MANAGING MALAYSIAN WATER RESOURCES DEVELOPMENT

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ABSTRACT

Water is a gift of God and Malaysia is rich in water resources. Water development has fueled socio-economic development of the country during the past decades. Dams and thousands of kilometres of pipes and canals divert water from the rivers to sustain domestic, industrial and agricultural needs. Lately, the water situation for the country has changed from one of relative abundance to one of relative scarcity. The population growth and the expansion in urbanisation, industrialisation and irrigated agriculture are imposing rapidly growing demands and pressure on the water resources, besides contributing to the rising water pollution. Water management is becoming increasingly comprehensive and complicated due to larger concentrations of population, commercial activities and industries around the cities and towns, increasing water consumption, increasing water pollution, increasing land use conflicts and climate changes. At the same time, development of new water resources to meet the ever increasing water demand is facing opposition from the environmentalists. Therefore, the preferred water supply management approach, whereby new supply sources are tapped to meet increasing demand should be replaced by water demand management approach, whereby efforts are directed towards managing the demand to keep it within available supply sources. Water demand management monitors and improves the efficiency of the supply system and all water users need to adjust their needs to the available water. The way forward to a prosperous and sustainable future is by keeping development to a level that is kept within the carrying capacity of the river basin while protecting and restoring the environment. As such, the water demand management should be practised within the broader context of integrated water resources management (IWRM). IWRM is an approach towards integrating and effectively coordinating policies, programs and practices addressing the water related issues which takes into consideration the aspects of socio-economic development and the conservation of the environment. The comprehensive management of water resources will cover three components namely, the management of water as a precious resource, the management of wastewater and water pollution, and the management of water related hazards such as floods, droughts and landslides. Whilst water related problems are essentially local issues, the solutions to such problems must be tackled from a broader perspective. These will require improved professional capability, and increased financial, legislative, managerial and political capacity.

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INTRODUCTION

Water resources development and management in Malaysia is associated with fragmented water related functions and activities of the various government departments and agencies. There is no single body responsible for the planning, development, regulation and management of the water resources in the country and as such these activities tend to take place in isolation. This may lead to competition in water use and duplication of works. The fragmentation of executive powers and functions has resulted in non-uniformity of policy and regulation, piece-meal development and conflicting priorities on water resources allocation.

Since the readily available surface water resources are being depleted and the cost of development is increasing with time, besides facing strong opposition from the environmental NGOs, the efficient development of water resources requires forward planning based on an assessment of long term needs and the sustainability of the environment. This is to avoid water related issues from affecting our quality living and the future plans for the progress of our beloved nation and to take heed of the following declaration made by the United Nations Economic and Social Council in Geneva in 1997:

> *Current pattern of water use in developing countries, countries with economies in transition and industrialised countries alike are often not sustainable. There is mounting evidence that the world faces a worsening series of local and regional water quantity and quality problems, largely as a result of poor resource management, including ill-adapted allocative mechanisms, wasteful use of the resource, unregulated effluent disposal and weak institutional frameworks. There is also a close interaction with declining biodiversity, desertification and pollution of the marine environment.*

This paper provides an overview of the status of water resources in the world and in the country, and the national water use. This is followed with an elaboration on the current practices, policies and laws. A discussion on the issues in water resources development and management is also described together with the possible action plans.

Status of water resources – global and national

With the dawn of a new millennium, the global community is concerned about the sustainability of the world water resources. Population growth, economic development, urbanization, and industrialization are imposing serious pressures on the water resources of many countries. One consequence is an increased competition in the use of water resources for water supply, irrigation, hydropower, etc. Another is an increased contamination of water resources that continues to damage the environment and threatens thousands of lives. The rapid growth in the use of water

over the last half of the century has precipitated a universal awareness to take stock of the present situation and examine the options for the future.

Global water resources

Only a small fraction of the world's freshwater resources is readily available. Estimates suggest that the freshwater in rivers and lakes consitute about 0.3 % of the overall freshwater resources (Gleick 1993; Engelman & Leroy 1993). Groundwater resources are much larger, or about 30 % of all freshwater resources. Water locked up in glaciers and permanent snow cover constitutes the largest source of freshwater. Based on the usable freshwater resources that is the freshwater in rivers, lakes and aquifers, groundwater resources account for about 99 %. The global water resources is summarised in Table 1.

Table 1: Global water resources

Type of global water	Volume ($x10^6$ km^3)	% total water	% freshwater
Total water	1386	100	
Oceans	1338	96.5	
Polar ice	24	1.7	68.6
Other ice and snow	0.3	0.025	1.0
Groundwater			
Fresh	10	0.8	30.l
Saline	13	0.9	
Surface water	0.2	0.01	0.3

National water resources

The annual rainfall over the Malaysian land mass amounts to 990 billion m^3, of which 566 billion m^3 appears as surface runoff and 64 billion m^3 becomes groundwater recharge. The balance of 360 billion m^3 returns to the atmosphere through the process of evapo-transpiration. In terms of the distribution of the annual surface runoff, Peninsular Malaysia receives 147 billion m^3, Sabah 113 billion m^3 and Sarawak 306 billion m^3. It is clear that there is an abundance of surface water resources in the country. On the other hand, the volume of groundwater stored in the aquifers throughout the country is estimated at 5000 billion m^3. Therefore, groundwater resources account for more than 90 % of the national freshwater resources (Keizrul & Azuhan 1998).

STATUS OF NATIONAL WATER USE

Streams and rivers with and without impounding reservoirs contribute 98 % of the total water use in Malaysia whilst the remainder is contributed by groundwater. River flow regimes are irregular and to secure safe yield from surface water sources, storage facilities were constructed. Currently, there are 47 single purpose and 16 multipurpose dams with a total storage of 25 billion m^3. There are more than 150 river systems in the country that is, more than 100 in Peninsular Malaysia and more than 50 in Sabah and Sarawak. In the case of groundwater resources, the most potential formation is the sandy or gravelly alluvium which exists in the coastal plains and valleys of the major rivers, followed by limestones and other sedimentary rocks. Other hard rocks such as granite has very limited groundwater potential. The presence of perennial rivers and the abundance of rainfall in Malaysia has meant that surface water resources have been exploited, leaving the ground water systems relatively 'untouched'. The current total water demand is estimated at 15.2 billion m^3. The major water user sectors are as follows:

Agriculture

The agricultural sector is the highest water consumer and irrigation is devoted almost entirely to rice production. In 1990, water consumption for agriculture was 9 billion m^3, accounting for over 75 % of the total water use in the country. There is no plan to expand the paddy irrigation area further, but it is envisaged that the entire area will be double-cropped. The crop diversification programme from paddy to non-paddy crops in marginal paddy lands is expected to reduce the increase in the overall demand for irrigation water supply. By 2020, the irrigation water demand is expected to increase to 13.2 billion m^3 but its national share is expected to decrease to 66 %. This is because of the streamlining of agricultural activities, particularly paddy irrigation, and the greater demand for water from the expanding industrial and domestic sectors.

Domestic And Industrial

As the country progresses towards industrialisation coupled with the increase in population and urbanisation, the demand for water in the domestic and industrial sectors grows rapidly. The current annual domestic and industrial water demand is 4.8 billion m^3 and is expected to increase to 5.8 billion m^3 in 2020. The present water supply system serves 99 % and 83 % of the urban and rural population respectively.

Non-Consumptive Users

The non-consumptive users include hydroelectric power generation, navigation, fishing and water-based recreation and a summary of these users are as follows:

- Hydropower constitutes about 10 % of the total national energy currently generated.
- River transportation is still widely use in Sarawak and Sabah because of the limited road networks.
- Even though freshwater fishing industry is relatively small when compared to the marine fishing industry, it is an important source of livelihood and protein for many rural riverine population.
- Natural amenities including water areas such as sea and beaches, lakes and reservoirs, waterfalls and rivers are gaining in popularity as holiday destinations, sports and hobbies.

Biological Diversity

Biological diversity or biodiversity encompasses all species of plants, animals and microorganisms and the ecosystem of which they are part. The freshwater bodies are the natural habitat to a wide array of plants, animals and microorganisms (flora and fauna) and their contributions to the stability of the environment is very important. Species diversity increases with the inclusion of marine environments such as coastal waters and estuaries.

CURRENT PRACTICES, POLICIES AND LAWS

Under the constitution, matters pertaining to natural resources such as land, mines, forest and water supply fall under the jurisdiction of the states. Water supply becomes a federal matter only if a dispute arises in the case of a river basin which crosses state boundary.

Institutional Responsibilities

The Government is primarily responsible for the planning, development and management of water resources projects in the country. The primary role of water resources management comes from the state governments and their agencies. There are a number of government departments and agencies which are responsible for a particular component or function related to water resources. A summary of the functions and roles of the major water related departments and agencies is given in Table 2.

Table 2: Functional responsibilities of water sector agencies

AGENCY \ FUNCTION	Water supply	Water sanitation	Irrigation	Hydropower	Flood control	Water quantity regulation	Water quality regulation	Watershed management	Integrated area development	Data collection	Research	Cloud seeding	Ports and navigation	Fisheries	Recreation
Department of Chemistry							■								
Department of Environment							■	■		■					
Department of Fisheries														■	
Department of Forestry								■							
Department of Irrigation and Drainage			■		■			■		■					■
Department of Mineral and Geoscience										■					
Department of Sewerage Services		■													
Department of Town and Country Planning								■	■						■
Local Authorities		■			■			■	■						■
Malaysian Meteorological Services										■		■			
Ministry of Health (Engineering Division)	■	■					■			■					
Ministry of Transport													■		
National Hydraulic Research Institute Malaysia											■				
National Water Resources Council	■							■							
Royal Malaysian Air Force												■			
State Water Resources Management Authority						■	■	■	■	■					
Tenaga National Berhad				■											
Waterworks Department	■					■									

There is no single agency entrusted with the overall responsibility of holistic planning and management of water in the country. Conflicts in water resources management such as allocation of water rights, flood management, pollution control, environmental protection, etc. are currently resolved through inter-agency coordination and consultation. However, at the federal level, a National Water Resources Council (NWRC) was set up in 1998 to pursue a more effective water management, including the implementation of inter-state surface water transfers. At the state level, the Selangor State Government has set up in 1999, the Selangor Water Management Authority (SWMA) with the aim of adopting and implementing integrated water resources management at the river basin level; SWMA will be fully operational by early 2000. Prior to the establishment of NWRC and SWMA, the

Sarawak Government has formed the Sarawak Water Resources Council in 1991 with the aims of identifying all available water resources in the state and promoting the conservation, development and management of these water resources in conformity with the socio-economic development objectives.

Policies

Although there is no single comprehensive policy on water resources development and management in Malaysia, the subject is generally covered within other national policies such as the Industrial Master Plan (IMP) and the National Agriculture Policy (NAP). IMP aims at fulfilling the national vision of becoming an industrialised country by 2020 while NAP has an important bearing on water use. To accomplish VISION 2020, the Malaysian economy will be geared towards industrialisation and urbanisation resulting in manifold increase in water demand. This scenario will lead to substantial investments in water resources infrastructure such as dams, reservoirs, treatment plants and distribution systems. The objective of the NAP is to transform the agricultural sector into a modern, profitable and sustainable sector. Translated in terms of water use, the agricultural sector is expected to practise more efficient water use.

Water supply policy is also implicitly stated in many national development strategies. In the national five-year and perspective plans, it has been taken for granted that portable water will be made available in urban areas and to a substantial extent of the rural areas. However, as a result of the rapid pace of urbanisation and industrialisation, the supply of raw water has been adversely affected, both in terms of quantity and quality. In view of this problem, policy objectives on water supply need to meet the growing water demand and the protection of the water resources from potential pollution sources.

The national policy on hydropower energy also influences water use. Although non-consumptive in nature, hydroelectric generation requires that water be kept behind dams in order to provide the potential energy for power generation. The significance of this would be felt during periods of low flow when less water will be made available for the downstream water users. Other national policies such as those relating to water-based recreational activities, inland navigation and fishery have not been well developed and they need to be looked into to allow for their systematic development in the future.

Laws

Water is a fundamental natural resource which is related to different aspects of the socio-economic development of the nation. Malaysia has more than 30 water related laws covering various aspects of water resources development and management. Some of the laws were legislated as state laws while others as federal laws. For water resources development and management, considerable efforts have been made by various water related agencies at federal, state and local level. Water resources development and management is a federal-state-local matter not only within the constitutional framework but also in the administrative practices.

With respect to river and water management, the Waters Act, which is a state law, is the fundamental law. It contains provisions governing property in rivers, a permit system for river water use and river conservancy. Other legislation which deal on water use are:

- Mining Enactment, also a state law, legislates the mining industry including regulating the use of water for mining purposes.
- Water Supply Enactment deals with matters pertaining to water supply area, water rate and other provisions.
- Irrigation Areas Act and Drainage Works Act are both Federal laws relating to the establishment and regulation of irrigation areas and drainage works respectively.
- Fisheries Act has provisions relating to riverine fishing and fisheries as well as that of maritime and estuaries.
- River Launches Enactment deals with river navigation.

To incorporate control on water pollution, the Waters Enactment of some states were amended. The Environmental Quality Act which was enacted as a Federal law, relates to inland waters pollution. The local authority is also vested with the power to administer environmental matters such as the pollution of streams in accordance with the Local Government Act. The Street, Drainage and Building Act, a Federal law, forbids any water closet or privy or any trade effluent to be discharged into or communicate with any river, canal, stream or any stormwater drain without the written permission of the local authority. With respect to water quality monitoring, the Environmental Quality Act provides that the holder of the licences may be required by the Director-General of Environment to conduct a monitoring programme on water discharges.

Land use legislation which are related to water resources management include:

- National Land Code deals with matters pertaining to land such as the classification of land and categorisation of land use.
- Land Conservation Act deals with matters pertaining to watersheds such as the control of silt and erosion and the conservation of hilly lands.
- Forest Enactment and the National Parks Act provide the procedure for designating a forest reserve and National Park respectively.
- Town and Country Planning Act prohibits development without a planning permission. This Act together with the National Land Code, which provides for land category alteration, indirectly cope with the disorderly development of housing estates.

WATER RELATED ISSUES AND PROBLEMS

Some of the more important issues with respect to water resources management and development (Keizrul 1999) are briefly discussed below:

Competition for water

The growth in population and Gross Domestic Product (GDP) over the last three decades has resulted in a heavy demand for water. The increased demand for a supply of clean water has led to competition in water use among the various water users, and the continued economic growth will magnify this even more acutely. In addition, as the readily available portion of surface water resources has already been developed for use in practically all regions of major water demand, future surface water resources development will require the construction of more storage dams. These are not only costly, but there is a high environmental price to pay. Furthermore, the practicable limit of surface water resources development has been reached in some regions of high demand, and it has become necessary to consider inter-basin and inter-state surface water transfer schemes. Before the latter is implemented, the prospect of developing other water sources and water recycling, and the implementation of water demand management should be looked into.

Flooding problems

Although floods are natural phenomena that is, the effects of rainfall resulting in excess water running into streams and rivers, unregulated development activities in watershed areas and along river corridors and high sea level increase the severity of floods. The high rate of sedimentation in the rivers has adversely affected their drainage capacities, leading to more frequent occurrences of floods in downstream areas besides increasing their intensity.

Incidences of flash floods in urban areas is on the rise due to the changes in the runoff characteristics of built-up areas. The total impervious areas in built-up areas, is very high since the developers only have to comply to an open space of 10 %. With respect to catchment runoff, an increase in areal imperviousness from zero to 40 % would cut the time to peak discharge by about 50 % and increase the discharge magnitude by about 90 %. Before urbanisation, rainwater gets intercepted by the vegetation, infiltrates into the ground and takes time to travel to the river, but now it is rapidly collected from the roofs and other paved grounds and channelised efficiently to public drains, which in turn rapidly brings it to the nearest river. The rivers which could contain the runoff during the pre-development era are finding it difficult to contain the present runoff and this lead to frequent occurrences of flash floods in urban areas.

The high rainfall during the monsoonal periods results in large areas being inundated. It is estimated that 29,000 km^2 or 9% of the total land area in the country is flood prone affecting approximately 2.7 million people. The average annual flood damage has been estimated at RM 100 million (at 1980 prices) but this has increased as a result of urban and industrial expansion and the escalation of land and property values.

Environmental Degradation

The society pollutes much of the available freshwater resources and degrades it so that when it reaches the downstream areas, it is unfit for many uses. The socio-economic development of the country has given rise to the problems of increased water pollution. Table 3 shows the water quality of selected rivers for the period 1992-1997 whilst Table 4 shows the major pollution sources.

Table 3: Quality of river waters, 1992 – 1997

	1992		1993		1994		1995		1996		1997	
Category	No	%	No	%	No	%	No	%	No	%	No	%
Very polluted	7	8.1	11	9.5	14	12.1	14	12.2	13	11.2	25	21.4
Slightly polluted	55	63.2	73	62.9	64	55.2	53	46.1	61	52.6	68	58.1
Clean	25	28.7	32	27.6	38	32.7	48	41.7	42	36.2	24	20.5
Total	87	100	116	100	116	100	115	100	116	100	117	100

Table 5: Major pollution sources (1991)

Sources	Proportion of contribution
Sediments	56%
Human/animal wastes	20%
Industrial wastes	10%
Others	14%

River water quality and pollution control need to be addressed urgently since 98 % of the total water use originates from the rivers. Almost all of the investments in water related infrastructure in Malaysia depend on reasonable quality river waters. As river water pollution increases, it leads to three effects, namely :

- increases water 'quantity scarcity' since there is lesser volume of good quality water available for use;
- higher water treatment costs due to the presence of new pollutants and an increase in the concentration of existing pollutants; and
- erodes the ecological health of the water bodies and the surrounding eco-systems, affecting aquatic lives and habitat, and recreational activities.

Thus, at a time of increasing demand, we are conversely facing a diminishing supply of clean water downstream, and even this is being affected by acid rain which is contributed by air pollution. Acid rain is a result of rainwater combining with sulphur dioxide and nitrogen oxide to form sulphuric and nitric acid respectively. These gases are emitted from the burning of fossil fuels and the sources include

thermal power stations, automobiles and industries. The acid content of rain in Malaysia is relatively high and is on the increase. Generally, there is higher acidity of rain in urban and industrial areas and the most severe occurrences were recorded in Klang Valley, Prai and southern Johore. Acid deposition has an impact on the aquatic ecosystem and human and their artifacts since it pollutes water sources and erodes buildings and monuments whose outside material is limestone or marble.

Efficiency of water use

The irrigation efficiencies are in the range of 40 % to 65 %. This is partly due to the fact that most of the irrigation systems are open systems which are designed for flood irrigation of the rice fields. On the other hand, there is no incentive for the farmers to use water efficiently since the irrigation rate is relatively cheap and is charged on a per area basis rather than volume of water utilised.

In the public water supply systems, about one third of the water is lost before it reaches the consumers. This unaccounted-for-water is a result of water leaks in the distribution systems, pipe bursts and illegal connections.

Institutional and legal issues

The restraints to the adoption of best management practice in the national water sector have been described in section 4.0 and they could be summarised as follows:

- fragmented development of water resources among government agencies.
- no comprehensive National Water Policy.
- no comprehensive Water Law.

Needs of an affluent society

Even though floods can be more damaging in terms of economic losses than drought, most urban and rural communities are more concerned with the problems of inadequate or unreliable water supply. Clean water is the key to healthy life whilst abundant water is the key to progress and comfortable life. A distinction must be made between basic human and environmental "needs" for water and the much larger set of "wants" for water to provide additional goods and services. There is a large gap between the “needs” and “wants”. The basic human needs of water is only 50 litres/ person/day (lpd) whilst for luxury living, the water "wants" can be as high as 500 lpd.

Water use is influenced by the economic status of the person and the demand for water grows as the luxury uses of water increases. Since the standard of living of the Malaysians is increasing, this will bring about greater demand on the water resources through both direct and indirect water consumption. Direct water consumption refers to the use of water for personal hygiene, food preparation, and cleaning and recreational purposes. Indirect water consumption refers to the purchase of material goods since a large volume of water is used in their production.

Capacity building

There is a need to build up local expertise in comprehensive water resources planning, design and management and the incorporation of incentives for career development. Most of the water professionals in the country are associated with surface water resources and adopt the principle of developing new surface water resources to meet the rising water demand. At the same time, the professionals working in the field of construction of water supply infrastructures are highly rewarded compared to those in the water management and planning sector.

Research and development in the national water sector is also lacking. The government has not listed the water resources sector as a key sector for research and development. The research in this sector is incorporated within the agricultural and strategic sectors of the Intensification of Research in Priority Areas (IRPA) programme. Promoting research and development in water resources is a basic necessity to ensure that the country is equipped with the state of the art technology to cope with the future challenges facing the nation's water resources.

THE WAY FORWARD

In developing a suitable institution for water resources administration in the country, it is necessary to recognise and understand the close relationship between land use and water resources management issues. The setting up of the National Water Resources Council (NWRC) is a step forward towards an integrated approach in water resources management. The NWRC was established to perform the co-ordinating function and to ensure uniformity in policies, standards and priorities. NWRC can be the forum where the federal and state governments link water and land matters so that a successful overall water resources development and management strategy can be formulated resulting in optimal utilisation and conservation of the nation's water resources. Other steps which can be adopted to improve the water resources management are described in the following sections:

Management of water as a precious resource

Water is life. The national water resources should be conserved for our benefits and the benefits of the generations to come. As such, the socio-economic development of the nation should be carried out in a sustainable manner. A transformation in the institutional set up is needed in order to adopt the best management practice in both water resources development and the enforcement of a comprehensive legislation with respect to the conservation of water resources and the provision of clean water. The adoption of the following strategies could pave the way for the best management practice in the national water sector:

- integrated water resources management (IWRM).
- National Water Policy.

- National Water Law.
- Environmental Protection Agency.
- River Basin Organisation – assessment of the carrying capacity of the river basin and water catchment protection.
- National Water Resources Centre – data banking, continuous water resources assessment, and research and development in the water sector.
- shift from water supply management to water demand management.
- improving the efficiency of water use.
- water recycling.
- urban stormwater management and rainwater harvesting.
- conjunctive water use – development of groundwater resources.
- wastewater and water pollution management.
- environmental education and public awareness.

The environment is the most critical element in laying the foundation of sustainable development in the future. All development projects must incorporate the concept of sustainability, that is, to minimise adverse impact on the environment so that the project can meet the present needs without compromising the ability of future generations to meet their needs and aspirations. An awareness of the importance of preserving and conserving the environment must be cultivated among all water users. They must realise the importance of water for their day to day activities and the development of the nation. The water users should adopt water saving habits and play an active role in the protection and conservation of the environment.

The yield of water resources in rivers and storage reservoirs is seriously affected by development activities which encroach into the water catchment areas. Stringent measures should be introduced to safeguard existing water catchments and protect potential ones in order to ensure that water yields in terms of both quantity and quality are sustained. This can be achieved through zoning exercise where the types of activities which can be permitted in specific areas are identified based on their potential pollution impact on the water yield and quality. Similar protection should also be accorded to areas with good groundwater potential. Monitoring and enforcement are crucial activities to ensure the success of water catchment conservation.

The impact of development in the upstream areas on the water resources is not unique. A reduction in the vegetation cover and the introduction of vegetation can both contribute to the reduction of water resources. A combination of undulating topography, a concentration of precipitation in the monsoon period and a denudation of vegetative cover in large parts of the area, has led to a situation whereby the water stemming from heaving rainfall during the monsoon period quickly leaves the area in the form of rapid surface flows (Kharuna 1998). On the other hand, the introduction of commercial plantation forestry can result in high water intake and the direct consequence is a reduction of streamflow (Enright 1999). These two scenarios demonstrate the close and complex relationship between land use and hydrological parameters.

A sustained development of groundwater resources may be carried out especially in areas where the surface water resources have been developed to their limits. Groundwater can be used on its own or used conjunctively with surface water resources. The development of groundwater should be accompanied by a monitoring system to ensure the sustainable yield of the production wells besides monitoring the groundwater quality and other related impacts.

It is an established fact that in areas with abundant surface water resources, groundwater starts to be considered for use only after most of the surface water resources have been allocated. Malaysia is no exception. It now depends upon the researchers, scientists, engineers, managers, authorities and public opinion in general to develop a strong awareness of the importance and challenges of groundwater, the invisible resource, for the country's development. The extent of the impacts of urbanization and industrialization and irrigated agriculture on the aquifers - the natural water stores - are unknown. Since aquifers are vulnerable to pollution from land use activities, it is expected that contamination of the aquifers has occurred; the majority of problems are yet unidentified, hidden from view below the land's surface. We should avoid the scenario that we need to clean up the aquifer first before we could proceed to use the groundwater.

The management of wastewater and water pollution

Water pollution can result in water quantity scare, affects human health and destroys aquatic lives and habitat. As more water is consumed, more wastewater is subsequently produced. One way of reducing wastewater is through the adoption of water recycling. Water recycling can be practised by all water user sectors but it is more appropriate for the irrigation and industrial sectors. Incentives should be provided for the use of water recycling. The practice of water recycling reduces both the demand on the water supply and the production of wastewater.

High priority should also be placed on establishing hygienic sewage disposal and treatment systems in both urban and rural areas. An efficient waste management system can alleviate the problems of water quality deterioration of both surface and groundwater resources. Local government can reduce the pollution caused by the communities by improving garbage collection and the setting up of recycling collection centres at strategic locations such as in the car parks of shopping complexes.

Water is a renewable resource and the rivers have a limited natural self cleansing ability. Water pollution should be addressed at source since the curative programme such as the desilting of rivers and the trapping of garbage is useless if the development of land in the upstream reaches continues to deposit sediments into the rivers whilst the riverine population continue to dump waste into the rivers. The discharge of treated industrial effluents into the rivers should be regulated and the industries should not rely on river water to provide the dilution effect. In the agricultural sector, the use of fertilisers and herbicides should also be regulated in order to prevent contaminated irrigation return from reaching both the surface water and groundwater systems. The

'polluter pays principle" should be viewed as one of the prime strategy to fight pollution of the water courses.

The management of wastewater and water pollution, and the provision of clean water for domestic use are inter-related with regard to human health. The improvement in human health depends a lot on the provision of clean water and good sanitation services especially with respect to infections which are sensitive to hygiene practices such as some diarrhoeas, scabies, ringworm, typhus, yaws, and trachoma. Besides this, there are infectious organisms that are water-borne, water-based, and water-related. Typhoid, cholera and hepatitis A belong to the first group that is those diseases where water acts as a passive vehicle for the organism. Diseases involving an infective agent that lives for a time in aquatic organism such as a crustacean, fish or shellfish, make up the second group. Two examples are Guinea worm and schistosomiasis. The third category of diseases include malaria, Japanese Encephalitis and yellow fever. These are spread by insects such as mosquitoes and flies that either breed in water or live near it. The question now arose that providing more water is not a good health action. This is supported by the fact many negative aspects of water development have emerged in many developing countries such as the increase cases of malaria and schistosomiasis (UNESCO and UNEP 1990). These various factors led some individuals and organisations to reconsider whether provision of clean water should be the first step toward providing a healthful life. However, it is noted that the health of the people in a water project area will improve because of higher incomes resulting from the project, and better nutrition and housing. The number of cases for the four major diseases associated with water for the period 1993 – 1997 (MOH 1998) is shown in Table 5.

Table 5: Cases of diseases associated with water (1993 – 1997)

Type of disease	Year				
	1993	**1994**	**1995**	**1996**	**1997**
Cholera	995	523	2027	1486	380
Dysentries (all types)	261	151	152	121	132
Typhoid (all types)	1442	1031	906	953	701
Hepatitis A	915	402	419	849	341

The management of water related hazards

There are three major geologic hazards associated with water they are floods, droughts and landslides. The first two phenomena are due to the extremes of water, whereby floods are due to excess water from too much rainfall, whilst drought is associated with a lack of water from too little rainfall. The occurrence of landslides are also associated with prolonged period of rainfall.

i. Floods

The unregulated land development in the upstream areas results in soil erosion problems leading to the siltation of rivers. This affects the drainage capacities of rivers which can lead to more frequent occurrences of floods besides increasing the intensity of the floods. Whilst the increase incidences of flash floods in urban areas is due to the increase in impervious surface areas.

Absolute control over floods is rarely feasible either physically or economically. However, flood mitigation measures can be undertaken to reduce flood damage to a minimum consistent with the cost involved. Besides the construction of dams and reservoirs, there are other measures especially in urban areas, to store the excess water from floods for use during the dry periods besides increasing the time to peak discharge and reducing its magnitude. These include the use of small detention and retention ponds, the retention capacity of wetlands, and underground storages. Underground storages may include the use of natural water storage in aquifers by implementing artificial recharge projects through the use of infiltrating basins and recharge wells. These measures could be associsted with stormwater management and the concept of "zero contribution to peak flow". The adoption of stormwater storage can serve three purposes that is, alleviating the intensity of flash floods in urban areas, reduce the capacity of urban drains and a source of water during the dry spells.

Similarly, the adoption of rainwater harvesting can also contribute towards reducing flash floods besides reducing the demand on the public water supply. This is because the collected rainwater can be effectively used in the household for toilet flushing, gardening and cleaning of car. It is estimated that at least 40 % of the water use in the household could be catered for by untreated water. It is proposed that in new housing development projects, rainwater harvesting and storage facilities should be provided in individual units. The latter can alleviate flash floods and avoid the need of larger urban drains.

ii. Droughts

Drought is a recurring climatic conditions affecting many areas in Malaysia. The surface water resources will be the first to be affected by drought. The wise use of groundwater resources can play a significant role in reducing the impact of drought in both urban and rural environments. For maximum benefit, however, it is important to be able to predict when droughts will occur, how long they will last, and how severe they will be, so that emergency use rate for groundwater during the drought can be estimated to make sure the water will last long enough (Driscoll 1986).

The crisis driven development of water resources, that is on ad-hoc basis, is not cost effective and should not be a strategy to overcome the frequent occurrences of water stress. The management of water resources to cater for current and future needs and for emergencies should be carried out under properly developed policies and strategies. The management of water resources should be an important component of long-term drought management rather than to cope with the immediate

effects of drought under a crisis situation. The adjustments to urban drought (Haas 1978) is shown in Table 6.

Table 6: Adjustments to drought for urban areas

1. Modification of sources and water systems.
• Develop groundwater resources to supplement surface water or existing groundwater supplies.
• Integrate wastwater reuse into community water management.
• Build desalination facilities so that lower quality water can be used.
2. Modification of demand.
• Regulate land use so that population growth is controlled consistent with the water supply.
• Enact economic incentives and penalties so that conservation becomes attractive to consumers.
• Institute legal mechanisms that control demand such as spring-loaded faucets, minimum-use toilets and dishwashers, and the prohibition of swimming pools.
• Create "voluntary" changes in demand by altering attitudes and values held by the public about water.
• Formulate priorities among competing demands so less vital uses can be minimised during drought.

Landslides

Water is associated with the stability of slopes, stability of mines both surface and subsurface mines and the construction of basements and other underground infrastructure. There is more water in hilltop areas after development than before development and this fact is summarised in Table 7:

Table 7 shows that there is a significant increase in groundwater storage as a result of development. With all the leakages in the water supply, waste water and drainage systems, the quantity of groundwater subsequently increases. The increase in groundwater is further contributed by the considerable drop of groundwater intake by the flora due to the absence of trees and other vegetation. The groundwater will flow and can appear on the face of the slope either as seep or springs. In a seep, water flows out over a relatively wide area and this occurs in unconsolidated sediments such as clay, sand and loose filled materials. Seep may not be visible because the rate of seepage may be lower than the evaporation rate or the seepage surface (the area where seep occurs) is covered by vegetation. In a spring, water exits the ground as a significant flow from a relatively small opening and this occurs in consolidated or hard rock formation. Slope failures or landslides will occur when there is a lot of

water in the ground (the ground is over saturated) and above the ground (overflowing drains). This shows that water both surface and subsurface should be taken into account in the design, construction and maintenance of development in hilltop and hillslope areas.

Table 7: Water in hill top areas

Before development	After development
✓ The only source of water is from precipitation. ✓ The rainfall is intercepted by the trees and other vegetation. ✓ Substantial evapo-transpiration from the trees and other vegetative covers –substantial groundwater is used up by the trees and other vegetation. ✓ The surface runoff is impede by the vegetation – lengthening time to peak and a smaller peak discharge.	✓ Besides precipitation, there are additional sources of water and these sources contribute to groundwater: • Leaks from incoming water supply pipelines. • Leaks from sewerage pipelines. • Leaks from service reservoirs. • Leaks from swimming pools. • Leaks from drains. ✓ Large quantity of surface runoff due to higher proportion of paved areas and lesser vegetative cover – shortening time to peak and bigger peak discharge. ✓ Significant reduction in evapo-transpiration due to deforestation – less groundwater is used up by the trees and other vegetation.

CONCLUSIONS

Water resources development and management is an important component of infrastructure development to support and promote the socio-economic growth of the country. The management of water resources to cater for current and future needs and for emergencies should be carried out under properly developed policies and strategies. It is important that long-term strategies and action plans be developed through an integrated and consultative approach involving the relevant authorities at all levels in partnership with the general public. Water resources management should move from the phase of reactive and curing water problems to a more effective phase of pro-active and prevention of water problems. Sustainable water resources management depends on a continuous water resources assessment activity whereby sufficient information is continuously collected as new issues emerged. The complexity of many water related issues poses a major challenge to policy makers, planners, professionals and others who are directly or indirectly involved in the planning, development and management of water resources. Pricing is an important

instrument for water conservation. Supply management is still required, but increased attention must be given to demand management practices.

Climate determines water quantity and distribution whilst population and economic development influence water quality and demand but, a good socio-economic, water and catchment management ensures a constant supply of good quality water for the present needs and the needs of the generations to come. Sustainable socio-economic, water and catchment management planning is achieved by partnerships and not simply by legislation and should be practised within the context of integrated water resources management.

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