areas cover 1.6% of Indonesia, on the island of Java the figure is 12.8%.

Population in Urban Areas

2020: 154,188,546

2050: 234 104 967

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

Urbanization Rate

2020: 56.6%

2050: 72.8%

OVERVIEW OF KEY CLIMATE IMPACTS IN URBAN AREAS

Climate change impacts on Indonesian cities are connected mainly to sea level rise and rising temperatures.

HEATWAVES AND HEAT STRESS

Observations for the 1960 to 2003 period show an increase in the number of hot days and warm nights. In the city of Bandung, almost 50% of the survey respondents indicated that they had experienced difficulties during their commuting or at work due to hot weather.

Under a high emissions scenario, heat-related mortality for elderly people in the Jakarta metropolitan area will increase by 12 to 15 times in the 2050s.

2050

Cooling Degree Days

% of change

+41.9%

+17.0%

+10.9%

2050

Heatwave frequency

% of change

+97.9%

+59.5%

+33.6%

2050

Heatwave duration

% of time

+7,933%

+911%

+328%

HEAT AND AIR POLLUTION

High levels of air pollution further exacerbate the impacts of heatwaves, in particular in urban areas. According to WHO data, almost the entire population of Indonesia is exposed to high air pollution levels.

2017

Population exposed to air pollution

95.6%

COASTAL FLOODING

75% of Indonesian cities are situated close to the coast. Approximately 175 million people, amounting to almost 70% of the total population, are living in 42 cities and 182 districts found within 50 kilometres of the coast.

Under a future prospective of sea level rise and land subsidence, impacts for the three major coastal cities (Jakarta, Surabaya and Semaran) are expected to rise up to 1 billion, 38.3 million and 0,38 million USD respectively. In Jakarta the number of persons affected would be 318,000, in Surabaya 751,000 and in Semarang 334,000 persons.

Projected sea level rise

2050

0.23 m

0.18 m

2100

0.77 m

0.38 m

FLOODING

Larger urban areas like Jakarta are vulnerable to river flooding, due to reduced drainage and storage capacity of inland watercourses and urban drainage clogged by solid waste and sediments, which adds up to reduced drainage due to sea level rise and land subsidence. Indonesian coastal cities are flooded regularly. In 2007, Jakarta experienced a severe flood that submerged parts of the city under 5 metres of water, killing 46 people.

In 2020, flooding in the city also left 66 people dead and displaced more than 36,000. By 2055 the number of Indonesians exposed to river flooding will increase by 75%, and by 73% for those exposed to coastal hazards. In both cases, the increase is a result of both population growth and climate change bringing more intense precipitation events, rising sea levels and storm surges.

2050

Runoff increase

% of area

+35%

+18%

+9%

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.

GROUND WATER ABSTRACTION AND SUBSIDENCE

Land subsidence makes global sea level rise worse by increasing the amount of flood prone areas and salt water intrusion into coastal aquifers. In Jakarta the current rate of subsidence is the fastest in the region compared to other megacities, and estimated to be as high as 11 centimetres per year.

Low income urban dwellers are the most vulnerable, as they are largely concentrated in urban peripheries, with little and low quality infrastructure.

2010

% of urban population

Population living in slums

30.6%

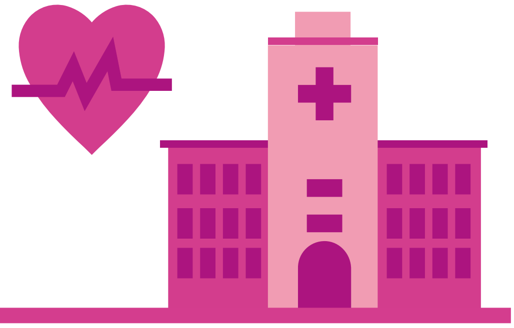
2018

% of total population

Urban population living in areas where elevation is below 5 meters

3.8%

INDONESIA HEALTH



OVERVIEW

Indonesia has a tropical climate with a monsoonal wet season and a dry season. Topography is extremely varied, ranging from sea and coastal systems to peat swamps and montane forests. More frequent and severe heatwaves, floods, and droughts will increase the incidences of vector-borne diseases such as malaria and dengue (especially during the rainy seasons), water-borne diseases such as diarrhoea, and respiratory diseases. An increase in the incidence of severe respiratory problems due to increase in the frequency and spread of wildfires is also expected.

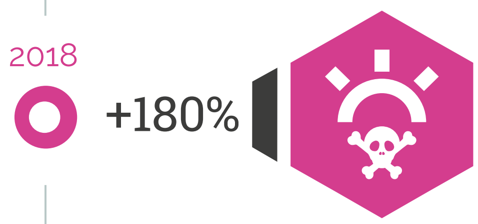
HEAT RELATED MORTALITY

Rapid industrialisation and a high population density render Indonesia vulnerable to the likely effects of climate change. Climate variability and climate change are already exacerbating many of the disaster risks that the country faces.

Heat-related deaths in the elderly (65+ years) are projected to increase to 53 deaths per 100,000 by 2080 under a high emissions scenario, and 8 deaths per 100,000 under a low emissions scenario - compared to a baseline of less than 1 death per 100,000 annually from 1961 to 1990. In 2018, there was a 180% increase in heat-related deaths in Indonesia compared to the 2000 to 2004 baseline, one of the highest increases in the world.

Heat-related mortality

% change with respect to 2000-2004



IMPACTS ON LABOUR

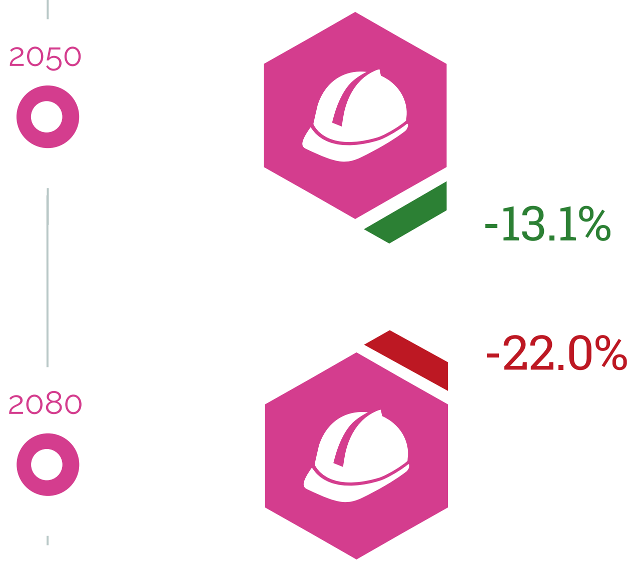
Labour is directly affected by changes in environmental conditions. Warming affects both the number of hours worked (labour supply) and on the productivity of workers during their working hours (labour productivity). Both labour supply and productivity are projected to decrease under future climate change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

Future warming is projected to significantly affect workers in high-exposure sectors in Indonesia. Total labour in Indonesia is expected to decline by 13.1% under a low emissions scenario, and by 22% under a medium emissions scenario.

Impact on total labour

% change with respect to 1986-2005 baseline



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.

Zika suitability

% of population at risk

DENGUE AND ZIKA: POPULATION AT RISK

The mean relative vectorial capacity for dengue fever transmission is projected to increase under both high and low emissions scenarios.

Under a medium emissions scenario, 86.9% of the population will be at risk of transmission-suitable mean temperature for dengue by 2050, whereas 85.6% will be at risk under a high emissions scenario. In the case of Zika, 81.8% of the population will be at risk by 2050 under a medium emissions scenario, whereas 84.3% will be at risk under a high emissions scenario.

CLIMATE CHANGE AND MALARIA

As temperatures rise and water becomes increasingly contaminated, malaria, dengue and cholera are expected to increase. By 2050 more than 98% of the Indonesian population will be at risk of malaria under a low and high emissions scenario – amounting to more than 300 million people.

Malaria suitability

% of population at risk

POLLUTION AND PREMATURE MORTALITY

Air pollution is likely to increase the incidence of respiratory diseases and infections, as well as skin and eye irritations. 29% of deaths from ischemic heart disease, stroke, lung cancer, chronic obstructive pulmonary disease, and acute lower respiratory infections in Indonesia can be attributed to household air pollution.

INDONESIA ENERGY

ENERGY SYSTEM IN A NUTSHELL

Indonesia is rich in energy resources. It is the world's fourth-largest coal producer and first exporter (455 million tonnes in 2019), and it also exports natural gas and biofuels (of which Indonesia is the world's largest producer - mainly biodiesel from palm oil). However, internally the use of energy is moderate, and Indonesia manages to keep its energy intensity at very low levels.

0.071
ktoe/US$
Energy intensity

5.8%
AC Share in electricity consumption

CLIMATE CHANGE TODAY

EXTREME EVENTS - FLOODS AND TYPHOONS

Typhoons and the ensuing flooding have affected the operation of power plants by: soaking coal and making it impossible to burn, preventing carriers from delivering fuel, damaging power grids and causing outages.

EXTREME EVENTS -HEAT AND DROUGHTS

Drought and heatwaves affected the cooling potential of power plants and hence their efficiency.

ENERGY SUPPLY

The current (2019) energy mix of total primary energy supply in Indonesia is strongly dominated by fossil fuels (33.5% oil, 17% natural gas, 24% coal, for a total of 74.5% of total primary energy supply). Renewables account for 25.5% with wind and solar claiming over 10% of total total primary energy supply, biofuels 14.5%, while hydropower is negligible. Wind and solar underwent a 13-fold expansion since 1990. The country imports oil, but is otherwise is more than self-sufficient.

ENERGY DEMAND

In Indonesia, energy is mainly used for transport (34.8% of final demand in 2018), industry (37.5%, including 5.4% share of total demand for non-energy use) and residential (22.4%), followed by commercial use (3.9%) and agriculture (1.2%). Air conditioning's contribution to residential electricity demand was 5.8% in 2017.

FUTURE ENERGY DEMAND

Indonesia has a tropical climate; hence only cooling needs are of relevance. This is projected to result in an increase in electricity demand of 1,454 PJ (or 404 million KWh) by 2050 under a medium emissions scenario. Air conditioning units are expected to increase exponentially from 12 million units in 2016 to 236 million units in 2050.

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

2050

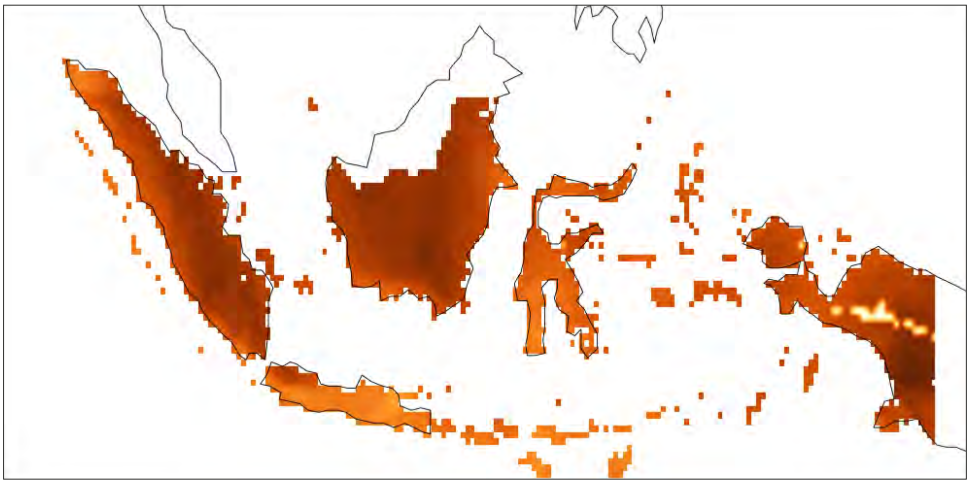
+ 403.97

COOLING NEEDS

Marked increases in cooling degree days are expected all over the country particularly in the interior of the largest islands (Borneo, Sumatra and New Guinea), and in the area of Jakarta.

COOLING DEGREE DAYS

0 512

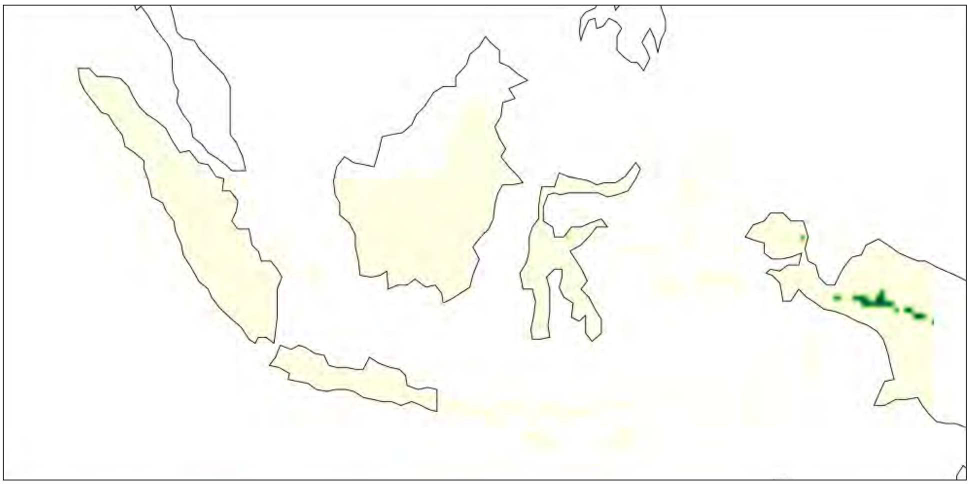


HEATING NEEDS

Heating needs anomalies are practically of no relevance. Nominally they affect only the mountain peaks in New Guinea which are hardly inhabited.

HEATING DEGREE DAYS

-464 0



FUTURE ENERGY SUPPLY

The future configuration of the Indonesian energy mix is likely to be determined by the evolution of energy policies and hence is outside the scope of this report. There appear to be no long-term plans for decarbonization, and the recently planned investments in new coal capacity point to a prevalence, in the coming decades, of vulnerabilities related to fossil fuels.

Change in Hydropower generation
% of change

2050

-2.25%

-1.83%

EXPECTED IMPACTS OF CLIMATE CHANGE

The main concern is for the increased frequency of extreme events, in particular for coastal infrastructure, and the impact of droughts on the thermal efficiency of coal power plants.

In a perspective of increasing cooling demand, severe stress for the electricity system may result, particularly in the more densely populated and economically advanced islands.

INDONESIA ECONOMY

OVERVIEW

Indonesia ranks 17th in terms of GDP among G20 countries. Indonesia was hit less severely by the COVID 19 pandemic compared to other G20 countries, recording a decline in real GDP of 2.1% in 2020 and recovering in 2021 with growth in real GDP of 4.3%.

IMPACTS ON GDP

Climate change will have an effect on the growth rate and overall economic performance of the country. GDP is predicted to decline under both low and high emissions scenarios.

By mid century, costs could reach between 18 and 41 billion EUR (or 2% - 4.4% of GDP) under low and high emissions scenarios, respectively. By the end of the century costs are predicted to become even more severe: Indonesia could stand to lose up to 13.3% of GDP, or 123 billion EUR under a high emissions scenario.

GDP Loss

% change w.r.t baseline

2050

2.79/4.4%

0.61/2%

2100

7.51/13.27%

1.92/7.98%

SECTORAL ECONOMIC IMPACTS

IMPACTS ON INDUSTRY AND INFRASTRUCTURE

Indonesia is an archipelagic state made up of 17,480 islands, accordingly, flooding caused by sea level rise poses serious threats. Many significant infrastructures and economic assets, as well as a large share of the population (50-60%), are located in coastal areas.

IMPACTS ON AGRICULTURE

Agriculture is a key component of the Indonesian economy, contributing 12.8% to GDP (2018 data), and employing almost a third of the labour force. Climate change can exert differentiated impacts on Indonesian crop production.

It is predicted that by the mid century the economic value of corn and rainfed rice may increase, but this will be cancelled out by substantial losses to irrigated rice which makes up a much larger share of overall agricultural output.

Therefore, by mid century climate change is expected to result in a 4 billion EUR reduction under a medium emissions in the overall value of agricultural output. An additional 117 million EUR in damages is expected to occur in the agricultural sector as a result of coastal flooding by mid century.

IMPACTS ON FORESTRY AND FISHERY

Indonesia is the world's largest archipelagic state, and its surrounding waters are among the most fertile fishing areas in the world. The fishing sector is thus an important contributor in terms of food security and employment to the country.

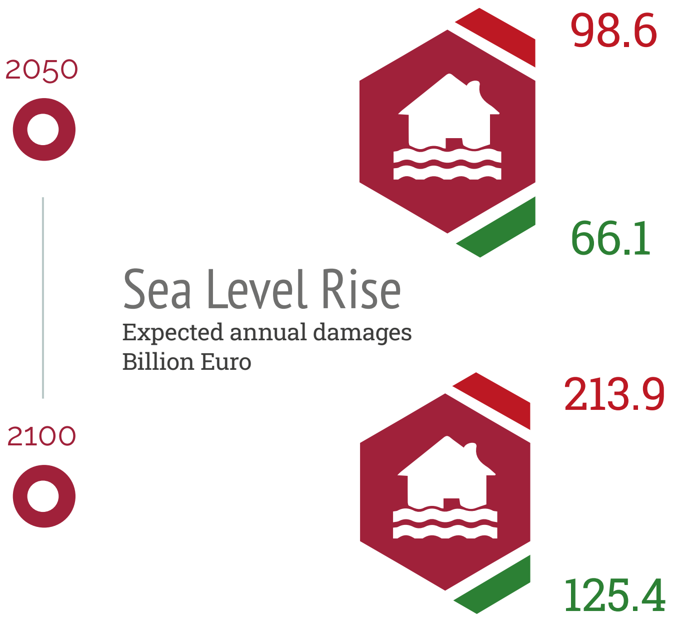
Indonesia is the second largest fish producer in the world, in 2017 fishery related exports totalled approximately 3 billion EUR and fishing activity contributed 2.56% to the country's GDP.

Climate change is projected to adversely affect fish stock and consequently catches. Indonesia is predicted to experience some of the largest reductions in fish stocks around the world with a reduction in maximum catch potential of 23% by mid century.

SEA LEVEL RISE DAMAGES

In the absence of any adaptation measures, sea level rise is predicted to increase the risks of coastal flooding and result in extensive economic losses. By mid century these costs are estimated to be 12 to 66.1 billion EUR and 98.6 billion EUR in terms of expected damages to assets under low and high emissions scenarios, respectively.

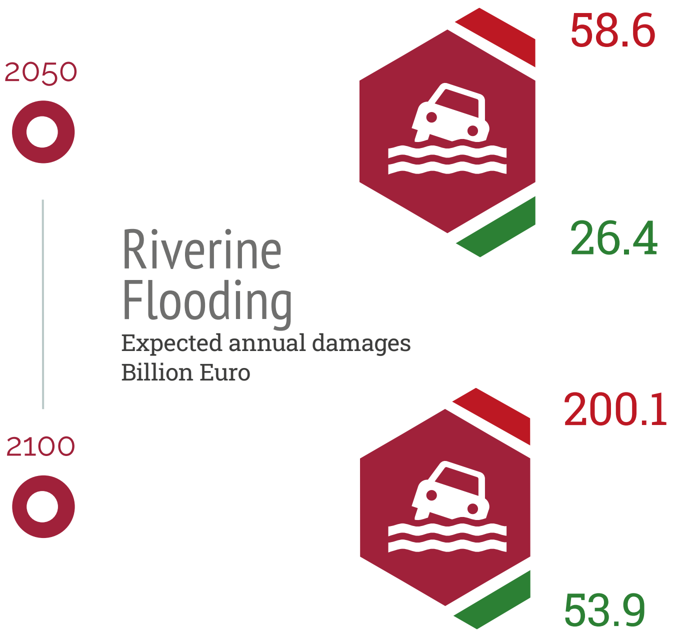
By the end of the century, the losses are projected to be between 125.4 billion and 167 billion EUR under a low emissions scenario and 213.9 billion EUR under a high emissions scenario. Regional analysis shows that the majority of economic losses from sea level rise are likely to occur in Jakarta.



RIVER FLOODING DAMAGES

Fluvial flooding will also cause damage and economic losses. Annual damages are projected to be 26.4 billion EUR under a low emissions scenario and 58.6 billion EUR under a high emissions scenario by 2050.

By the end of the century costs are projected to rise to 53.9 billion EUR under a low emissions scenario and reach 200.1 billion EUR under a high emissions scenario.



IMPACTS ON ENERGY

As with all other economic sectors, energy supply and energy networks in Indonesia will undergo more intense stress from extreme events, such as typhoons, floods and forest fires.

Economic impacts of shifts in household and firm energy demand (see chapter on energy) are difficult to predict and will mostly lead to redistribution effects. In the case of Indonesia, there is no demand for heating of any significance, and hence the large increase in cooling demand is expected to result in a substantial increase in energy bills.

IMPACTS ON TOURISM

Tourism has grown considerably in Indonesia in recent years and accounts for about 4.1% of GDP and employs 10.5% of the labour force. There is a lack of estimates on the economic impacts of climate change on the sector, but some qualitative inferences can be made.

Small island tourism is one of the most popular activities for tourists in Indonesia. Due to reliance on the country's natural resources - clear waters, aesthetic beauty, habitat for biodiversity - one can say with a high degree of certainty that the sector is extremely vulnerable to the effects of climate change and will suffer some economic losses.

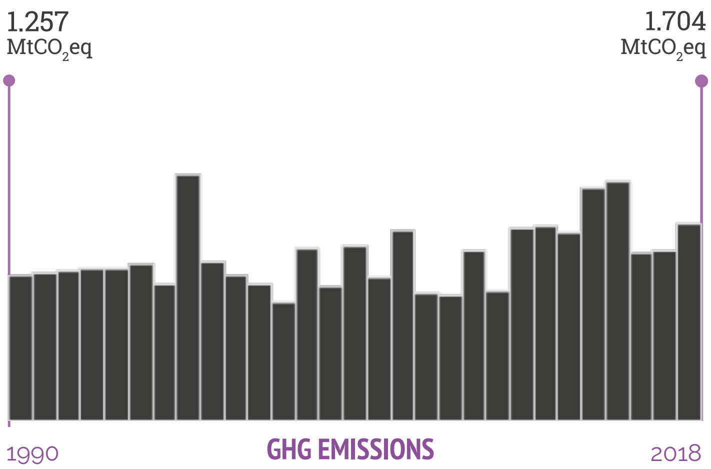
Coral bleaching is expected to increase as sea temperatures rise, reducing the natural beauty and attraction of coral reefs for tourists and locals alike.

Additionally, coastal erosion and the loss of beaches poses serious threats for coastal tourist areas, for instance Bali, where 80% of the population rely on tourism related industries as a source of income. Tourism in low-lying areas will be particularly vulnerable, where built up areas are located very close to the sea with virtually no buffer zone. These areas could become completely inundated by waves during extreme high tides resulting in economic losses.

INDONESIA
POLICY

OVERVIEW

Indonesia is the 4th most populous country in the world, accounting for 3.5% of global emissions. Emissions trends are not steady, as these are highly dependent on land use change and forest wildfire emissions which can vary greatly from year to year.



INTERNATIONAL COMMITMENTS

Indonesia ratified the Paris Agreement in 2016. In its NDC, Indonesia commits to decrease emissions by 26% in 2020 and by 29% in 2030, with reference to a business as usual scenario.

CLIMATE POLICY COMMITMENTS CHRONOLOGY

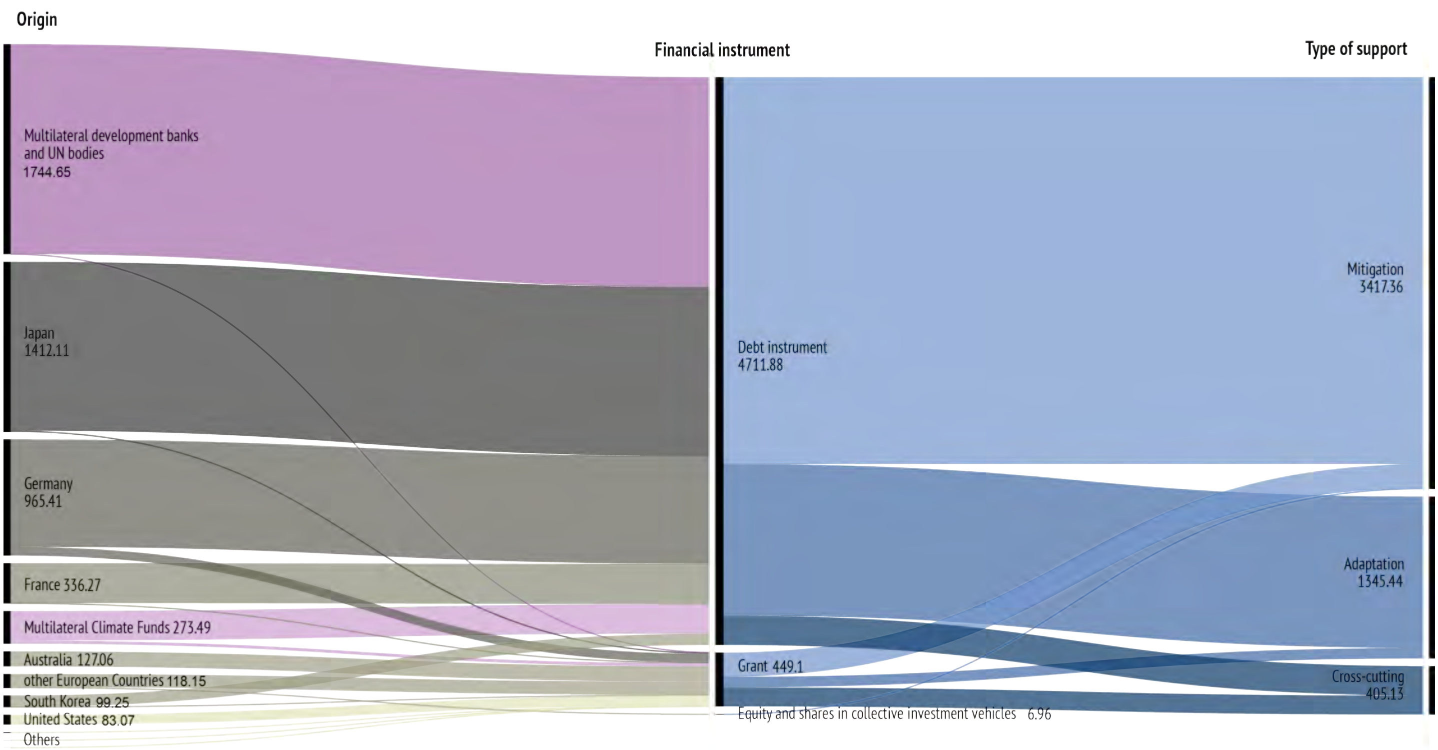
2004 — **KYOTO PROTOCOL - 1ST PERIOD**
No target

2016 — **PARIS AGREEMENT - 1ST NDC**
26% reduction in GHG by 2020 and 29% reduction by 2030, with reference to a specific business-as-usual scenario

2021 — **PARIS AGREEMENT - NDC UPDATE**
Submitted. Commitments unchanged

INTERNATIONAL CLIMATE FINANCE ASSISTANCE

According to OECD DAC data, Indonesia received 5.1 billion USD in climate-related development aid in 2017-2018. Bilateral agreements are the main sources of finance, in particular from Japan and Germany. Debt represents the main instrument. Mitigation accounts for the majority of finance.



SUSTAINABLE RECOVERY POLICY

In 2020, the amount of funds dedicated to post-covid recovery was negligible: 150 million USD. No resources were dedicated to sustainable investments according to the Global Recovery Observatory.

84.35 billion $ Total Spending

0.15 billion $ Recovery Spending

0 billion $ Green Spending

DOMESTIC ADAPTATION POLICY

Indonesia mentions adaptation in its NDC. The country adopted an Adaptation Strategy, but no plan. Sub-national entities are designated to plan adaptation.

Domestic Adaptation Policy (policy not in place)
- Inclusion of Adaptation in NDCs (active policy)
- Integrated Adaptation & Mitigation Policy (policy not in place)
- Dedicated Adaptation Strategy (active policy)
- Dedicated Adaptation Plan (policy not in place)

Subordinate Adaptation Policies (policy not in place)
- Sectoral Adaptation Plans (policy not in place)
- Subnational Adaptation Plans (active policy)

Policy not in place   Active policy

ADAPTATION POLICY HIGHLIGHTS

TRANSNATIONAL INITIATIVES

Coral Triangle Initiative (CTI)

CTI was launched to preserve and conserve 75,000 square kilometers of coral reef resources from the impact of climate change and simultaneously strengthen food security for fisheries through an ecosystem approach

South East Asia Network Climate Change (SEAN-CC)

The network aims to strengthen capacities of the South-East Asian governments on the area of climate change to share knowledge and experience of policy formulation and implementation

NATIONAL INITIATIVES

Adaptasi Perubahan Iklim dan Ketangguhan (APIK)

APIK integrated adaptation and disaster risk reduction into national and subnational governance frameworks. It also built the capacity of local communities to address climate change and weather-related hazards

Climate Information System of Indonesia

The national climate change information system of the national Met service in Indonesia is the result of a cooperation between GIZ and the Indonesian Weather, Climate and Geophysics Agency

SUBNATIONAL INITIATIVES

Climate Action Plans (CAP) in Balikpapan and Bogor

The 2 cities of Balikpapan and Bogor developed two CAPs based on an integrated adaptation and mitigation approach, which takes also into account other development agendas for the benefit of the wider community

Jakarta Coastal Defence Strategy

The strategy copes with flooding from the sea, a phenomenon that is increasing in frequency because of sea level rise and soil subsidence in Northern Jakarta

ENERGY TRANSITION

Indonesia has achieved significant results in the process of transformation of its energy sector and is among the top Asian countries in the overall Energy Transition indicator. Notwithstanding many issues, in particular with forestry policy which still persist, the level of CO2 emission per capita and of air pollution has diminished in recent years, with positive effects not only for climate change but also for citizen well-being. The transition pathway is also well reflected in indicators such as Renewables. In these domains, the country has entered into a positive process of transformation. Nevertheless, looking at the Electrification indicator, there is still room for improvement.

Indicator	G20 Average	Country
Energy Transition	58.7	61.5
Fossil Fuels	45.3	55.9
Renewables	19.7	23.5
Efficiency	84.9	77.3
Electrification	70.8	64.9
Emissions	72.9	86.1

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.