VULNERABILITY OF MALAYSIA TO SEA-LEVEL CHANGE

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ABSTRACT

Malaysia, with a land area of some 330,000 km^2 and a coastline of some 4,800 km sits on the geologically stable Sunda Shelf. About half the coastline is beaches and slightly less than half is mangrove fringed; there is little rocky coasts. It has been estimated that some 30% of the coastline is subject to varying degrees of erosion.

Sea level was some 120 metres below the present level during the last glacial (some 12,000 year BP) but rapidly rose to some 5 metres above the present level some 5,000 year BP before falling gradually to its present level. Thus over the last 5,000 or so years there has been a fall in sea level (a mean rate of about 1 mm per year) around the Malaysian coast. Unfortunately, there has not been any accurate enough measurements to show if this rate has changed in the past couple of hundred years (since the industrial revolution, when humans, through the burning of fossil fuels, have significantly increased the concentration of atmospheric carbon dioxide).

Its human population of 23 million is small for countries in the region but its population growth rate of some 2.4% is amongst the highest. Over 60% of the population lives along or close to the coasts. Although the human population is relatively small, development along the coasts and hinterland has been extensive. Extensive areas were harvested for timber or converted to rubber (and later to oil palm) and agriculture and alluvial tin mining was rampant (in the Peninsula). It must be noted that despite these activities some 210,000 km^2 of land was still under forest cover (with the an annual deforestation rate of around 2,200 km^2). Erosion is significant and may contribute to coastal sedimentations rates (in protected areas) of a few millimetres per annum. Many coastal areas (especially where mangroves occur) have been bunded (to prevent saline or tidal intrusion) and reclaimed or have been raised above sea level by pumping in sand from the surrounding sea or from imported sand.

There is generally no feeling of vulnerability to sea level rise as the geological evidence shows that Malaysia may not be (for the time being, at least) vulnerable. Nevertheless Malaysia has taken a precautionary approach by considering the possible biophysical and socioeconomic impacts of different sea-level rise scenarios. This was in a recent submission of Malaysia's Initial National Communication to the United Nations Framework Convention on Climate Change (Ministry of Science, Technology and the Environment).

1. Background

Malaysia, with a land area of some 330,000 km^2 and a coastline of some 4,800 km sits on the geologically stable Sunda Shelf. There is thus only some 69 km^2 of land per km of coastline. About half the coastline is beaches and slightly less than half is mangrove fringed; there is little rocky coasts. Geologically the coast on the Peninsula is oldest and the more jagged coast of Sabah, the youngest. There was active geological activity (folding and uplift) on the Peninsula during the late Jurassic some 200 million years ago) but in Sarawak and Sabah folding and lifting occurred more recently (during the Pliocene, some 5 million years ago) and in Sabah, uplifting is still evident today (e.g. Mount Kinabalu continues to increase in height). The Holocene marine transgression saw the rapid rise of sea level from over a hundred metres below its present level some 12,000 years ago and reaching some 5 metres above the present level some 6,000 years ago. This was followed by a sea recession, with the sea level falling to its present level. This last transgression and recession, and the accompanying erosion and depositional processes, has resulted in the coastal geomorphology that is seen today. The in filling process is less complete in Sabah, hence the more jagged coastline.

Accretion and erosion processes continue. It has been estimated that, at present, some 30% of the coastline is subject to varying degrees of erosion. Except in very localised areas, this should not be a problem. Unfortunately, bylaws on set-backs for development are often not adhered to, resulting in damage or threatened damage to man-made structures. Hard engineering solutions are often applied but these are costly and inefficient in the long term, at best or cause downstream problems, at worst.

Malaysia's human population of some 23 million is small for countries in the region but its population growth rate of some 2.4% is amongst the highest. Per-capita GDP (Purchasing-Power Parity, based on World Bank ratios) is $8,513 with a growth of 8.8%. Per-capita GNP is $3,248. Life expectancy is 72 years and infant mortality, 8 deaths under the age of one per 1000 live birth. There is 1 telephone to every 5 people and 1 doctor to every 1,477 people. The literacy rate is 93.7%. Much (over 60%) of the population lives along or very close to the coast (Malaysian Ministry of Science, Technology and the Environment, 2000).*

*[The figures in paragraph 3, above, were taken from the 20 October, 2000 issue of Asiaweek]

Although the human population is relatively small, development along the coasts and hinterland has been extensive. Extensive areas were converted to rubber (and later to oil palm) and agriculture. Timber extraction was extensive in the second half of the twentieth century. Alluvial tin mining was rampant (in the Peninsula) from the 1940s to the 1970s. It must be noted that despite these activities some 190,000 km^2 of land (1994) was still under forest cover (with the an annual deforestation rate of around 2,200 km^2, for 1986 to 1990). Erosion is significant and may contribute to coastal sedimentations rates (in protected areas) of a few millimetre per annum.

Extensive areas of mangroves (especially on the Peninsula) have been cleared and reclaimed for agriculture, aquaculture, industry, housing and other uses (Ong, 1982). At least half of the mangroves on the Peninsula has been lost in the past 50 years. Bunds are built at the edge of the reclaimed land with whatever that is left of the mangroves to prevent saline and tidal intrusion. Thus, for most of the mangroves on the Peninsula, there is no more room for mangrove colonisation should there be a rise in sea level (Ong, 1994 & Ong, 1998). If sedimentation does not keep pace with sea level rise then the remaining mangrove will eventually drown.

On the Peninsula and to a much lesser extent in Sabah and Sarawak, there has been reclamation of land from the sea. There are plans for huge areas of shallow seas on the west coast of the Peninsula to be converted to dry land. Significant areas have been converted in Penang and Malacca. This reclamation is done either by pumping in sand from the adjacent seabed or by importing fill from other areas (e.g. sand is imported from Indonesia but sand was also exported to Singapore). Many of these projects do not even mention sea level rise!

Tourist hotel development sits on most of the sandy beaches. In many areas the development densities are high and often, development goes not only right to the water's edge but right into the sea (building sitting on stilts). It is not known if such developments take into account sea level rise and its associated consequences (e.g. larger waves as a result of increasing depth).

2. Sea Level Change Assessment

Sea level change is a certainty but trying to determine how much and in which direction on a short time scale (tens of years) is a very complex and difficult exercise. Many factors are involved: apart from the expansion or contraction of seawater with change in global temperatures and the freezing or melting of ice which causes a global change (or what is known as the eustatic change), there are many local conditions like the rise or fall of land due to plate movements or the elastic rebound of plates from ice melts (tectonic change) as well as the local rate of sedimentation in the coastal area. Thus if the climate change effects are not severe (e.g. only a few millimetres a year) local factors may work in the opposite direction at an even greater rate. Different regions will be affected differently.

Sea level was some 120 metres below the present level during the last glacial (some 20,000 y BP) but rapidly rose (starting from some 12,000 y BP) to about 5 metres above the present level some 6,000 y BP before falling gradually to its present level. Thus over the last 5,000 or so years there has been a fall in sea level (at a mean rate of about 1 mm per year) around the Malaysian coast. There is good geological evidence for this (e.g. see Geyh *et al.*, 1972 & Kamaludin, 1989).

Unfortunately, there has not been any accurate enough measurements, in Malaysia, to show if this rate has changed in the past couple of hundred years (since the industrial revolution, when humans, through the burning of fossil fuels, have significantly increased the concentration of atmospheric carbon dioxide). Peltier & Tushingam (1989) estimated that the global sea level change (isostatically filtered tide gauge data) over the past 50 years to be +2.4±0.9 mm y^{-1}.

If there is little or no tectonic change, then sedimentation would be playing a very important role in maintaining the sea level around the Malaysian coast. Erosion figures for the Peninsula, Sabah and Sarawak are 355, 518 and 1,524 tonnes km^{-1} (MOSTE, 2000). The differences are due to land use practice with more shifting cultivation (on hill slopes) and timber harvests in Sabah and even more so in Sarawak. These translate to a few millimetres of (vertical) sedimentation in the near coasts per year, more than enough to offset the global (eustatic) tidal level change.

3. Vulnerability Assessment

There is no official view as to whether rising sea level is a problem but Malaysia has recently considered a number of scenarios based on IPCC predictions. The two tables (below), taken from the Malaysia Initial National Communication submitted to the United Nations Framework Convention on Climate Change (MOSTE, 2000) is the official vulnerability assessment.

A number of adaptive measures were also suggested, which included: defence (essentially hard engineering solutions), accommodation, retreat, counter attacking (by reclaiming land from the sea), coastal land buy back (buying coastal land from the private sector and converting to buffer zones and reserves) and integrated coastal zone management.

Table 1. Biophysical Impacts Resulting from Sea Level Rise [from: MOSTE,2000]

Type of Bio-physical Impact	*Sea Level Rise Scenarios (Year 2100)* 20 cm (or 0.2 cm/yr)	*50 cm (or 0.5 cm/yr)*	*90 cm (or 0.9 cm/yr)*
Tidal Inundation			
(a) Mangrove fringed mudflats			
(i) Bunded	Insignificant as bunds will be raised	Insignificant as bunds Insignificant as bunds	Perhaps 300 m strip may be lost (retreat bund)
(ii) Unbunded	Insignificant as bunds are likely to be built	Insignificant as bunds are likely to be built and topped up	Perhaps 300 m strip may be lost (retreat bund)
(b) Sandy shores	Insignificant as existing ground level is higher	Insignificant as existing ground level is higher	Insignificant as existing ground level is higher
(c) Increased flooding	Reduced drainage efficiency of tidal control gates	Reduced drainage efficiency of tidal control gates	Tidal gates rendered non-operational and replaced by pumped drainage
Shoreline Erosion			
(a) Sandy shoreline	Insignificant	Insignificant	Insignificant
(b) Mangrove loss	Vertical accretion rate able to keep pace	Vertical accretion rate able to keep pace	Total mangrove loss
Increased Wave Action	Insignificant	Reduced factor of safety, but taken into account during refurbishment if necessary	Taken into account during refurbishment
Saline Intrusion	Unlikely to be of concern due to shift towards reservoir development		

Table 2. Socio-economic Impacts resulting from Sea Level Rise [from: MOSTE,2000]

Type of Impact	Socio-economic Impacts based on High Rate of Sea Level Rise (0.9 cm/yr).
Loss of agricultural production from eroded/ inundated lands	RM46 million for Western Johor Agricultural Development Project area. The West Johor Project area accounts for about 25% of the national drainage areas.
Displacement and relocation of flood victims with associated disruption of business / economic activities resulting from increased flooding	Long-term annual flood damage estimated at about RM88 million for Peninsular Malaysia and RM12 million for Sabah/Sarawak based on 1980 price level. If the flood frequency is doubled, the annual flood damage will increase by 1.67 times.
Loss of fisheries production due to mangrove loss	RM300 million loss based on 20% loss of mangrove resulting in a loss of about 70,000 tonnes of prawn production valued at RM4,500/tonne.
Interruption of port operation	May see some improvement due to reduced siltation.

4. Discussion

The geological evidence suggests that relative sea level, in the Strait of Malacca, has been falling for the past 5,000 or so years (at a mean rate of around 1 mm y^{-1}). The global tidal level is dropping at 2.4 ± 0.9 mm y^{-1}. The sedimentation rate is in the region of a few millimetres per year and this appears to be playing a critical role in relative sea level change in Malaysia. Since there is no reliable direct measurements of the rate of relative sea level change around the coast of Malaysia to show otherwise, the general perception is that Malaysia may not be (for the time being, at least) vulnerable to sea-level rise. In its submission of the 'Initial National Communication' to the United Nations Framework Convention on Climate Change, Malaysia has taken a precautionary approach by considering the possible biophysical and socioeconomic impacts based on different predictions of sea level rise.

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