

A GEOGRAPHICAL PERSPECTIVE OF FLOOD HAZARD CREATION AND PERPETUATION IN PENINSULAR MALAYSIA

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Kertas ini menunjukkan bahawa bahaya banjir bukannya hasil tunggal sistem semula jadi tetapi adalah akibat kombinasi sistem semula jadi dan sistem manusia. Di Semenanjung Malaysia, banjir adalah bahaya semula jadi yang paling umum dan ianya banyak dihasil dan dikekalkan oleh interaksi sistem peristiwa semula jadi dan sistem penggunaan manusia. Semenanjung Malaysia terletak dalam kawasan tropika lembap khatulistiwa di mana angin monsun bermusim membawa beberapa waktu hujan lebat yang sering menghasilkan banjir yang meluas, khasnya disepanjang wilayah Pantai Timur. Faktor geografi semenanjung merupakan sebab utama kenapa banyak wilayahnya sering dilanda banjir. Geografi fizikal dan manusia sama-sama mencetus bahaya banjir. Daripada segi geografi, ciri-ciri semula jadi seperti keterdedahan kepada angin monsun sejuk dan tekanan rendah monsun yang membawa hujan lebat bermusim, ribut perolakan hujan yang kuat, topografi rendah, saluran yang tidak mencukupi dan lain-lain faktor tempatan telah menghasilkan risiko banjir yang tinggi di kebanyakan tempat di semenanjung. Kawasan berhampiran dengan sungai dan dataran pinggir pantai sering dibanjiri, dengan kebanyakan tempat dibanjiri lebih daripada satu kali setahun. Dari segi geografi manusia pula, penggunaan dataran banjir baik secara sengaja atau tidak oleh manusia (pada masa dulu dan sekarang) seperti penanaman padi, kegiatan perikanan, pertanian ladang (terutamanya getah dan kelapa sawit), perlombongan timah dan perkembangan bandar dan lain-lain telah meningkatkan pendedahan manusia dan benda kepada bahaya dan kemusnahan di dataran banjir.

This paper demonstrates that flood hazards are not solely the consequence of natural system but a combination of both natural and human systems. In Peninsular Malaysia, floods are the most common natural hazard and are largely created and perpetuated by the interaction of natural event system and human use system. The peninsula is located in the wet equatorial tropics where seasonal monsoon winds bring forth heavy rain spells which often result in widespread flooding, particularly along its entire East Coast region. More than any other factor, the geography of the peninsula is probably the key reason why many regions are highly flood-prone. Both the physical and human geography of the peninsula are conducive for flood hazard creation. Geographically, natural characteristics such as exposure to cold monsoon surges and 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. Riverine and coastal areas are flooded annually, with many places being flooded more than once a year. In terms of its human geography, inadvertent and deliberate human use of floodplains (both past and present) such as padi farming, fishing, plantation agriculture (mostly rubber and oil palm), tin mining, city and town expansion and others have resulted in increased human and material exposure and vulnerability on floodplains.

INTRODUCTION

This paper attempts to demonstrate that flood hazards in Peninsular Malaysia are created and perpetuated by a combination of the work of nature and humans. It refutes the often accepted contention that natural hazards¹ are all powerful and that their creation are solely the work of the natural event system beyond human interference (Semple 1911). Some have even gone as far as implying that natural hazards are acts of God and are therefore beyond human enquiry (Smith, 1992). When hazards research first came to prominence in the 1940s, natural hazards were viewed as acts of God. For instance, droughts were seen as acts of God although the losses arising from them were viewed as acts of man (White, 1935). This perspective seems to imply that humans do not have any part to play in the creation of such hazards. Gradually, however, results from researches in hazards, particularly in the flood hazard, indicated that humans do play an important role in the creation of such hazards mainly through the choice of location (Burton, et al. 1978). It is only when humans choose to locate properties and live in areas affected by extreme natural processes that hazards exist. For instance, flooding in an uninhabited swamp is not considered a hazard (unless it gives rise to substantial ecological or other environmental effects). Thus, Blaikie et al. (1994) assert that '...there is no risk if hazard and vulnerability do not coincide'². Generally, it is often difficult to distinguish a hazard that is attributed to nature from one that is attributed to humans. In fact, the same hazard in one area may be more directly attributable to nature but can be largely created in another area by humans. For instance, seasonal flooding during the monsoon months along riverine mangrove forests in the East Coast of Peninsular Malaysia is considered a natural cause but the occurrence of flash floods in urban areas is considered a human cause (due to rapid development, inadequate drainage, poor planning and others). Yet, it is not uncommon to see the prefix natural being conveniently attached to hazards (disasters or catastrophes) in the current literature, particularly in the media and political publications. This is because the very use of the term natural implies that the hazard associated with it has a natural origin and this thereby exonerates humans from any blame. This, it has been suggested, is an ideological argument in favour of consensus and denies conflicts in the community arising from socially constructed inequalities of power and control

(Burgess, 1978).

Peninsular Malaysia is one of many countries in Southeast Asia which is geographically located in an area conducive for the occurrence of floods. It is located in the wet equatorial tropics where seasonal monsoon winds bring forth heavy rain spells which often result in widespread flooding, particularly along its entire East Coast region (Figure 1). More than any other factor, the geography of the peninsula is probably the key reason why many regions are highly flood-prone. Both the physical and human geography of the peninsula are conducive for flood hazard creation. Flooding is, therefore, a major natural hazard in Peninsular Malaysia. It is frequent and widespread, often exacerbating into disasters which cripple the economy, communications, public services and result in property damage and loss of life (Table 1). Major floods have occurred regularly about once every few years. Major floods in 1926, 1954, 1967, 1970, 1971, and 1988 have caused havoc in affected areas resulting in significant loss of life and damage to properties, crops and livestock, businesses, industries and public amenities (Winstedt, 1927; DID Undated). Even the annual occurrence of normal seasonal monsoon floods (not considered severe) were shown to put strains on the country's resources. Annually, floods were shown to account for almost the entire reported national cost for disaster preparedness, mitigation, relief and rehabilitation. Smith (1985) has shown that household flood damage and their effects are significant when compared to mean household incomes of floodplain dwellers. Damage to building contents and structures, crops and livestock, and vehicles were the main categories of flood loss suffered by individual households. Intangible effects such as stress, worry and health were also shown to be important. Damages to commercial properties and their businesses, especially in large urban centres such as Kuala Lumpur and Georgetown are expected to be substantial. Industrial damages are also expected to be substantial and currently under-reported.

THE PHYSICAL GEOGRAPHY OF FLOODS

(a) Geographical Location

Peninsular Malaysia is geographically located at the southernmost part of the Asian mainland. The peninsula lies just north of the Equator between latitudes 1° 20'N and 6° 40'N, and longitudes 99° 35'E and 104° 20'E. It is bounded on the north by Thailand, on the west by the Straits of Malacca, on the east by the South China Sea and on the south by Singapore. Its longest extent from north to south is about 800 km and its widest extent from east to west is about 320 km. The peninsula covers an area of 131,794 sq km, over half and one-quarter of which are highlands above 152 m and 305 m respectively. Because of its geographical location, the seasons in the

peninsula are distinguished not by temperature but by rainfall. Basically (although there are small variations between regions), the year is 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.

(b) Relief

Although Peninsular Malaysia is generally considered hilly with more than one-third of its total land area above 152 m, it possesses wide coastal floodplains which are highly flood-prone. Its mountain ranges are located in the northern and central parts of its interior and strike northerly with a somewhat NNE trend (Figure 2). Between the East and West coasts and the interior mountain ranges are gently rolling country known as the 'foothill regions' with elevations between 76 m and 152 m. Owing to their good drainage, the foothill regions are prime agricultural areas and are intensively cultivated with rubber, oil palm and other plantation crops. From the foothills to the coasts are flat coastal plains on both the east and west of the peninsula. These coastal plains contain the bulk of the peninsula's population, economic activities, infrastructure, and natural resources (Chan 1995). 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. The average heights of coastal plains in the peninsula are not more than a few metres and most of the plains coincide with the floodplain regions of the peninsula. The geography of the coastal plains are, therefore, highly flood-prone.

(c) Wind Systems

Peninsular Malaysia 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: 33). 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 1). These two predominant wind systems significantly affect 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. The Northeast Monsoon winds (November to March) are

responsible for floods which occur every year in one state or another, particularly in the East Coast of the peninsula. In many cases, extreme conditions created by the winds have deposited rainfall exceeding 600 mm within a 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 an a tropical depression was superimposed on the Northeast Monsoon winds (considered an extreme meteorological condition) during the nation-wide 1971 flood.

The other predominant wind of the region, the Southwest Monsoon (May to September), on the other hand, does not normally cause widespread floods because the peninsula is sheltered by the Indonesian island of Sumatra. However, heavy rains do occur in many parts of the West Coast during the period of the Southwest Monsoon which may lead to localised floods. Also, during this same period, small intense and short-lived squalls called 'sumatras' move across the Melaka and Johor coasts, on the southern parts of the West Coast. These localised winds bring heavy torrential rains but fortunately they are rather localised and do not normally cause large scale floods. However, in many instances, especially in the more developed urban areas, flash floods usually accompany these squalls. Other than the sumatras, there are also strong land and sea breezes which affect the coastal parts of the peninsula. However, these winds do not bring about large scale floods. During the two short transitional periods (April and October), long periods of calm conditions exist and there is no dominant wind (Chan, 1990a: 47). Such conditions encourage the build-up of intense convective rain and thunderstorms which frequently give rise to the occurrence of flash floods, especially in densely populated urban areas in the West Coast.

(d) Rainfall and Flooding

In Peninsular Malaysia, the Northeast Monsoon Season brings forth the rainy season which coincides with the flood season, particularly in the East Coast. Generally, the seasons in the peninsula are differentiated by the amount of rainfall. The timings of wet and dry seasons vary, depending on the region (Figure 3). 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, for example in 1971, the spill-over effects of the Northeast Monsoon rains spread across the central mountain ranges over to the West Coast, giving rise to widespread 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 the exact timing, duration and magnitude of flooding

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 usually not widespread but on a 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. Consequently, the temporal aspect of flooding in the West Coast region is highly unpredictable. Although flash floods generally occur just before the onset of the Northeast Monsoon Season or during either of the two inter-monsoon periods, they are known to occur at 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, 1991:70; DID, 1992).

The mean annual rainfall of Peninsular Malaysia is highly variable from place to place, but ranges from about 1,500 mm to more than 3,500 mm (Figure 4). In general, rainfall decreases from the East Coast to the West Coast (Chia, 1975). 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. 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 the two short inter-monsoon seasons in April and October where torrential convectional rains occur (Chan, 1981). 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: 41). During the Southwest Monsoon Season, however, the variation in rainfall totals between the two coasts is 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 runoff (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 runoff rates, the occurrence of flash floods are therefore a common phenomenon in the West Coast. In the East Coast, however, rainfall intensities are much lower, about 2.5 mm per hour (Ooi, 1979: 71). However, the lower intensities are more than compensated 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.

(e) Rivers and Flooding

The abundant water resources and wet equatorial climate of the peninsula support a perennial network of rivers and streams. 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 communication 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 of tin. As a result, most of the major settlements in the peninsula are located near to the rivers. Although modern day use of rivers has 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. Frequently, this has resulted in an increase in the frequency and magnitude of flooding as well as a corresponding increase in flood losses.

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 5). 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 (JICA, 1982).

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 typically vertical profile in the upper stretches to a flattened appearance in the middle to lower stretches. 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 sheltered West Coast, 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 along 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 Geography of Floods

Natural conditions can foster and create floods but flood hazards are the consequence of human inhabitation on floodplains. If a severe flood event (a natural extreme event) occurs in an uninhabited area (e.g. a mangrove swamp), then the resultant flood would not be considered a hazard, much less a disaster. Human activities interact with the natural system to produce flood hazards (Figure 6). Floodplains have always been preferred settlement locations of human civilisation. The lure and attractiveness of the floodplain as a place of occupancy is well documented (White, et al. 1958; Parker, 1976; Smith, 1992: 230-1). In Peninsular Malaysia, it has been estimated that approximately 2.5 million people³ live in floodplains and are vulnerable to flood of varying probabilities (JICA, 1982: P-14). Floodplains are also

regions where a significant proportion of the peninsula's population and much of the economic activity are concentrated (Leigh and Low, 1978: 49). Table 2 indicates the extent to which populations have settled 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. 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 per year from 1988 to 1992 and indications and projections point to it at least maintaining that momentum over the medium term (Government of Malaysia, 1991). 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 income opportunity and equity amongst the various ethnic groups may well force the predominantly rural Malays to abandon their traditional padi (paddy) farms and to move into jobs in urban centres. According to Mahathir Bin Mohamad (1970:107-14), 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 groups.

All of these impending developments will undoubtedly lead to further swelling of 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 3). For example, the federal capital of Kuala Lumpur is expected to merge with the nearby urban centres of Petaling Jaya, Shah Alam and Kelang into a continuous conurbation stretching the entire length of the Kelang River valley by the year 2020. 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: D-17).

There are many reasons why floodplains have been the 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 (Figure 5).

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. 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, 1991a). 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 source 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 and Low, 1978). Miners discovered that many floodplains of the peninsula, notably the Kinta and Kelang Valleys contained rich deposits of alluvial tin⁴ 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 include the two largest cities Kuala Lumpur and Ipoh, Seremban, Taiping, Ampang, Kampar and others. Some properties adjacent to riverine areas may also command high property values because of their central location within cities. 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 the centuries amongst Malay society is the stilt house (Voon, et. al., 1978). 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, among other reasons, which largely accounts for their reluctance to leave the flood-prone area and relocate elsewhere, despite encouragement by the government (Chua, 1972).

This paper demonstrates that a combination of natural flood-producing mechanisms and human-use of floodplains has resulted in increased risk and exposure to floods in Peninsular Malaysia. While risk may be defined as the probability and other physical characteristics of hazards, it is essentially a product of hazard and vulnerability. There is no risk if hazards do not coincide with vulnerability. 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 and 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 and Harding, 1992), and that commercial logging resulted in significant increases in storm flow volume and initial discharge (DID 1986). Peninsular Malaysia is a land 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: 93). 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 runoff 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 70.0 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; CAP, 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, undergrowth 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 soils and the hydrological regimes (Daniel and 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 and 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 of 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 is a water yield increase of between 3 mm to 5 mm for every percentage of forest cover cleared. Toebes and Goh (1975: 10) showed that logging activities caused significant changes in flood peaks, flood volumes and flood frequencies.

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 1992 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 populations, it has contributed to increased flood risk.

Human exposure to floods has also increased. If exposure is defined as a measure of the population at risk, then it has increased proportionately as the peninsula's major cities grew and spilled onto floodplains (JICA, 1982). 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).

CONCLUSIONS

This paper has demonstrated that flood hazards are created and perpetuated in Peninsular Malaysia by a combination of the work of nature and humans. Floods are therefore, neither solely acts of God nor acts of humans. It has demonstrated that Peninsular Malaysia is geographically located in a region where natural conditions favour flood occurrences. However, more significantly, it has revealed that floods are not necessarily a hazard unless human populations are exposed to them. Thus, flood hazards and resulting flood disasters are the consequence of a combination of factors originating from both the natural and human dimensions. Both 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 others have resulted in increased human and material exposure and vulnerability. This paper also reveals evidence 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.

NOTES

- 1 The term natural hazard has given rise to much debate. In the context of this paper, it refers to an event based in nature such as an earthquake, a flood, a drought, or a volcanic eruption. However, it does not imply that such an event is created solely by natural forces. For example, although floods are events based in nature, human interference with the natural system such as deforestation, global warming, urbanisation and other changes to the earth's surface can exacerbate and contribute significantly to flood hazard creation.
- 2 Some researchers are convinced that hazards and disasters are not natural but largely created by human activities (Cannon, 1993).
- 3 Based on the country's annual average rate of population increase of 2.5

per cent between 1982 and 1993 (Government of Malaysia, 1991: 28), the total floodplain population would be 3.3 million in 1993. This figure is expected to be higher if rural-urban and international migration (mostly Thais and Indonesians) are taken into account.

- 4 It was the discovery of rich alluvial tin deposits in the early 19th century that triggered off in-migration of the Chinese from China and later of the British intervention in the Malay peninsula which led to almost three-quarters of a century of British colonial rule. It has been demonstrated that tin mining was a contributory factor in flood hazard creation in the Kinta and Kelang valleys (Leigh and Low, 1978). British colonial rule has also been alleged to have aggravated flood problems by over-developing the West Coast and neglecting the East Coast (Chan, 1995).

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Table 1: Official flood loss estimates for selected floods in Peninsular Malaysia

Flood Event (Year)	(Place)	Damage (\$ million at 1993 prices)	Deaths	Persons Evacuated
1967	Kelantan R. Basin	199.3	38	320,000
1967	Perak R. Basin	154.5	0	280,000
1967	Terengganu R. Basin	40.2	17	78,000
1971	Pahang R. Basin	93.1	24	153,000
1971	Kuala Lumpur	84.7	24	NA
1979	Peninsular Malaysia	NA	7	23,898
1982	Peninsular Malaysia	NA	8	9,893
1983	Peninsular Malaysia	NA	14	60,807
1984	Batu Pahat R. Basin	20.3	0	8,400
1986	Peninsular Malaysia	NA	0	40,698
1988	Peninsular Malaysia	NA	37	100,755
1988	Kelantan R. Basin	33.0	19	36,800
1991	Peninsular Malaysia	NA	11	NA
1992	Peninsular Malaysia	NA	12	NA
1993	Peninsular Malaysia	NA*	22	17,000

NA = Not Available

* In the state of Kelantan, a total of 200 schools were closed during the 1993 flood resulting in 113,000 students missing school for a total of between 6 to 11 days.

(Source: DID Malaysia and Malaysian National Security Council)

Table 2: 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	316,200	919,600	190.8
Ipoh(2)	Kinta	125,800	293,849	133.6
Georgetown(3)	Pinang	234,900	248,241	5.7
Johor Bahru(4)	Johor	75,100	246,395	226.6
Kelang(6)	Kelang	75,600	192,080	154.1
K. Terengganu(7)	Terengganu	29,400	180,296	513.3
Kota Bharu(8)	Kelantan	38,100	167,872	340.6
Kuantan(11)	Kuantan	23,100	131,547	469.5
Melaka(12)	Melaka	69,900	87,494	25.2
Alor Setar(15)	Kedah	52,900	69,435	31.3
Muar(16)	Muar	39,100	65,151	66.6
Batu Pahat(17)	Batu Pahat	40,000	64,727	61.8
Keluang(20)	Mengkibol	31,200	50,315	61.3
Teluk Intan(21)	Perak	37,000	49,148	32.8
Sungai Petani(22)	Merbok	22,900	45,343	98.0
Dungun(29)	Dungun	12,500	28,903	131.2
Kulim(31)	Kulim	17,600	26,817	52.4
Kemaman/Cukai(43)	Kemaman	NU	15,952	NA
Kuala Kangsar(45)	Perak	15,300	14,539	-5.0
Mersing(48)	Mersing	NU	13,888	NA
Pasir Mas(50)	Kelantan	NU	13,402	NA
Tangkak(52)	Tangkak	NU	13,251	NA
Kota Tinggi(53)	Johor	NU	13,056	NA
Ampang(54)	Kelang	NU	12,987	NA
Kuala Krai(57)	Kelantan	NU	12,607	NA

NU = Non urban NA = Not Applicable

* Figures in brackets indicate the ranked position of urban centres in terms of total population.

(Source: Karim 1990: 78-9)

Table 3: 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: Ooi, 1979 and International Law Book Services, 1991)

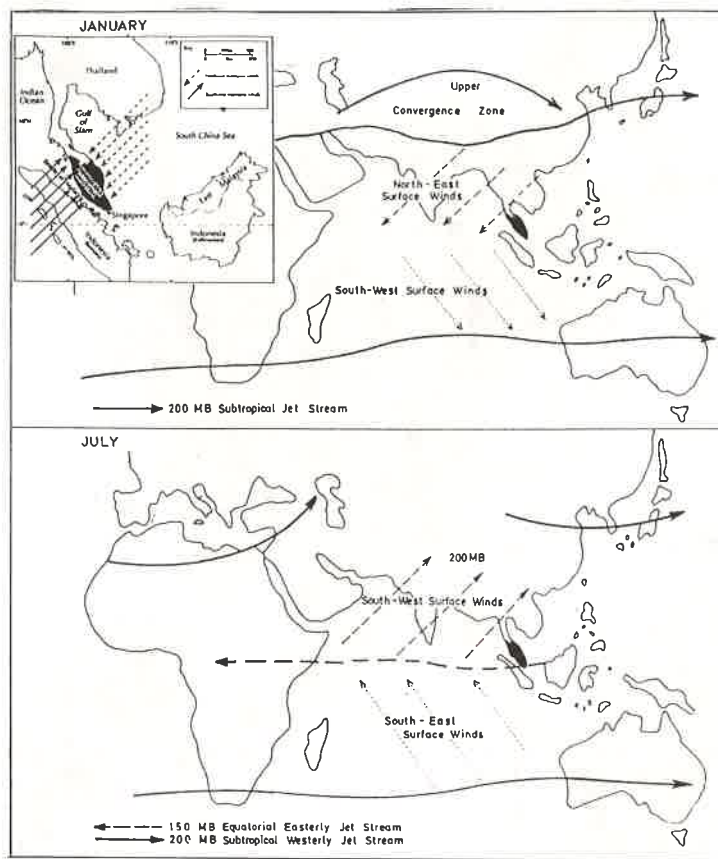


Figure 1: Geographical location of Peninsular Malaysia within the wet equatorial tropics and its relation to surface winds (Inset: The influence of monsoon winds on the peninsula).

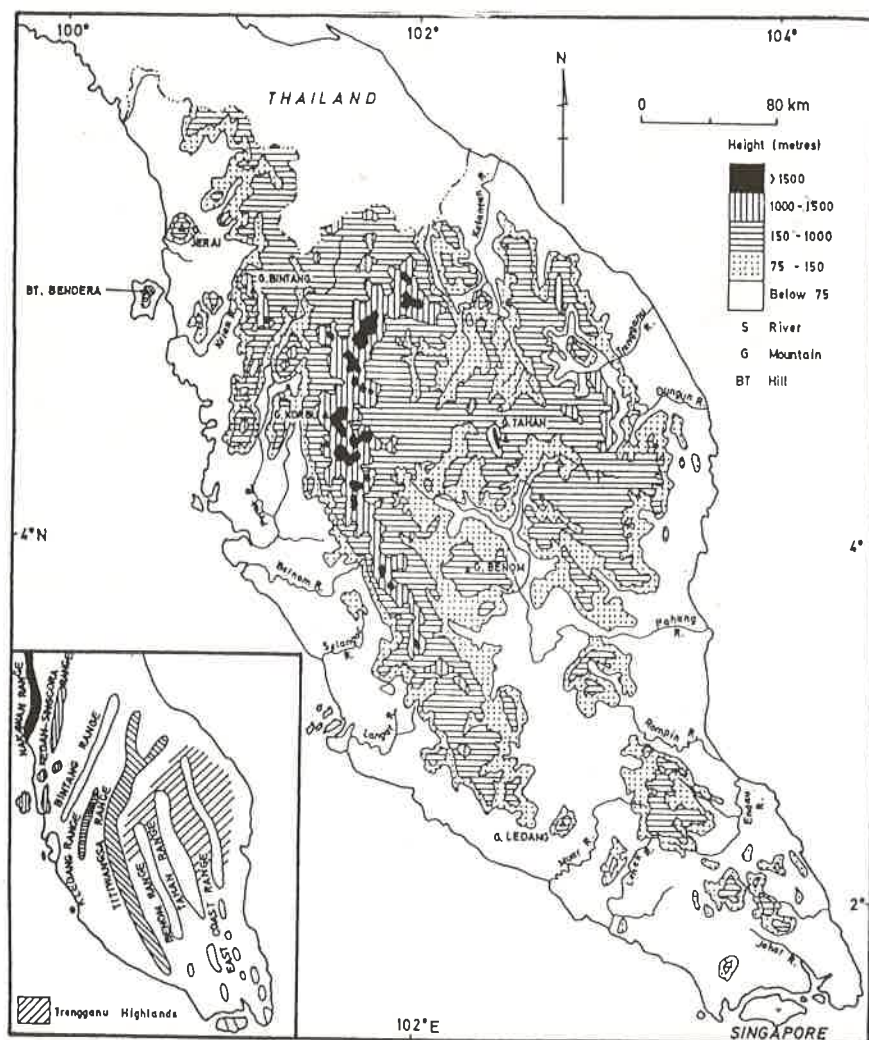


Figure 2: Peninsular Malaysia - Topography (Inset - Mountain ranges).
(After Ooi 1979)

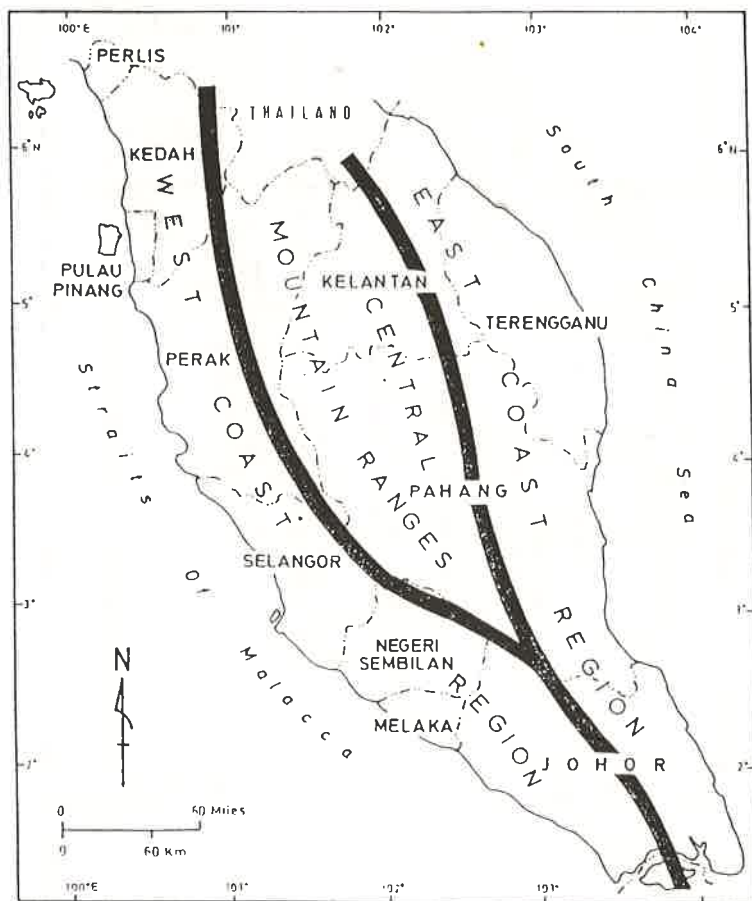


Figure 3: Broad division of regions in Peninsular Malaysia

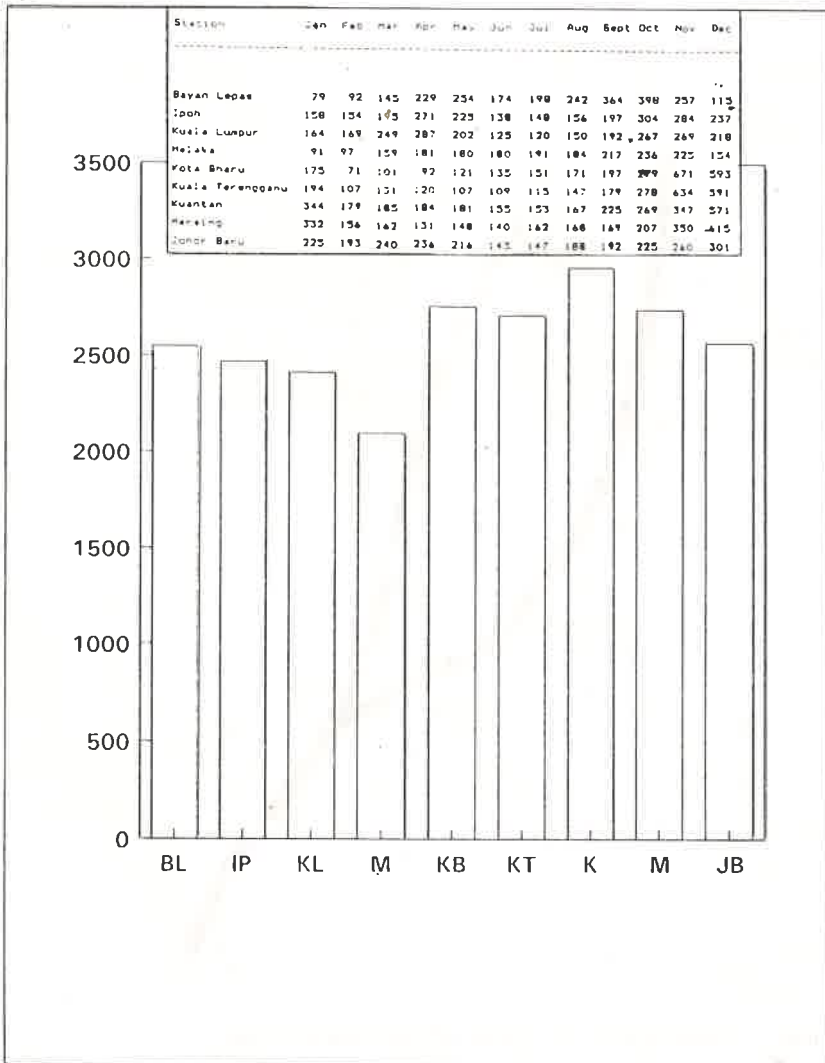


Figure 4: Annual rainfall (mm) at various places in Peninsular Malaysia

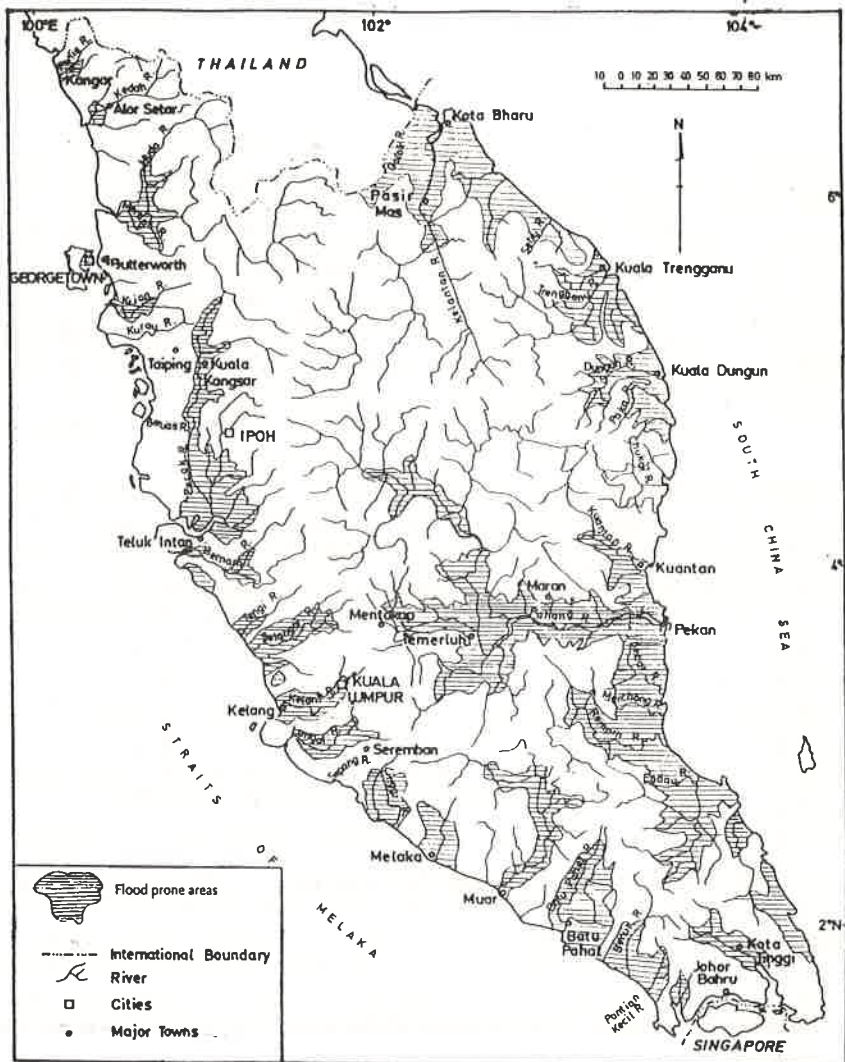


Figure 5: Distribution of river systems in Peninsular Malaysia

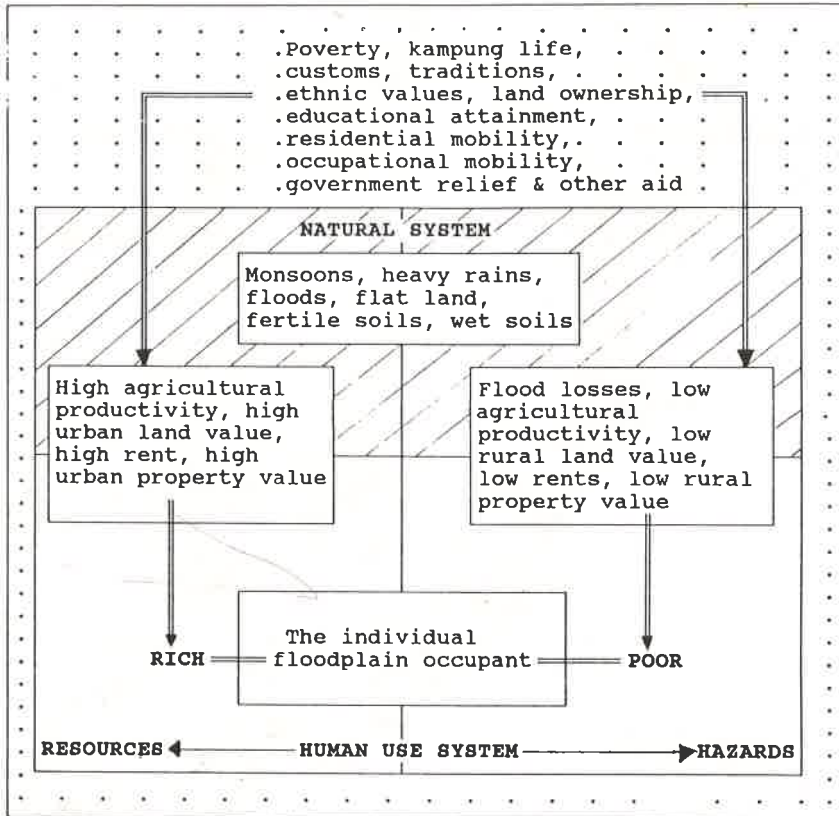


Figure 6: The creation of flood hazards via the interaction of the natural and human systems.