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Regional Resource Centre for Asia and the Pacific

Climate Factsheet
Malaysia (MSY)

People and Geography

» Malaysia (MSY) is a country, located in southeast Asia, which lies between 0° 51′ N and 7° 33′ N, and 98° 01′ E and 119°30′ E, together with its territorial waters.[2]

» MSY shares borders with Brunei (381 km), Indonesia (1,782 km), Thailand (506 km), Singapore and the south China Sea in the south of Vietnam and it is located within the humid tropic and has abundant water resources.[4]

» MSY consists of 13 states and 3 federal territories. Among them, 11 states and 2 federal territories (Kuala Lumpur and Putrajaya) are in Peninsular Malaysia and these are separated by the south China Sea from another 2 states; namely Sabah and Sarawak in the island of Borneo. The Federal Territory of Labuan, consisting of the island of Labuan, is located off the coast of western Sabah.[2]

» MSY has an area of approximately 330,345 km^2, with about 8,840 km of coastline and over 879 islands.[2]

» Peninsular Malaysia has a land area of approximately 131,898 km2 and a coast length of about 1,938 km. Its north-south extent is about 746 km and its maximum east-west width is about 315 km. The topography of Peninsular Malaysia ranges from coastal areas to mountainous regions.[2]

» Sabah lies on the northeastern part of Borneo Island and it has approximately 73,904 km2 of land area and 2,155 km of coastline. The topography of Sabah is mountainous, especially in the west coast, with undulating lowland basins in the eastern part.[2]

» On the other hand, Sarawak with a land area of approximately 124,451 km2, lies on the north central and western parts of Borneo Island and it has a coastline of about 1,109 km. The topography of Sarawak is flat coastal plains followed by a narrow belt of hills before sharply rising into a mountainous region towards the Kalimantan border.[2]

» MSY's coastlines share the border with eight major bodies of water: the Andaman Sea, the Celebes Sea, the Gulf of Thailand, the south China Sea, the Straits of Malacca, the Straits of Singapore, the Sulawesi Sea, and the Sulu Sea.[7]

Forests

Approximately **55.3%** of the total land area of the country was covered by forests in MSY in 2014.[2]

One of the world's mega-diverse countries

MSY is one of the world's mega-diverse countries because MSY's terrestrial biodiversity is concentrated within its tropical rainforests that extend from coastal plains to mountain areas, including inland waters such as lakes and rivers.[2]

» Moreover, marine biodiversity is also found among islands and coastal ecosystems, especially in coral reefs and sea grasses.[2]

» MSY possesses 8,000 flowering plants species, 2,000 tree species, 800 orchids types, 200 palms types and numerous types of wildlife. Moreover, MSY's bird population is abundant and varied, particularly in east Malaysia.[7]

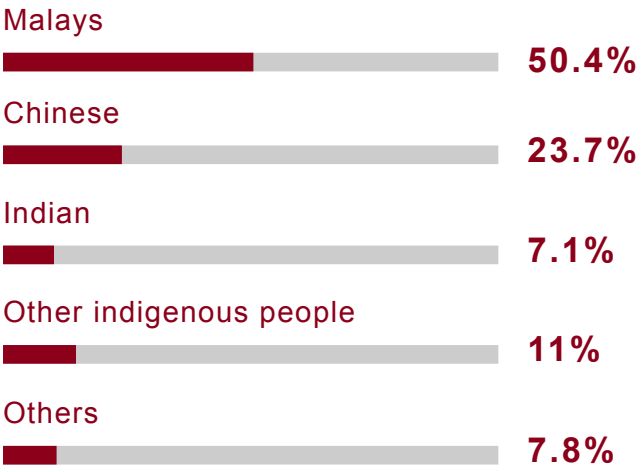
» MSY depends on its annual rainfall for its main water resources and it receives about 973 billion cubic meters of water from rainfall annually. Moreover, 97% of the nation's water demands are provided from rivers and reservoirs.[2]

» On the contrary, the estimated groundwater use in MSY in 2010 was 450 million liters per day (3.4% of the total water consumption in the country) and total groundwater storage in MSY is estimated to be around 5,000 billion cubic meters.[2]

» MSY has abundant water, however, demand for water usage increases annually due to population growth and economic growth of the country.[13]

» There are 191 river basins in MSY, of which 144 river basins (86 are in Peninsular Malaysia, 32 in Sabah and 26 in Sarawak) are prone to flood.[2]

MSY has a multiethnic and multicultural population composed of[4]



The total population of MSY in 2015 was 31.2 million

and it was found that population increased approximately 32.8% over the period 2005-2015 because the population density of MSY was 94 per km² in 2015, compared to 79 per km² in 2005.[2]

» Selangor is MSY's most populous State (5.1 million), followed by Johor (3.3 million) and Sabah (3.2 million), these three states' total population is equivalent to 42.4% of MSY's total population.[7]

» Urbanization rate of MSY increased from 66.5% in 2005 to 74.3% in 2015.[2]

» The most heavily urbanized states are the Federal Territory and Kuala Lumpur (100%), as well as Selangor (88.4%) and Pulau Pinang (80.9%).[7]

» MSY is a coastal country and approximately 98% of the total population resided within 100 km of the coast in 2003.[7]

» Marine fish capture (including shellfish collection) was 1.486 million tonnes in 2015, compared with 1.210 million tonnes in 2005.[2]

» Aquaculture production in Malaysia increased from 207,000 tonnes in 2005 to 506,000 tons in 2015.[2]

» Approximately 25.0% of the total population of MSY was under 15 years old, 69.1% was between 15 to 64 years old and only 5.9% was over 65 years of age.[2]

» The average life expectancy of MSY is found to be steadily increasing because it was 74.6 years in 2015, compared to 73.6 years in 2005.[2]

» In details, female life expectancy increased from 76.0 years to 77.1 years during that period as well as male life expectancy increased from 71.4 years to 72.4 years.[2]

» Gross Domestic Product (GDP) of MSY has a continual upward trend between 2005 and 2015 and the year-on-year average growth rate for GDP at constant prices between those periods was approximately 5% GDP per capita.[2]

The main contributors to GDP in MSY[2]

Services sector
Manufacturing sector
Mining and quarrying sectors

» Similarly, the unemployment rate of MSY improved from 3.5% to 3.1% between 2005 and 2015.[2]

Poverty line

In MSY, **5.1%** of households were living below the poverty line in 2002 and the adult literacy rate was **92%** in 2008.[4]

» According to the UN Human Development Index, MSY ranks 66th out of a total 182 countries in 2009.[4]

» MSY is geographically located just outside the “Pacific Ring of Fire” and is generally free from severe natural disasters such as earthquakes, volcanic eruption, and typhoons, however, it is not spared from other disasters such as flood, man-made disaster, landslide, and severe haze.[3]

» Oil palm and rubber are the two most important agricultural crops. The land area planted with oil palm increased by 39% between 2005 and 2015.[2]

Climate

» MSY has an equatorial climate with relatively uniform diurnal variations of temperatures throughout the year.[2]

» Moreover, MSY has high humidity and copious rainfall.[4]

» The daily mean temperature of MSY is between 26°C and 28°C. At the lowlands, temperatures are between 22.5°C during the night and 33°C during daytime.[2]

» Sea-surface temperatures of MSY vary between 26°C and 28°C in January and between 28°C and 29°C in July. Air temperature near the sea surface seldom varies more than 1°C above or below the sea surface temperature.[7]

Rainfall

Total annual rainfall of MSY is 990 billion m^3 while the annual surface runoff is approximately 566 billion m^3 (147 billion m^3 in Peninsular Malaysia, 113 billion m3 in Sabah and 306 billion m3 in Sarawak).[4]

» The wind over the country is generally light and variable, however, some uniform periodic changes in the wind flow patterns are found.[2]

» Northeasterly winds prevail during the boreal winter monsoon (November to March) and south westerly winds prevail during the boreal summer monsoon (May to September). These monsoons are separated by two shorter inter-monsoon periods.[2]

» Topography and monsoon heavily influence rainfall distribution, which lead to abundant annual rainfall (2,000 mm to 4,000 mm).[2]

» During the northeast monsoon, the east coast of Peninsular Malaysia, northeast of Sabah and southern Sarawak can have heavy rainfall lasting about three days, which sometimes causes severe floods although the southwest monsoon is drier.[2]

» Furthermore, during the inter-monsoon periods, heavy rain from convective showers and thunderstorms occurs in the late afternoons and evenings.[2]

» MSY’s average annual rainfall ranges from 2,420 mm in Peninsular Malaysia to 3,830 mm in Sarawak.[7]

» Increasing tropical storms in the south China Sea have contributed to more extreme events of rainfall and gusting in not only east but also west Malaysia.[3]

MSY receives about **six hours of direct sunlight per day** and clouds cut off a substantial amount of direct sunlight in the afternoons and evenings.[2]

» The groundwater recharge of MSY is estimated at 64 billion m^3 annually, while the balance 360 billion m^3 returns to the atmosphere as evapotranspiration.[4]

Global Climate Change

Temperature

» Global warming will continue an increasing trend due to existing Green House Gases (GHGs) content in the atmosphere, even if emissions are reduced to acceptable levels.[9]

» The Intergovernmental Panel on Climate Change (IPCC) stated that the world’s surface air temperature increased an average of 0.6°C during the last century.[3]

» The global mean temperature was 1.1 ± 0.1°C above pre-industrial level in 2019 and the same year, it was the second warmest year in industrial periods. The last five years were the five warmest on the record and 2010 - 2019 was also the warmest decade.[15]

» As of 2019, the same year marks the 43rd consecutive year (since 1977) with global land and ocean temperatures, at least nominally, above the 20th century average.[1]

Ocean Acidification and Sea Level Rise

» The ocean heat content in the upper 700 m and upper 2,000 m were either the highest or second highest on record in each three-month period of 2018.[14]

» The oceans absorbed around 90% of the heat which was trapped in the earth system by greenhouse gases concentration increasing, which was a record-high level in 2019.[15]

» The oceans absorbed almost 25% of anthropogenic carbon dioxide emissions which led to ocean acidification. Moreover, it is clearly seen that pH level in oceans had a decreasing trend over the last 30 years.[14]

» Over the last two centuries, the increasing CO2 emissions from fossil fuel combustion have led to an increasing amount of CO2 dissolved in the ocean, which caused ocean acidification by reducing the ocean pH level.[3]

» According to the IPCC, sea level has risen by 2.4 mm to 3.8 mm annually at global level.[12]

» Mean global seal level in January to July 2018 was 2 to 3 mm higher than the equivalent period in 2017.[14]

» In 2019, the global mean sea level reached its highest value since January, 1993.[15]

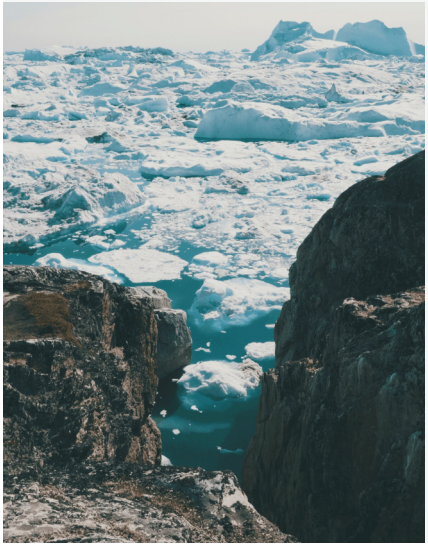
» Global mean sea level has risen about 21–24 centimeters (8–9 inches) since 1880, with about a third of that coming in just the last two and a half decades.[17]

» The rising sea level is mostly due to a combination of meltwater from glaciers and ice sheets and thermal expansion of seawater as it warms.[17]

» In 2019, global mean sea level was 87.61 mm (3.4 inches) above the 1993 average—the highest annual average in the satellite record (1993-present).[17]

» From 2018 to 2019, global sea level rose 6.1 mm (0.24 inches).[17]

» The rate of sea level rise has doubled since 1993 compared to the 20th century average.[17]



Glacier Melting

» Glaciers faced ice loss of 0.85 m water equivalent in the hydrological year of 2016/ 2017. Moreover, 7 out of 10 most negative mass balance were recorded after 2010.[14]

» The extent of Arctic sea-ice was below average throughout 2018, especially in September, its extent was 5.45 million km2 which was approximately 28% below average.[14]

» On the other hand, the extent of Antarctic sea-ice was also below average throughout 2018, the monthly average was 17.82 million km^2 which was 4% below average.[14]

» In 2019, the Arctic and the Antarctic faced losing extent of sea-ice and there were record-low extents in some months of 2019.[15]

» Global atmospheric mole fraction of greenhouse gases reached record level in 2018 with carbon dioxide (407.8± 0.1 ppm), methane (1,869± 2 ppb) and nitrous oxide (331.1± 0.1 ppb), which represented 147%, 259% and 123% of pre-industrial level respectively.[15]

Regional Climate Change

» As of 2019, Asia had the third warmest year on the record.[16]

» The Asia and the Pacific region are more vulnerable to climate change because of its geography, weak institutional structures, densely populated coastal area and considerable portion of the population being poor.[9]

» According to the Global Climate Risk Index, four of the world's ten countries most affected by climate change are ASEAN countries, though MSY was ranked as 8th worst affected countries out of 10 ASEAN countries.[10]

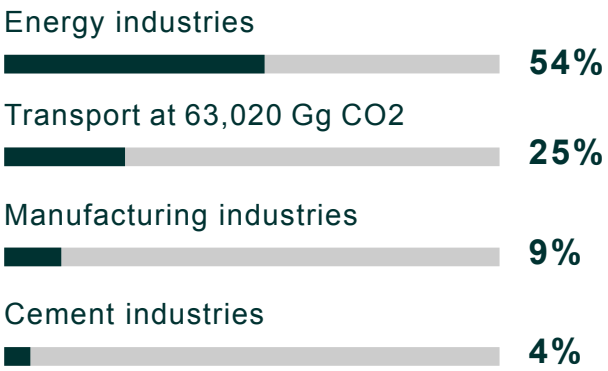
» Furthermore, the Climate Vulnerability Index indicated that ASEAN countries' including MSY's population and ecosystems are highly or extremely vulnerable to climate change.[10]

» The total GreenHouse Gas (GHG) emission for 2014 was 317,626.83 Gg $CO2_{eq}$, removal was 267,147.77 Gg $CO2_{eq}$ accounting 50,479.06 Gg $CO2_{eq}$ as the net emission of the country.[2]

» In 2014, the energy sector was the highest contributor to GHG emissions at 80%, followed by the waste sector at 9%, Industrial Processes and Product Use (IPPU) sector at 6%, Agriculture Forestry and Other Land Use - Agriculture (AFOLU - Agriculture) sector at 4% and Agriculture Forestry and Other Land Use -Land Use Land Use Change and Forestry (AFOLU-LULUCF) at 1%.[2]

» Emissions in the energy sector increased by 28%, IPPU sector by 34%, (AFOLU)-Agriculture sector by 8%, waste sector by 29% and AFOLU-LULUCF net removals increased by 23% between the years 2005 and 2014.[2]

Major source of CO2 emission was from[2]



» In 2014 the highest methane emission was from the oil and gas industries (41%) of the CH4 emissions, followed by emissions from industrial wastewater treatment and discharge (28%), solid waste disposal sites (18%), rice cultivation (4%). Over 99% of the emissions from industrial wastewater treatment and discharge was from Palm Oil Mill Effluent (POME).[2]

» Major source of nitrous oxide emission in 2014 was agricultural soils (60%).[2]

» Analyzing the GHG emission data from 1990-2014, emission grew at the rate of 5.5%. The emission from the energy sector increased at the rate of 5.8% per year, emissions from the IPPU sector grew at the rate of 6.9%, emission from the agricultural sector grew at the rate of 2.2%, and the waste sector grew at the rate of 4% between the same period.[2]

Temperature

» According to the IPCC, the temperature of almost 0.3°C and rainfall of about 3% increased in southeast Asia during the last decade.[13]

» Over the past five decades, positive trends in temperature increase have been observed in MSY.[1,2]

» The surface mean temperature of MSY increased in a range of 0.14°C to 0.25°C per decade. Moreover, the surface maximum temperature increased by 0.17°C to 0.22°C per decade, and the surface minimum temperature increased by 0.20°C to 0.32°C per decade in MSY.[1]

» The highest daily maximum temperature in MSY shows an increasing trend in Peninsular Malaysia, Sabah, and Sarawak. Among them, the highest daily maximum temperature is found in Peninsular Malaysia, followed by Sarawak and Sabah.[2]

» However, the lowest daily minimum temperature shows a different trend; Sabah records a decreasing linear trend, Sarawak an increasing linear trend and Peninsular Malaysia a nearly zero linear trend.[2]

» In each half century, the maximum temperature was increased between 0.7 – 1.1°C, mean temperature increased between 0.6 – 1.2°C whereas minimum temperature was increased between 1.1 – 2.0°C in MSY.[3]

Rainfall

» Southeast Asia and some parts of Australia face dry conditions during the El Nino which leads to drought in many areas of the region.[11]

» In the recent decade, rainfall intensity has increased, and it leads to more severe monsoonal floods in MSY. Urban areas are also becoming more prone to flash floods due to the higher rainfall intensity.[1]

» The occurrence of extreme weather events in MSY has been increasing during the recent years especially the winter monsoon of 2006 – 2007 and 2007 – 2008 brought in heavy rainfall and caused severe floods. In southern Peninsular Malaysia, the heavy rainfall during the winter monsoon of 2006 – 2007 was the worst ever recorded.[3]

Future Climate Projections

Average annual air temperature for MSY[2]

increase to **0.5°C – 1.0°C** during the period of 2030 (2020-2040)

increase to **0.9°C – 1.6°C** during the period of 2050 (2040-2060).

» Rainfall intensity would increase in all regions during the period of 2030, except in the west coast of Sabah (it would decrease by 3.9%).[2]

» These rainfall intensity in Sabah and Sarawak would become smaller during the period of 2050 when compared to 2030, whereas there would be drastic average annual rainfall increments of 7.1% to 10.6% in the four regions of Peninsular Malaysia.[2]

» The projected average mean annual flow of 11 river basins in Peninsular Malaysia shows an increasing trend during the period of 2030 and 2050, compared to the historical period.[2]

» Among these river basins, the Muar river basin shows the highest increment of mean annual river flow for both periods (+25.4% and +26.5% for 2030 and 2050, respectively), followed by the Selangor river basin (+14.8% and +16.9% for the respective periods).[2]

» Almost all the river basins in Sarawak also shows a similar trend for mean annual river flow, which would be higher during the periods of 2030 and 2050. On the contrary, more river basins in Sabah are projected with reduced future river flows during the periods of 2030 and 2050.[2]

» The assessment of total flood areal extent in 15 flood prone basins in Peninsular Malaysia (totally 65,906 km^2, which covers 50% of Peninsular Malaysia) shows that total flood areal extent would increase from 3,918 km^2 (6% of total basin area) to 6,007 km^2 (9.1%) and 6,210 km^2 (9.4%) during the periods of 2030 and 2050, respectively.[2]

» Among these flood prone basins, the Batu Pahat basins shows the highest increments of 196% and 217% in 2030 and 2050, respectively, followed by the Kelantan basin with increments of 153% in 2030 and 145% in 2050.[2]

» The dry spells with return periods 5-10 years (up to 36.3% of rainfall reduction) may occur in MSY recently. The most severe dry spell severity is projected to occur during the period of 2025-2035 in Peninsular Malaysia, whereas they are expected to occur within 2045-2055 in Sabah and Sarawak.[2]

The west coast of Peninsular Malaysia is projected to face a maximum sea level rise of 0.05 – 0.10 m for the period of 2030 and 0.11 – 0.21 m for the period of 2050. On the other hand, the east coast of Peninsular Malaysia is projected to face lower maximum sea level rise during the same periods (0.03 – 0.07 m and 0.11 – 0.15 m, respectively).[2]

» In Sabah, the maximum sea level rise is projected to be at 0.11 – 0.15 m for the period of 2030 and 0.21 – 0.62 m for 2050, whereas it is projected to be at 0.04 – 0.12 m for 2030 and 0.15 – 0.22 m for 2050 in Sarawak.[2]

» The areas which will experience the highest Sea Level Rise (SLR) are the coasts of Kedah and Kelantan in Peninsular Malaysia, Sarawak river estuary and most estuaries located on the east coast of Sabah.[2]

» Under 2xCO2 (doubling of carbon dioxide concentration) scenarios, an increase of 10% to 20% in storm magnitude is expected which would lead to double designed storm frequency or return period.[4]

» In wet months, the increasing temperature of 1°C to 3°C will lead to the long-term runoff reducing between 1% and 5% and between 2% and 17% respectively. On the contrary, runoff will reduce between 1% and 16% and between 1% and 24% respectively.[4]

» Moreover, in wet months, the reduction rainfall of 10% will lead to the runoff reducing between 12% and 31% and it will reduce between 13% and 38% in dry months.[4]

» Therefore, the runoff will reduce between 13% and 35% in wet months and between 14% and 43% in dry months if there is a combination of changes of increasing temperature 1°C and lesser 10% rainfall.[4]

It is expected that more **hydrological** conditions such as floods and droughts will occur. **Droughts** especially will occur more frequently during projected dry years in 2028, 2029, 2034, 2042 and 2044 in MSY.[4]

» Under a high emission scenario, mean annual temperature of MSY is projected to rise by almost 4°C on average from 1990 to 2100. However, it is limited to about 1.1°C if emissions decrease rapidly.[8]

» It is also expected that there is a possible increase in the frequency and intensity of severe drought in the future due to increased concentrations of carbon dioxide and other atmospheric trace gases.[11]

» Under a high emission scenario and without large investments in adaptation, an annual average of 234,500 people are projected to be affected by flooding due to sea-level rise between 2070 and 2100. However, it is limited to about 300 people if emissions decrease rapidly and there is a major scale up in protection.[8]

» Under a high emission scenario, heat-related deaths in the elderly (65+ years) are projected to increase to almost 45 deaths per 100,000 by 2080 compared to the estimated baseline of under one death per 100,000 annually between 1961 and 1990. However, it is limited to 6 deaths per 100,000 in 2080 if there is a rapid decline in emission.[8]

Impacts of Climate Change

» Climate change is severe in MSY and the impacts are being felt such as floods and haze, resulting in losses of revenue and productivity. Climate change will also lead to health risk as it leads to changes in ambient temperature, extreme weather events, rise in sea level, rapid long-term changes in weather patterns, that are induced by human activities.[5]

» For MSY, climate change is cross-sectoral in nature, involving more than merely environmental issues, but also affecting economic growth and human well-beings.[6]

» The direct impact of climate change on water resources will affect the water cycle due to precipitation and evaporation cycle changes. Furthermore, climate change will indirectly impact water resources in terms of migration of people in search of food in arid areas and to safer places due to floods because of sea level rise.[13]

» Malaysia is prone to seasonal monsoon floods and average annual direct loss from these floods amounts to RM915 million.[1]

Flood and storm events.

The five top natural disasters in MSY from 1980 to 2009 were **all flood and storm events.** Among them, floods were among the most severe in the top five with 29 floods, which represented 89% of natural disasters, followed by 6 storms, 4 wildfires, 1 drought and 1 tsunami.[4]

2.9 billion

In the extreme floods in 2014, damage to public infrastructure amounted to RM 2.9 billion.[1]

» Major floods have occurred in 2010, 2012 and 2014. The 2014 northeast monsoon floods was one of the worst in recorded history of MSY.[2]

» Floods in MSY affected the highest number of people (90%), followed by storms (8%) as well as floods were causing the highest economic damage with 54%, followed by tsunami (27%) and wildfires (16%).[4]

» Although most floods in MSY occurred due to heavy and irregular rainfall and inadequate drainage systems, a series of floods occurred in Johor state in 2006 – 2007 were caused by global climate change and sea level rise impacts, which damaged worth of RM 1.5 billion.[12]

» These floods displaced 110,000 people and damaged almost RM 0.35 billion for infrastructure and RM 2.4 billion for economic losses. Additionally, these floods damaged almost RM 84 million worth of agricultural products and affected 7,000 farmers.[4]

» Coastal flooding due to the La Nina phenomenon in Johor in 2011 and 2012 caused potential income losses from palm oil production at RM 155.10 million and 168.22 million during that two years.[12]

» Heavy rainfall in MSY has caused dam water levels to increase above the critical level resulting in the need to release huge volumes of water from the dams in order to prevent untoward incidences.[2]

» Excess water releases from 8 dams during the rainy seasons in 2013 and 2014, and another 2 dams during 2006 and 2007, caused flooding in the downstream area of respective dams.[2]

» On the other hand, a very strong El Nino in 2016, which resulted in prolonged dry periods and associated water shortages, heat waves and wildfires, negatively affected the economics of MSY.[2]

» The El Nino, occurred between March 2015 and April 2016, had caused dams in MSY to fall below the 50% warning or alert level for at least three consecutive months in 2016.[2]

» Moreover, the El Nino occurred between 1997 and 1998 caused extensive impact to environment and social activities throughout the MSY.[4]

» Saltwater intrusion to the aquifers threatens groundwater in MSY which represents 3.4% of the total water consumption of the country because of sea level rise.[2]

» MSY's long coastline (about 8,840 km) is constantly experiencing climate-related hazards like coastal erosion, coastal flooding, and storm surges.[2]

» Erosion and sedimentation rates increased during and after strong storms in MSY. There is a higher risk of slope failures of riverbanks and hills, faster rate of sedimentation of reservoirs and channels, and more extensive loss of soil nutrients such as in the Kelantan river. A 20% discharge increase causes a sediment load increase of 33% and an increase of 20% in high flow magnitudes and frequencies lead to a 44% surge in sedimentation load in Sabah and Sarawak.[4]

» In 1991, drought in MSY caused the drying up of Durain Tunggal dam and resulted in prolonged water rationing in most parts of the state of Malacca.[4]

» Drought occurred in 1998, which caused high rainfall deficits for 4 to 9 months, affected more than 2,797 km^2 and 170,000 people in MSY. Among them, almost 1,580 km^2 was engulfed in wildfire, of which more than 100 km2 were agricultural lands, which led to almost 7,200 farmers for loss of about RM 7 billion.[4]

This drought also caused extensive impacts

Environment

Social activities

throughout the MSY and it also led to extensive wild forest fire in Selangor, Sarawak, and Sabah. Particularly, it affected 1.8 million residents in southern Kuala Lumpur, Bangi and Kajang because of disrupting water supply.[11]

» The Second National Communication (NC2) shows that a temperature increase of 2°C would reduce the yield of rice cultivations by 13% of yield or RM 200 million.[5]

» Oil palm yields would reduce by 30% or RM 5 billion with a 2°C rise above optimum temperature level and decrease in rainfall by 10%.[5]

» In terms of the forestry sector, an increase of 1 – 2°C would cause an upward shift in climate conditions in the montane forest ecosystem.[5]

» In MSY, within Peninsular alone 13.5% of amphibians, 5.8% of birds and 5.4% of mammals are highly vulnerable to ecosystem changes brought on by climate change.[6]

» Coral reefs in Malaysia have a total coverage area of 4,006 square kilometer.[2]

» The annual Coral Reef Health Surveys for the last nine years show that the Malaysia coral reefs are at the upper level of "Fair" (26% - 50%).[2]

Coral reefs

The first significant mass coral reef bleaching event reported in Malaysia was in 1998. **An estimated 40% of corals in reefs around Peninsular Malaysia died.[2]**

» The Coral Reefs Bleaching Surveys show coral bleaching also occurred in 2010, 2014 and 2015. In 2016, coral bleaching occurred again with bleaching reaching 40-60%.[2]

» MSY also faces numerous potential threats to population health and development due to climate change.[8]

» Communities living in coastal regions could be at risk of flooding due to sea-level rise. Furthermore, climate sensitive diseases such as malaria, cholera, dengue and heat-stress are likely to rise with increased temperature and changes in rainfall patterns in MSY.[8]

» One-meter increase in sea level rise will cause 700 km^2 of land loss (21%) and displace more than 0.3% of the population in MSY.[12]

» Moreover, it will also damage 180,000 hectares of agricultural land, 15% - 20% of Mangrove forests along the coastal lines and relocation of shore-based power stations. Therefore, potential sea level rise is the most vulnerable in MSY.[12]

» Water resources are significantly and positively affected by climate change in 13 states of MSY. The higher the cloud cover, the more water resources will be available from the rainfall in these regions because there is a close linkage between climate and hydrological cycle.[13]

Mitigation and Adaptation to Climate Change

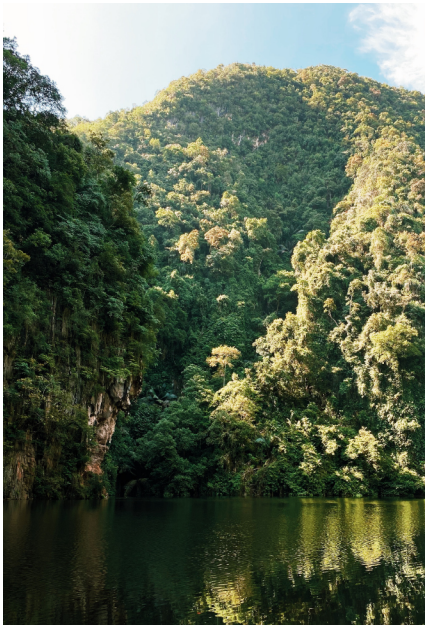
» Diversified climate adaptation measures are implemented by the countries in Asia and the Pacific region to address climate change impacts.[9]

» The effectiveness of these adaptation measures depends on the location, sectoral capacity, and socio-economic situation of each country. Not only structural but also non-structural measures are used to overcome floods and inundation in the region.[9]

» To address climate change issues, MSY government has also taken many initiatives such as promoting utilization of renewable energy, energy efficiency in industry, building and transport sectors, restructuring the public transport system, cleaner fuel, stringent efficient standards, and alternative industrial processes technique.[3]

» In MSY, actions taken for addressing climate changes are guided by Malaysia's international obligations and commitments, namely three conventions: 1) United Nations Framework Convention on Climate Change (UNFCCC), 2) United Nations Convention on Biological Diversity (CBD), and 3) United Nations Convention to Combat Desertification (CCD).[6]

» Supporting development partners in climate change adaptations of MSY are the United Nations Development Program (UNDP) with funding from the Global Environment Facility (GEF), the World Bank, the Asian Development Bank (ADB), the European Communities-Association for Association of Southeast Asian Nation (ASEAN) Energy Facility, the Danish International Development (DANIDA), Japanese International Cooperation Agency (JICA), and New]Energy and Industrial Technology Development Organization (Japan).[6]



MSY's adaptation responses come in the form of[6]
Improved ecosystem management
Water resources management
Secured agricultural production

» The existing commitment of ASEAN countries to international climate policy provides a good foundation for joint regional climate-policy formulation and action.[10]

» MSY has ratified the Kyoto Protocol in 2002 and the Paris Agreement in 2016.[10]

» MSY intends to reduce its greenhouse gas (GHG) emissions intensity of Gross Domestic Product (GDP) by 45% by 2030 relative to the emissions intensity of GDP in 2005, which was 0.531 tons CO2eq per thousand RM.[1]

» This consists of 35% on an unconditional basis and a further 10% is condition upon receipt of climate finance, technology transfer and capacity building from developed countries. Timeframe of implementation is 10 years (2021 to 2030) and coverage of gases are carbon dioxide, methane, and nitrous oxide.[1]

» MSY continues to allocate financial resources for the implementation of climate change mitigation programs through both public and private sector initiatives.[1]

» The climate-related policies are implemented along with national priorities such as poverty eradication, improving quality of life and development in MSY.[1]

» Since the Ninth Malaysia Plan (2006-2010), MSY has started initiatives to increase the share of use of non-fossil fuel energy and MSY had also introduced the biodiesel B7 programme at the end of 2014.[1]

» The Tenth Malaysia Plan (2011-2015) focused on sustainable growth and introducing mitigation strategies to reduce emissions of GHG. During the Tenth Malaysia Plan, MSY spent RM 51 billion to enhance resilience against climate change.[1]

» National Physical Plan – 3 (NPP-3) is the highest-ranking planning document aimed to enhance adaptation to, and mitigation of climate change.[2]

» A national adaptation plan would be developed to provide greater coordinated implementation. Moreover, over RM 12 billion were spent by MSY for improving the water sector infrastructure, with over RM 5.6 billion being used for developing the water supply for the rural areas.[1]

» MSY government continues to pursue the green growth goal under the Eleventh Malaysia Plan (2016-2020) which focuses on pursuing green growth for sustainability and resilience.[1]

» MSY aims to strengthen the regulatory framework of the water services industry, expand the water supply network and treatment capacity infrastructure, and increase the efficiency of water supply services during the Eleventh Malaysia Plan.[1]

» In order to fulfill water supply requirements, a Review of the National Water Resources Study (2000-2050) was completed in 2011 and a National Water Resources Policy was formulated in 2012.[1]

» A National Dam Safety Management Guidelines and a National Dam Safety Management Act are under development.[2]

» A National Coastal Vulnerability Index to sea-level rise is being developed and detailed sea level rise studies have also been conducted at some of the vulnerable coastal areas to project future vulnerabilities in a 20-year sequence from 2020 to 2100.[1]

» In 1985, a National Coastal Erosion Study (NCES) resulted in 208 structural coastal protection projects implemented between 1985 and 2015 to protect over 212 km of coastline.[2]

» By 2017, Integrated Shoreline Management Plan (ISMP) studies were carried out for Pahang, Melaka, Negeri Sembilan, Pulau Pinang, Labuan, Miri in Sarawak, Sabah, and Johor.[2]

» From 2004 to 2014, Malaysia has invested over RM 9.3 billion on flood mitigation. Furthermore, flood mitigation programs and strengthening of disaster risk management and resilience of infrastructure would be further enhanced in the Eleventh Malaysia Plan and beyond.[1]

» The launch of the National Water Resources Policy (NWRP) in 2012, which was established based on the results of 2011 National Water Resources Study (NWRS), is one of the critical milestones for sustainable and integrated water resources management of MSY.[2]

» The National Steering Committee on Climate Change (NSCCC) was established in 1994 to formulate and implement climate change policies including mitigation of GHG emissions and adaptation to climate change in MSY.[6]

» Moreover, MSY government established the National Green Technology and Climate Change Council in 2010 to coordinate and facilitate the implementation of the National Policy on Climate Change and National Green Technology Policy.[6]

» The National Policy on Climate Change is also one of the important considerations for better management of MSY's water resources.[2]

The objectives of the National Policy on Climate Change are;[6]	
1	Mainstreaming climate change through wise management of resources and enhanced environmental conservation resulting in strengthened economic competitiveness and improved quality of life
2	Integration of responses into national policies, plans and programs to strengthen the resilience of development from arising and potential impacts of climate change
3	Strengthening of institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change

» The National Water Balance Management System (NAWABS) is one of the adaptation measures that are being implemented in MSY and the River Basin Water Balance System for 7 river basins namely, Kelantan, Melaka, Muda, Kedah, Bernam, Klang and Similajau will be developed under NAWABS.[2]

» The National Dam Safety Management Guidelines and the National Dam Safety Management Act are under development to reduce dams' vulnerability to flood events.[2]

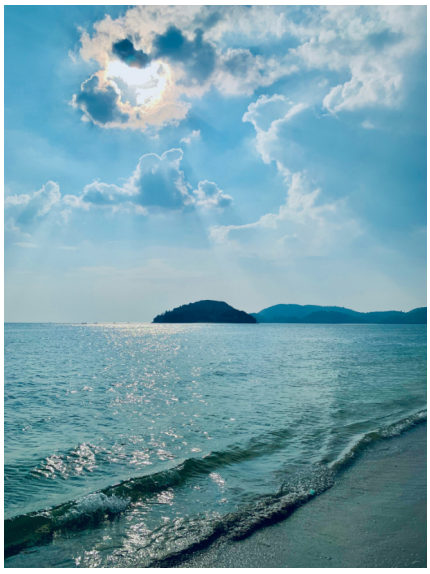
» In total, 121 water catchment forests have been gazetted in Peninsular Malaysia, 29 catchment areas have been gazetted in Sarawak and 20 catchment areas is being processed to gazette in Sabah for ensuring water quality and adequate water supply to the storage dams of MSY.[2]

» An Integrated Flood Management (IFM) approach has been adopted where efficient use of flood plain to reduce floods as well as 184 flood structural measures have been carried out and 70 new flood mitigation projects would be implemented under the Tenth Malaysia Plan and the Eleventh Malaysia Plan.[2]

» Moreover, a National Flood Forecast and Warning Center (PRABN) and a National Disaster Management Agency (NADMA) were established in order to provide early warning and coordinate response during disasters.[2]

» The National Hydraulic Research Institute of Malaysia (NAHRIM) is also a key knowledge actor in the region within the water sector. NAHRIM was established in response to MSY's increasing water-related challenges and deteriorating water quality, competing users, erosion, accretion, sedimentation, and impending impacts of climate change on water resources.[6]

» Regional climate modelling, an important tool to aid the development of science-based adaptation and mitigation measures. This is carried out at the NAHRIM, the Malaysian Meteorological Department (MetMalaysia), School of Environmental and Natural Resource Sciences of National University of Malaysia (UKM) and Institute of Ocean and Earth Sciences of University of Malaya. This will help MSY to develop and implement policies and measures that ensure climate-resilient development.[2]



» The Urban Stormwater Management Manual (MSMA) had been published in 2000 in order to prevent floods by emphasizing peak discharge control at source.[4]

» The Regional Hydro-climate Model (Reg-HCM) was prepared for Peninsular Malaysia in 2006 and for Sabah and Sarawak in 2010 by NAHRIM to generate climate and hydrological projections.[5]

» A study on the impact of sea level rise in MSY was conducted in December 2010 with the objective to project sea level changes along the Peninsular Malaysia and Sabah and Sarawak coastlines.[5]

» MSY has also been using another projection model "Providing Regional Climate for Impact Studies (PRECIS)", which was developed by the Hadley Center for Climate Prediction and Research, UK Meteorological Office, for understanding and projecting climate change impacts and adaptation needs.[6]

» The Malaysian Network for Research on Climate, Environment and Development (MyCLIMATE) has done extensive research in the area of climate change adaptation and disaster risk reduction and provided key inputs into monitoring and documentation of international developments on global climate regimes for formulating strategic national positions and responses.[6]

» MSY implemented Integrated Water Resources Management (IWRM) plans for strengthening the country's ability to deal with floods and droughts. Moreover, MSY has also taken adaptive measures to strengthen its infrastructure such as Storm Water Management and Road Tunnel (SMART) for addressing urban floods.[6]

» Under the Tenth Malaysia Plan (2011-2015), 184 flood structural measures have been carried out and for the Eleventh Malaysia Plan (2016-2020), an additional 70 new flood mitigation projects would be implemented.[2]

The implementation of the Integrated River Basin Management (IRBM) plan, which considers integrated management of
Water resources
land resources
Ecosystems
Socio-economic needs
will enable to reduce the vulnerability of the water sector to climate change.[6]

» The National Disaster Management Agency (NADMA) is set in place to cope with more frequent and severe natural disasters.[2]

» Implementation of rainwater harvesting practice, which has been included in the Road, Drainage and Building Act 1974 Uniform Building By-Law (Amendment 2012), is mandatory and compulsory in Johor, Kelantan, Malacca, Perak, Perlis, Pahang, Negeri Sembilan and Selangor to help reduce flood peak during heavy rain.[2]

» The National Physical Plan, Structure Plans and Local Plans have categorized flood prone areas as Environmentally Sensitive Areas (ESAs), in which only approved controlled new development activities are allowed.[2]

» To reduce socio-economic losses, a National Flood Forecast and Warning Centre (PRABN) and a National Disaster Management Agency (NADMA) were established to provide early warning and coordinate response during disasters. Social media tools have also been incorporated for the wider dissemination of flood warnings.[2]

» Moreover, laws in MSY such as the National Water Services Commission Act (2006) and the Water Services Industry Act (2006) are the key laws to promote sustainable water use and better water management for adapting to climate change.[6]

» Structural adaptation measures such as flood mitigation projects to protect the Muda Agriculture Development Authority (MADA) granary areas have prevented the re-occurrence of seawater intrusion.[2]

» Implementation of flood mitigation projects along the Golok river and the Sungai Kelantan Integrated River Basin Development Project helped to protect the Kemubu Agriculture Development Authority (KADA) granary areas.[2]

» Improving irrigation management through efficient demand and supply management such as the water supplement management, has been implemented to overcome water stress problems in the granary areas. As a result, MADA was able to increase its usage of recycled drainage water from 6% to 8% and KADA managed to overcome its water deficit problem during off-seasons.[2]

» Identification and use of improved varieties of seeds resistant to climatic stress, adoption of proper agricultural practices, good drainage system in water stressed regions are some of the adaptation measures adopted for Palm and Rubber plantation in Malaysia.[2]

» One of the adaptation measures that is being used for the fisheries sector is the capacity building for fishermen to make the use of the Fishing Site Identification System.[2]

» To enhance the fish resources, the Department of Fisheries Malaysia has implemented the conservation zone (0-1 n.m. from coastline) for the west coast of Peninsular Malaysia. The use of trawlers in zone B is being banned on the west coast of Peninsular Malaysia.[2]

» To synergize forest and biodiversity conservation the Central Forest Spine (CFS) Master Plan was adopted by the Government in 2011. The CFS Master Plan institutionalized in the Malaysia National Physical Plan 2 (2010) will provide national strategic spatial planning policies and measures in land use, physical development and conservation in Malaysia till 2020.[2]

» The Heart of Borneo (HoB) initiative was introduced in 2007 by the Governments of Brunei, Indonesia, and Malaysia as a trans-boundary collaboration to enable conservation (forest, and biodiversity) and sustainable development. The HoB initiatives along with non-government organizations (NGOs), aims to ecologically connect approximately 200,000 square km of forests in Borneo.[2]

» Awareness on High Conservation Value Forests (HCVF) has led to its recognition as an important criterion in the assessment of Permanent Reserved Forests (PRFs) resulting in conservation of biodiversity and enhancing ecosystem services.[2]

» To reduce the occurrence of forest fire especially during the dry spells and El Niño events a centralized coordination mechanism has been established, a Fire Danger Rating System (FDRS) adopted for early warning and build check dams and tube wells at fire prone peatland areas.[2]

» The Ecosystem Approach to Fisheries Management (EAFM) has been accepted and ready to be implemented.[2]

Adaptation of the marine ecosystems to climate change is part of Malaysia's action plan on the Coral Triangle Initiative on
Coral Reefs
Fisheries
Food Security

This initiative is supported by the Ministry of Science, Technology, and Innovation.[2]

» The Tun Mustapha Marine Park established in 2015 has almost doubled the extent of Marine Protected areas in Malaysia. Temporarily closure of marine parks practiced during mass bleaching incidences to enable the coral reefs to recover.[2]

» With regards to the public health sector, MSY is taking steps to address the potential health impacts of climate change by managing the aspects of climate change which affect public health.[8]

Research on Mitigation and Adaptation to Climate Change

» National Hydraulic Research Institute of Malaysia (NAHRIM) was mandated by the council to conduct research to identify vulnerability of water related infrastructures and the impact of changing rainfall patterns on agriculture and sea level rise.[2]

» Under the Ninth Malaysia Plan (2006- 2010) study was conducted to assess Impact of Climate Change on Hydrologic Regime and Water Resources of Sabah and Sarawak (2010) and under Tenth Malaysia Plan (2011-2015) the extension study of the Impact of Climate Change on Hydrologic Regime and Water Resources of Peninsular Malaysia (2014) was conducted.[2]

» NAHRIM's research has led to the publication of two water management technical guidelines – future design rainstorm and rainwater harvesting - for spatial planning and implementing agencies.[2]

» The Malaysian Palm Oil Board (MPOB) is currently undertaking a remote sensing survey to update the planted area of oil palm on peat and mineral soils in Sarawak including the research on greenhouse gas fluxes in oil palm plantation.[2]

» The Rubber Research Institute of Malaysia (RRIM) is studying the carbon sequestration potential of rubber plantation on the new latex timber clone.[2]

» Under the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF), the World wide Fund for Nature – Malaysia (WWF-Malaysia) assesses the impacts of climate coral reefs and marine turtles. The project aims to identify the vulnerability factors and recommend adaptation measures.[2]

» WWF-Malaysia together with University Malaysia Sabah (UMS) also conducted a climate change vulnerability assessment for Semporna Priority Conservation Area (PCA) in Sabah between July 2013 and June 2014. The objectives of the assessment were to introduce and apply the Local Early Action Planning Guide and the Coastal Integrity Vulnerability Assessment Tool (CIVAT) in Semporna as tools to determine the vulnerability of the local communities and resources to climate change.[2]

» For the power generation sector, Tenaga National Berhard (TNB) Research (TNBR), is the research arm of the main power utility company. Their research areas are on increasing energy efficiency, reducing GHG emissions, low carbon electricity generation, application of smart grid technologies, renewable energy (utility solar solutions) and adaptation projects to protect TNB's power generation, distribution, and transmission assets from impacts of climate change.[2]

» SIRIM with Solar Energy Research Institute (SERI) of University Kebangsaan Malaysia (UKM) conducts research to develop advanced air-based drying systems of marine products such as seaweed, anchovies and salted fish and usage of solar PVs for electricity generation.[2]

- Research in the forestry sector mostly focused on the carbon sequestration aspect of forest.[2]
- Malaysian Palm Oil Board (MPOB) completed a full life cycle assessment for the Malaysian palm oil from the nursery to palm biodiesel, as part of its commitment to sustainable development and compliance to European Commission requirements in 2010. The findings showed that palm oil is not harmful to the environment.[2]
- SIRIM is developing the Life Cycle Inventory Database of Palm oil in collaboration with the industrial sector.[2]
- As of June 2016, 355 river water level stations (online and offline) and 559 rainfall stations (online and offline) along the 98 river basins were established.[2]
- The Department of Irrigation and Drainage (DID) operates a flood forecasting system for six major river basins and Very High Frequency (VHF) flood forecasting systems in some smaller river basins in the urban areas.[2]
- Currently, there are 21 dam-level stations, 22 river water level stations at gauging sites and 48 rainfall stations providing information on the real time situation on storage in dam and river flows including rainfall data.[2]
- The Department of Survey and Mapping of Malaysia collects tidal data and publishes the tide observation record annually. These data are used by NAHRIM to assess the rate of SLR and its impacts.[2]
- There are 22 Department of Survey and Mapping Malaysia tide stations along the coastline in Malaysia.2
- The most recent inventory in Peninsular Malaysia – the Fifth National Forest Inventory (NFI-5) - was completed in 2013 and covered an area of 5,674,131 hectares.[2]
- The monitoring of marine environment in Malaysia is carried by the Marine Parks Department of Peninsular Malaysia, Sabah Parks and Sarawak National Parks and Wildlife Department in collaboration with Reef Check Malaysia (RCM), WWF-Malaysia and other non-governmental organizations and universities.[2]

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