Impacts and adaptation to climate change in Malaysian real estate

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Abstract

Purpose – There is a growing concern in recent years regarding climate change risks to real estate in the developed and developing countries. It is anticipated that the property sector could be affected by variable climate and related extremes as well as by the strategies adopted to combat greenhouse gas (GHG) emissions. This paper aims to analyse the current knowledge regarding future climate changes to understand their possible impacts on the real estate sector of Malaysia with an aim to help stakeholders to adopt necessary responses to reduce negative impacts.

Design/methodology/approach – Available literature is reviewed and data related to climatic influences on buildings and structures are analysed to understand the climate change impacts on real estate in Malaysia.

Findings – The study reveals that temperature in the Peninsular Malaysia will increase by 1.1 to 3.6°C, rainfall will be more variable and river discharge in some river basins will increase up to 43 per cent during the northeast monsoon season by the end of this century. These changes in turn will pose risks of property damage and increase property lifecycle costs. Furthermore, property prices and the overall growth of the property sector may be affected by the government policy of GHG emission reduction by up to 45 per cent by the year 2030. This study concludes that the property sector of Malaysia will be most affected by the implementation of GHG emission reduction policy in the short term and due to the physical risk posed by variable climate and related extremes in the long term.

Originality/value – The study in general will assist in guiding the operational responses of various authorities, especially in terms of those interventions aimed at climate change risk reduction in the property sector of Malaysia.

Keywords Climate change, Real estate, Adaptation, Extreme events, Greenhouse gas emission

Paper type Research paper

1. Introduction

The climate of Malaysia is changing in line with global climate change (NAHRIM, 2006; Shaaban *et al.*, 2008, 2012; Deni *et al.*, 2008; MMD, 2009; Mayowa *et al.*, 2015). It is anticipated that climate change will affect water resources, public health, agriculture, energy,

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infrastructure and many other sectors of Malaysia in number of ways (Yusuf and Francisco, 2009; Shaffril *et al.*, 2011; Begum *et al.*, 2011; Vaghefi *et al.*, 2011; Ahmed *et al.*, 2011; Shahid *et al.*, 2015; Shahid and Minhans, 2016). There is a growing concern in the recent years about climate change risks to real estate in the developed and developing countries (Parkinson, 2009; WRI, 2010; Toller *et al.*, 2011; Butsic *et al.*, 2011). Although the connections between climate changes and their impacts on the property sector are yet not well understood, it is anticipated that the sector could be vulnerable due to variable climate and related extremes, as well as to policies adopted to combat greenhouse gas (GHG) emissions. A number of studies (NAHRIM, 2006; Shaaban *et al.*, 2008, 2012; Deni *et al.*, 2008; MMD, 2009) show that climate change will increase daily temperature, change precipitation patterns, raise the sea level, increase soil salinity, change soil moisture levels and land stability and increase the frequency and severity of extreme events. These changes may pose risk of damages to property structures (Parkinson, 2009; Warren, 2010; Eves *et al.*, 2010; Ayyub *et al.*, 2012). Climate change may cause constraints on energy and water resources (WRI, 2010; Toller *et al.*, 2011). As 80 per cent of a building's lifecycle costs are water and energy related, climate change may raise utility prices and property lifecycle costs (Shafie *et al.*, 2011; WRI, 2010). On the other hand, the real estate sector will be financially affected by government policies to reduce the GHG emissions. Malaysia has agreed to reduce its carbon dioxide emissions by up to 45 per cent by 2030 compared with 2005 levels (CarbonBrief, 2015). It is reported that a major portion of energy consumption, carbon dioxide emissions and solid waste are directly or indirectly related to the Malaysian property industry (Koh, 2010; Shahid *et al.*, 2014). Therefore, real estate has to play a major role to ensure climate-resilient development to fulfil national aspirations for sustainability. This will certainly affect the property price and overall growth of the property sector.

Malaysia property market is currently in the early stages of a promising growth spurt (Razak *et al.*, 2013). Due to a strong economic climate and government policies to encourage foreign investment in real estate, many worldwide property purchasers are currently looking to Malaysia as a lucrative property market in which to invest. Despite a challenging external economic environment, the property sector in Malaysia grew 6.8 per cent in 2011 (Bursa Malaysia, 2011). At present, the real estate sector directly contributes 4.2 per cent to Malaysian gross domestic product (BFTA, 2014). Malaysia aspires to become one of the largest contributors of property development in the Asia-Pacific region (Hamzah, 2011). Climate change may pose a challenge to this aspiration. A study to identify the possible ways by which climate change may pose a risk to the property sector of Malaysia is therefore very important.

Though climate change is supposed to play a decisive role in property business and management in the near future, only a few studies existing regarding climate change impacts on the real estate sector (Rubin and Hilton, 1996; Parkinson, 2009; Warren, 2010; WRI, 2010; Ayyub *et al.*, 2012; Jia and Tang, 2011; Butsic *et al.*, 2011). Rubin and Hilton (1996) analysed the development impacts of climate variation in the Pere Marquette Watershed region of central-western Michigan (the USA) and reported that employment in real estate sector is sensitive to climate variation. Parkinson (2009) proposed that many property investments with a design life of 30 to 75 years or more are on a collision course with rising sea level; therefore, the resulting impacts will be significant. Warren (2010) produced a detailed literature review of current climate change predictions and the likely consequences of building assets in the face of extreme weather events. Ayyub *et al.* (2012) studied the impacts of climate change-induced sea level rise on real estate property in the city of Washington (the USA) and reported damages to the local properties of US$2bn. Jia and Tang (2011) analysed the constraints of low-carbon real estate development and suggested structure optimisation

of the real estate industry. Butsic *et al.* (2011) used a hedonic framework to estimate and simulate the impact of global warming on real estate prices near ski resorts in the western USA and Canada and found that changes in snowfall will affect property values. Water Research Institute (WRI, 2010) assessed the financial impacts of select environmental trends on current and planned real estate properties in India, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. The study proposed that emerging energy insecurity, water scarcity and climate change trends in South and Southeast Asia would affect the risk and return associated with investments in real estate. McNamara and Keeler (2013) modelled the dynamics of coastal adaptation, as the interplay of underlying climatic risks and reported that property owners invest heavily in defensive expenditures in the near-term and then abandon coastal real estate at some critical risk threshold that presages a period of significant price volatility. McNamara *et al.* (2015) developed an empirical model coupling coastal property markets with shoreline evolution and reported that the policy-induced inflation of property value grows with increased erosion from sea level rise or increased storminess. Hirsch *et al.* (2015) assessed the climate change risks for real estate and reported that the real estate industry will be affected by a significant rise in monetary damages caused by extreme weather events.

Punctual attention can substantially reduce the negative impacts of climate change on the property sector of Malaysia. The objective of this study is to summarise the present knowledge of possible direct and indirect effects of climate change on property infrastructure and property prices in Malaysia to propose necessary adaptation measures. It is hoped that the study will help raise awareness among developers, policy makers and agencies related to the property sector of Malaysia to incorporate climate resilience policies in future development.

2. Methodology

Climate change impacts on real estate are analysed based on historic changes and future projections of the climate and climate-related extreme events in Malaysia. Literature available on climate change in Malaysia is thoroughly reviewed to identify possible changes in temperature, rainfall, extreme weather events, floods, river discharges, soil moisture, sea level rise, salinity, etc., that could affect the property sector of Malaysia. In some cases, data are collected from corresponding departments or organisations to anticipate the changes. For example, historic rainfall and temperature data are collected from the Malaysian Meteorological Department (MMD), information related to floods are collected from National Hydraulic Research Institute of Malaysia (NAHRIM), statistical data related to population, water and energy uses, etc., are collected from the Malaysian Statistical Department, and information related to sea level rise is collected from the Department of Irrigation and Drainage (DID), Malaysia. These data are used to understand changes in rainfall, temperature, salinity, urban population, property development, water and energy uses, floods and climate-related extreme events in Malaysia. Information about the property sector of Malaysia is gathered from available literatures, such published journal articles, annual reports, newsletters, booklets and online databases of various organisations responsible for property development and management in Malaysia. Impacts of climate change on real estate are identified through analysis of information gathered from the above-mentioned sources as well as other published materials such as newspaper and magazine reports.

3. Climate variability and changes in Malaysia

Situated in the equatorial region, Malaysia has a tropical climate characterised by uniform high temperatures, high humidity and abundant rainfall. The heaviest rain spells are usually observed on the east coast of the Peninsular Malaysia during the northeast monsoon season.

On the other hand, the months of June and July during southwest monsoon are the driest period when most regions of the peninsular, except the southwest coastal region, experience minimum monthly rainfall of typically only 100 to 150 mm (Pour *et al.*, 2014). Being an equatorial country, Malaysia experiences uniform temperature throughout the year. The annual variation is less than 2°C around the mean temperature of 27°C. The daily range of temperature is large, ranging from 5 to 10°C at the coastal stations and from 8 to 12°C at the inland stations. The excessive day temperatures, which are found in continental tropical areas, are never experienced. The mean monthly relative humidity in Malaysia ranges between 70 and 90 per cent (Lim and Abu Samah, 2004).

Past records of Malaysian climate show a similar trend to that encountered globally (IPCC, 2007). The country's temperature increased 0.18°C per decade since 1951 (MOSTE, 2000). A recent study revealed an average annual rise of sea level of approximately 1.25 mm/year since 1986 at a southern coastal site in the Peninsular Malaysia (INC, 2000). A study by NAHRIM (2006) showed larger increase in minimum surface temperature of 1.5°C over the past 50 years for the Peninsular Malaysia compared to mean and maximum surface temperatures. Annual averaged daily mean temperature at the Subang (Kuala Lumpur) station over the period 1961 to 2015 is shown in Figure 1 and clearly indicates a trend of increasing temperature. Increasing trends in number of extreme indices, such as number of days with extreme rainfall, number days with extreme wind and number of thunderstorm days, are observed on the Peninsular Malaysia (MMD, 2009).

A number of studies carried out by different organisation aimed to predict the future climate of Malaysia (NAHRIM, 2006; Wan Azli *et al.*, 2008; MMD, 2009; Shaaban *et al.*, 2012; Paterson *et al.*, 2015). NAHRIM (2006) projected a substantial increase in mean monthly rainfall over the northeast coastal region and over Kelantan and a decrease in mean monthly rainfall over Selangor and Johor. In terms of river discharges, an increase in mean monthly river discharge is predicted in Kelantan and Pahang and a decrease in Selangor and Johor. The maximum monthly flow is projected to increase by 11 to 43 per cent in Kelantan and Pahang from the base years (1961 to 1990) (MMD, 2009; Shaaban *et al.*, 2008). High variability in inter-annual and inter-seasonal rainfall and river discharge is projected on the Peninsular Malaysia by climate models (Shaaban *et al.*, 2008, 2012; NAHRIM, 2006). In some parts of the Peninsular Malaysia, the frequency of long dry periods will be higher, with a significant increase in the mean and variability of the length of the dry spells (Deni *et al.*, 2008). At the same time, there will be a significant increase in the overall mean monthly streamflow in the watersheds of

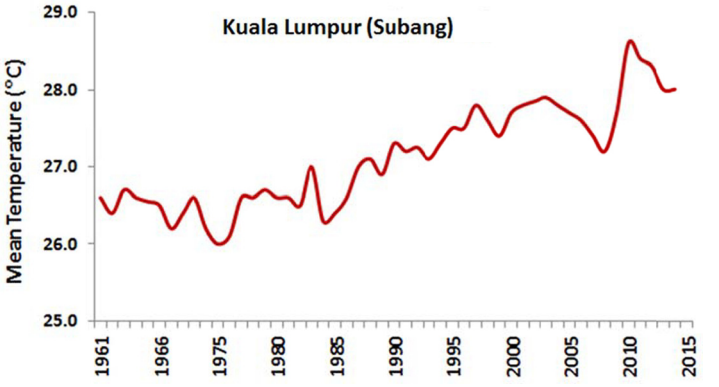

Figure 1.
Trend in annual averaged daily mean temperature at Subang station during 1961 to 2015

Kelantan and Pahang, and high flow conditions will be magnified in Kelantan, Terengganu, Pahang and Perak watersheds during the wet months (Shaaban *et al.*, 2008). Therefore, the projections indicate more frequent hydrologic extremes, such as floods, droughts, etc., in Kelantan, Pahang, Terengganu and Kedah. Paterson *et al.* (2015) used two Global Climate Models (GCMs), namely, CSIRO-Mk3.0 and MIROC-H, to explore the impacts of climate change in Malaysia under the A1B and A2 climate change scenarios for 2030, 2070 and 2100. They also reported an increase in heat stress and dry stress in Malaysia and the surrounding region.

The MMD (2009) conducted climate simulations for the Malaysian region using nine coupled Atmosphere-Ocean GCMs (AOGCMs) based on the A1B scenario. Projections of temperature and rainfall by different AOGCMs for the Peninsular Malaysia are shown in Figures 2(a) and (b), respectively. The results indicate a rise of temperature in the Peninsular of Malaysia at the end of this century in the range of 1.1 to 3.6°C. The spatial distribution of projected rainfall in the Peninsular Malaysia by climate models (Figure 3) shows an increase in rainfall over the western Peninsular Malaysia and a decrease in the eastern Peninsular Malaysia. A Regional Climate Model known as PRECIS under A1B emission scenario also projected an increase in rainfall and temperature in the Peninsular Malaysia by the end of this century.

The Intergovernmental Panel on Climate Change (IPCC) reported an increasing trend of significant wave heights in the South China Sea and eastern parts of the Andaman Sea, which directly impacted Malaysian coasts over the past 50 years (IPCC, 2007). According to Malaysia Initial National Communication (INC, 2000), the rise in the sea level was about 13 to

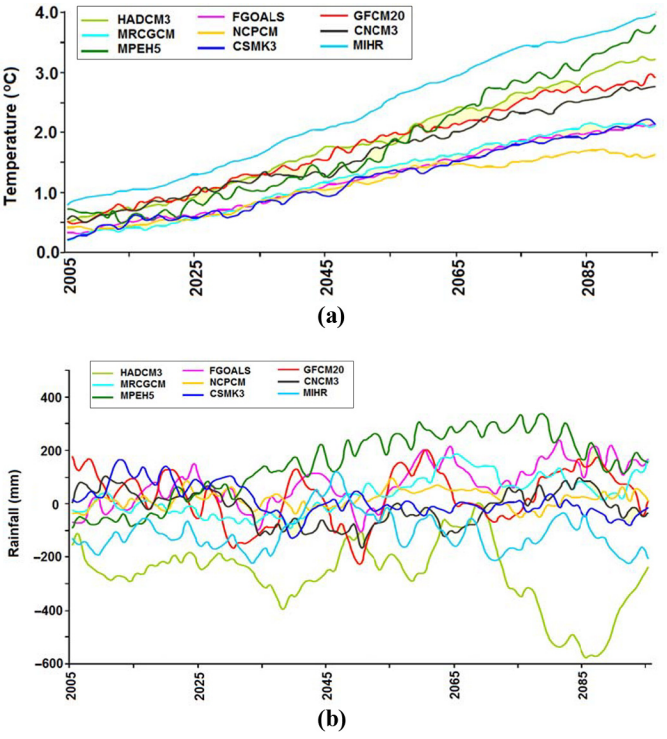

Figure 2.
Projected (a) temperature and (b) rainfall relative to the baseline (1961-1990) for the Peninsular Malaysia based on A1B Special Report on Emissions Scenario (SRES)

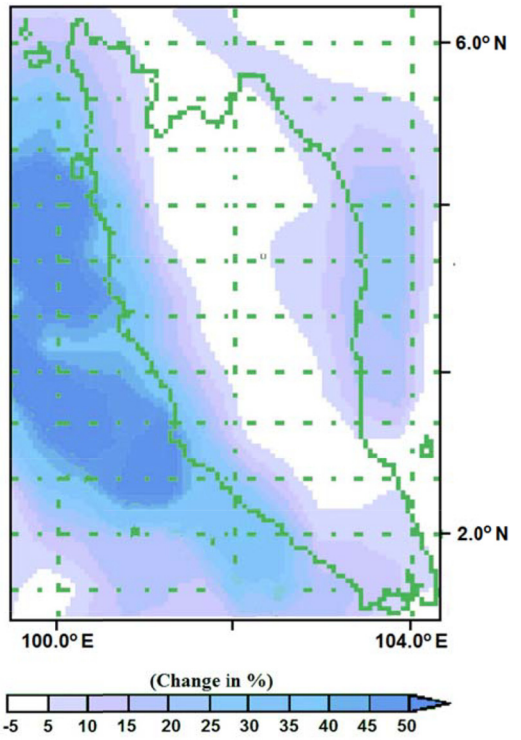

Figure 3.
Annual mean rainfall anomaly (percentage) predicted during the period 2090 to 2099 relative to 1990 to 1999

94 cm over the past 100 years on the east coast of Malaysia and is set to continue to increase up to 1 m by 2100 (Frihy, 2003).

The review of possible changes in climate discussed above reveals that Malaysia is already facing higher daily temperatures, which will continue to increase. Though an increase in rainfall in Malaysia is predicted by most of the climate models, it is still not yet significantly observable. Therefore, it can be said that the imminent impacts of climate change in Malaysia will be due to the higher daily temperatures and temperature-related extreme events. The impact of rainfall-related extremes should be more prominently visible in the later part of the present century.

4. Impacts of predicted climate change on the Malaysian real estate sector

Climate change and real estate research can be divided into two broad branches: impact of climate change on property infrastructure and impacts of GHG emission reduction measure on real estate. The first branch of study analyses the possible impacts of predicted climate change on the real estate sector. The second branch of the study analyses the policies to reduce GHG emissions and the effect they have on the real estate sector. In the following sections, both the vulnerability of the property sector to climate change and the impacts of GHG reduction initiatives on the real estate sector are discussed.

4.1 Vulnerability of real estate to climate change

Malaysia is considered as a moderately vulnerable country to climate change (Guillaumont and Simonet, 2011; Center for Global Development, 2012), and a combination of higher

temperatures and potential increases in extreme weather events may create conditions unfavourable for real estate. Possible ways by which climate change may physically affect the property sector of Malaysia are discussed in following sections. Possible impacts of climate change on the real estate sector in Malaysia are arranged in the following section according to the certainty and timing of impacts. The certainty of impact uses available knowledge of climate change to assess the likelihood of impacts and the timing implies whether they are likely to manifest themselves in the first or the second half of this century. Impacts of the changes of different climatic variables like rising temperature, variable precipitation, etc., are arranged according to primary and secondary impacts.

4.1.1 Rising temperature. Rising temperature may directly affect property in number of ways. Temperature and humidity have a major effect on dyeing, and thus increased temperatures may affect paintwork and exterior finishes, leading to the requirement for more frequent maintenance of properties (Austin *et al.*, 2008). High temperatures, along with higher humidity levels due to increased rainfall, can also increase concentrations of some indoor pollutants (EPA, 2012). The rate at which products like pressed wood or textiles release formaldehyde can change. Formaldehyde emissions will generally decrease as products age (EPA, 2012).

Secondary impacts of rising temperature will be more diverse compared to direct impacts. Located in the tropics, Malaysia experiences hot weather all over the year. Therefore, a huge amount of energy is used in Malaysia for space cooling. On average, space cooling accounts for nearly 40 per cent of a building's total energy requirements (Dong, 2010). Increased baseline temperatures will lead to overheating of buildings, which will lead to increased electricity demand for artificial cooling. This will certainly raise building operational costs. Rising temperatures due to climate change in combination with urban heat island effects will exacerbate the condition in big cities. The main cause of power failures in residential buildings is the power demand surge during peak load hours, and it is likely that there will be more power failures due to increased extreme hot weather events if proper measures are not taken.

Rising temperature may cause a number of negative impacts on power generation and distribution in Malaysia. Reduction in the efficiency of power plants and greater losses in transmission and distribution are likely to occur in Malaysia, as in other tropical countries (Shahid, 2012). This may raise electricity prices and building operation costs.

With economic development, water demand in the urban areas of Malaysia has increased rapidly. Though the per capita water demand has decreased in recent years, in the areas surrounding Kuala Lumpur where much of the recent urban development has taken place, total water use has increased rapidly (Bari *et al.*, 2015). A recent report showed that total water demand in greater Kuala Lumpur increased from 2,858 million litre per day in 2000 to 4,563 million litre per day in 2014. As there is a direct relation between temperature and water demand, climate change-induced temperature rise will certainly raise the per capita water demand in Malaysia. Capital investments for dams and other engineering constructions to enhance water supply to meet the rising demand are supposed to affect water price and, consequently, property operation costs.

Higher temperatures may increase the risk of aggressive insect infestation, such as wood-boring and other invasive insects. Rouault *et al.* (2006) investigated the impacts of high temperatures on forest insects and noted that wood-borers were positively influenced by the high temperatures. Populations of many types of mites and insects responsible for destroying timber and wood products would benefit from climatic warming (Peterson, 2010; Ahmed *et al.*, 2011). Ahmed *et al.* (2011) reported that the potential for increases in economically devastating termite outbreaks in response to climate change is high. It is likely

that changes in termite populations will keep pace with gradual warming (Peterson, 2010). Therefore, termites are expected to develop more quickly and to expand more quickly under climate change scenarios in many parts of the world. How much termite damage will increase in these areas will thus depend not only on the degree to which the climate changes but also the degree to which termite-preventative measures are taken. According to Colins *et al.* (2007), the biggest influence climate change will have on termites may be the influence it has on house construction. Though it is not possible to project accurately how much potential termite damage may cost as a result of climate change, in a general sense, termite populations are likely to increase everywhere, and structures with no treatment or a failed treatment will be more likely to be damaged by termites (Peterson, 2010). Building practices that emphasise the long-term protection of wood is essential for termite protection.

4.1.2 Changing rainfall patterns and floods. Most of the climate models predict increasing rainfall in the coastal regions of the Peninsular Malaysia, which may cause more floods. Increased frequency of extreme rainfall may also cause frequent flash floods in urban areas of Malaysia. The real estate sector may be directly affected by flooding if flood-proofing measures are not incorporated in construction and planning.

A number of studies indicated that the occurrence of flooding reduces a property value compared to similar properties without flooding (Eves, 2002; Eves *et al.*, 2010; Guttery *et al.*, 2004). Kauko *et al.* (2002) reviewed empirical literature and found flooding and drought to be an extreme negative and to cause a reduction in property value. Recent floods in Thailand slowed property sales drastically in a short period. It was reported that demand patterns in terms of preferred location and product in Bangkok changed, as buyers are hesitant to purchase in areas where heavy floods have occurred. Building construction costs also increased, as buyers now pay more attention to design features, and flood protection measures and developers need to ensure flood protection features (Property Wire, 2011). Similar trends were reported in Shah Alam, Malaysia, where floods have reduced property prices by 10 to 30 per cent in recent years (Gomez, 2006).

Intense rainfall events projected by climate change models might also have direct impacts on property. The risk of water penetration through exterior walls will increase, which will affect the integrity of the building surface. Driving rain will affect properties with rendered walls to a greater extent than those with cladding (Lisø *et al.*, 2003). Cavity wall insulation, which is often recommended to increase the thermal efficiency of buildings, may actually render buildings more vulnerable to rain penetration in conditions of intense rain. Increased cavities and gaps in the insulation may be needed to address this problem (Sanders and Phillipson, 2003). These all together may increase capital and maintenance costs of property.

Malaysia has heavy rainfall and warm sunshine all year round. This implies that buildings in the country potentially weather rapidly, particularly in respect to external building materials that are exposed to external elements, such as rain and solar radiation (Ahmad, 1994). Higher rainfall and temperature, as well as more extreme rainfall and temperature events, may aggravate the situation. The combination of rising temperatures and changing rainfall patterns may alter humidity and moisture levels, which in turn may cause fungal stain, harmful growth, peeling paint, erosion of mortar joints and defective plaster, etc. (Ahmad, 1994).

There may be a number of secondary impacts of changing rainfall patterns on the property sector. Changing rainfall patterns may create problems of water management with greater fluctuation in water supply over time and space. Long dry spells and decreased rainfall in some parts of Malaysia, such as Selangor and Johor, are predicted by climate models. Supply enhancement to meet increasing water demands will increase water prices and consequently building operation cost.

Post-flooding construction costs always increase due to a high demand for construction materials and skilled labour, particularly qualified technicians and contractors to restore damaged properties. Affordability and pricing are also affected, particularly for the entry level and middle market, as many buyers face additional expenses such as repair or replacement of damaged cars. As the intensity and impact of flooding due to climate change is a growing concern in Malaysia, increased floods due to climate change will likely affect property prices and the property market in the country in the near future.

4.1.3 Changing soil moisture and land stability. Landslides are a common feature of tropical Malaysia where heavy rainfall plays a major role in soil erosion and destabilisation. A total of 26 landslides were recorded in Malaysia between 1993 and 2002, resulting in 150 deaths and thousands of evacuations. This equates to an average of almost three landslides a year, with approximately 6 deaths per incident (Mohd Ishak *et al.*, 2008). As a consequence of increased extreme rainfall events due to climate change, increases in landslide activity may occur in Malaysia. Jakob and Lambert (2009) studied the climate change effects on landslides on the southwest coast of British Columbia, and their results supported the earlier prediction of increased landslide frequency in the twenty-first century. Moore *et al.* (2010) and Winter *et al.* (2010) reported strong relationships between antecedent rainfall, groundwater and ground movement rates, confirming that prolonged periods of heavy rainfall and excess groundwater levels are a fundamental control on landslide behaviour. Therefore, sea level rises and increased rainfall due to climate change may accelerate ground movement rates resulting in more frequent landslide events.

Mohd Ishak *et al.* (2008) reported that many slopes in Malaysia are stable in unsaturated conditions but fail during or soon after a rainfall event. Rapid urbanisation, over-development and deforestation further aggravated soil destabilisation, with a greater number of heavy, concrete structures being built upon gradually weakened earth. Gofar *et al.* (2005) reported that the main factor contributing to landslides in Malaysia is the reduction of shear strength due to an increase in soil moisture content prompted by the formation of tension cracks on the ground surface of the slope. They studied landslides in 2002 and found that this year experienced a longer and much dryer period than the 20-year rainfall average. This distinctive climate variation is one of the factors that lead to the landslides. The study suggested that the main causes of land failure are dramatic changes in climate and rainfall patterns (Gofar *et al.*, 2005). Therefore, it is very clear that the higher frequency and magnitude of extreme weather events due to climate change will result in frequent rainfall-triggered landslides in Malaysia. Climate change may promote landslides in other ways as well. A recent landslide in Yemen, which claimed 60 lives, was blamed on mountain boulders shifting due to changes in temperature. As landslides represent a major threat to property and constructed facilities in Malaysia (Nadim and Solheim, 2009), it can be concluded that more landslides triggered by climate change will severely affect the real estate sector of Malaysia.

4.1.4 Sea level rise. The major impacts of sea level rises are the reduction of fresh water availability by salinity intrusion, increase soil salinity and increased coastal erosion. These may affect property in number of ways. Increasing soil salinity due to sea level rises is a major problem in many countries of the world (Faye *et al.*, 2009; Essink *et al.*, 2010). According to Hashim (2009), a 1,116 km^2 area of Malaysia is already saline affected. A study shows that salinity in some parts of the coastal region of Malaysia has increased in recent years (DID, 2011). Salts dissolved in saline water can move with water into building materials by capillary action. Increased soil salinity due to sea level rises may cause damage to houses, buildings and other structures in coastal regions through the deterioration of brick, mortar and concrete due to saline water crystallising in brickwork. It may cause

corrosion of metal in structural concrete buried in the ground as well as underground pipes, cables and other infrastructures. It may also cause shifting or sinking of foundations, which in turn may result in structural cracking, damage or collapse.

Most parts of the Malaysian coast are low-lying areas with an elevation of less than 0.5 m above the highest tide, or are within 100 m inland of the high-water mark (DID, 2011). Therefore, the coastal region of Malaysia is highly vulnerable to sea level rises leading to coastal erosion, inundation and coral bleaching. The National Coastal Erosion Study revealed that about 29 per cent of the Malaysian coastline is facing erosion (DID, 2011). Therefore, climate change-induced sea level rises and related extremes may aggravate the coastal erosion and put property in coastal areas of Malaysia at risk.

4.2 Impacts of greenhouse gas reduction initiatives on real estate

Malaysia agreed to reduce its carbon dioxide emissions by up to 45 per cent by the year 2030, compared with 2005 levels (CarbonBrief, 2015). Toller *et al.* (2011) assessed the life cycle of Swedish property and reported that the real estate management sector contributes between 10 and 40 per cent of hazardous chemical products and emissions of gases contributing to climate change. A similar study in Malaysia reported that up to 40 per cent of energy consumption, 40 per cent of carbon dioxide emissions and up to 40 per cent of solid waste are directly or indirectly related to the property industry, which means that the Malaysian property industry will play a key role in reducing GHG emissions (Koh, 2010). To fulfil the goal of GHG emission reduction, the property sectors have to transit fast to energy saving practices. Construction of energy-saving buildings or incorporation of energy save technologies in existing buildings will hike property prices in the near future.

The Malaysian population increased from 13.7 million in 1980 to 28.3 million in 2010 (JPM, 2011). In keeping with Malaysia's rapid development, the proportion of urban population increased to 71 per cent in 2010 compared to 62 per cent in 2000. By 2030, 82.2 per cent of Malaysian population is expected to live in urban areas (UNFPA, 2007). As urbanisation is the principal element behind higher energy demand in the residential buildings, energy demand is expected to grow very fast in Malaysia. However, energy resources in Malaysia are depleting rapidly. It is projected that Malaysia will be a net energy importer very soon (Taha, 2003). Therefore, it is clear that Malaysia will focus more on energy demand management to meet the growing demand and limited supply. More emphasis will be put on energy efficient building construction, energy efficient utilities and incorporation of energy saving technologies in real estate. Similar conditions are expected for water demand and supply. To ensure the continuous supply of water to the large population concentrated in the urban Malaysia and to meet the growing water demand in the context of rising temperature, government and local authorities have to focus on both increasing supply and reducing demand. More emphasis will be given on water-saving technologies in buildings. At the same time, new investments to augment water and energy supply may increase energy and water prices. As 80 per cent of a building's lifecycle costs are water and energy related (WRI, 2010), higher electricity and water prices will increase building lifecycle costs.

5. Adaptation to climate change impacts in real estate

Due to its location in tropics and hot climate all over the year, the Malaysian property sector will not benefit from climate change induced temperature increases or changing patterns of rainfall. Rather, the sector may face a number of direct and indirect negative impacts to property construction, operation and maintenance. As it is not possible to change the natural course of events, concerted action is essential to build capacity and reduce vulnerability of property to climate change. Adaptation to climate change will help to not only reduce the

physical damages and interruptions to critical services but also yield additional benefits of reduction of building lifecycle cost and GHG emissions.

Climate resilient building design and construction are necessary to reduce the climate change impacts on real estate (Shafaghat *et al.*, 2016). It is also necessary to upgrade poor structures, relocate extremely vulnerable settlements, develop neighbourhood storm water drainage, redesign neighbourhood flood control infrastructure, develop resilient water and power systems and services, undertake spatial planning and land management to reduce the risks and to plan energy efficient construction. It is necessary to incorporate guidelines on planning, design, construction, operation and maintenance of building structures to meet these needs. Long lead times and huge investments are necessary to modify the existing structures, which may be very difficult due to financial constraints. Therefore, the major challenge is to identify cost-effective, easily applicable and widely acceptable adaptation options.

Exiting storm-water management systems in neighbourhood settlements may not be enough to handle the increased severity of extreme rainfall events. The design and implementation of retention and detention ponds, retention gardens, etc., is therefore required to mitigate flooding in neighbourhoods. Settlement landscapes should also be designed with the knowledge of possible future changes in rainfall and temperature patterns.

The heating, ventilation and air-conditioning (HVAC) systems designs based on historical climate data will not be sufficient to cope with future changes in temperature extremes. New HVAC systems should be designed considering that temperature related extremes are predicted to increase both in frequency and severity. The HVAC systems of existing structures should also be changed to cope with the predicted future climate.

A "Green" building focuses on increasing the efficiency of energy, water, and material use while at the same time reducing the building's impact on human health and the environment during its lifecycle, through better sitting, design, construction, operation and maintenance (Majid *et al.*, 2010). Green buildings should be designed and operated to reduce the overall impact of the built environment on its surroundings. Green building practices are reported to reduce a building's operating costs by as much as 9 per cent, increase building values by 7.5 per cent and realise a 6.6 per cent increase in return on investment (Koh, 2010). Therefore, green buildings may be beneficial in the long term but in the short term will certainly increase the property price. WRI (2010) suggested that investment in green buildings could minimise energy and water-related risks while achieving net positive returns in few years.

It is necessary to review the risks to the property sector of Malaysia in the context of climate change. New risk maps in the context of climate change may consider property that was previously considered to be risk free to now potentially be liable to risk. Therefore, mapping of flood risk zones and coastal inundation zones under different climate change scenarios is necessary when planning and developing new properties.

Finally, more research is required to generate proper knowledge on climate change on real estate, as it is essential for sufficient adaptation to climate change impacts. The projection of probable changes in climate on a local scale is very important for this purpose. Identification and quantification of all possible impacts are also urgently required for adoption of optimum adaptation measures. Furthermore, prediction and early warning of floods and other extreme hydrological events is needed to prevent the adverse outcomes due to climate change.

6. Conclusion

The present paper discusses possible ways by which climate change may affect the property sector of Malaysia. The study reveals that the Malaysian property sector will be affected by variable climate and climate-related extremes, as well as by policies designed to combat GHG

emission. However, as climate change is a slow phenomenon, it can be anticipated that the physical impacts of climate change on the real estate sector of Malaysia may not be felt within next two or three decades. The major pressure the real estate sector will face in the coming year will be to adopt green building technology and/or building retrofication for the reduction of GHG emissions, which will increase the property prices and consequently affect the property market. Therefore, it can be concluded that the Malaysian property sector will be most affected by implementing government policies to reduce GHG emissions in the short term and by the physical risks of climate change-induced rising temperatures and extreme events in the long term.

Qualitative assessment of climate change impacts on real estate is carried out here. Quantification of climate change impacts on different aspects of building and structures can be conducted in future. Furthermore, available data can be analysed to confirm the climate change impacts identified in this study. Nonetheless, it is expected that the present study will be beneficial not only to a number of stakeholders, particularly property developers, but also to the development/planning authorities and risk insurers to improve their understanding regarding climate change impacts on the property sector of Malaysia. As vulnerability assessment is one of the main aspects of risk mitigation and planning, it is hoped that this study will assist in guiding the operational responses of various authorities, especially in terms of those interventions aimed at climate change risk reduction in the property sector of Malaysia.

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