OFFICIAL RESPONSE TO FLASH AND MONSOON FLOODS IN MALAYSIA

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ABSTRACT

Flooding is the only significant natural hazard affecting Malaysia and its people. Annually, it accounts for a significant number of casualties, disease epidemics, property and crop damage and other intangible losses. Flash floods are an ephemeral form of inundation usually caused by convectional storms accompanied by intense rainfall over a short period of time. Usually, they are localised, of short duration, cause limited damage and are responsible for a limited number of drownings. However, because of their rapid onset, they are difficult to predict and warning lead times are short. In contrast, monsoon floods are seasonal, of longer duration and are generally more extensive and severe. Monsoon floods exert a heavy toll on the government annually in terms of their management.

As a country which is almost annually affected by flooding, there are no lack of measures and strategies to reduce floods in Malaysia. While the many strategies employed hitherto have been responsible for reducing some of the impacts of flooding, they have not been entirely successful in the overall management of floods. This is largely due to a reactive approach based on evacuation, relief and rehabilitation, the low salience of floods on government agendas, the lack of interaction and cooperation amongst government agencies dealing with floods, the bureucratic nature of government agencies, and the victims' reluctance to relocate. In addition, rapid urbanisation and floodplain encroachment have exacerbated flood hazards as more and more flood-prone land are developed and urban floodplain expand. People are also forced to occupy floodplains due to the shortage of land, high rents and rural-urban migration. This paper analyses official response to flood hazard management in Malaysia in terms of various strategies adopted.

INTRODUCTION

Malaysia is located in a geologically stable region free from earthquakes, volcanic activities, and strong winds which periodically affect some of its neighbours. However, it experiences a wet equatorial climate which generates heavy intense rain storms often giving rise to frequent flash floods. Furthermore, a large part of the country is exposed to seasonal monsoon winds which bring forth seasonal monsoon flooding every year. As a result, flooding is the only significant natural hazard affecting the country and its people. Annually, it accounts for a significant number of casualties, disease epidemics, property and crop damage and other intangible losses (Chan, 1995a). In general, there are two main types of floods, viz. flash and monsoon floods (**Figure 1**).

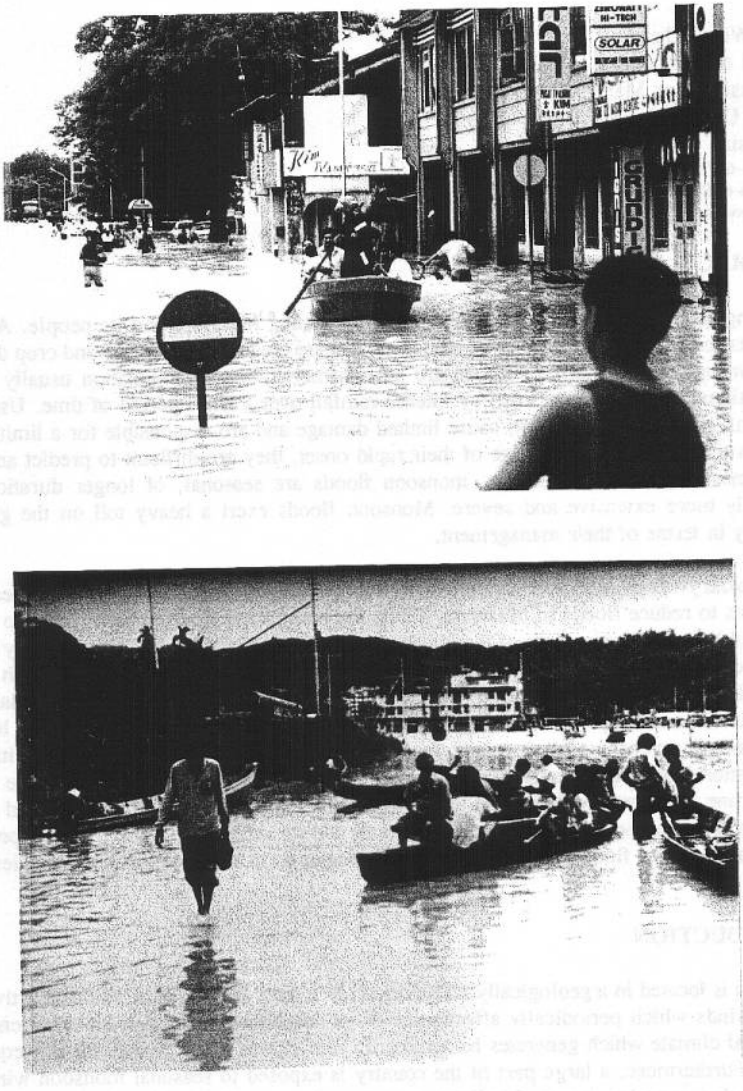

Figure 1: Top - The September 1995 flash flood in Georgetown, Penang which lasted for half a day. Bottom - The 1988 monsoon flood in the outskirts of Kota Bharu, Kelantan which lasted for a few weeks. In this picture, rural inhabitants have resorted to using "sampans" (Malaysian canoes) as a means of transport.

Flash floods are an ephemeral form of inundation usually caused by convectional storms accompanied by intense rainfall over a short period of time (Jahi, 1985). Usually, these storms occur most frequently during two relatively short Inter-Monsoon Seasons around April and October. These transitional periods are prone to torrential rainstorms as light winds and calm atmospheric conditions coupled with hot and abundant sunshine give rise to intense convection currents culminating in convective thunderstorms in the late afternoons. During any such storms, the life span of which is usually less than 24 hours, the resulting rainfall is of high intensity and greatly exceeds soil infiltration capacity. This is common in urban areas where much of the land surface is made up of impermeable materials. As a result, a greater portion of the rainfall flows as surface runoff entering the river system in double quick time. The river's capacity to carry the discharge is quickly exceeded giving rise to flash flooding.

Flash floods are usually localised and its main characteristic is its rapid onset and equally rapid subsidence. During flooding, the hydrograph shows a rapid attainment of the peak flow (flood peak) over a very short period, usually within half an hour from the onset of rainfall but often within minutes in the case of highly urbanised catchments. As a result, flash floods are difficult to predict and warning lead times are at best within minutes before the onset of flooding. Despite their localised nature and short duration, flash floods can cause considerable inconvenience, massive traffic jams in densely populated areas, damage to propety, vehicles and public infrastructure, and sometimes the loss of life. For example, large cities such as Kuala Lumpur and Georgetown are highly prone to flash flooding (Chan and Goh, 1995).

In contrast, monsoon floods are seasonal in nature, of longer duration and are generally more extensive and severe (Leigh and Low, 1978). Although both the Southwest Monsoon Season (May to September) and Northeast Monsoon Season (November to March) bring with them heavy seasonal monsoon rainfall to the exposed coastal regions (**Figure 2**), it is the latter which gives rise to more severe and extensive floods. During this season, an average rainfall of 2500 mm is not uncommon. As a result, the Northeast Monsoon is largely responsible for the extensive floods in the east coast of Peninsula Malaysia and the west coast of East Malaysia. In contrast, flooding during the Southwest Monsoon Season is relatively mild as a greater part of Malaysia is sheltered from the winds by the adjacent islands of Indonesia. However, during this season, south westerly winds coupled with small intense and short-lived squalls called 'sumatras' often bring heavy rains to the west coast of the peninsula, giving rise to flooding of a smaller scale (Cheang, 1987; Sooryanarayana, 1988).

Monsoon floods occur annually in Malaysia causing extensive damage to properties and loss of life. It is useful to distinguish between 'normal' from 'major' monsoon floods. 'Normal monsoon floods' are seasonal floods which occur annually, usually during the Northeast Monsoon Season. During these floods the waters do not normally exceed the stilt height of traditional Malay houses. For example, people living in stilt houses in the rural areas in the east coast of Peninsular Malaysia are well adapted to normal monsoon floods. It is the major monsoon floods, which are 'unusual' or 'extreme' events that render flood victims helpless. Major monsoon floods also have their origins from seasonal monsoon rains but statistically occur once every few years (although the historical records show that they can occur in consecutive years, for example in 1970 and 1971 in Pekan) (DID, Undated). These floods are extensive, severe and often last for weeks. They result in significant loss of life, damage to crops, livestock, property, and public infrastructure. In a major monsoon flood, the victims' coping mechanisms are totally ineffective and they are forced to rely on government relief for recovery (Chan, 1995b).

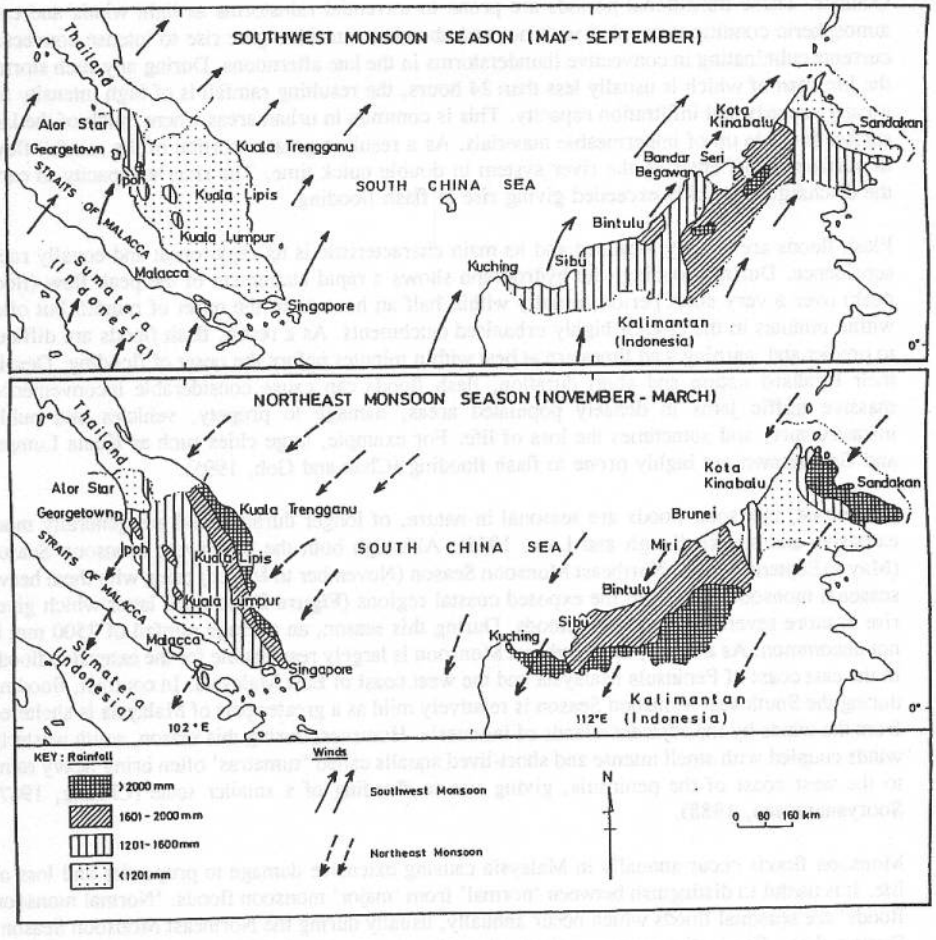

Figure 2: The influence of Monsoon Winds on Seasonal Rainfall Distribution in Malaysia. Exposed areas such as the east coast of Peninsular Malaysia and the coastal regions of East Malaysia receive abundant rainfall during the monsoon seasons and are therefore exceptionally susceptible to monsoon flooding.

During major monsoon floods, a flood depth of 3 metres is not uncommon.

The occurrence of floods in Malaysia can be attributed a combination of natural and human factors. While monsoon floods are largely caused by natural factors inherent in the physical geography of the peninsula, flash floods are mainly caused by human activities which have disrupted the natural hydrological cycle (Chan, 1996a). For example, Wan Ruslan (1994) has shown that hydrological parameters in Malaysia can be exacerbated by urbanisation. Similarly, Chan and Wan Ruslan (forthcoming) conclude that human impacts (mostly urbanisation) on the hydrological cycle in Malaysia is largely manifested in increased runoff, excessive sedimentation and magnified flood peaks. Thus, 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 a high incidence of monsoon floods in many parts of the peninsula, inadvertent and deliberate human use of floodplains (both past and present) such as deforestation, urbanisation, housing, plantation agriculture, tin mining, city and town expansion and others have resulted in increased flash flooding in major urban centres.

LOSSES FROM PAST FLOODS

Despite being the only significant natural hazard affecting the country, the annual costs incurred by the Malaysian Government in rescue and flood relief operations, as well as rehabilitation of public works and utilities is substantial. It is estimated that the damages for an annual flood, a 10-year flood and a 40-year flood are M$3.0 million, M$18.0 million and M$44.0 million respectively (JICA, 1982). Very little is remembered of the 1886 flood except that it was called the "Storm Forest Flood". This was because the flood, accompanied by gale force winds, destroyed several hundred square kilometres of lowlying forests in the Kelantan River and Besut River flood plains. The 1926 flood was perhaps the biggest flood in living memory. During this flood most parts of the peninsula were affected. The 1971 flood was so serious that it was declared a national disaster by the Prime Minister. During this flood, most parts of the peninsula suffered damages on an unprecedented scale. The federal capital of Kuala Lumpur (M$34 million flood damage) and the Pahang River Basin (M$30 million flood damage) were the two worst hit areas. The 1967 flood was also a big one causing the most damage in the Kelantan, Terengganu and Perak river basins. The damage estimated for the Kelantan River Basin alone was M$78 million. More recently, the 1986 flood in Kelantan and Terengganu caused an unprecedented postponement of the public school examinations (Sooryanarayana, 1988). A summary of flood damage for selected floods is shown in **Table 1**.

OFFICIAL RESPONSE TO FLOODING

Prior to the 1971 nation-wide flood which affected almost the entire country, official response to flooding had been unfocussed and largely depenedent on individual states and smaller administrative units such as the district, mukim[1] and kampung. There was no federal, state or even a statutory body which was specifically given the mandate to manage and control floods. As such, flood management was often carried out by many government agencies often leading to over-lapping and disagreement. The 1971 flood exposed the inadequacies of such disparate official flood management and the non-existence of a central body to plan, manage and monitor

Table 1 : Official Estimated Flood Loss for Selected Floods in Peninsular Malaysia

(Year)	Flood Event (Place)	Damage (M$million)	Death	Persons Evacuated
1967	Kelantan R. Basin	78.4	38	320,000
1967	Perak R. Basin	60.8	0	280,000
1967	Terengganu R. Basin	15.8	17	78,000
1971	Pahang R. Basin	37.7	24	153,000
1971	Kuala Lumpur	84.7	24	NA
1984	Batu Pahat R. Basin	18.0	0	8,400
1988	Kelantan R. Basin	33.0	19	36,800
1991	Peninsular Malaysia	NA	11	NA
1991	Georgetown	1.2*	0	42
1992	Peninsular Malaysia	NA	12	NA
1995	Alor Setar, Kulim & Baling	NA	0	2,250
1995	Pulau Pinang	NA	0	1,240
1995	Shah Alam & Kuala Lumpur	NA	0	7,000
1996	Sabah (June)	NA	1	9,000
1996	Sabah (December)	300.0**	220***	23,000

NA = Not Available

* = Not including flood loss in the private sector. There were many factories which suffered severe heavy losses due to production stoppages, damage to goods and machinery.

** = The Sabah Government estimated that damage to roads, bridges, schools, power lines, government offices and other public utilities would need at least RM130 million to restore (The Star, 1st January 1997). Another RM170 million was estimated for destruction of properties (more than 4,553 houses were destroyed during this event), and crops and livestock loss. If losses suffered by industries, businesses, shipping vessels and other privately owned assets are taken into account, the damage figures would be much higher.

*** = Another 108 people are still missing more than a month after the event (The Star, 27 January 1997).

(Sources: DID, National Security Council and local newspapers)

all aspects of flood mitigation in the country (Chan, 1993). Furthermore, it showed that rapid development of flood plain regions since independence in 1957 had substantially increased flood damage potential, particularly in urban areas. Despite this flood and others which followed, flood mitigation has seldom featured highly on government agendas, except perhaps during the aftermath of a major flood. Being a rapidly developing country aiming to evolve into a fully industrialised country by the year 2020 (Chan, 1996b), the pursuit for rapid economic development is relentless. For almost eight years now, since 1988, the Malaysia economy (measured by its GDP) has grown at an average rate of 8.0 percent per annum (Government of Malaysia, 1996). Often, this single-minded goal has been at the expense of the environment, including flood hazard mitigation which is often considered of lesser importance vis-a-vis economic development. Consequently, attempts by the Malaysian government to tackle both monsoon and flash floods have largely been of a reactive approach relying on disaster preparedness, evacuation, and post-disaster rehabilitation (Chan, 1995c). Admittedly, the cost of implementing a proactive approach to reduce the impacts of extensive monsoon floods can be beyond the budgetary constraints of the authorities.

One of the official flood mitigation strategies is the establishment of flood hazard institutions. The Permanent Commission on Flood Control (PCFC) was established in 1971. Its main objective is to prevent floods, but in the event of unavoidable flooding, its secondary objective is to minimize flood damage in terms of loss of life and property. Despite its many successes in reducing flood loss, the PCFC does not meet as regularly and as often as it ought to, given the frequency and magnitude of flooding in the country. Usually, it meets before the monsson season or during the aftermath of a major flood. Its organisational structure is also not cohesive or permanent as its name suggests. This is because it is made up of independent government agencies which are often very diverse and different from one another. Different agencies may also compete for power, often giving rise to non-cooperation. The PCFC also does not have a permanet budget to carry out its duties as it is more of an advisory body made of professional organisations with functions related to flood mitigation.

The National Disaster Relief and Preparedness Committee (NDRPC) is responsible for coordinating all relief operations before, during and after a flood. It is theoretically responsible for all the operations at the national, state, district, mukim and village levels. In reality, however, it coordinates operations at the national level and overlooks operations at the state level. Much of the operations in each state is left to be run by the respective state authorities. Its main task is to ensure that assistance and aid are provided to flood victims in an orderly and effective manner from the national level downwards. As a result, its approach to flood mitigation is largely reactive. It meets annually just before the onset of the northeast monsoon season to organise flood disaster preparedness, evacuation and rehabilitation work. It is also more of a welfare body than it is a flood management organisation.

The Drainage and Irrigation Department (DID) is the recognised authority officially responsible for flood mitigation since 1972 (Lim, 1988). It is now responsible for the maintenance of river channels, preventing siltation, de-silting of river beds, diversion of river channels for mining and other purposes, river improvement works, river training and the construction and maintenance of other engineering structures for flood protection. Although the DID is officially recognised as the authority on all aspects of river use and management, it has no legislative authority or enforcement powers when it comes to rivers. All such powers are still vested with the respective State Authorities or the District Offices. Given the present status quo, the States will never

relinquish their stranglehold on their rivers. At the moment, all the DID can do is to give advice to the State authorities when a certain project concerning a river is proposed. There is even no provision that a State authority needs to seek advice from DID's experts. Even if it does, it may not adhere to DID's recommendations. So the only way to be certain that flood mitigation is given due consideration in any project is to make the DID one of the authorities that approve or reject the proposals. This would be difficult as legislation would have to be passed by the Federal Parliament.

Another strategy was the establishment of The Flood Disaster Relief Machinery (FDRM). The FDRM was set up to ensure that all assistance and aid can be brought to the flood victims as quickly and as efficiently as possible. It is coordinated by the NSC and the NDRPC is a part of this machinery (**Figure 3**). When the Malaysian Meteorological Service (MMS) and DID have forecast an impending flood, the machinery will be activated. However, the full machinery will only be activated when floods occur in several states or when a state experiences a massive flood which cannot be adequately handled by the state authorities. In the event of massive and widespread flooding seriously crippling several states, then the NSC will advise the Honourable Prime Minister who may then decide whether or not to declare the flooding as a national disaster.

At the federal level, the National Security Council (NSC) is the secretariat for the Flood Disaster Relief and Preparedness Committee (FDRPC), which comprises members from the Ministries of Information, Finance, National Unity and Social Development, Transport, the Federal Chief Secretary, the Federal Police Department and the Federal Armed Forces. The FDRPC coordinates all relief operations from the Malaysian Control Centre in Kuala Lumpur. At the state level, there are 11 State Flood Relief and Preparedness Committees (SFRPC) for Peninsular Malaysia. Each state is given funds by the Federal Government every year to enable it to run its own flood relief operations. At the district level, there are several district committees under each state, depending on the number of districts in a particular state. Each district will have its own District Flood Relief and Preparedness Committees (DFRPC) which receives funds and directives from the SFRPC. Below the district level, there are several Mukim Flood Relief and Preparedness Committees (MFRPC), again depending on the number of mukims in each district. Each MFRPC is headed by a penghulu[2]. Finally, there are many Village Flood Relief and Preparedness Committees (VFRPC) under each mukim. Each VFRPC is headed by a ketua kampung[3]. The FDRM is also basically a flood disaster response mechanism. As such, its approach towards flood reduction is reactive. It is specifically targeted for monsoon flooding, mainly on the east coast of the peninsula. Consequently, its work is not comprehensive as it seldom includes flash flooding unless the occurrence is of extreme severity.

Besides the above flood mitigation strategies, there have been other supporting developments, usually on an ad hoc basis, which have contributed to flood loss reduction. One is the collection of hydrological and flood data which is used in the planning, design and implementation of flood mitigation schemes and in flood forecasting and warning models. Accurate hydrological data forms the basis of all aspects of water resource planning and management. Recognising this importance, the Malaysian Government has invested substantially in a programme to expand, update and improve the hydrological network in the peninsula. However, the use of telemetric real time equipment is still inadequate and the employment of remotely sensed data such as radar and satellite rainfall is not yet in the pipeline. These are major impediments towards greater flood loss reduction.

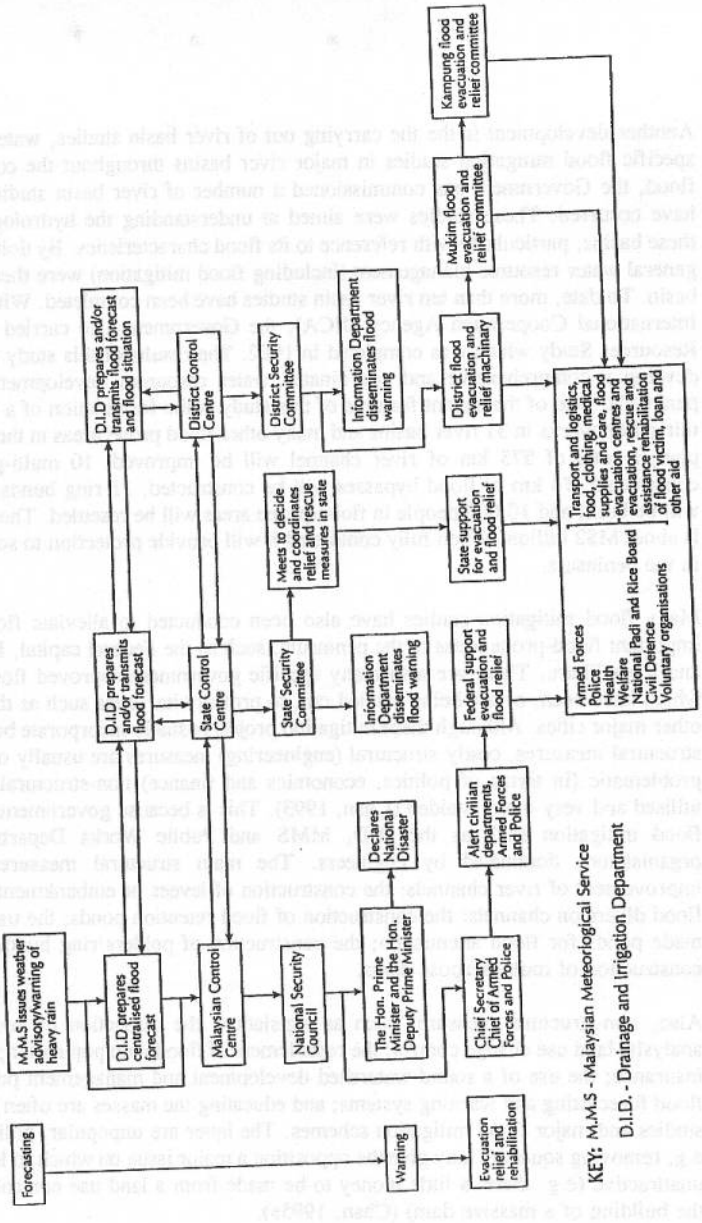

Figure 3: The Flood Disaster Relief Control Machinery Malaysia.

Another development is the the carrying out of river basin studies, water resource studies and specific flood mitigation studies in major river basins throughout the country. Since the 1971 flood, the Government has commissioned a number of river basin studies where major floods have occurred. These studies were aimed at understanding the hydrological characteristics of these basins, particularly with reference to its flood characteristics. By doing so, master plans for general water resource management (including flood mitigation) were then be prepared for each basin. To date, more than ten river basin studies have been completed. With the help of the Japan International Cooperation Agency (JICA), the Government also carried out a National Water Resources Study which was completed in 1982. The results of this study are now being used to develop a comprehensive and coordinated water resources development programme for the peninsula. One of the salient features of this study is the formulation of a 20-year plan for flood mitigation works in 31 river basins and many other flood prone areas in the peninsula. Under this plan, a total of 573 km of river channel will be improved, 10 multi-purpose dams will be constructed, 74 km of flood bypasses will be constructed, 11 ring bunds around urban centres will be built, and 10,000 people in flood-prone areas will be resettled. The cost of the entire plan is about M$2 billion. When fully completed it will provide protection to some 1.6 million people in the peninsula.

Many flood mitigation studies have also been conducted to alleviate flooding in strategically important flood-prone areas in the peninsula, such as the Federal capital, Penang Island, Kelang and Kota Bharu. There are also many specific government approved flood mitigation projects which have been, or are being carried out, to protect vital areas such as the Federal Capital and other major cities. Although these mitigation projects usually incorporate both structural and non-structural measures, costly structural (engineering) measures are usually over-emphasized while problematic (in terms of politics, economics and finance) non-structural measures are under-utilised and very often avoided (Chan, 1993). This is because government agencies in charge of flood mitigation such as the DID, MMS and Public Works Department (PWD) are all organisations dominated by engineers. The main structural measures employed are the improvement of river channels; the construction of levees or embankments; the construction of flood diversion channels; the construction of flood retention ponds; the use of natural and man-made ponds for flood attenuation; the construction of polders/ring bunds/tidal bunds; and the construction of multi-purpose dams.

Also, non-structural measures such as legislation; the restriction of development; flood risk analysis; land use change control; the resettlement of floodplain population; flood proofing; flood insurance; the use of a sound watershed development and management policy; improvement of flood forecasting and warning systems; and educating the masses are often included in feasibility studies and major flood mitigation schemes. The latter are unpopular, politically hazardous (for e.g. removing squatters may give the opposition a major issue on which to lobby), and financially unattractive (e.g. there is little money to be made from a land use control project compared to the building of a massive dam) (Chan, 1995a).

CONCLUSION

As a country which is almost annually affected by flooding, there are no lack of measures and strategies to reduce floods in Malaysia. While the many strategies employed hitherto have been responsible for reducing some of the impacts of flooding, they have not been entirely successful

in the overall management of floods. This is largely due to an outdated reactive approach based on evacuation, relief and rehabilitation, the low salience of floods on government agendas, the lack of interaction and cooperation amongst government agencies dealing with floods, the bureucratic nature of government agencies and the victims' reluctance to relocate. In fact, floodplain encroachment has even exacerbated flood hazards as more and more people are forced to occupy floodplains due to the shortage of land, high rents and rural-urban migration. Urban floodplains have also extensively developed as a result of rapid urbanisation leading to greater flood damage potentials (Chan, 1996c). Flood forecasting and warning systems have also not developed as quickly as expected. The current system being used is not state-of-the-art technology. It does not have radar information or satellite rainfall forecast which can be used as inputs into computer models. The number of automated telemetric rain gauges and river level recorders are also short of the required number. As a result, the advantages of flood forecasting and warnings have not been optimally realised and the current system appears cumbersome and ineffective. This has led to a lack of confidence amongst floodplain users and flood victims in the flood forecasts and warnings (Chan, 1995d).

As a developing country, Malaysia's flood management strategies can be described as commendable. Since the First Malaysia Plan (1971-1975), the country's expenditure on flood mitigation has increased substantially. From a mere M$14 million in this plan, it has shot up to a massive M$700 million for the Sixth Malaysia Plan (1991-1995), a 50 fold increase over a 20 year period. Even after discounting inflation, the real increase is still substantial. With the many structural and non-structural measures being implemented for flood control and for flood relief, the country is moving in the right direction towards a comprehensive programme of flood mitigation. Yet, there are many areas which can still be improved.

While the total number of telemetric stations for rainfall and river flow in the peninsula seems large enough, a closer scrutiny exposes the inadequacies of their uneven distribution. Most telemetric stations are located in populated areas while the sparsely populated areas, especially highland watershed areas, do not have enough telemetric stations. The MMS and DID also do not have access to remotely sensed rainfall data (radar and satellite sensed rainfall) as an input in its forecasting models. This could have been deliberately overlooked because of the high cost involved but real-time flood forecasting cannot be detached from the usage of such techniques, especially in terms of flash flooding.

Legislation related to flood control should also be improved. While there are currently some laws governing the regulation of river use (eg. the Waters Enactment 1920, the Mining Enactment 1929, the Drainage Works Ordinance 1954, and the Land Conservation Act 1960, and others) which have some bearing on flood mitigation, they are not sufficiently clear or forceful enough as measures of flood mitigation. These laws were formulated mainly for the purpose of regulating and managing single sectoral water use. More stringent and clear-cut laws must be passed to enable the authorities to have direct control in all aspects of water use which may affect flooding. This should include laws that specify clearly water rights administration, water resource development, flood plain management and all aspects of flood mitigation. Alternatively, the existing laws should be updated with a stronger emphasis on flood mitigation.

Finally, flood hazard management in Malaysia must be viewed in the context of the country's rapid development. Malaysia is a newly-industrialising country in which the pace of social, economic and political change is fast, as is the pace of physical and environmental change. Other

things being equal, these are the contexts in which flood hazards can be magnified and mismanaged. The contexts themselves are also changing and changing physical systems have given rise to increased risk, exposure and vulnerability to flood hazards. Other contexts, largely structural, such as persistent poverty, low residential and occupational mobility, landlessness, and ethnic culture have also contributed to increased vulnerability to flood hazards amongst specific communities, mainly the poor. Thus, in order to better manage floods and move towards greater flood loss reduction, flood management must be given a higher salience on official agendas. In a country where poverty reduction and income equity amongst all races are targets of achievement, the reduction of flood loss appears to be an important vehicle towards achieving those targets. This is because the poor are the most vulnerable to flooding in Malaysia and any substantial increase in flood protection and flood loss reduction will reduce the income gap between the rich and the poor. The government should also adopt a more pro-active and dynamic approach towards flood management, rather than adhere to a reactive approach. Finally, a multi-disciplinary approach encompassing a well balanced mixture of structural and non-structural measures should be adopted. In this respect, the employment of legislation to control floodplain encroachment, the development of hill land, and urbanisation is vital if Malaysia is to successfully develop at a sustainable pace and yet protect and conserve its environment, and at the same time manage flood hazards effectively. If not, flood hazards will continue to put a tremendous strain on the country's economy, exacerbate poverty and income inequity, and delay its efforts in becoming a newly industrialising country (NIC) by the year 2020.

NOTES

1 A "mukim" is an administrative unit just below that of a district. A district is made up of several mukims. Likewise, a mukim is made of several kampungs (villages), the latter being the smallest administrative unit.

2 A "penghulu" is the Malay term for headman to a group of villages. However, in some areas the term is used synonymously with "ketua kampung" or village head.

3 A "ketua kampung" is the Malay term for village head.

REFERENCES

Chan N W 1993 *Flood Hazard Mitigation in Peninsular Malaysia.* In P A Merriman and C W A Browitt (eds) **Natural Disasters: Protecting Vulnerable Communities**, Thomas Telford, London, pp. 194-209.

Chan N W 1995a **A Contextual Analysis of Flood Hazard Management in Peninsular Malaysia**, Flood Hazard Research Centre Publication No. 267, Enfield (UK).

Chan N W 1995b *Flood Disaster Management in Malaysia: An Evaluation of the Effectiveness of Government Resettlement Schemes*, **Disaster Prevention and Management: An International Journal** 4(4), pp. 22-9.

Chan N W 1995c *Choice and Constraints in Persistent Floodplain Occupance: The Influence of Structural Forces on Residential Location in Peninsular Malaysia*, **Disasters** 19(4), December, pp. 287-307.

Chan N W 1995d *Flood Disaster Preparedness, Warning, Evacuation and Relief in Malaysia.* In R Clementson (ed) **Proceedings of 'Emergency Planning 95 - An International Conference'**, Lancaster (UK), 2 - 6 July 1995, pp. 53-67.

Chan N W 1996a *Bandar dan banjir kilat*. **Utusan Malaysia**, 17 October, p. 7. (Translation: Cities and Flash Floods").

Chan N W 1996b *Floods: Who's to blame?* **The Star**, 24 January 1996, pp. 1, 7-8.

Chan N W 1996c *Vulnerability of Urban Areas to floods.* **The Star**, 26 January 1996, pp. 4-6.

Chan N W and Goh B L 1995 *Washed Up*. **The Sun Megazine**, 23 November 1995, pp. 4-9.

Chan N W and Wan Ruslan Ismail (forthcoming) *Impak Manusia Terhadap Sistem Hidrologi di Malaysia*, **Jurnal Kemanusiaan**. (Translation: Human Impacts on the Hydrological System in Malaysia)

Cheang B K 1987 *Short- and long-range monsoon prediction in South-east Asia.* In J S Fein and P L Stephens (eds) **Monsoons**, John Wiley, London.

DID Undated **Unpublished Annual Flood Reports**, Various years, DID Headquarters, Kuala Lumpur.

Government of Malaysia 1996 **Seventh Malaysia Plan 1996 - 2000.** Government of Malaysia, Kuala Lumpur.

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

Jahi J M 1985 *Flash flood problems and human responses to the flash flood hazard in Kuala Lumpur area, Peninsular Malaysia,* **Akademika** 26, January, 1985, pp. 45-62.

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

Lim T K 1988 **Malaysian rivers and floods**. Paper presented at the Seminar Tebatan Banjir, Kuala Lumpur (Malaysia), 14 - 17 November.

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, Sydney, August.

Wan Ruslan Ismail 1994 **Pengantar Hidrologi**. DBP, Kuala Lumpur. (Translation: Introduction to Hydrology).