



Review

Climate change in Malaysia: Trends, contributors, impacts, mitigation and adaptations

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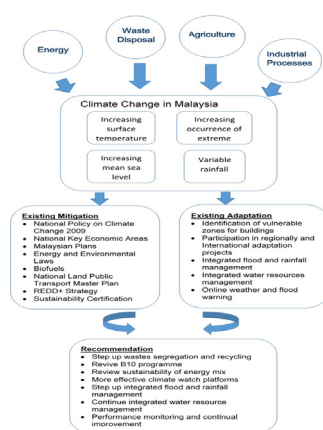
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HIGHLIGHTS

- Surface temperatures, sea level and extreme weather events in Malaysia show increasing trends.
- More emphasis has been placed on mitigation of climate change than adaptations.
- Adaptation strategies which bridge the current gaps of adaptation are crucial.
- The review calls for continual improvement of mitigation and adaptation programmes.
- Stricter enforcement of laws and penalty is crucial for successful mitigation and adaptation.

GRAPHICAL ABSTRACT



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ABSTRACT

Purpose: This paper reviews the past and future trends of climate change in Malaysia, the major contributors of greenhouse gases and the impacts of climate change to Malaysia. It also reviews the mitigation and adaptations undertaken, and future strategies to manage the impacts of regional climate change.

Methodology: The review encompasses historical climate data comprising mean daily temperature, precipitation, mean sea level and occurrences of extreme weather events. Future climate projections have also been reviewed in addition to scholarly papers and news articles related to impacts, contributors, mitigation and adaptations in relation to climate change.

Findings: The review shows that annual mean temperature, occurrences of extreme weather events and mean sea level are rising while rainfall shows variability. Future projections point to continuous rise of temperature and mean sea level till the end of the 21st century, highly variable rainfall and increased frequency of extreme weather events. Climate change impacts particularly on agriculture, forestry, biodiversity, water resources, coastal and marine resources, public health and energy. The energy and waste management sectors are the major contributors to climate change. Mitigation of and adaptations to climate change in Malaysia revolve around policy setting, enactment of laws, formulation and implementation of plans and programmes, as well as global and regional collaborations, particularly for energy, water resources, agriculture and biodiversity. There are apparent shortcomings in continuous improvement and monitoring of the programmes as well as enforcement of the relevant laws.

Originality/value: This paper presents a comprehensive review of the major themes of climate change in Malaysia and recommends pertinent ways forward to fill the gaps of mitigation and adaptations already implemented.

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1. Introduction

Climate change is a global phenomenon and is particularly evident in the past three decades. The Intergovernmental Panel on Climate Change (IPCC), in its Fifth Assessment Report, reveals an increase of average global land and ocean temperature by 0.85 °C from 1880 to 2012. The IPCC is highly confident that the period between 1983 and 2012 was the warmest in the past 800 years (PCC-AR5-WG1, 2013).

While surface air temperature is most commonly used to elucidate climate change, sea level, sea surface temperature, arctic sea ice and the occurrence of extreme weather have also been monitored in tracking the phenomenon (Nakicenovic et al., 2000; PCC-AR5-WG1, 2013). Variation of sea level as a result of climate change is measured using the global mean sea level (GMSL). The rate of sea level variation has shifted from low during the late Holocene in the range of tenths of mm per year, to high presently in the order of mm per year, owing primarily to ocean thermal expansion and glacier melting. Warming ocean has very likely resulted in sea level rise of 0.8 mm/year from 1971 to 2010. The global glaciers have been retracting at a likely rate of 226 Gt/year from 1971 to 2009 and 301 Gt/year between 2005 and 2009. The glacial shrinkage has reached the tipping point and will continue even after the global surface temperature ceases to increase. Similarly, the Greenland ice sheet has been confidently diminishing over the last 20 years (PCC-AR5-WG1, 2013; Kamaruddin et al., 2016).

Warming of the upper ocean was observed between 1971 and 2010 and it is likely that ocean warming had extended to a depth ranging from 700 m to 2000 m from the sea surface between 1957 and 2009. Climate change also leads to extreme weather events in the atmosphere and on the ocean. A highly probable increase of the number of warm days and nights was predicted between 1951 and 2010. Heat wave had occurred more frequently in Europe, Asia and Australia in mid-20th century (PCC-AR5-WG1, 2013). Floods of greater magnitude have also been reported in eastern Asia, northern and central Europe, and the western Mediterranean in the past five centuries. On the ocean, increased frequency of high sea level events have been anticipated since 1970 (Nakicenovic et al., 2000).

Being a global phenomenon, there has been increasing interest to look at how climate change and its impacts unfold regionally, including in Malaysia. Malaysia is a Southeast Asian country consisting of two regions, i.e. the Peninsular Malaysia and the Malaysian Borneo. The country has a total land area of 330,803 km² and an estimated population of 32 million in 2017 (Ab Rahman et al., 2013). The country experiences equatorial climate characterized by hot and humid weather all year round. The annual climate variability is closely tied to the Southwest and the Northeast Monsoons. The Southwest Monsoon occurs in the months of April to September while the Northeast Monsoon occurs from October to March. The Southwest Monsoon features drier weather

with less rainfall compared to the Northeast Monsoon which brings more precipitation (Kwan et al., 2013).

Malaysia has experienced warming and rainfall irregularities particularly in the last two decades, thus, garnering much attention in the study of climate trends and the implications. Sammathuria and Ling (2009) investigated the historical annual mean of daily temperatures as well as annual precipitation for selected regions in Malaysia. The study also included simulations of temperature and rainfall anomalies. The Malaysian Meteorological Department (2009) published a report on climate change scenarios for Malaysia but used data from limited stations to demonstrate the past temperature and rainfall trends. The report focused on simulating regional climate variations.

Much of the research on climate change in Malaysia is dedicated to studying the effects of climate change rather than examining the historical and future trends, and a large proportion of the studies is related to agriculture. A plausible reason that impacts of climate change on agriculture have received much attention in Malaysia is its importance as a major national Gross Domestic Product (GDP) contributor (Department of Statistics Malaysia, 2018). In 2016, agriculture sector comprised 8.1% of the GDP with paddy recorded the second largest agricultural production after oil palm (Department of Statistics Malaysia, 2018). Besides, agriculture is highly dependent on climatic factors, rendering climate change a significant concern to the sector.

The interest in the effect of climate change on paddy was immense with numerous dedicated research. Vaghefi et al. (2011) examined the economic implication of climate change on rice production in Malaysia while Alam et al. (2012) investigated adaptability of paddy farmers to climate change by means of questionnaire survey conducted on 198 paddy farmers in Selangor Malaysia. Prior to this, Alam et al. (2010) also produced guidelines in determining climate change adaptation approach for the Malaysian agricultural sector in general. An earlier study by Matthews et al. (1995) modelled the impact of climate change on rice production in Asia, including Malaysia, with little highlight on adaptation strategies. A statistical approach was adopted by Murad et al. (2010) to establish the correlation between climate change and agricultural growth within a defined duration which the authors found were negative but insignificant. However, the study was not paddy-specific.

With oil palm holding the largest agricultural yield in Malaysia, the research of climate change's impacts on oil palm cultivation does not garner proportional interest as that on paddy. Oil palm cultivation is controversial in the sense that it has been regarded as a culprit of tropical deforestation (Fitzherbert et al., 2008) and contributor of climate change due to cultivation on carbon-dense ecosystems such as peat swamp (Butler and Laurance, 2009). Beyond the agricultural sector, a study on social adaptation of fishermen due to climate change have

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