

**Case studies**

**Mekong Delta 1**

The Mekong Delta is a low-lying region in southern Vietnam and Cambodia. Around half of the Mekong Delta is less than 2 m above sea-level, making it vulnerable to fluvial flooding, storm surges and saline intrusion. Sea-level rise is a threat to the economy and ecology of the region. The Mekong Delta alone generates over half of Vietnam's total rice production.

Under a 4 °C global average temperature increase, the global average sea-level could rise by up to 80 cm by the end of the century. Taking account of local variations in sea-level and changes in land height, this would translate to a local, relative sea-level rise of 65 cm in the Mekong Delta region. Such sea-level rises could submerge the lowest parts of the delta as a significant proportion of the land mass in the area is very low-lying. It could also increase the threat of saline intrusion and storm surge damage to rice crops across the region.

**Singapore 2**

A global average temperature rise of 4 °C has the potential to have severe impacts on Singapore.

Global average sea-levels could rise by up to 80 cm by the end of the century, corresponding to a local, relative sea-level rise of around 65 cm. For a small country with a high population density and surrounded by sea, this could have implications for flooding, coastal land loss and salt water intrusion of groundwater aquifers.

Fresh water supplies are required to support the high population density of Singapore but are limited by the country's small amount of land. Water supplies may be affected in the future as parts of South East Asia could see drought events occurring more than twice as frequently.

The unique geography of Singapore makes increasing temperatures under climate change a particular health concern. Any increase in temperature as a result of climate change will be in addition to the higher temperatures that result from the urban heat island effect. In such areas, the combination of hotter daytime temperatures and the lack of respite as a result of warmer overnight temperatures are major factors in heat-related mortality. Singapore can also be affected by smoke haze pollution caused by forest fires in Indonesia. The climatic changes associated with a global average temperature rise of 4 °C are projected to increase the risk of forest fires across Indonesia, putting the population of Singapore at a greater risk of pollution-related health problems, such as upper respiratory tract illness, asthma and rhinitis.

**Fishing in Indonesia 3**

In Indonesia, fishing and aquaculture play a vital role in the country's economy, influencing the livelihoods of much of the Indonesian population. In 2010, inland fisheries, marine fisheries and aquaculture provided more than five million people with direct employment, with over half depending on marine capture fisheries for their income. Fisheries also play an important role in national food security, since fishery products are generally consumed by poor households across the country and fish is the main source of animal protein in the typical Indonesian diet.

A 4 °C rise in global average temperature is expected to have negative implications for fishing and aquaculture across Indonesia. Research into the effects of a global temperature rise on marine capture fisheries around the world has found that Indonesia may be one of the countries that experience the largest decline in catch potential. Warmer ocean temperatures can directly affect the physiology, life history, productivity and distributions of fish in the oceans. Furthermore, the availability of food for fish and shellfish, known as primary production, is influenced by variations in nutrient recycling, a process controlled by ocean currents, coastal upwelling and the frequency of El Niño events – all of which could change under a warmer climate.

Such projections may have large implications for food security across Indonesia, due to the negative impact on communities so dependent on fisheries for food and revenue.



**Case studies**

**Forestry in Borneo 4**

Over half of the island of Borneo (which is shared by Indonesia, Malaysia and Brunei) is covered by tropical rainforest. This forest has an important role to play within the carbon cycle and the mitigation of climate change. However, it is also vulnerable to changes in climate through fluctuations in temperature and rainfall patterns.

Most trees in rainforests are not well adapted to withstand forest fires. The humidity of the climate and the dense canopy mean that the ground is usually damp and not suitable for combustion. This lack of natural adaptation means that, for example, many trees have relatively thin bark in comparison to the thicker bark of trees more used to experiencing natural forest fires.

Many forest fires across South East Asia are human-induced, for a variety of reasons. However, the climatic changes associated with an increase in global average temperature of 4 °C are projected to alter conditions so that the forest fire risk across the region could increase. It is the complex interaction between human ignition of fires and changes in the atmospheric conditions suitable for the fires to spread that increases the risk of forest fires. In addition, changes in the El Niño Southern Oscillation, which influences the amount of rainfall in the region, could have significant positive or negative impacts on the risk of forest fires in Borneo.

Forest fires are already a problem in the region, not just because of the destruction of the forest, but also as a result of the widespread pollution caused by the smoke plumes. Currently, some cities such as Singapore and Kuala Lumpur suffer periods of reduced air quality from this haze.

**Rice-growing in Thailand 5**

Thailand is the world's sixth largest producer of rice and the world's largest exporter, selling around 10 million tonnes in 2008 and contributing about a third of the total world rice trade. Rice is also the staple food of the Thai population, regardless of their income.

During growth, rice plants are very sensitive to extremes of temperature. Crops can become sterile if temperatures exceed 35 °C around flowering time, reducing the amount of rice available for consumption. Low temperatures during other stages of the plants' growth can also have a significant negative effect on yield. With a global temperature rise of 4 °C, the risk to rice crops from low temperatures may decrease, but this is likely to be offset by reductions in yield across Thailand due to the higher temperatures. With the hottest days of the year as much as 6 °C warmer over parts of the country, and without adaptation measures, the possibility of rice sterility is significantly greater. Rice crops may also be affected by an increased risk of drought. The potential of a relative sea-level rise of 65 cm across parts of the country brings an increased risk of salt water intrusion on vulnerable coastal agricultural land, also threatening rice yields.

Because of the importance of rice to Thailand, significant reductions in yield could threaten national food security in addition to damaging the country's economy. As rice is also the principal staple crop of Asia, any deterioration of rice production systems could prejudice food security in the continent as a whole.

**Tropical cyclones in the Philippines 6**

The Philippines is the country most exposed to tropical cyclones across South East Asia. Severe storms, known locally as 'bagyo', often lead to considerable loss of life. Flooding, landslides and high winds can all contribute to the death toll during a storm. Populations situated in vulnerable locations, for example on low-lying coastal areas or on slopes prone to landslides, are particularly at risk. Lives may also be lost at sea when fishing boats are unable to avoid the storm. Widespread damage to infrastructure and crops as a result of tropical storms also has an impact on the economy of the Philippines.

In 1991, Tropical Storm Thelma (Bagyong Uring) made landfall in the Visayan Islands of the Philippines, killing over 5,000 people and leaving 20,000 homeless. Deaths resulted from extensive flash flooding, the failure of a dam and numerous landslides. Such large events highlight the threat to the population of the Philippines from such a destructive natural disaster.

As a result of a 4 °C rise in global average temperature, tropical cyclones could be more intense. The potential rise in sea-level across South East Asia could further increase the country's vulnerability to storm surges and other coastal flooding.

**7 Agriculture**

Yields of cereal crops such as rice and maize could decrease by up to 5% across South East Asia. However, this reduction in yield may be a best-case scenario. If crop growth does not respond positively to increased carbon dioxide as expected, then reduction in yield may be as much as 30% or higher. Any reduction in rice yield could be very significant for large rice producers such as Indonesia, Thailand and Vietnam.

Other impacts of a 4 °C warming that will affect cereal crops include an increased incidence of extreme temperatures (which affect grain production), increased risk of drought and increased potential for saline intrusion on vulnerable coastal agricultural land as a result of sea-level rise. The magnitude of these impacts on cereal productivity is at present not quantified, but when accounted for could significantly reduce future yields.

**8 Water availability**

There is a high degree of uncertainty about how water availability may change with a global average temperature rise of 4 °C. Global average amounts of rainfall are likely to increase, but this will not be true for every area. In South East Asia, some countries may see increases in water availability, while other areas experience decreases.

Climate change may also affect the South East Asian monsoon and the seasonal pattern of rainfall. While there is evidence that the incidence of drought will increase in South East Asia, this does not mean that the average annual amount of rainfall will decrease. El Niño and La Niña have very strong influences on changes in the seasonal patterns of rainfall from year to year. It is not well understood how El Niño and La Niña may be affected by climate change.

**9 Sea-level rise**

Highly populated and low-lying delta areas along the South East Asian coast are particularly vulnerable to sea-level rise. Across Bangkok, without adaptation, a relative sea-level rise of 65 cm by 2100 would flood large parts of the city that has an average height of just 2 m above mean sea-level. Cities such as Manila, Jakarta and Ho Chi Minh City are also very low lying.

**10 Tropical cyclones**

Tropical cyclones could be more intense. Global population increases, particularly in coastal areas, and sea-level rise mean greater cyclone- and hurricane-related losses, disruptions to infrastructure and loss of life as a result of storm surges. For major cyclone disasters, flooding from storm surges has been the primary cause of death.

**11 Marine ecosystems**

Marine ecosystems could be fundamentally altered by ocean acidification which could have a significant impact on fisheries. This could cause substantial loss in revenue and jobs. The loss of coral reef habitats due to acidification may affect many commercial fish species and could have implications for coastal communities relying on subsistence fishing of reef species. At the moment, many communities in Indonesia, Malaysia, Thailand, Cambodia and the Philippines rely on fisheries for their income. In addition to acidification, the rise in ocean temperatures also has the potential to negatively impact both coral reef habitats and fish populations.

**12 Extreme temperatures**

Hottest days of the year could be as much as 6 °C (11 °F) warmer over inland areas of South East Asia, such as areas of Thailand, Laos and Borneo.

**13 Drought**

Drought events could occur almost twice as frequently over South East Asia.

**Health**

The impact of a global average temperature rise of 4 °C on health could include more incidences of heat-related illness, including heat stress, strokes and cardiovascular disorders. City populations (such as in Jakarta, Manila, Bangkok) may be particularly at risk from rising temperatures, especially where air quality is already poor. Vector-borne diseases, such as malaria and dengue fever may change in geographical spread, and the duration of the transmission seasons could lengthen.

Change in temperature from pre-industrial climate

+ °Celsius	1	2	3	4	5	6	7
+ °Fahrenheit	2	4	5	7	9	11	13

Major cities of the South East Asian region

**El Niño Southern Oscillation**

South East Asia is annually affected by climate extremes, particularly floods, droughts and tropical cyclones, while large areas of the region are influenced by monsoons and are prone to flooding. There is a very strong relationship between the El Niño Southern Oscillation (ENSO), which includes both El Niño and La Niña events, and the seasonal weather patterns in South East Asia.

The ENSO has an important influence on weather patterns in the region. However, scientists do not yet know how climate change may affect the frequency or intensity of the ENSO.