Akademika 49 (Julai) 1996: 107 - 137

Risk, Exposure and Vulnerability to Flood Hazards in a Rapidly Developing Country: The Case of Peninsular Malaysia

CHAN NGAI WENG

ABSTRAK

Pada dekad-dekad kebelakangan ini, Semenanjung Malaysia telah berkembang pesat daripada segi perindustrian. Kadar pertumbuhan ekonomi pada tahun-tahun kebelakangan ini juga menunjukan bahawa trend ini akan berterusan pada tempoh jangka pendek ke tempoh jangka medium. Berikutannya, kadar perubahan sosial, ekonomi, politik dan teknologi juga pesat. Sejak kemerdekaan, perkembangan pesat dalam sektor pertanian, perlombongan, industri dan pembandaran (dan juga di dalam lapangan lain) telah mengubah banyak sistem semula jadi. Dengan menganggap hal-hal lain tidak berubah, maka perkembangan-perkembangan tersebut telah membawa kepada rejim-rejim hidrologi terganggu dan lain-lain parameter berkait dengan kejadian banjir. Justeru, bahaya banjir adalah dikekalkan terutamanya oleh gangguan manusia yang boleh membesarkan bahaya tersebut. Perkembangan ekonomi pesat dan hasrat kerajaan kini untuk mencapai taraf 'negara industri baru' merupakan konteks ubahan pesat. Apabila konteks-konteks ini berubah, sistem-sistem semula jadi/fizikal akan turut diubah. Perubahan-perubahan begini telah menghasilkan peningkatan risiko banjir, pendedahan manusia dan harta-benda kepada banjir dan vulnerabiliti mereka yang tinggal di dataran banjir.

ABSTRACT

Peninsular Malaysia is rapidly industrialising in recent decades and economic growth rates in recent years suggest that it will continue to do in the short to medium term. The pace of social, economic and political change is fast, as is the pace of technological change. Since independence, rapid economic development in agriculture, mining, industries and urbanisation (as well as other fields) has changed much of the natural system. Other things being equal, these developments have significantly contributed to disturbed hydrological regimes and other parameters relating to flood occurrences. Flood hazards are, therefore, being reinforced and perpetuated largely through human interference which can lead to their amplification.

Rapid economic developments and the current push by the Malaysian government to attain the 'newly industrialised country' status are described as rapidly changing contexts. As these contexts change, natural/physical systems are affected and they change accordingly. Such changes have given rise to increased flood risk, exposure and vulnerability amongst those living on floodplains.

INTRODUCTION

In Peninsular Malaysia, the risk of flooding affects a significant section of its population. As floodplains are rapidly developed and being encroached upon, more and more people and property (including public infrastructure, communications and private industries and business) are exposed to flood risk (JICA 1982). As population pressures build up in floodplains, the capacity for public response is diluted and reduced, and this increases vulnerability. Floodplain occupants are also largely from the lower income groups (Chan 1995), and they are the most vulnerable sections of Malaysian society when affected by flood hazards. Floods are a major natural hazard affecting many parts of Peninsular Malaysia. Early settlements prospered on the banks of major rivers in the peninsula. As they grew, floodplains became more developed and densely populated. A combination of population pressures and deterioration of physical conditions resulted in floods becoming more and more of a serious hazard. Both the 'natural/physical events system' such as monsoon winds, heavy seasonal rainfall, low-lying topography, river characteristics, drainage etc. and the 'human use system' such as agriculture, housing, commerce, deforestation, floodplain encroachment etc. interact in the creation and perpetuation of flood hazards in Peninsular Malaysia. In recent decades, the pace of economic development is rapid, as is the pace of technological change. The country has experienced rapid economic development in agriculture, mining, industries and urbanisation (as well as other fields) since independence in 1957. Rapid economic growth rates of 8.0 per cent or more in the last decade (The Economist July 1994 p61) and the country's incessant push towards industrialisation (Government of Malaysia 1991), have all contributed to changing much of the natural system. Other things being equal, these developments have significantly contributed to disturbed hydrological regimes and other parameters relating to flood occurrences. Flood hazards are, therefore, being reinforced and perpetuated largely through human interference which can lead to their amplification. These developments may be described as rapidly changing contexts. As these contexts change, natural/physical systems are affected and they change

accordingly, giving rise to increased flood risk, exposure and vulnerability amongst those living on floodplains.

Flood hazards and disasters are, therefore, neither solely the work of nature nor are they solely caused by humans, but result from the interaction of both the natural events system and the human use system (Figure 1). Not with standing the favourable natural conditions which foster the occurrence of floods in the peninsula, human factors are becoming increasingly more influential in flood hazard creation. This is especially so in the outcome of flood hazards and their translation into disasters. While both natural and human factors contribute to the occurrence of flood hazards and disasters in the peninsula, human factors

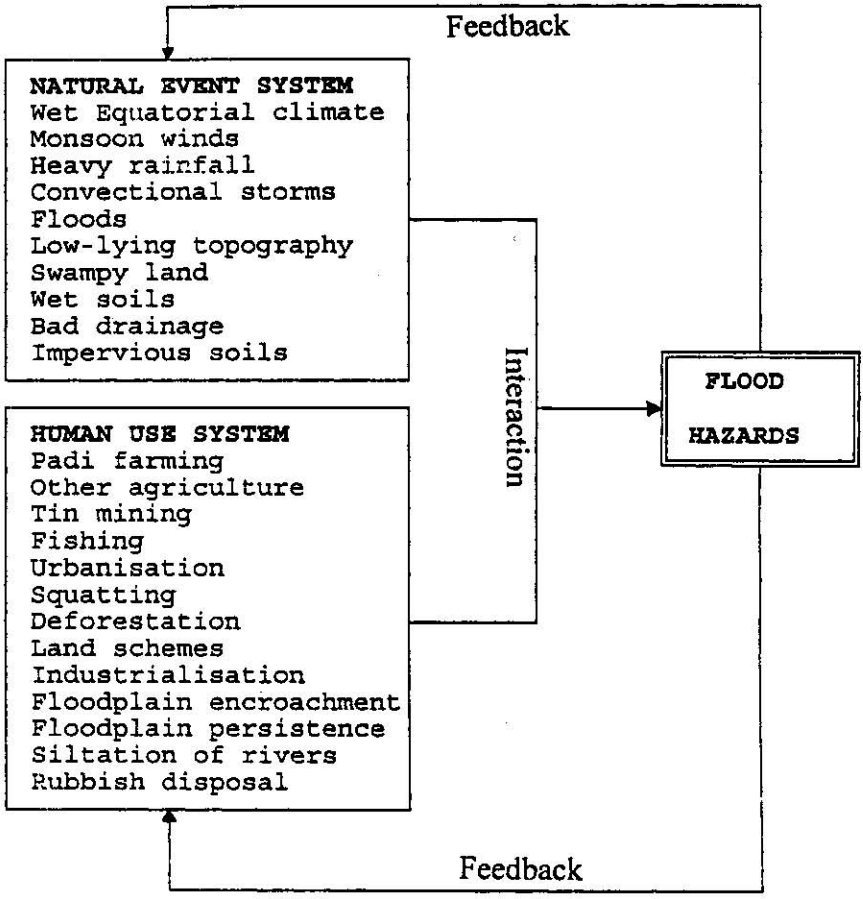

FIGURE 1. The interaction between the natural event system and the human use system to produce flood hazards in Peninsular Malaysia.

are becoming increasingly more influential. This is especially so in the outcome of flood hazards and their translation into disasters. While both natural and human factors contribute to the occurrence of flood hazards and disasters in the peninsula, human factors are becoming increasingly more influential. This is especially so in the outcome of flood hazards and their translation into disasters. The flood enhancing characteristics of the natural events and human use systems in Peninsular Malaysia are demonstrated by examples from the four selected study areas of Kuala Lumpur, Pulau Pinang, Pekan and Kelantan. Although natural conditions in the peninsula favour the creation of floods, flood hazards are fundamentally the consequence of human action. More significantly, however, is the fact that risk, exposure and human vulnerability to flood hazards are all increasing largely because of activities in the human use system which contribute to an reinforce their creation and perpetuation.

Flood hazards are, therefore, more of a consequence of human action (i.e. through the mismanagement of flood related activities) than they are by naturally inducing factors. Malaysians are historically a riverine people as early settlements grew on the banks of the major rivers in the peninsula. Coupled with natural factors such as heavy monsoon rainfall, intense convection rain storms, poor drainage and other local factors, flood have become a common feature in the lives of a significant number of Malaysians. Floods are the most common 'natural hazard' faced by the inhabitants of Peninsular Malaysia. On the national scale, the flood hazard accounts for almost the entire reported annual cost for disaster preparedness, mitigation, relief and rehabilitation. Furthermore, flood hazards are often amplified into flood disasters through human mismanagement (either via ineffective public flood reduction schemes or inappropriate response from the people at risk).

The examination of the contributory effects of the both the natural event system and the human use system towards flood hazard creation and perpetuation is, therefore, not only a necessary pre-requisite for a thorough understanding of floods but also for more effective flood hazard management in the peninsula. This paper examines the extent to which the natural and human use characteristics have contributed to the creation and perpetuation of flood hazards in Peninsular Malaysia. It analyses flood risk, flood exposure and human vulnerability to flood hazards. Examples from key flood-prone case study areas in the peninsula are used as examples to substantiate the extent to which rapid economic development has exacerbated flood hazards in the peninsula. The analysis is supported by results from structured interviews with members of 618 flood prone households undertaken in 1992/93. Interviews were completed in four sample locations: two on the West Coast – Kuala Lumpur (114 interviews) and Pulau Pinang (172 interviews); and two on the East Coast –

Pekan (140 interviews) and Kelantan (192 interviews). Qualitative in depth interviews are also employed to supplement the structured interviews.

THE LURE AND ATTRACTION OF FLOODPLAINS: A HISTORICAL PERSPECTIVE

The lure and attractiveness of the floodplain as a place of occupancy is well documented in the natural hazards literature (White et al. 1958; Parker 1976; Smith 1992 0-1; Alexander 1993). There are many reasons why floodplains have been preferred locations for early settlements. The peninsula comprises numerous rivers and a central mountain range flanked by flat marshy swamp-land near the coastline. The early settlers must have found the floodplains between the mountain range and the marshy swamps suitable for agriculture and easily accessible by river. As a result, early Malay settlements grew rapidly on the banks of rivers, particularly at their confluences and estuaries. It is not surprising therefore, to find that most of the major cities and towns in Peninsular Malaysia are located near to or just beside the major rivers.

Despite susceptibility to frequent flooding floodplain occupation has progressively increased. This is because the social, economic and other benefits of inhabiting and using floodplains are often perceived to outweigh the negative effects of flooding (Alexander 1993). Floodplain encroachment has become more and more difficult to control. Floodplains are continually enriched with deposits of fertile alluvium and soil moisture for agriculture, most notably for padi. Such alluvium is impermeable and ideally suited for wet padi cultivation. Furthermore, as floodplains are never too far from rivers the availability of irrigation is an added bonus for agriculture. Irrigation has enabled padi to be cultivated twice a year (Chan 1991). In the early days of settlement when roads were few and far between, communicating through the thick equatorial forest between settlements was difficult. Consequently, settlements flourished beside the major rivers because of the ease of riverine communication and transport. Today, although river communication has declined considerably due to the vast improvement in roads and railways, many rural settlements still depend on it. Rivers also serve as the main sources of domestic water supply. The headwaters of many rivers in the peninsula are used as catchment areas and many are dammed as reservoirs. Some examples are the Kelang gates Dam on the Kelang River and the Kenyir Dam on the Terengganu River. Rivers also provide a basic form of rich protein from fisheries and edible freshwater plants. As padi farming usually involves only two months of intensive work during the year,

farmers are left with plenty of time to get involved in supplementary income generating activities. Fishing is one such activity.

Towards the mid-19th Century tin mining became an important economic activity in the peninsula. It was also an activity which exacerbated the flood hazard as forested land was cleared for mines, the disposal of tailings caused siltation of rivers, and abandoned mines increased rates of erosion (Leigh & Low 1978). Miners discovered that many floodplains of the peninsula, notably the Kinta and Kelang Valleys contained rich deposits of alluvial tin washed down from the foothills. This created a 'tin rush' which sparked an influx of immigrants, notably Chinese into the peninsula. Not only did the immigrants build settlements on the floodplains but also around the mines. In fact, some of the major urban centres in the peninsula today originated as mining towns. They included the two largest cities Kuala Lumpur and Ipoh, and Seremban, Taiping, Ampang, Kampar and others. Some properties adjacent to riverine areas may also command high property values because of their locational values. Such is the case of properties in and around the confluence of the Kelang and Gombak Rivers in the heart of Kuala Lumpur. Finally, in much of the peninsula a combination of population pressures (due to population increase and rural-urban migration) and rapid development in urban centres has forced many people to inhabit the more hazardous zones not previously occupied on the floodplain.

To the indigenous Malays whose ancestors have lived on the floodplains for centuries, floods have become an integral part of their history and culture. This is especially so in the case of rural Malay peasant farmers and fishermen who regard seasonal flooding as something to be expected and as part and parcel of their life. Living on floodplains is second nature to them and cohabiting with the flood risk for long periods has made them well adapted to the flood hazard. A good example of the traditional 'natural style' adaptation to floods that has evolved through he centuries amongst Malay society is the 'stilt house'. Living in stilt houses enables most families to cope reasonably well with 'normal floods', i.e. those with flood depths below the height of the stilts. It is this, amongst other reasons, which largely accounts for their reluctance to leave the flood-prone area and relocate elsewhere, despite encouragement by the government (Chua 1972; Chan 1955).

THE NATURAL EVENT SYSTEM IN RELATION TO FLOOD OCCURRENCES

The location of the peninsula in the wet equatorial tropics, its exposure to monsoon winds, the existence of wide low-lying coastal and riverine

alluvial floodplains are all conditions conducive for the creation of floods. Thus, it is hardly surprising that the natural/physical systems in the peninsula generally foster the creation of floods. As a result of its wet climatic regime, the seasons in the peninsula are distinguished not by temperature but by rainfall. Basically (although there are small variations between regions), the year may be divided into four seasons: (1) The Northeast Monsoon Season (November – March); (2) The Southwest Monsoon Season (May – September); (3) The First Inter-Monsoon Season (April/May); and (4) The Second Inter-Monsoon Season (October). However, the timing of these four seasons varies slightly between the northern and southern parts of the peninsula. It is the first of these four seasons that is highly associated with seasonal flood occurrences (Sooryanarayana 1988; Chan 1995). The inter-monsoon seasons, however, are more associated with the occurrence of flash floods (especially in urban areas on the West Coast).

During the northeast Monsoon Season, the predominant winds are north-easterlies which originate from the heart of the Asia continent. In general, the peninsula is located in an area in Southeast Asia which is under the influence of about eight or nine main airstreams which originate from places such as Siberia, North India, Tibet, the North Pacific, Australia, the South Indian Ocean and the South Pacific (Ooi 1979). The combined effects of these airstreams have given rise to the region's two dominant surface wind systems, viz. the north-easterlies and the south-westerlies or better known in the country as the Northeast and Southwest Monsoons (Figure 2). These two predominant wind systems significantly affect the both the physical and human geography of the peninsula. On the positive side, these winds bring forth heavy rains which are needed for seasonal wet rice cultivation, water for domestic water supply, and other forms of human use. On the negative side, the winds destroy crops and traditional houses, cause rough seas which stop fishing activities, and worst of all bring heavy rains that often result in hazardous floods. In the East Coast of the peninsula, the Northeast Monsoon winds are responsible for floods which occur every year in one state or another. In many cases, extreme conditions created by the winds have deposited rainfall exceeding 600 mm within 24 hour period. Furthermore, with the prevailing easterly winds, there is also the likelihood of flood producing rains spilling over the central mountain ranges of the peninsula, thereby flooding many parts of the West Coast as well. This was the case when a tropical depression was superimposed on the Northeast Monsoon winds (considered an extreme meteorological condition) during the nation-wide 1971 flood. Thus, seasonal wind systems annually create the conditions conducive for flood occurrence.

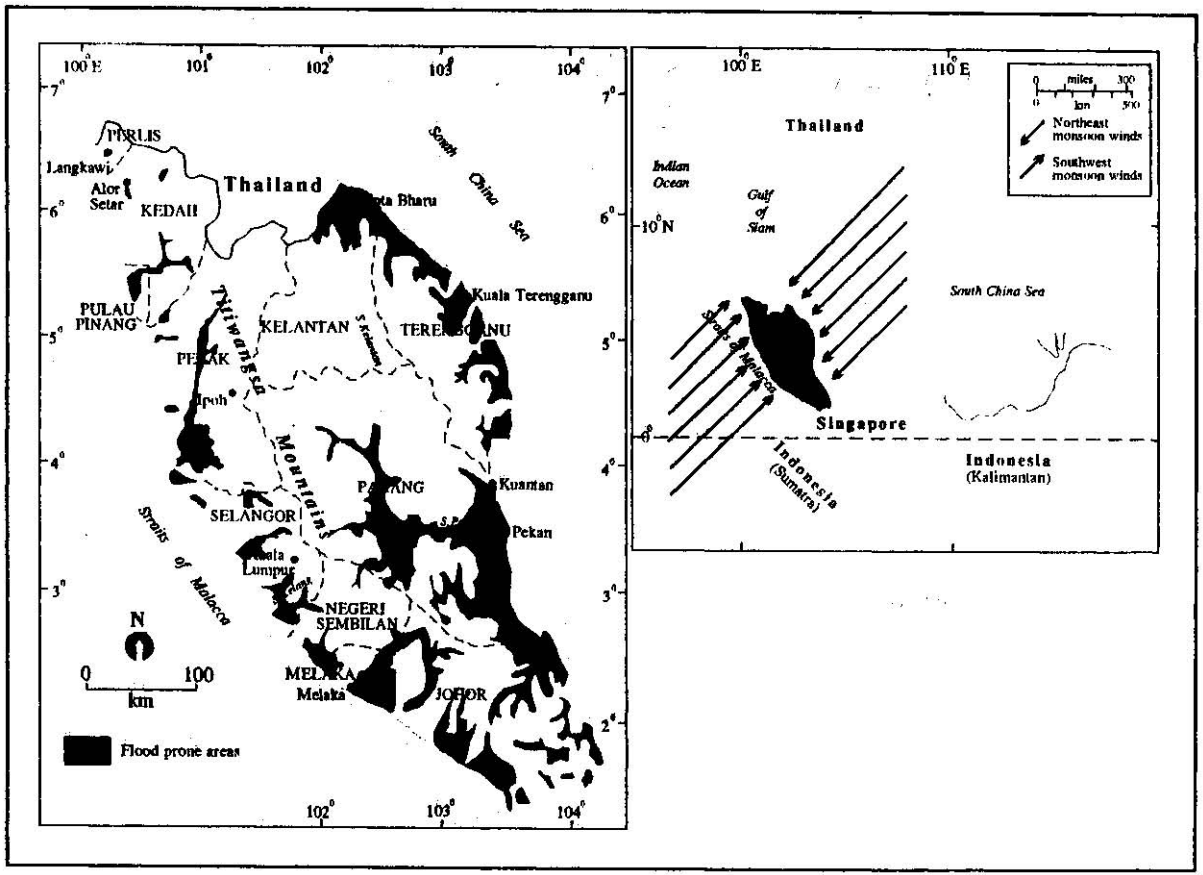

FIGURE 2. Flood-prone areas in relation to river systems in Peninsular Malaysia.
Insert: Location of Peninsular Malaysia in relation to Monsoon winds.

In terms of rainfall, the East Coast Region (because of its exposure to the Northeast Monsoon winds) is a much wetter region than the West Coast Region (which is sheltered from the Northeast Monsoon by its central mountain ranges and from the Southwest Monsoon by the Indonesian island of Sumatra). In the East Coast Region, there is one maximum and one minimum rainfall period. The maximum coincides with the rainy season from November to March while the minimum corresponds with the dry season from April to August. During the rainy season floods occur almost every year in one place or another in the East Coast. In some extreme years, the spill-over effects of the Northeast Monsoon rains spread across the central mountain ranges over on to the West Coast, giving rise to wide spead floods as well. As a result of the connection between monsoon rains and floods, flooding is often said to be 'predictable' in the East Coast. What is unpredictable, however, is when exactly flood will occur during those five months of the Northeast Monsoon Season.

In the West Coast Region, there are two maximum and two minimum rainfall periods. The two maxima occur in April and October-November while the two minima occur in February and July. The two maxima coincide with the period of the two short inter-monsoon seasons, two transitional periods where calm conditions prevail for most of the time and there is no distinct or predominant winds. It is during the two maxima that most flooding occur. Unlike the East Coast region, flooding in the West Coast region is not widespread but on a small localised scale. Most flooding are also flash floods caused by convection rain-storms or thunderstorms and/or a combination of such storms and monsoon rain-storms. However, the temporal aspect of flooding in the West Coast region is not as predictable as that in the East Coast region. Although flash floods mostly occur just before the commencement of the Northeast Monsoon Season or during either of the two inter-monsoon periods, they are known to occur any time of the year. In recent years, flash floods have been occurring rather more frequently and there has been no clear identifiable pattern (Friends of Penang Hill 1991; DID 1992).

The mean annual rainfall is highly variable from place to place, but ranges from about 1,500 mm to more than 3,500 mm (Figure 3). In general, rainfall decreases from the East Coast to the West Coast (Chan 1995). In the East Coast regions where floods are the most serious and frequent, the annual rainfall in any year can be as high as 5,000 mm. The bulk of this rainfall is deposited during the Northeast Monsoon Season from November to March. The West Coast region, however, is shadowed by the Indonesian island of Sumatra from the Southwest Monsoon Winds and by the Titiwangsa Range of the peninsula from the Northeast Monsoon Winds. As such, most of the rains in the West Coast fall during

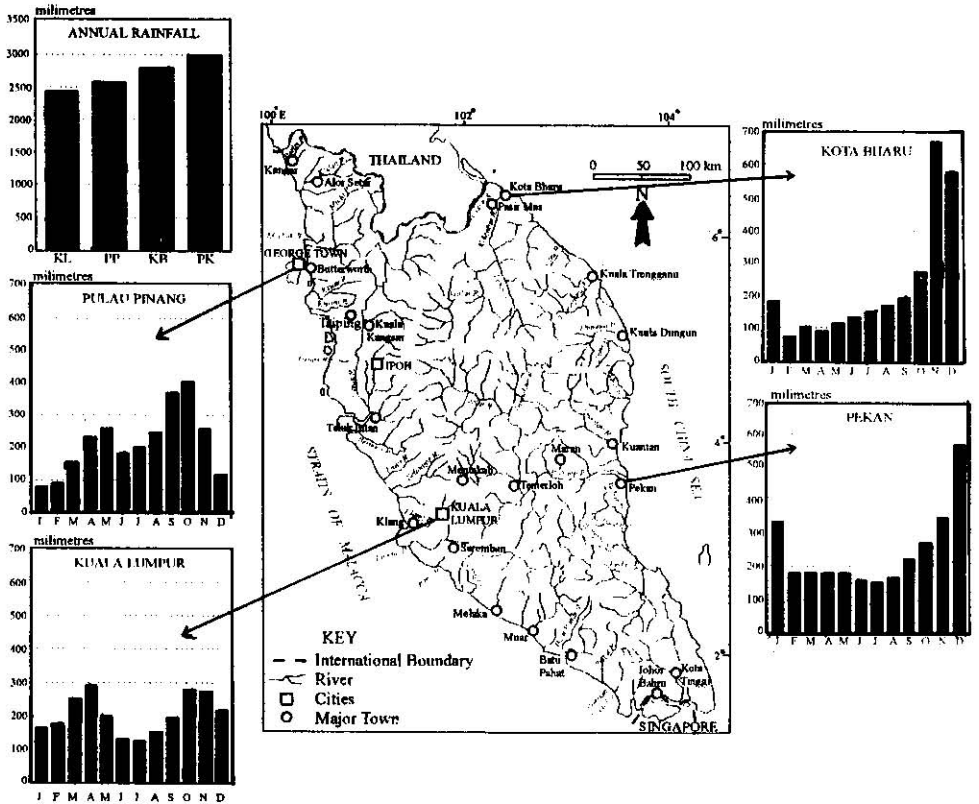

FIGURE 3. Distribution of annual and monthly rainfall at selected stations in Peninsular Malaysia. Main figure: River systems in relation to location of key cities and towns in Peninsular Malaysia.

the two short inter-monsoon seasons in April and October where torrential convectional rains occur. The difference in the mean seasonal rainfall is more distinct between different regions in the peninsula. For instance, while most areas in the East Coast region receive more than 2,000 mm of rain during the Northeast Monsoon Season, areas on the West Coast receive less than 1,000 mm of rain during the same period (Chan 1990b). During the Southwest Monsoon Season, however, the variation in rainfall totals between the two coasts are less pronounced, with both regions receiving between 1,000 mm to 1,500 mm of rain.

Rainfall intensities in the peninsula are generally high, especially during convectional rainstorms which are of short duration. The intensity of a particular rainfall is important as it determines the rate of splash erosion and the rate of surface run off (which in turn determines land surface erosion and flooding). In general, average rainfall intensities are around 150 mm per hour. Wycherley (1967) found that the rainfall intensity during an unstable rainstorm in Kuala Lumpur was around 203 mm per hour. With such high rainfall intensities and the subsequent high run off rates, the occurrence of flash floods are therefore a common phenomenon in the West Coast (Jamaluddin 1985). In the East Coast, however, rainfall intensities are much lower, about 2.5 mm per hour (Ooi 1979). However, the lower intensities are more than balanced by the much longer duration of the rainfall which often lasts for four or five days continuously. As a result, floods are not flashy but tend to be of the large scale and long duration type, often lasting several days to a few weeks. Thus, the rainfall characteristics of the peninsula are also conditions which highly favour flood occurrences.

Other than the above natural conditions, the topography of Peninsular Malaysia also contributes to flood occurrences. Although the peninsula is generally considered hilly with more than one-third of its total land above 152 m, most of its mountain ranges are located in the northern and central parts. Of more significance, however, is the fact that the majority of its population, economic activities and infrastructure is concentrated on the narrow coastal plains on boths its East and West Coasts (Leigh & Low 1978). These coastal plains are low-lying and can be easily flooded in many parts. The coastal plains on the West Coast are generally wider than those in the East Coast. For instance, in the state of Perak, the coastal plain is about 60 km wide. The narrower coastal plains in the East Coast are between 20 to 40 km wide. In the state of Kelantan, there is a fan-shaped delta at the estuary of the Kelantan River. This is an area that is almost constantly under threat from flooding. Another area, the Pahang River Delta, is also highly flood-prone. In general, the average heights of the coastal plains in the peninsula are not more than a few metres in most places. Most of these coastal plains coincide with the

floodplain regions of the peninsula. Due to their low-lying topography, the coastal plains on both coasts are highly susceptible to flooding. As they are also preferred settlement locations, the incidence of flood risk, exposure and vulnerability are consequently high.

Poor natural drainage may be another natural factor that has contributed to flood-proneness. Rivers have an important place in the history of Peninsular Malaysia. Historically, rivers have been the life and blood of early Malay civilisation, British colonial rule and modern day Malaysia. In the past, rivers were the only source of communications between the Malay hinterland and the outside world. Furthermore, rivers provided water for both irrigation of crops and domestic water supply, a rich source of food, fertile soils, and in many areas a rich mineral deposit called tin. As a result, most of the major settlements in the peninsula are located near to the rivers. Although modern day use of rivers have been reduced, they are still very important as natural drainage ways, for harnessing hydro-electric power, recreation, fishing, and unfortunately as a convenient means of waste disposal. However, indiscriminate use of rivers and a combination of rapid deforestation, agriculture and uncontrolled urban development of floodplains have disrupted the natural regime of rivers and resulted in the deterioration of rivers as a natural means of drainage (Ferng 1988). Frequently, this has resulted in an increase in the frequency and magnitude of flooding as well as a corresponding increase in flood losses (JICA 1982).

The heavy all year round rainfall in the Malaysian peninsula has given rise to a dense network of rivers and streams, though there is no single large river dominating the drainage pattern. The rivers in Peninsular Malaysia are rather small by world standards. The largest, the Pahang River, with a catchment area of 29,300 sq km is only about 430 km long. The other major rivers are the Perak (14,000 sq km), the Kelantan (13,100 sq km), the Muar (6,595 sq km), the Terengganu (4,650 sq km) and the Kelang (1,425 sq km). There are more than 100 river systems in Peninsular Malaysia (Figure 3). The Titiwangsa Range is the main divide which determines whether a river flows eastward into the South China Sea or westwards into the Straits of Malacca. Due to the nature of its topography, the river courses in the peninsula are relatively short. The gradients of the rivers in the upper courses are steep, some drop about 1,200 m in less than 24 km before they emerge on to the coastal floodplains. In the lower stretches and the floodplains, the river gradients are gentle and flat, giving rise to widespread meandering patterns. Although the year-round precipitation ensures perennial streamflow and no river course is ever completely dry at any one time of the year, the torrential and localised nature of the rainfall causes rapid fluctuations in the river discharge giving rise to the occurrence of floods.

During flooding, flood flows in the upper river stretches are usually transient but increase greatly in duration and intensity in the lower stretches, particularly in the floodplains. As the densities of population, public amenities, infrastructure and property are greatest in cities, towns and other settlement types in the floodplain regions, they are high exposure areas and have the highest flood loss potentials (Figure 4).

In the East Coast, the rivers are more frequently flooded than their counterparts in the West Coast, due mainly to the effects of the Northeast Monsoon. Quaternary changes in sea level and progressive sedimentation have also given rise to most rivers taking on a profile with a typically vertical profile in the upper stretches to a flattened appearance in the middle to lower stretches (Lim 1988). This is because when the river beds were raised, the rivers' erosive and transportation capacities were reduced but its rate of deposition correspondingly increased. As a result, this has given rise to the formation of extensive floodplains with the typical fluvial formations such as meanders, ox-bow lakes, natural levees and swamps. In the estuaries the rivers empty their loads into the sea and cause progressive sedimentation along the coasts. In the Weat Coast which is sheltered, fluvial deposition has given rise to large tracts of tidal and freshwater swamps which further impede drainage. Many rivers flowing westwards often disappear into such swamps before they re-emerge and flow into the sea. In the East Coast, there are few such swamps (due to the exposed coast-line to the South China Sea) but floodplains are built around the estuarine areas and all long the major rivers. On both coasts, the rapid physical development and occupation of such floodplains have increased human vulnerability and damage potentials of flooding in such plains.

THE HUMAN USE SYSTEM IN RELATION TO FLOOD HAZARD CREATION AND PERPETUATION

There are probably as many human uses as there are floods in relation to flood hazard creation and perpetuation in the peninsula. It is impossible to examine all these uses but key human uses which are closely associated with flood hazards are examined in detail. Deforestation is a sensitive issue which has caused much controversy between the affluent North and the developing South. This problem is further complicated by inconclusive research results tying deforestation to increasing flood occurrences. Yet, the issue cannot be ignored as the conversion of natural forest into human land use can be detrimental on hydrological parameters even though flood peaks may not yet be correlated to the proportionate increase in deforestation. Peninsular Malaysia is a land

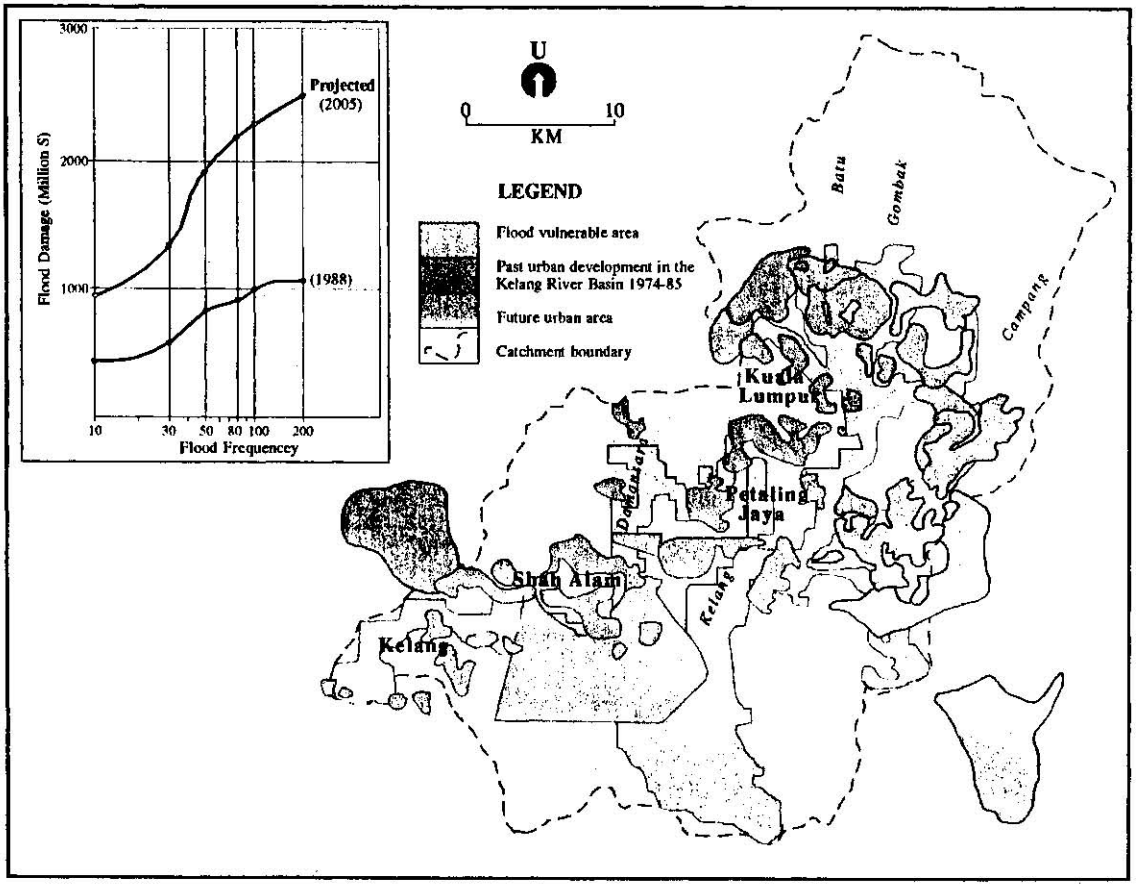

FIGURE 4. Future expansion of urban and other human land uses in the Kuala Lumpur - Petaling Jaya - Shah Alam - Kelang conurbation.Inset: Projected future flood damage potentials in Peninsular Malaysia (After JICA 1989).

naturally well endowed with its dense equatorial rainforest which until today is still a commercially important natural resource. The economy of the peninsula is still very much dependent on its forestry products. In 1990, total commercial tree felling in the peninsula amounted to 11 million cubic metres, with sawn timber alone contributing a total value of $2,520.9 million (Government of Malaysia 1991). In the past, uncontrolled logging has given rise to a rate of deforestation which has threatened not only the ecology of the rainforest but more significantly increased run off and erosion (on the regional scale) and contributed to warming of the atmosphere (on the global scale) (World Rainforest Movement 1991). Due to extensive exploitation of the peninsula's forests either through logging, agriculture and other land use, less than 70.00 per cent of its total land area is now under forest.

Forest cover is a natural form of flood prevention. In Peninsular Malaysia, deforestation is a controversial issue (Shiva et al. 1991; Kenyalang 1992; Sahabat Alam Malaysia 1992; Utusan Konsumer 1992; Malayan Nature Society 1992). The dense evergreen equatorial forest of the peninsula protects the top soil from splash erosion and overland flow through its thick, multi-layered structure, undergowth and litter layer. Natural forest also absorbs part of the rain water during and after a rain event, leaving only a portion of the rain water into the streams. Finally, interception of the rainfall by the forest canopy, tree trunks, branches, undergrowth and leave litter increases the lag time by which the rain water reaches the streams. All the above factors have significant implications for flood occurrences. For instance, forest conversion and logging of commercial trees have been shown to have disastrous consequences on soil and the hydrological regimes (Daniel & Kulasingam 1974; Kamaruzaman 1990; Friends of Penang Hill 1991; Hamirdin 1992). Research has also revealed that significant water yield increases occur after deforestation (Abdul Rahim 1988, 1990; Abdul Rahim & Harding 1992). For example, Abdul Rahim (1990) showed that logging in the peninsula has substantially increased water yield between 55.0 per cent to 70.0 per cent (unsupervised logging) and between 28.0 per cent to 44.0 per cent (supervised logging with conservation measures). The DID (1986, 1989) has also shown that clear-cutting to dipterocarp forest resulted in a water yield increase of 822 mm (470.0 per cent), 793 mm and 476 mm in the first, second and third years respectively. Zulkifli and Abdul Rahim (1991) found that there was a water yield increase of between 3 mm to 5 mm for every percentage of forest cover cleared. Toebes and Goh (1975 p10) showed that logging activities caused significant changes in flood peaks, flood volumes and flood frequencies.

The government is aware of the importance of its forests both as an economic resource as well as an ecological safeguard environment degradation. It is now pursuing a policy of 'sustainable development of natural resources'. In its Sixth Malaysia Plan (1991-95), the growth rate for sawn logs is estimated at -6.7 per cent. This negative growth rate is in line with its efforts in protecting and regenerating its forest as well as in protecting the environment and control floods. However, despite this policy of sustained yield and conservation, poor enforcement of its policies (resulting in illegal logging) may yet see the trend of uncontrolled deforestation continue in the future (Hani Ahmad 1991).

Floodplain encroachment is yet another form of human use which is at once prominent and yet hard to curb. Successful modernisation and growth in a developing country like Malaysia brought growth to the urban sector with accompanying problems of urban unemployment, squatters and slums (Faaland et al. 1990 p299). Since independence, there has been a rapid development of the country's urban areas accompanied by a general rise in education level, especially among the children of rural inhabitants. Education is provided free to all Malaysians by the government. The New Economic Policy (NEP) also emphasised improving the status and standard of living among the Malays and most Malay school children get some form of scholarship. This has resulted in an influx of young rural migrants into the major urban centres for education and employment (Muhammad Razha 1978). While this influx has initially solved some of the problems of labour shortages, it has now become a significant problem not only because it has exacerbated urban unemployment (Khor 1987) and put great demands on housing and other public services, but more significantly because it enhances floodplain encroachment and exacerbates flood hazards. According to Faaland et al. (1990 p301), a net exodus of at least 375,000 Malays and 3000,000 non-Malays migrated from rural to urban areas over the period 1967 to 1985. Some of these migrants may have moved directly into modern urban employment, but the majority of them are forced into the low-productivity, high unemployment, increasingly over-populated traditional urban sector. For housing, the majority of migrants end up in low priority areas such as ex-mining land, hill slopes, and on squatter settlements below. Rural-urban migration has, therefore, increased floodplain encrochment and increased the flood vulnerable population. Rapid urbanisation (induced by rural-urban migration) is a key factor in the growth of vulnerability, particularly amongst low-income squatters (Davis 1981 1987; Blaikie et al. 1994). People continue living in riverine squatter settlements in the cities despite recurrent flooding simply because it is the only place they can afford to lie in. Rural-urban migration can, therefore, be considered a structural force partly

responsible for the creation and perpetuation of people on floodplains. With the rapid development of the economy in recent years, rural-urban migration is expected to have increased significantly bringing with it an even greater to urban floodplain encroachment.

In Peninsular Malaysia, squatting is a major structural force which creates and exacerbates urban flood hazards. It results from a combination of poverty, landlessness, rural-urban migration (to search for better paying jobs), influx of illegal immigrants (mostly Indonesians and Thais) and other structural causes. Since urban floodplains are probably the only vacant space left undeveloped in the cities, squatters inevitably occupy these hazardous flood-prone areas, and consequently become exposed to flood hazards. In urban areas, squatters are the most vulnerable group of people as they are amongst the poorest in Malaysian society, and least able to recover from a flood disaster.

Squatting is both historical as well as a modern phenomenon. During the colonial period, squatters were mainly immigrant Chinese and Indians but after independence, squatting by Malays due to rural-urban migration, also became a problem (Azizah Kassim 1982). In 1957, one out of three persons Kuala Lumpur (the federal capital) was a squatter and there were as many as 20,000 squatter families (Fish 1957). By 1980, there were 48,709 squatter families Kuala Lumpur and it has been estimated to increase at a rate of 9.7 per cent annum (Dewan Bandaraya Kuala Lumpur 1982). Wan Abdul Halim (1982) has identified 202 squatter settlements in Kuala Lumpur, the majority of which lie on flood-prone areas near the main rivers running through Kuala Lumpur.

Squatting in Kuala Lumpur is only one example. All the major urban centres in Peninsular Malaysia have squatter settlements. For example, Ipoh (Perak state), Johor Bahru (Johor state) and Prai (Pulau Pinang state) have approximately 60,000, 50,000 and 20,000 squatter families respectively (Khor 1989). Squatting on flood-prone areas in the major in Peninsular Malaysia urban centres is a social problem facing the authorities. Squatter live in the most hazardous of floodplains simply because they are too poor to live any there else. In the current study, it was found that 62.9 per cent of squatter households in the peninsula were flooded 10 times or more in the last 10 years compared to 43.3 per cent of non-squatter households. Perhaps the story of Abdullah from Kampung Bumiputra in Kuala Lumpur demonstrates the extent to which squatting has increased floodplain encroachment and in the process contributed significantly to increased flood risk, exposure and vulnerability amongst urban floodplain occupants. More significantly, flood hazards are exacerbated due to activities oriinating from the human use system.

The example of Abdullah (an urban squatter) clearly demonstrates the seriousness of squatting and its implications on floodplain encroachment. Like most of the inhabitants of Kampung Bumiputra, Abdullah is a squatter. He was born in a small kampung in Tanjung Karang, Perak. He is a peasant heritage as his parents are both padi farmers. But like most of his peers (the younger generation), padi farming did not appeal to him. A farmer's life was tough and the remuneration hardly lucrative. There were simply too many hazards associated with padi farming and through his childhood experiences Abdullah remembers vividly how his family always lived in poverty. He was determined to get out of it even though generations of his family had been farmers. After he failed his Lower Certificate of Education Examinations (Form Three), he packed his bags and went to stay with his uncle in Kampung Bumiputra, hoping to learn a trade and make his fortune in the federal capital. He had hoped that he would soon make enough money to move out to a rented place of his own and thereafter to buy his own house. This remains a distant dream as with his poor education, Abdullah could not find gainful employment. All he could find gainful employment. All he could find were odd jobs in construction sites, hawking, and selling cheap goods at night markets. As a result, he has never made enough to move out of his uncle's house. Abdullah is not the only nephew staying with his uncle. There are two other distant cousins from remote kampungs in Terengganu also trying their luck in the federal capital. All three of them share a room. Nevertheless, Abdullah and his two cousins refuse to admit defeat and return home to a sedentary peasant life as his would spell shame and disgrace. Instead, they stay back and join the thousands of unemployed rural youngsters in the federal capital hanging on to the dream that one day they will strike it rich.

Kampung Bumiputra is full of Abdullahs and they keep coming from the rural areas. This wave of rural-urban migration became especially pronounced during the past five years or so as Malaysia enjoyed an economic boom. As the squatter population swell the number of squatter huts also increase. Elsewhere, in the federal capital, many new squatter settlements grow unnoticed. Squatter huts are often erected at a rate faster than the speed at which the authorities can tear them down. The lack of low cost housing and social, political and economic considerations may also have prompted the authorities to close a blind eye on the squatter problem. Other than erecting new huts, many of the existing squatter huts are also extended or partitioned into more rooms. Kampung Bumiputra is only one of hundreds of squatter settlements in the federal capital and other major cities in the peninsula. They are prime targets for squatters as the land on which their huts are built are the most

flood-prone land which are deliberately avoided by developers. Hence, squatter settlements like Kampung Bumiputra are intricately linked to flood hazards and have become a major social problem for the authorities. Because of their origins and riverine location, these settlements are high risk flood zones. Increasingly dense populations in squatter settlements, the weak house structures of 'make shift' wooden huts and the high incidence of poverty have increased the squatters' vulnerability to flood hazards.

The example of Kuala Lumpur perhaps epitomises the extent to which urban floodplains have been occupied, thereby increasing risk, exposure and vulnerability. From a meagre population of a few hundred miners when it was founded in 1857 (at the confluence of the Gombak and Kelang rivers), Kuala Lumpur's population has grown to 1,145,075 in 1991 (Department of Statistics Malaysia 1992). With ever increasing development and urbanisation, the federal capital's population is expected to increase further in the near future. Although the government has given an estimated figure of 2.4 per cent (average annual growth rate) over the Sixth Malaysia Plan period (Government of Malaysia 1991), Kuala Lumpur's rate of population increase is expected to be much higher than the national average. According to the Kelang Valley Perspective Plan, the population of the Kelang Valley (of which Kuala Lumpur occupies the middle and part of the lower sections) is estimated to reach 4,760,000 by the year 2000 (Figure 4). Kuala Lumpur's population is projected to reach 2.2 million by the year 2000 and a significant proportion is expected to occupy floodplains as land become scarce, thereby increasing exposure and vulnerability. Property development is also expected to increase flood damage potentials.

INCREASING FLOOD RISK, EXPOSURE AND HUMAN VULNERABILITY

In Peninsular Malaysia, it has been estimated that approximately 2.5 million[10] people live in floodplains and are exposed to flood risks of varying probabilities (JICA 1982). While 'risk' may be defined as the probability and other physical characteristics of hazards, it is essentially a product of hazard and vulnerability as 'there is no risk if there are hazards but vulnerability is nil, or if there is a vulnerable population but no hazard event' (Blaikie et al. 1994). Heavy monsoonal and convectional rainfall, flat topography on both coasts, heavy siltation of rivers, and human activities have all contributed to high flood risk. Risk is increasing because flood characteristics are changing due to rapid urbanisation of catchments (Yaziz & Sulaiman 1985; Friends of Penang Hill 1991; Hamirdin 1992). Deforestation and other environmentally

damaging human land uses have also significantly altered hydrological parameters. Research has revealed that significant water yield increases occur after deforestation (Abdul Rahim 1988 1990; Abdul Rahim & Harding 1992), and that commercial logging resulted in significant increases in storm flow volume and initial discharge (DID 1986). Other human activities such as tin mining have also contributed to flooding. Climatic change inducing sea level rise may also be an important flood inducing mechanism which can increase future flood risk (Parry et al. 1992). Flood reports for the period 1925 to 1993 (Chan 1995) also suggest that flooding has become progressively more frequent, with flash floods mainly affecting the federal capital and Pulau Pinang. Flooding magnitudes have also appeared to have increased since the 1970s (a period of rapid economic development) in the East Coast states. The physical contexts of floods have, therefore, changed. Together with greater exposure and vulnerability of human population, it has contributed to increased flood risk.

Floodplains are also regions where a significant proportion of the peninsula's population and much of the economic activity are concentrated (Leigh & Low 1978). Table 1 indicates the extent to which populations have settle on urban centres in the floodplain regions in the peninsula. The three largest urban centres in the peninsula are located on floodplains and are susceptible to frequent flooding. In addition, five of the top ten urban centres and more than half of all urban centres are located on flood-prone areas. Thus, the exposure of population and property such as infrastructure, economic activities and industries in the peninsula is high. Exposure is, therefore, a measure of the population at risk. As the peninsula's major cities grew they spilled onto floodplains progressively increasing flood exposure (Chan & Parker) and flood damage potentials. Some prominent examples are the rapid development of the Kuala Lumpur-Petaling Jaya-Shah Alam-Kelang conurbation and rapid industrialising Georgetown. Expansion in existing urban areas (the majority of which are already on floodplains) due to population expansion and rural-urban migration have also forced people to inhabit the more hazardous parts of existing floodplains. A 'classic' result of urban encroachment of floodplains is the growth of a large squatter population in the major urban centres (Wan Abdul Halim 1982).

Urbanisation may well accelerate in the near future as Malaysia pushes further towards goals of rapid development and income equity. The Malaysian economy has grown by over 8.0 per cent year from 1988 to 1993 and indications and projections point to it at least maintaining that momentum over the medium term (*The Economist* July 1994, 61). With such a rapid growth rate existing urban areas will expand and many rural areas will be transformed. Also, the government's policy for greater

TABLE I. Rate of increase in the population of major urban centres located on the banks of major rivers in Peninsular Malaysia between 1957 and 1990

Centre	River	1957 Population	1990 Population	% Increase
Kuala Lumpur(1)*	Kelang	316200	919600	190.38
Ipoh(2)	Kinta	125800	293849	133.6
Georgetown(3)	Pinang	234900	248241	5.7
Johor Bahru(4)	Johor	75100	246395	226.6
Kelang(6)	Kelang	75600	192080	154.1
K. Terengganu(7)	Terengganu	29400	180296	513.3
Kota Bharu(8)	Kelantan	38100	167872	340.6
Kuantan(11)	Kuantan	23100	131547	469.5
Melaka(12)	Melaka	69900	87494	25.2
Alor Setar(15)	Kedah	52900	69435	31.3
Muar(16)	Muar	39100	65151	66.6
Batu Pahat(17)	Batu Pahat	40000	64727	61.8
Keluang(20)	Mengkibol	31200	50315	61.3
Teluk Intan(21)	Perak	37000	49148	32.8
Sungai Petani(22)	Merbok	22900	45343	98.0
Dungun(29)	Dungun	12500	28903	131.2
Kulim(31)	Kulim	17600	26817	52.4
Kemaman/Cukai(43)	Kemaman	NU	15952	NA
Kuala Kangsar(45)	Perak	NU	14539	−5.0
Mersing(48)	Mersing	NU	13888	NA
Pasir Mas(50)	Kelantan	NU	13402	NA
Tangkak(52)	Tangkak	NU	13251	NA
Kota Tinggi(53)	Johor	NU	13056	NA
Ampang(54)	Kelang	NU	12987	NA
Kuala Krai(57)	Kelantan	NU	12607	NA

NU = Non Urban
NA = Not Applicable
* Figures in brackets indicate the ranked position of urban centre in terms of total population.
Source: Karim (1990)

income opportunity and equity amongst the various ethnic groups may well force the predominantly rural Malays to abandon their traditional paid (paddy) farms and to move into jobs in urban centres. According to Mahathir bin Mohamad (1970), the current prime minister, the Malays must be urbanised and encouraged to migrate to urban centres (mostly dominated by Chinese), to stand any chance of catching up with the other ethnic group.

TABLE 2. Increasing rate of urbanisation in Peninsular Malaysia, 1911 to 1990

Year	Total population	Percentage Urban	Number of Urban Centres
1911	2,339,000	10.7	8
1921	2,907,000	14.0	14
1931	3,788,000	15.1	16
1947	4,908,000	15.9	20
1957	6,279,000	26.6	36
1970	8,810,000	28.7	49
1980	11,473,000	37.5	68
1985	12,968,000	41.1	NA
1990	14,605,000	44.7	NA

NA = Not Available

(*Source*: From Ooi (1979) and International Law Book Services (1991)

All of these impending developments will undoubtedly lead to further swelling or urban population, thereby exacerbating the pressures for floodplain encroachment in urban centres located on or adjacent to floodplains. The rate of urbanisation in the peninsula has increased more than four fold from 10.7 per cent in 1911 to 44.7 per cent in 1990 and the number of urban centres has also increased more than eight fold (Table 2). For example, the federal capital of Kuala Lumpur is expected to merge with the nearby urban centes of Petaling Jaya, Shah Alam and Kelang into a continuous conurbation streching the entire length of the Kelang River valley by the year 2020 (JICA 1982). It is expected that the total urbanised area in the Kelang valley would be about 44.0 per cent in the year 2005 but the middle section of the valley around this conurbation would be 80.0 per cent urbanised (JICA 1989).

If vulnerability is the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural disaster' (Blaikie et al. 1994), then Peninsular Malaysia is a prime example where high and increasing vulnerabilities are found. The outstanding feature of the peninsula is its wide disparity in regional development (mainly between the East Coast and West Coast states) and its extremely variegated ethnic mix which also exhibit significant in incomes. Those who find it hardest to recover from a flood disaster and reconstruct their lives are the most vulnerable, and these are generally the poor. And because those who occupy floodplains are the poor (comprising peasant farmers and fishermen in rural areas and squatters in urban areas), they are the most vulnerable. Thus, the poverty syndrome is directly related to vulnerability (Davis 1978, 11, 1981, 14). Increased vulnerability to flood hazards in Peninsular Malaysia,

therefore, is caused fundamentally by poverty and is persistently reinforced by increased flood risk and exposure. Vulnerability, however should not be simply equated with poverty. These are causes such as class, caste, gender, ethnicity, disability, and age or seniority, and vulnerability is produced by a combination of these factors and the economic resilience (i.e. access to resources and poverty) of people (Blaikie et al. 1994 Cannon 1993; Cannon 1994). Nevertheless, may would agree that, in practice, it is the poor who suffer the most in a disaster (Cuny 1983; Davis 1984; Varley 1994), and flood disasters may be found at the interface between flood hazards and vulnerable conditions (Davis 1984b).

Poverty due to the lack of access to resources is a fundamental cause of hazard vulnerability studies (Davis 1978, 1984a, 1984b; Blaikie et al. 1994; Cannon 1994). In Peninsular Malaysia, poverty is one of the main reasons why many people persist on hazardous floodplains. Chan (1995) has demonstrated how contextual forces have created poverty and perpetuated flood hazards in the peninsula. The Government of Malaysia (1991) reports that the current poverty level in the country is still significantly high at 17.1 per cent. Most of the poor households are located in the remote traditional kampungs (mostly Malays), deteriorating rubber plantations (mostly Indians), new villages (mostly Chinese) and squatter settlements in urban areas (mixed ethnicity). Poverty is a structural problem initially generated by colonial neglect but presently reinforced by ineffective public policies and over-emphasis on economic development of urban areas vis-a-vis rural areas. In the context of the flood hazard, because poor areas roughly coincide with flood-prone areas, the majority of floodplain inhabitants in the peninsula are either poor or living close to the poverty level (Chan 1995).

Figure 5 reveals that approximately 9.0 per cent of all respondents are 'hard-core' poor households earning incomes below $175 while more than a quarter of respondents are poor, earning monthly incomes below $350. A third of floodplain households are also low income families living close to the poverty level with monthly incomes between $350 and $749. On the whole, nearly two-thirds of all respondents are either poor or living close to the poverty level. A majority of those who had no locational choice are from the lower income group, with 61.4 per cent earning monthly incomes less than $750 and 43.9 per cent earning monthly incomes less than $500. Considering that the 1993 poverty level is estimated at $394 (Chan & Parker), a significant proportion of those who had no choice in location are either poor or are living on the margin of poverty. Research results from this study indicates that households from East Coast areas are comparatively poorer than their counterparts from West Coast areas. Therefore, households from the East Coast who

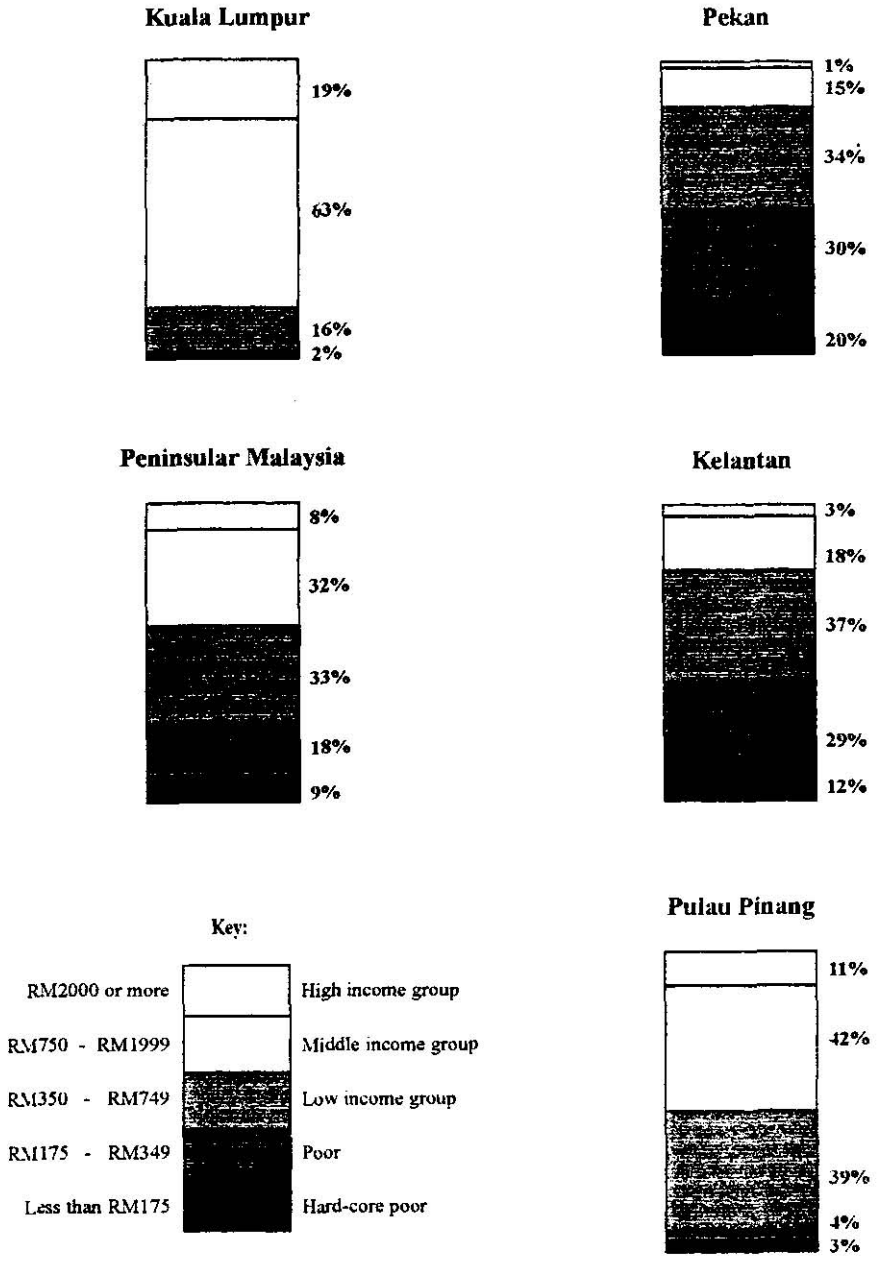

FIGURE 5. Poverty levels and income groups amongst floodplain households in Peninsular Malaysia and the four selected case study areas.

are also more exposed to flood hazards, are expected to be more vulnerable to flood hazards compared to those from the West Coast.

The capacity to anticipate, cope with, resist and recover from the impact of flood hazards depends largely on an individual or household's economic situation. Generally, the wealthier ones are less vulnerable because they have a greater capacity (at least economically) to with stand floods. Accumulated wealth enables them to survive and recover with ease. In the worst scenario, they have the option to move or migrate. In contrast, the poor are the most vulnerable simply because of their limited ability and resources in the face of flood disasters. Thus, on the basis of the high levels of poverty amongst floodplain inhabitants, vulnerability to flood hazards is consequently high. Thus, human use of floodplains are largely responsible for increasing risk, exposure and vulnerability to flood hazards in Peninsular Malaysia.

SUMMARY AND CONCLUSIONS

In Peninsular Malaysia, attributes and characteristics of the 'natural/physical events system' such as monsoon winds, heavy seasonal rainfall, low-lying topography, river characteristics, drainage etc. are demonstrated to be conducive to flood occurrences. Therefore, it cannot be denied that the natural system contributes significantly to flooding in many parts of the peninsula. However, despite the influence of the natural system, it was shown that it was the combined action of both the natural and human systems that contribute to flood hazards. More significantly, this study has demonstrated that attributes from the 'human use system' such as deforestation, floodplain encroachment, squatting and other forms of human land use are more important in flood hazard creation and prepetuation. Rapid growth in terms of physical and economic development, and population pressures in recent decades in many parts of the peninsula has increased the frequency of flooding, resulting in various problems and unprecedented damages.

Current rapid development of urban floodplains have also exacerbated flood problems resulting in high potential flood damage in such areas. The debate on deforestation is still unresolved as research relating flood occurrence to deforestation has been inconclusive. Yet, to treat deforestation as insignificant would be dangerously naive as deforestation has certainly changed hydrological parameters and contributed to flooding, especially that of urban flash flooding.

This research concludes that a combination of natural and human factors have contributed to increasing flood hazards in Peninsular Malaysia. While natural characteristics such as exposure to cold surges

and monsoon depressions leading to heavy seasonal rainfall, intense convection rain storms, low-lying topography, poor drainage and other local factors are responsible for high flood risk in many parts of the peninsula, inadvertent and deliberate human use of floodplains (both past and present) such as padi farming, plantation agriculture (mostly rubber and oil palm), tin mining, city and town expansion and other have resulted in increased human and material exposure and vulnerability.

More significantly, although flood have evolved to become a common feature in the lives of a significant number of Malaysians, increased exposure and vulnerability were demonstrated to be largely influenced by human activities. Human forces such as socio-cultural, political economy and institutional are probably more important than natural causes and they need to be researched. The answers to more effective floodplain management is expected to be found in the human dimension rather than the hitherto over-emphasised natural sphere. Thus, human contexts need to be identified and understood for more effective flood management. People are probably more likely to be trapped on floodplains by socio-cultural and political economy forces (amongst others) than they are by natural forces. Currently, floodplain occupants in Peninsular Malaysia are likely to be constrained in their selection of residential location because of poverty, low occupational mobility, low educational attainment and other human forces. These are, therefore, forces responsible for trapping individuals on floodplains, thereby increasing their risk, exposure and vulnerability to flood hazards. Future research directions should, therefore, focus on human forces as they are largely under-researched and ignored in the past. Thus, research evidence indicates that flood risk, exposure and vulnerability are all increasing in Peninsular Malaysia. With the sustained rapid economic, industrial and agriculture development expected well into the next century, the country's urban and rural floodplains are expected to grow. More people are expected to live in flood zones as encroachment becomes an inevitable solution to population and land pressures. Greater exposure and vulnerability will lead to greater damage potentials and exacerbation of flood hazards.

REFERENCES

Abdul Rahim, N. 1988. Water yield changes after forest conversion to agriculture land use in Peninsular Malaysia. *Jour. Trop. Forest Science* 1 (1): 67-84.

Abdul Rahim, N. 1990. The effects of selective logging methods on hydrological parameters in Peninsular Malaysia, PhD, University of Wales. London.

Abdul Rahim, N. & Harding, D. 1992. Effects of selective logging methods on water yield and streamflow parameter in Peninsular Malaysia, *Journal of Tropical Forest Science* 5 (2): 130-54.

Alexander, D. 1993. *Natural Disasters*. UCL: London.

Azizah Kassim. 1982. *A History of Squatting in West Malaysia with special reference to the Malays in Kuala Lumpur*. Occasional Paper No. 5. Department of Anthropology and Sociology, University of Malaya: Kuala Lumpur.

Blaikie P. Cannon T, Davis I & Wisner, B. 1994. *At Risk: Natural Hazards, Peoples' Vulnerability and Disasters*. London: Routledge.

Cannon, T. 1993. A hazard need not a disaster make: vulnerability and the causes of 'natural' disasters, In P. A. Merriman and C.W.A Browitt (eds), *Natural Disasters: Protecting Vulnerable Communities*. Proceedings of the IDNDR Conference in London, 13-15 October. Thomas Telford: London.

Cannon, T. 1994. Vulnerability Analysis and the Explanation of 'Natural' Disasters. In Varley (ed), *Disasters, Development and Environment*. Chichester: John Wiley & Sons.

Chan, N.W. 1990. Angin Monsun dan Reliabiliti Hujan di Pantai Timur Semenanjung Malaysia. *Ilmu Alam* 19: 35-52.

_____. 1991. Aspek-aspek sosio-ekonomi dan amalan-amalan pertanian kaum tani di Sawah Sempadan dan Sungai Burong, Mukim Tanjong Karang (Daerah Kuala Selangor) terhadap perubahan kualiti air permukaan, Social Science R & D Report, Science University of Malaysia: Pulau Pinang.

_____. 1995. Natural and Human Use Systems Relating to Flood Hazards in Peninsular Malaysia, Unpublished report, Flood Hazard Research Centre, Middlesex University, Enfield.

Chan, N.W. & Parker, DJ. Forthcoming. Response to dynamic flood hazard factors in Peninsular Malaysia. *The Geographical Journal*.

Chua, L. 1972. Pekan floodplain, Pahang: The attitude and behaviour of the floodplain occupants towards possible resettlement. B.A. Graduation Exercise, University of Malaya, Kuala Lumpur.

Cuny, F.C. 1983. *Disasters and Development*. New York: Oxford University Press.

Daniel, J.G. and Kulasingam, A. 1974. Problems arising from large scale forest clearing for agricultural use – the Malaysian experience, *Malaysian Forester* 37, 152-62.

Davis, I. 1978. *Shelter After Disaster*. Headington, Oxford. Oxford Polytechnic Press.

_____. 1981. Disasters and Settlements – Towards an Understanding of the Key Issues, In I. Davis (ed), *Disasters and the Small Dwelling*. Oxford: Pergamon Press.

_____. 1984a. Housing and natural hazards. In K. J. Miller (ed). *The International Karakoram Project*, Vol 2. Cambridge: Cambridge University Press.

_____. 1984b. Prevention is better than cure. *Ideas. RRDC Buletin* 18, October, 3-7.

_____. 1987 Safe Shelter within Unsafe Cities: Disaster Vulnerability and Rapid Urbanisation, *Open House International* 12 (3), 5-15.

Department of Statistics Malaysia. 1992 *Population and Housing Census of*

Malaysia – Preliminary Count Report. Department of Statistics Malaysia: Kuala Lumpur.

Dewan Bandaraya Kuala Lumpur. 1982. *Kuala Lumpur Draft Structure Plan*. DBKL: Kuala Lumpur.

DID. 1986. Sungai Tekam Experimental Basin, Transitional Report July 1980 to June 1983, *Water Resources Publication* 16. Kuala Lumpur: Drainage and Irrigation Department Malaysia.

DID. 1989. Sungai Tekam Experimental Basin Final Report, July 1977 to June 1986, *Water Resources Publication* 20. Kuala Lumpur: Drainage and Irrigation Department Malaysia.

DID. 1992. Laporan Banjir 1991. Unpublished report, DID Pulau Pinang.

Faaland J, Parkinson JR & Saniman R. 1990. *Growth and Ethnic Inequality: Malaysia's New Economic Policy*. London: Kuala Lumpur: Hurst & Company.

Ferng MC. 1988. Kuala Lumpur Flood Mitigation Scheme, Paper presented at the Seminar Tebatan Banjir, 14-17 November, Kuala Lumpur/Sri Layang.

Fish, W. 1957. Challenge of the squatter slums, *The Malayan Monthly* (June).

Friends of Penang Hill. 1991. *Penang Hill: The need to save our natural heritage*, Friends of Penang Hill: Penang.

Government of Malaysia. 1991. *Sixth Malaysia Plan 1991-1995*. Kuala Lumpur: Government of Malaysia.

Green, CH. 1992. Enabling effecting hazard management by the public, In D.J. Parker and J.W. Handmer (eds), *Hazard Management and Emergency Planning: Perspectives on Britain*. London: James and James.

Hamirdin Ithnin. 1992. Effects of Urbanisation on Small Stream Catchments in Kuala Lumpur: An Evaluation based on an Estimation Procedure, In Voon and Bahrin (eds), *The View From Within – Geographical Essays on Malaysia and Southeast Asia, The Malaysian Journal of Tropical Geography*.

Hani Ahmad. 1991. Sheer greed for money destroys forests. *Sunday Mail*, May 12: 10.

Harris, RC, Hohenemser C & Kates RW 1978 Our hazardous environment. *Environment* 20: 6-15, 38-40.

International Law Book Services. 1991. *Malaysia Kita, Panduan dan Rujukan untuk Peperiksaan Am Kerajaan*. Kuala Lumpur: International Law Book Services.

Jamaluddin MJ. 1985. Flash flood problems and human responses to the flash flood hazard in Kuala Lumpur area. *Akademika* 26 (January): 45-62.

JICA. 1982. *National Water Resources Study, Malaysia*, Sectoral Report Vol. 5, River Conditions. Kuala Lumpur: Japan International Coorperation Agency.

JICA. 1989. Study on flood mitigation of the Klang River Basin. Unpublished report to the Government of Malaysia.

Karim (ed). 1990. *Information Malaysia 1990-91 Yearbook*. Kuala Lumpur: Berita Publishing.

Keller, A.Z., Wilson, H. & Kara Zaitri, C. 1990. The Bradford Disaster Scale. *Disaster Management* 2(4): 207-13.

Kenyalang J. 1992. The politics of logging. *Aliran* 12(6): 15-8.

Khor. K.P. 1987. *Malaysia's Economy in Decline: What happened and what to do?*, Penang: Consumers' Association of Penang.

Khor, K.P. 1989. *Housing for the people: Why Malaysia has so far failed to meet housing needs of the poor.* Penang: Consumers' Association of Penang.

Leigh, C & Low, KS. 1978. The flood hazard in Peninsular Malaysia: Government Policies and Action. *Pacific Viewpoint* 19 (1): 47-64.

Lim, TK. 1988. Malaysian Rivers and Floods. Paper presented at the Seminar Tebatan Banjir, Organised by the Jabatan Parit dan Tali Air Malaysia and Japan International Cooperation Agency, 14-17 November, Kuala Lumpur.

Mahathir Mohamad. Singapore: 1970. *The Malay Dilemma.* Times Book International.

Malayan Nature Society. 1992. In Harmony With Nature. Proceeding of the International Conference on Conservation of Tropical Biodiversity, Golden Jubilee Issue of the *Malayan Nature Journal.* Kuala Lumpur: Malayan Nature Society.

Razha Abdul Rashid. 1978. One way street to Alor Star: A case study of migration, adaptation and ethnicity in a Malaysian town. Unpublished report. Alor Setar: Kedah State Government.

Ooi, J.B, 1979. *Semenanjung Malaysia.* Kuala Lumpur: Longmans.

Parker, D.J. 1976. Socio-Economic Aspects of Flood Plain Occupance. PhD, Department of Geography, University College of Swansea.

Parry, M.L., Blantrain de Rozari, M. Chong, A.L. & Panich, S. 1992. *The Potential Socio-Economic Effects of Climate Change in South-East Asia.* Nairobi: United Nations Environmental Programme.

Sahabat Alam Malaysia. 1992. Environment and ecology destroyed. *Suara Sam* 6 (1). Penang: Sahabat Alam Malaysia.

Shiva V, Anderson P, Schucking H, Gray A, Lohmann, L. & Cooper D. 1991. *Biodiversity: Social and Ecological Perspectives.* Penang: World Rainforest Movement.

Smith, K. 1992. *Environmental Hazards: Assessing Risks and Reducing Disasters.* London: Routledge.

Sooryanarayana, V. 1988. Floods in Malaysia. Paper presented at the Working Group on Tropical Climatology and Human Settlements of the 26th Congress of the International Geographical Union, August, Sydney.

The Economist. Various issues.

The Royal Society. 1983. *Risk assessment: report of a Royal Society Study Group.* London: Royal Society.

Toebes, C & Goh KS. 1975. *Some hydrological effects of land use change in Peninsula Malaysia.* Water Resources Publication No. Kuala Lumpur: Drainage and Irrigation Department, Ministry Agriculture and Rural Development Malaysia.

Tory WI: 1979. Anthropological studies in hazardous environments: past trends and new horizons. *Current Anthropology* 20: 517-40.

Utusan Konsumer. 1992. 5,000 acres of peat forests destroyed. Consumer Association of Penang, mid-September, 1-3.

Wan Abdul Halim Othman. 1982. *Squatter Communities in the Federal Territory,* Monograph Series No. 6. Centre for Policy Research. Pulau Pinang:

Universiti Sains Malaysia.

White, G.F., Calef, W.C., Hudson, J.W., Mayer, H.M., Sheaffer J.R. & Volk, D.J. 1958. *Changes in urban occupance of flood plain in the United States.* Research paper No. 57. Department of Geography, University of Chicago.

World Rainforest Movement. 1991. *Biodiversity: Social & Ecological Perspectives.* Penang: World Rainforest Movement.

Wycherly PR. 1967. Rainfall probability tables for Malaysia. *Planting Manual* 12. Kuala Lumpur: Rubber Research Institute of Malaysia.

Yaziz, M.I. & Sulaiman, W.N.A. 1985. Urbanisation and its effects on some hydrological parameters in the Sungai Batu catchment area of Kuala Lumpur, In Y.H. Yip and K.S. Low (eds), *Urbanization and Ecodevelopment, with reference to Kuala Lumpur.* Kuala Lumpur: Institute of Advanced Studies, University of Malaya.

Zulkifli, Y. & Abdul Rahim, N. 1991. Logging and Forest Conversion: Can we minimise their impacts on water resources? Paper presented at ASEAN Seminar on 'Land Use Decision and Policies: Will Tropical, Forest Survive Their Impacts?' 28-30 October, Penang.

Bahagian Geografi
Pusat Pengajian Ilmu Kemanusiaan
11800 Universiti Sains Malaysia
Pulau Pinang