THE TWENTY THIRD
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Dato' Ir. Syed Muhammad Shahabudin has been in the water engineering field for close to 50 years most of which in private practice as a consulting engineer. He graduated as an engineer from Plymouth College of Technology, United Kingdom and is a Professional Engineer Malaysia, a Member of The Institution of Engineers Malaysia, a Fellow of the Institution of Civil Engineers, United Kingdom and a Chartered Water and Environmental Manager, United Kingdom.

After serving the Government of Malaysia for 12 years, the last appointment being the Chief Executive Engineer of the newly-formed Penang Water Authority (1973-74) on secondment from the Public Works Department, he became as partner in the consulting engineering firm of Binnie dan Rakan (BDR) Malaysia, a member of the international group of Binnie and Partners, United Kingdom with practices in South-East Asia and Hongkong specializing in water engineering. BDR was restructured in 1980 as Syed Muhammad, Hooi dan Binnie Sdn Bhd and Dato' Ir. Syed Muhammad Shahabudin became the Chairman and Managing Director. The firm was completely taken over by Malaysians in 1995 and SMHB Sdn Bhd was formed. He assumed the duty as Executive Chairman.

Dato' Ir. Syed Muhammad Shahabudin has made many contributions towards the field of engineering particularly to the Association of Consulting Engineers Malaysia as President (1985 – 1987), the Malaysian Water Association as President (1994 – 2007).

As President of Malaysian Water Association, he led a team in initiating the transformation of water services industry, taking the matter up in 2004 to the Minister who obtained Government's approval to eventually form National Water Services Commission (SPAN) three years later.

As Chairman of Malaysian Water Partnership (2007 – 2011), he was committed to the implementation of Integrated Water Resources Management (IWRM) and strongly believes that this is the best approach which can promote sustainability of water resources management in Malaysia.

He has been a board member of Selangor Water Management Board (LUAS) since its formation in 2000 and is currently a member of the National Water Services Commission (SPAN) since its formation in 2007. He is a Fellow of the Academy of Sciences Malaysia, established under the Act of Parliament to pursue, encourage and enhance excellence in the field of science, engineering and technology. He is currently Chairman of Task Force on Water Demand Management.

Exploring The Viability of Dams is Key to Malaysian Water Resources Development of the Future

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ABSTRACT

It is said that civilization began and prospered when humans could control water; and that same civilization declined and vanished when that control is lost. Dams and other river flow barriers were built to harness and control water in the early days of civilisation in order to secure the benefits for human basic needs and comfort. Centuries later, more dams were built to cater for increasing population, especially in arid and semi-arid areas. But it is really in the past two centuries that many large-sized dams have been built to satisfy a wider range of development demands – hydropower, treated water supply, irrigation, flood control and environmental needs.

Towards the second half of the last century, society came to realise that dams can cause significant negative social and environmental impacts that could outweigh the original economic benefits. Opponents of dams protest vehemently world-wide against the development of more dams whilst proponents are convinced that they are a necessary feature to support growth and prosperity. It is these contradicting beliefs in mind that the public must be engaged to facilitate a better understanding of the views of both the proponents and the opponents of dam development before deciding on a long-term strategy. In the meantime, more effort may have to be made for water and energy conservation strategies and to realize the potential applications of low impact and non-structural solutions that complement existing dams and defer new dam development to as far into the future as possible.

This paper aims to provoke a critical debate amongst engineers and the public to look at the longer term future of dams in water resources development that could possibly reduce the fundamental demand for services that dam provides. In other words, to try and answer the question "Why should a country rich in water, as Malaysia is, need to construct dams and even plan for more?"

1.0 INTRODUCTION

It has often been argued by critics to large dams construction in water resources development that economic and social development can also be achieved without building dams. This is theoretically possible but not easily implementable. More time is needed for studies, research and assessment on alternatives or other options, for example, in water reuse, recycling, water footprint of conventional and renewable energy resources and optimizing the overall use of water by fully utilizing water demand management concept which calls for water conservation in reduction of usage and pollution. Furthermore, unlike advanced and industrialized countries where economically exploitable water resources are nearly fully developed, in many of the developing countries, demand for water is tremendous and extensive undeveloped exploitable water resources are still available for use. This is particularly so in energy production utilizing hydro-electric dams and multipurpose dams. Malaysia belongs to this category as a fast developing nation.

The challenge for the future will be the utilization of dams in conjunction with climate, environment and land use for the prudent management of water resources as part of the nation's social and economic development goals. This calls for opportunities to fully utilise the most effective approach to ensure the most sustainable outcome is achieved in cases where there is not much choice but to build dams.

2.0 ENGINEERING LARGE DAMS IN MALAYSIA

General

The engineering of dams is among the earliest structures built by mankind. Since early civilization, dams have provided the necessary quantities of water to sustain the population in semi-arid and arid regions with a huge seasonal variability of rainfall, with too little precipitation and too high evapotranspiration. In such cases, there was no other choice but to build dams and make water available for human needs and comfort especially to cultures highly dependent on irrigation for security of food supply.

For regions which experience significant precipitation, the sustainability of life is hardly threatened by the imbalance between demands and available supplies of water, food and energy. Malaysia is among the countries blessed with good water resources. Apart from the Bukit Merah Project, the provision of large dams is, therefore, deemed unnecessary until much later in time during the late 1920s and early 1930s.

International Commission on Large Dams (ICOLD) defines Large Dam as having at least heights of 15m or 5-15m with at least 3 million m3 (MCM) storage volume.

Table 2.1

Project	Year of Commission	Capacity	Ownership	Purpose
Bukit Merah Project, Perak	1906	Augmented supply for Irrigation (24,000 ha)	Perak Government (Federated MalayStates)	Irrigation water supply
Chenderoh Hydroelectric	1930	27 MW	Perak River Hydroelectric Company	Supply to tin mines and other areas
Gunong Pulai II and Pontian, Johor	1932	12 mgd	Straits Settlement Government, Singapore	Water supply to Singapore

The Early Dams

The earliest large dams in the country were constructed for three different purposes, namely for irrigation needs of agriculture, for hydroelectric generation and potable water supply (export to Singapore) as seen on Table 2.1 above.

View of Bukit Merah Dam, Perak

The first large dam to be constructed in 1906 was a homogeneous earth-fill dam at Bukit Merah, Perak built primarily for irrigation purposes but later extended for other uses like potable water supply, recreational use, fishing and flood mitigation. In fact Perak was the first state in the Federated Malay States to be involved in the rehabilitation of existing irrigation areas in Kerian in 1899. The interest in irrigation was towards increasing the food supply levels in the state (History of Irrigation in Malaysia: MOA). The dam reduced the risk of crop failures for the only one cropping season practiced at the time. The scheme was completed at a cost of 2,600,000 Straits Dollars. The dam heights was raised twice the first in 1965 and again in 1984 and currently serves 24,000 hectares of the Kerian Irrigation Scheme and double cropped every year. A view of the dam is seen on the photograph.

The dam is now one of the major components of the Kerian Irrigation Scheme, one of the 12 Granaries in Malaysia.

The Second large dam was built by the private company as the first hydro-electric project in the country: a 27 MW Chenderoh Hydro-electric Power Station, across the Sg. Perak, which was inaugurated in 1930, making it one of the largest hydro developments in the British Empire at that time and the largest in Southeast Asia until after the Second World War (TNB Publication 1993) as shown in Figure 2.1. The aim was to make electricity available to the State of Perak for all purposes. But the tin mining industry, especially after the advent of massive dredging operations, was the driving economic force behind the demand of electric power. The dam structure is a hollow buttress type concrete dam.

The third is a combination of large dams at Gunung Pulai II and Pontian in Johor, built by the Straits Settlment Government for Water Supply to Singapore as shown in Figure 2.2. Singapore was then part of the British administration in this region. The

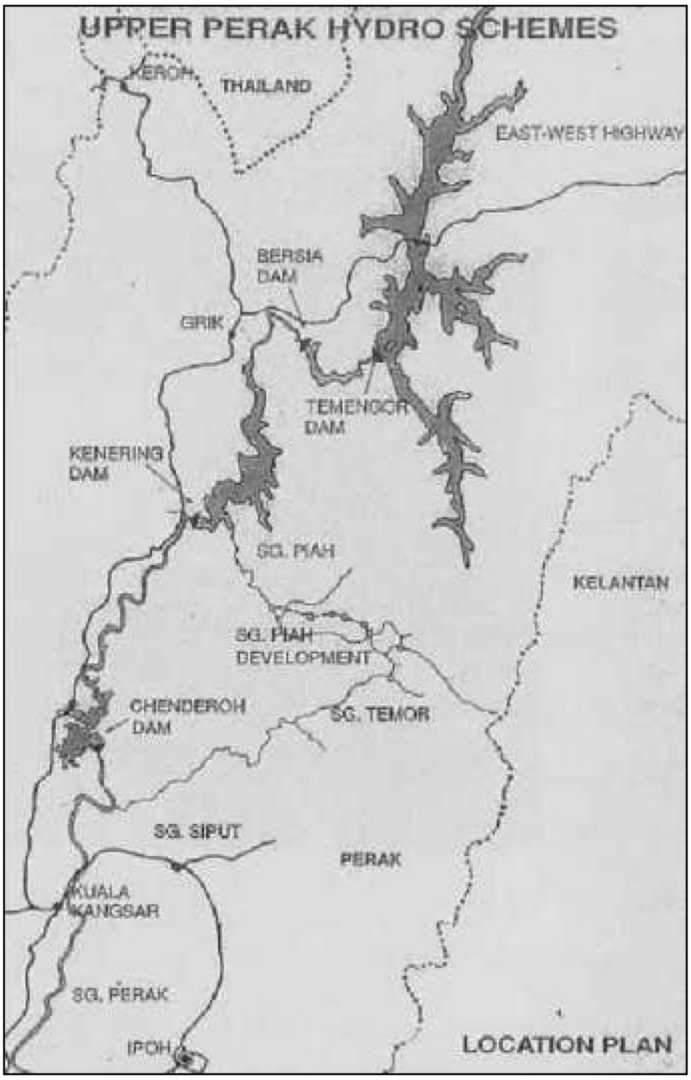


Figure 2.1

View of Pulai II Dam, Johor

scheme took six years to be completed and was commissioned in 1932 under difficult working conditions "on sites in tropical jungle with serious outbreaks of malaria where work on one dam had to be stopped to deal with the outbreak". (Binnie Short History, 1990). The job was completed by direct labour with resident site staff buying all plants and materials and hiring labour to get work done, using money provided by the client. The main dam, Gunung Pulai II, is a masonry gravity dam, 37m high as seen on the photograph and with a 31m high earth-fill dam at nearby Pontian. The Gunong Pulai II masonry dam is understood to be the only dam of its type built in Malaysia. The job was finished at a cost of £2.6 million, a princely sum in those days.

After the construction of these three earliest large dams, there was about a 30 year gap before more dams were considered for construction in the latter part of 1950s and after Merdeka. In the meantime, in most parts of the country, there was still abundant supply of water for abstraction and use.

The Post Second World War Period

The most significant period of dam construction took place worldwide after the Second World War. Elsewhere in the developed and industrialized countries, postwar reconstruction and economic development was accompanied by phenomenal construction of infrastructure systems between 1950-1980 when 7,600 large dams were commissioned in the 1970s (ICOLD: 2006).

For about the same period more large dams were planned to meet shortages in water supply as some parts of the country were not able to balance demand with supply of water for potable supply and agricultural needs. This was particularly so in urban centres like Kuala Lumpur and George Town with marked increase in population after the war years. The pre-war water supply from the upper reaches of Sg. Ampang at Ampang Intake and Impounding (5 mgd) and Kuala Sleh (10 mgd) for Kuala Lumpur municipal limits, could no longer meet the increased demand of Kuala Lumpur and new extended areas. Similarly George Town's main sources of supply at the waterfall (4 mgd), Guillemard (12 mgd) and Air Itam old plant (4 mgd) could no longer satisfy the increased demand of the population. Increased paddy cultivation to meet more food demand would require stable supply of water throughout the year. In addition, infrastructure systems were left much to be desired as the result of negligence during the war. The large rain-fed irrigation areas in Kedah, Perak and Kelantan were often at the mercy of poor crop production during dry periods and severe flooding.

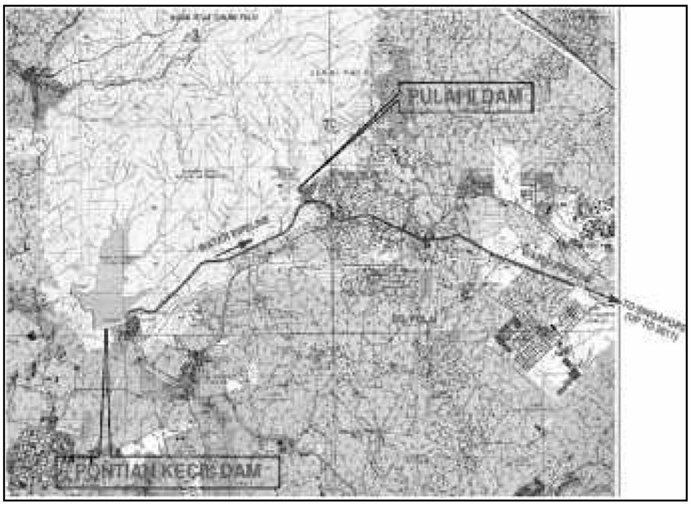


Figure 2.2: Gunung Pulai Scheme, Johor

However, with the formation of the Federation of Malaya in February 1948, when all states of the peninsula were united for the first time under a Federal System of Government, opportunities were created for reconstruction and development of infrastructures for the whole country. Prior to this, there was a Federal system in four states forming the Federated Malay States (Selangor, Perak, Pahang and Negeri Sembilan), and the three British Straits Settlements ((Singapore, Penang and Melaka). The five remaining states (Johor, Kedah, Perlis, Kelantan and Terengganu) were self-governing under British protection. The most remarkable advantage is the ability to reconstruct, plan and improve infrastructure system in a concerted and most effective way by all the states with close coordination by the Federal Government.

Meanwhile, in 1949, one of the most important events in the history of Malaysia's power supply (TNB Publication 1993) took place when public supply of electricity in the country became the vested interest of the newly formed Central Electricity Board (CEB).

With stability, after the war and unification of states in Malaya, came economic development and physical achievements especially in the urban centres. The eventual achievement of Independence in August 1957, economic development was further extended to cover the whole country notably the rural areas.

The First Dams After The Second World War

During the late 1940s until early 1960s, the following three large dams were built as indicated in Table 2.2.

The Labong Dam (Irrigation)

The need for irrigation facilities (including dams even for a single cropping system before the 1960s), is because of the variability of rainfall within a year, between years and also within the rainy and the dry seasons in a year. Dams provide the

[2] YTL does not condone exploitation of labour, nor does the company allow for labour practices that jeopardise the health and safety of its employees. In the 1980s, it acted within the purview of existing Malaysian Labour Laws that permitted 24-hour construction work. Thus, gaining strategic upper-hand over Japanese construction firms that were not permitted to do the same.

Table 2.2

Project	Year of Commission	Capacity	Ownership	Purpose
Labong Dam	1949	Augmented supply for Irrigation (1,184 ha)	Government of Johor	Irrigation water supply
Klang Gates Dam	1959	30 mgd	Government of Selangor	Water supply to KL and suburbs
Air Itam Dam	1963	6 mgd	City Council of George Town	Water supply to George Town

stability of irrigation water supply and thereby reduce the risk of crop failures, improve the chances of success for the only one cropping season then and for double cropping now. With dams, production became more consistent and therefore stable incomes for farmers as well. The Labong Dam for the Endau Rompin irrigation scheme, as shown in Figure 2.3, was commissioned in 1949 for single cropping system.

This dam is an earth-fill embankment dam and the scheme has recently been added to be another one of the Granary Areas for the country. With the re-activation, the whole scheme will be for double cropping. The reservoir also supplies 0.5 mgd for water supply needs.

The Klang Gates and Air Itam Dams (Water Supply)

The shortage of treated water supply became increasingly apparent with the expansion of Kuala Lumpur and its suburbs particularly the newly created Petaling Jaya in the 1950s which called for urgent attention and the first large dam in the country for water supply (if supply from Gunong Pulai II is discounted as water export) was commissioned in 1959 with the completion of the Klang Gates arch gravity concrete dam (this dam was eventually raised in 1979 to accommodate as a dual purpose dam for flood mitigation). In the north, George Town, Penang similarly needed to solve their water supply shortages. The second large dam for water supply in the country, an earth-fill dam, was built by the City Council of George Town and commissioned in 1963.

Major Post War Schemes Involving Dams

Pedu and Muda dams (Irrigation)

This is perhaps the largest "Twin" Dams in Malaysia. Constructed in 1966, it supplies 30% of the total irrigation requirement to the largest irrigation scheme in Malaysia, the Muda Irrigation Scheme (also known as the MADA: Muda Agricultural Development Authority) Granary, totalling 96,558 ha. Interestingly, this scheme is not within the Muda River Basin. The Muda River water is impounded by the Muda Dam and transferred into the Pedu Dam in the Pedu River Basin via the Saiong Tunnel (4.42 m diameter, 6.8 km length) and subsequently released to irrigate the paddy fields. This MADA Granary is now the premier rice bowl of Malaysia consistently producing 40% of the total National output with yields of more than 6 tons/ha per season.

The Muda Dam is concrete ambursen buttress type with overflow spillway. Its main dam is 37m height and 250m length. Its storage capacity is 160 MCM. The Pedu Dam is of rockfill with upstream asphaltic concrete membrane type with its main dam at 61 m height and 220 m length with a reservoir storage capacity of 1,073 MCM. The irrigation supply is augmented by the Ahning Dam, a rock-fill with concrete faced dam type, height 74 m, length 270 m, storage 275 MCM. The total annual release from these dams is 1,600 MCM.

Plans are already underway to augment irrigation supply to the southern region of this MADA Granary from the Beris Dam (concrete faced rock-fill type, 40 m high, 155 m long, 122.4 MCM storage capacity). The dams also supply water for water supply needs in Kedah, Penang and Perlis.

The Cameron Highlands hydroelectric dams

The year 1963 marked the CEB successful completion of its first major hydroelectric scheme in the Cameron Highlands.

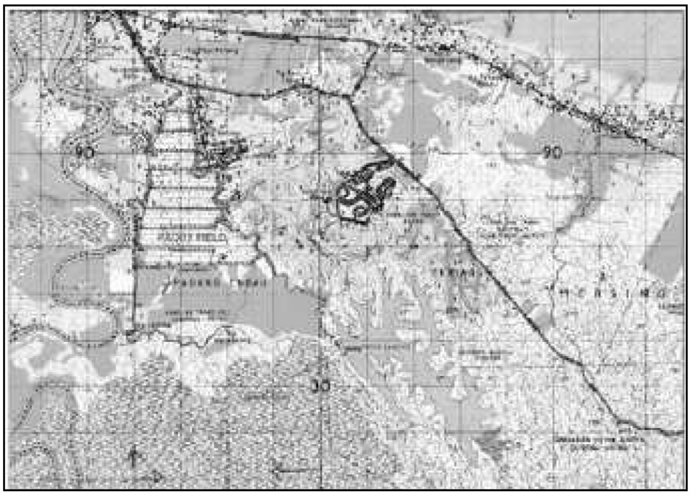


Figure 2.3: Labong Scheme, Johor

(Sources: http://www.mada.gov.my, http://www.water.gov.my/ : 22 October 2013-9.30am)

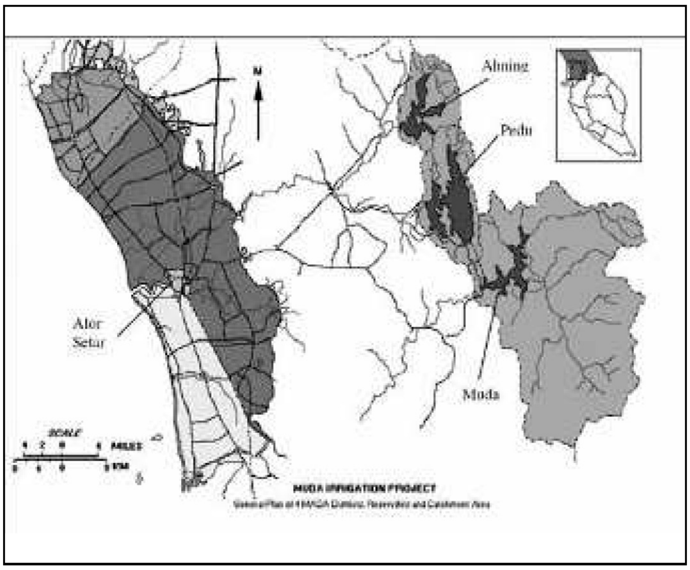
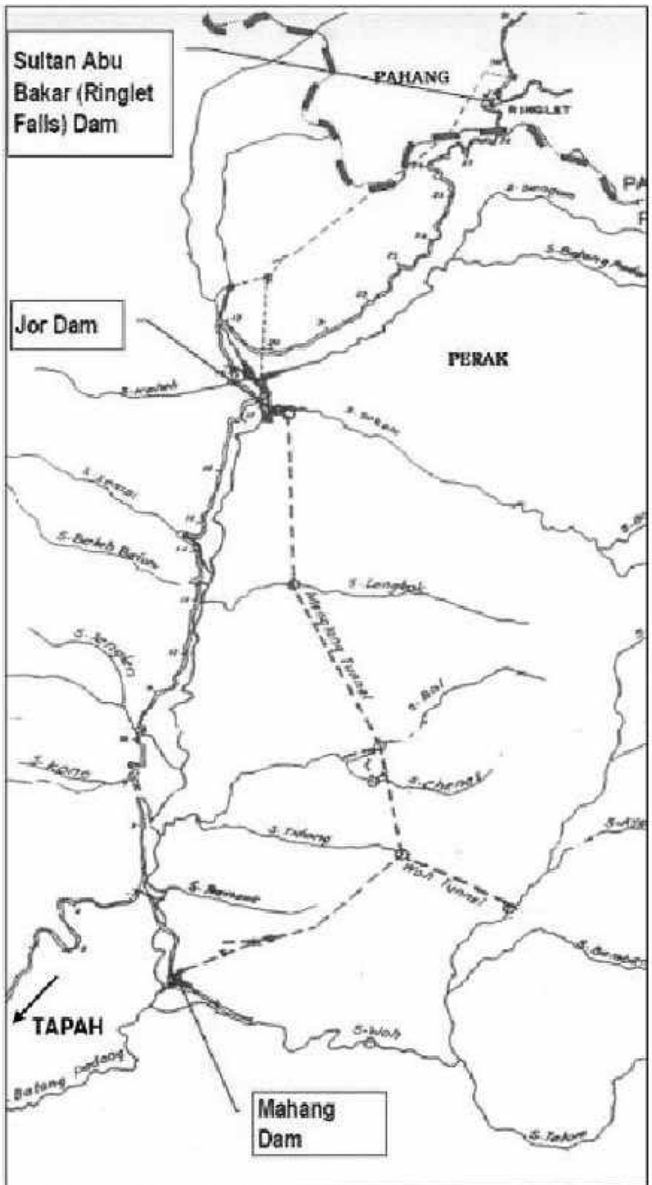


Figure 2.4

The scheme started in 1959 and about half the £15 million cost represented the civil engineering works (Binnie short history 1990). "Much of the initial survey work in 1955 had to take place in virgin jungle, but in addition there were still a number of guerilla camps in the area". The power house was constructed 260m underground, the machine hall being 24m high by 15m wide. Some 26km of tunnels were driven, the last section feeding the turbines having driven at 45º to the horizontal. The 40m high dam to pond the power water was a buttress design, Sultan Abu Bakar (Ringlet) dam, fully closed in on the downstream face to permit overspill to occur over the whole crest of the dam.

The construction of the similar Batang Padang hydroelectric scheme downstream followed immediately and involved another 20 km tunnel, a 46m high earth dam and another underground power station. Figure 2.5 indicates the Location Plan. The push towards nationwide power supply was becoming a reality and



Plan of Cameron Highlands & Batang Padang Hydro-Electric Scheme
Source: TNB-Cameron Highlands & Batang Padang

Figure 2.5

CEB was renamed National Electricity Board (NEB) in June 1965.

The 5-Year Development Plans

Systematic planning for economic development of the country started with two 5-year Malayan Development Plans (1960–1970) and followed by a series of 5-year Malaysian Development Plans (1970–2015). The country is currently undergoing implementation of 10th Malaysia Plan.

Table 2.3 indicates large dams built for various purposes numbering 69 altogether by the end of 2000s. The locations are shown on Figures 2.6 and 2.7. Over a period of 40 years of economic diversification from an agriculture based to industrialization between 1960 and the end of 1990s, 45 large dams were constructed in Malaysia; or at an average of more than one dam constructed every year. Of these, 20 were in the 1980s; an average of about 2 dams per year over the decade. Most of those dams were for water supply (43 dams), reflecting the need for timely water resources development to satisfy the growing demands of the population and industry over those 40 years. The largest dam for Malaysian water supply is the Sg. Selangor dam (235 MCM) as seen in the photograph. The dam development momentum continued into the new millennium.

Between the year 2000 and 2013, 18 more new dams were added or at an average of more than 1 dam per year, the largest being the Bakun Hydroelectric Scheme, Sarawak (44,000 MCM and with capacity 2400 MW) as seen in the photograph. Presently (2013), six new large dams are under construction. These are:

- Kelau, Pahang (water supply)
- Ulu Jelai, Pahang (Hydroelectric)
- Puah and Tembat, Terengganu (Hydroelectric)
- Murum, Sarawak (Hydroelectric)
- Paya Peda, Terengganu (Irrigation)

More dams are planned for the future. Based on the Review National Water Resources Study in 2012 and other proposals to date, another 73 dams are expected to be constructed in the future.

Since 1960, not only were new dams constructed but there were also existing dams re-developed to increase their capacities by raising their dam heights. These are the Bukit Merah Dam (1965 and 1984), the Klang Gates Dam (1979), Durian Tunggal Dam (1992), Lebam Dam (1992) and Sg. Tinggi (2003). Works

View of Sg. Selangor Dam

to raise the TimahTasoh Dam height are currently on going and plans to raise the Mengkuang Dam height are already firmed. Unlike some dams in other countries (e.g. Mangla Dam in Pakistan and Hinze Dam in Australia) that were planned and constructed to be raised in the future, none of the existing dams in Malaysia are known to have been planned, designed and constructed to account for such long-term phased-development. However there

View of Bakun Hydroelectric Dam

are already serious considerations to review the existing dams for possible dam height raise either to meet increasing needs or as an adaptation strategy to absorb the projected extreme flood flows due to climate change impacts.

Most of the dams in Malaysia are earth-fill dams. The majority of sites are in mountainous country and foundations are relatively uncomplicated. Alluvium depths are rather shallow (10-15m) or absent. The weathered rocks in place have adequate strength and stiffness. So they rarely control the embankment slope angles. The residual soil and weathered rocks of Malaysia makes an ideal fill material. The strength of the soil, the ease with which it can be compacted and its fairly rapid rate of consolidation to provide an economical cross-section for a central core embankment dams.

The first Roller Compacted Concrete (RCC) dam in Malaysia was completed in 2006 as the Sg. Kinta dam at Ulu Kinta, Perak. Dams were previously built by different government agencies like the Public Works Department and various Water Authorities

Figure 2.6

Table 2.3: Major Dam Development in Malaysia

No.	Purpose (Primary / Secondary)	Before 1950s		1950s		1960s		1970s		1980s		1990s		2000s		2010-2013		Total
A	Water Supply	Gunung Pulai Scheme 1. Pulai II Dams 2. Pontian Kechil Dam	3	Klang Gates Dam[2]	1	Air Hitam Dam, Penang Damansara Dam, Selangor	2	Lebam Dam, Johor Durian Tunggal Dam, Melaka Langat Dam, Selangor	3	Semenyih Dam, Selangor Terip Dam, Negeri Sembilan[1] Malut Dam, Kedah Ahning Dam, Kedah[1] Mengkuang Dam, Penang Layang Upper Dam, Johor Layang Lower Dam, Johor Timbangan, Semporna, Sabah Sika, Bintulu, Sarawak Bukit Kuda, Labuan Paka (Bukit Bauk), Terengganu	11	Sg. Buloh (Tinggi) Dam, Johor Air Kuning (Taiping) Dam, Perak Pedas Dam, N.S. Juaseh Dam, N.S. Upper Muar Dam, N.S. Gemencheh Dam, N.S. Kelinchi Dam, N.S. Barbagon Dam, Sabah	9	Sg. Selangor Dam, Selangor Chereh Dam, Kuantan Betotan Dam, Sandakan Milau Dam, Kudat, Sabah Gerugu Dam, Sarikei, Sarawak Labu Dam, Selangor Teluk Bahang Dam, Penang Telibu Dam, Sabah Kerteh (KIPC), Terengganu[1]	11	Kinta, Perak Terian, N.S. Batu Hampar, N.S.	3	43
B	Hydropower	Chenderoh Dam, Perak	1			Cameron Highland Scheme Sultan Abu Bakar (Ringlet Falls) Dam, Pahang Batang Padang Scheme Jor and Mahang, Perak	3	Temenggor Dam, Perak[5]	1	Kenyir Dam, Terengganu[5] Batang Air, Sarawak Bersia Dam, Perak Kenering Dam, Perak	4	Pergau Dam, Kelantan[5]				Bakun Dam, Sarawak Murum, Sarawak	2	12
C	Irrigation	Bukit Merah Dam, Perak[1] Labong Dam, Johor	2			Mahang Agricultural Development Authority Scheme Pedu and Muda Dams		Bukit Kwong Dam, Kelantan	1	Anak Endau Dam, Pahang[1] Pontian Dam, Pahang[1]	3	Timah Tasoh Dam, Perlis[3]	1	Beris Dam	1			10
D	Flood Mitigation									Sg. Batu Dam, Selangor[4] Sembong Dam, Johor[1] Machap Dam, Johor[3]	2	Bekok Dam, Johor[4]	1					3
E	Environmental					Silt Retention Repas Baru Dam, Pahang[1]												1
F	Recreation													Putrajaya Dam, Wilayah Persekutuan	1			1
			6		1		8		5		20		12		13		5	69

(Water Supply). Department of Drainage and Irrigation (Irrigation and Flood Control), National Electricity Board for Peninsular Malaysia, Sarawak Electricity Supply Company and the Sabah Electric Board Sdn Bhd. Since 2004, most of the construction of water supply dams has been taken over by agencies under the State Governments and Ministry of Energy, Green Technologi and Water (KeTTHA), and irrigation dams by agencies under the state government and Ministry of Agriculture & Agro Based Industry (MOA). The states of Sabah and Sarawak are directly responsible for construction of dams undertaken by their agencies.

Catchment Control

A major problem facing reservoir operation in Malaysia is the potential for intense erosion of the catchment. The majority of the reservoirs have steep jungle-covered catchments. Under conditions of intense tropical rainstorms even virgin jungle catchments will produce serious soil erosion, as commented by WJ Carlyle, a dam expert from United Kingdom, conversant with dam implementation in Malaysia. According to him, "it is not uncommon for 75% of the annual sediment yield to move in a single storm even in normal conditions."

In his expert view, the Sultan Abu Bakar (Ringlet Falls) reservoir in the Cameron Highlands "presents a good example of where the catchment area has been progressively denuded to grow tea and vegetables and in 20 years of operation, the reservoir has been virtually filled with sediment. An interesting secondary problem of catchment management at Ringlet Falls Reservoir is the development that has encroached into the corridor of the river valley downstream. This used to be a "jungle" river when the scheme was built, but has now been cleared for intensive vegetable and flower cultivation. The concrete dam has float-operated crest radial gates which open in response to rising reservoir levels. It is now unsafe to operate these gates because of the risk of life loss downstream."

The recent tragedy which occurred on 23rd October, 2013 involving the loss of 3 lives, downstream of Sultan Abu Bakar dam (as seen in the photograph) as a result of releases of large volumes of water from the dam, emphasized on the need to keep river reserves and corridors downstream free of human settlements and flow obstructions. This problem of catchment management was previously raised by W.J. Carlyle in his inspection report.

Catchment control needs an integrated approach by all parties concerned at state level to maintain the designed life expectancy of any dam as well as to minimize the risks associated with dam structural integrity and dam operations particularly during large volume releases of water during excessive stormwater flows.

Problems

In his review of dams built before 1990s, WJ Carlyle was not aware of a failure of any Malaysian large dam over the 60 years of dam history. He is aware of only three incidents of any significance:

(i) Serious leakage of an asphalt deck rockfill dam. Leakage was much reduced by underwater placement of clay blanket layer

(ii) Failure of the spillway section of a low irrigation dam due to piping and erosion of the concrete toe, which was rebuilt.

(iii) Slam failure of a 1800 butterfly guard valve upstream of a fully opened 1400 regulator valve on a 2200 outlet pipe causing failure of pipe joints and some flooding. On the same dam but unrelated to the first incident the accidental flooding of the outlet culvert (old diversion tunnel) causing floatation of the empty twin 2200 pipes 500 m long, resulting in damage to pipe addles and support straps -now repaired.

According to him, this is a good record and a credit to the dam owners and builders. These are large dams designed by qualified engineers.

However, there are many small dams mainly in estates and for storage of tailings that are constructed without proper design. A famous tailing dam failure is Ampang Pechah in Kuala Kubu Baru with a loss of many lives. Recently, another tailing dam failed in Gambang, Pahang.

Photo credit: STAR publications (M) Bhd.
View of illegal farms within the Sg. Bertam reserve

Dam Safety

Malaysia has no central authority for enforcement of dam safety, nor any governing legislation. Each dam owner is responsible to carry out the inspection on the maintenance and safety of his dam. State authorities are owners of dams for water supply purposes, flood control and agricultural dams. The Ministry of Agriculture and Agro-based Industry is jointly responsible with state authorities for management of major agricultural dams. The other owners are the electrical power authorities which own and operate the hydroelectric dams in the Peninsula, Sabah and Sarawak. Of recent times, design and construction of dams for water supply purposes has been known to be privatized.

Although, there is no doubt that there is an appropriate awareness of dam safety needs in Malaysia, the time has come for need to have governing legislations to cater for Dam Safety. This is also covered in Section 3 under "Effective Governance of Water Resources Management"

A "Guideline for Operations, Maintenances and Surveillance of Dam", dated October 1989, was prepared by an Inter-Departmental Committee on Dam Safety in Malaysia. The members of the Committee were Public Works Department, Tenaga Nasional Bhd, Department of Irrigation and Drainage, Sabah Electricity Board, Sarawak Electric Supply Company and Penang Water Authority.

It is understood that since 1999, the Inter-Department Committee on Dam Safety has not been operating.

Transfer of Technology and Special Training in Dam Engineering

Immediately after Merdeka, the bulk of the engineers upon graduating from overseas or University of Malaya (being the only university at the time) were taken in to serve the Government, under the Malayanisation Programme to replace expatriates in the Government service. However, a few joined foreign firms of consulting engineers based in the country or newly established local consulting engineering firms. These engineers formed the core of local engineers in the private sector including the pioneers in geotechnical works involved in the large dam schemes such as the Cameron Highlands hydroelectric schemes (1959-1963), Penang-Air Itam dam for water supply scheme (1963-1965) and MADA irrigation project (1666-1970) in Kedah.

During the subsequent years in the 1970s to the 1990s, a number of the foreign owned firms were taken over by Malaysian engineers and among such firms involved in dam engineering were SMHB Sdn Bhd, SSP, and Ranhill Bersekutu. Among the locally established firms with background experience in dam engineering were JKC, KTA Tenaga, Angkasa Consulting Services and RPM engineers. These local engineers received in-house peer training and also gained considerable experience through transfer of technology from their overseas associates.

For the future, it is considered appropriate for new firms intending to be involved in dam engineering to have engineers specially trained and qualified for design, supervision of construction, environmental and safety inspection of dams. These engineers may need to be accredited possibly with a yet to be formed 'Government Commission on Dams'. This is particularly important as far as dam safety is concerned. The consequential effect of failure of dams can be disastrous causing loss of lives to entire villages and townships and to properties downstream of the dams.

3.0 MAIN ISSUES OF CONCERN IN DAMS, ENVIRONMENT AND DEVELOPMENT IN MALAYSIA

Introduction

Malaysia has undergone rapid economic development since the 1960s after achieving independence from Great Britain. A series of 5-year development plans have been implemented with the current 10th Malaysia Development Plan due for completion in 2015. Ensuring adequate supply of water resources remains a key prime mover in the much needed development of the country to meet the rising demands of the increasing population, the requirements of the fast expanding industrial development, irrigated agricultural needs and for energy generation in the hydro-electric process. The increasing demand of water is shown in Table 3.1 and for energy in Figure 3.1 (Generation Mix) which indicates increase in electricity demand from 2015 to 2030. It is interesting to note that hydroelectric source is projected to be 23% of the Generation Mix when the total demand increases from 121,000 GWh in 2015 to 211,000 GWh in 2030.

Due to climatic condition in the country where, sometimes, prolonged dry periods take place, adequate storages are provided to ensure stability in the supply of water. Like other countries, Malaysia highlights that damming of rivers, where economically and socially feasible, is still an important priority for water managers and policy makers. It is a convenient and most feasible way to solve and meet evolving water and energy needs by building dams. However, since the past two decades, another issue emerges in the immediate need to protect and conserve the environment particularly in the provision of dams and storageswhere extensive area of fertile land and forests are inundated permanently with water.

So the issues of concern is not only on freshwater scarcity, causing a crisis, but also on adverse effect, caused by a remedial measure in the provision of dams, to the environment. To put

Table 3.1

	TOTAL CONSUMPTIVE WATER DEMAND (MLD)				
	2010	2020	2030	2040	2050
Perlis	837	819	783	778	771
Kedah	8,006	8,152	7,785	7,871	7,881
Pulau Pinang	2,096	2,271	2,289	2,395	2,450
Perak	5,342	5,267	4,927	4,933	4,962
Selangor	6,133	6,823	7,041	7,561	8,005
Negeri Sembilan	932	989	982	1,002	1,026
Melaka	885	1,003	1,030	1,120	1,202
Johor	1,958	2,410	2,832	3,189	3,563
Pahang	1,990	2,594	2,455	2,495	2,624
Terengganu	2,421	2,671	2,657	2,736	2,811
Kelantan	4,472	4,435	4,344	4,385	4,393
Pen. Malaysia	35,065	37,427	37,137	38,481	39,680
Sabah	2,501	3,712	3,813	3,954	4,035
FT Labuan	49.29	65.89	71.05	75.79	79.28
Sarawak	2,898	5,933	5,830	5,967	6,171
Sabah. FT Labuan & Sarawak	5,429	9,719	9,719	9,990	10,262
Total Malaysia	40,512	47,128	46,856	48,488	49,938

Source: Adapted from Review NWRS 2000-2050 (2012) using Mld conversion everything in the right perspective, the final issue of concern, at the moment, is the absence of an effective coordinating mechanism at the national level to initiate, develop and monitor the implementation of policy reform that are of national significance and requires cooperative action by State Governments. This mechanism can also be responsible for legislation on dam safety and regulation on provision of dams that includes the design and maintenance of dams for the country similar to what is being practiced in developed countries like Australia, South Africa, South Korea and Europe.

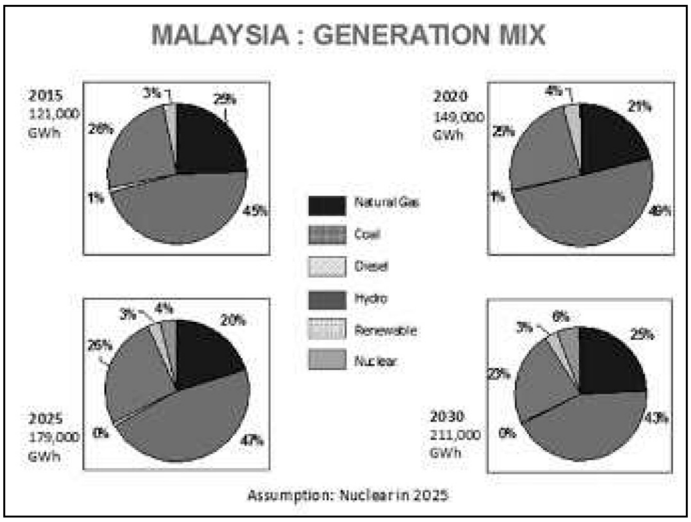


Figure 3.1

Source: EPU - Malaysia Energy Outlook 2010-2030

Pre-empting Water Crisis

The new study on Asia-Pacific region water security warns that many countries face an imminent water crisis unless steps are taken immediately to improve their management of water resources (ADB-Asia Pacific Water Forum). "As a whole the region is faced with a number of unique challenges – most notably rapid urbanization and industrialization. The region's huge population is also very exposed to the expected impacts of climate charge" (Makin ADB).

From a UN data, Malaysia is among the handful of Asian nations largely free of water stress at present. However, the threat of scarcity of freshwater in the near future is already there. The main issue of concern is to address this threat and pre-empt it from happening.

Addressing scarcity of freshwater resources

The threat of scarcity of freshwater resources is as shown in Figure 3.2 (NWRS Review : 2000-2050) where consumptive water demand (irrigated agriculture and potable water supply) is increasing whilst unregulated flow is decreasing. This alarming situation, if unchecked on time, would result in serious water shortages in the immediate future. Some parts of the country are already experiencing unregulated flow freshwater deficit, as shown in Table 3.2. The deficits are in Perlis, Kedah and Penang (irrigated agriculture and potable water supply and in Selangor and Melaka (potable water supply). Melaka is already importing water from Johor to augment the storage and Selangor will soon be using water from Pahang. The total deficits in the five states is calculated to be 4,202 MCM (11,512 Mld) which is about 28.4 per cent of the total Malaysian demand of 14,787 MCM (40,512 Mld) in 2010 (or 32.8 per cent compared to total demand in Peninsular Malaysia (Reference Table 3.2 and graphically Figure 3.2).

These shortages are, in fact, being managed at above stress level mainly by regulated releases from storages impounded by dams as additional water required during dry periods. The role played by dams is certainly vital to maintain a consistent supply of freshwater for use throughout the year.

Security of water resources is very much dependent on climatic conditions. Although Malaysia is among the countries with high average annual rainfall, it is however, seasonal and very

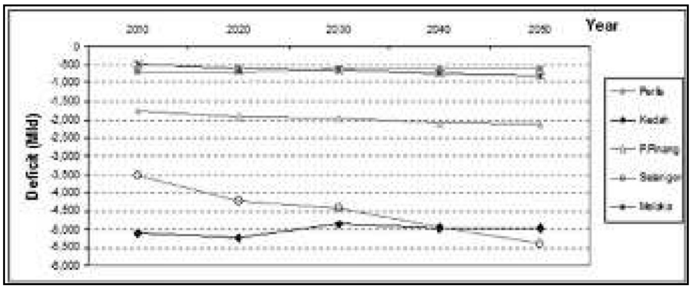


Figure 3.2

Table 3.2

States	Land Area (sq. km)	Total Consumptive Water Demand (mm)					Effective rain (mm)	Excess/(Deficit)(mm) - Unregulated Flows				
		2010	2020	2030	2040	2050		2010	2020	2030	2040	2050
Perlis	821	372.1	364.2	348.1	345.7	342.8	70.5	(301.6)	(293.7)	(277.6)	(275.2)	(272.3)
Kedah	9,500	307.6	313.2	299.1	302.4	302.8	112.5	(195.1)	(200.7)	(186.6)	(189.9)	(190.3)
Pulau Pinang	1,048	729.9	790.9	797.1	834.2	853.1	120.0	(609.9)	(670.9)	(677.1)	(714.2)	[illegible]
Perak	21,035	92.7	91.4	85.5	85.6	86.1	139.5	46.8	48.1	54.0	53.9	53
Selangor	8,396	266.6	296.6	306.1	328.7	348.0	114.0	(152.6)	(182.6)	(192.1)	(214.7)	(234.0)
Negeri Sembilan	6,686	50.0	54.0	53.6	54.7	56.0	72.5	22.6	19.5	19.0	18.8	17.5
Melaka	1,664	194.1	219.9	225.9	245.7	263.7	85.5	(108.6)	(134.4)	(140.4)	(160.2)	(178.2)
Johor	19,210	37.2	45.8	53.8	60.6	67.7	171.0	133.8	125.2	117.2	110.4	103.3
Pahang	36,137	20.1	26.2	24.8	25.1	26.5	165.0	144.9	138.8	140.2	139.9	138.5
Terengganu	13,035	67.8	74.8	74.4	76.6	78.7	253.5	185.7	178.7	179.1	176.9	174.8
Kelantan	15,099	108.1	107.2	105.0	106.0	106.2	175.5	67.4	68.3	70.5	69.5	69.3
Pen. Malaysia	132,631	96.5	103.0	102.2	105.9	109.2	159.0	62.5	56.0	56.8	53.1	49.8
Sabah	73,631	12.4	18.4	18.9	19.8	20.7	177.0	164.6	158.6	158.1	157.4	157.0
FT Labuan	91	197.7	264.3	285.0	304.0	318.0	322.5	124.8	58.2	37.5	18.5	4.5
Sarawak	124,450	8.5	17.4	17.1	17.9	18.1	220.5	212.0	203.1	203.4	203.0	202.4
Sabah, FT Labuan & Sarawak	198,172	10.0	17.9	17.9	18.4	18.9	260.5	250.5	250.6	250.0	250.1	249.6
Total Malaysia	330,804	44.7	52.0	51.7	53.5	55.1	225.0	180.3	174.0	173.5	171.5	169.9

Source: Review NWRS 2000-2050 (2012)

Demand Increasing

Unregulated Flow in Deficit

Unregulated Flow Declining

Malaysia

pronounced. In an extreme case during the water crisis in Selangor in 1998, there was hardly any rainfall for nearly six months resulting in a severe drop of flows in rivers and waterways. Occurrences of flood is more frequent, particularly on the east coast of Peninsular Malaysia during the monsoon season. Adequate storage is deemed necessary. The main issue is the ability to harness and store the excess rainfall for use effectively over the remaining period of the year whilst concurrently attending to flood mitigation measures in dams like large hydroelectric reservoirs as multi-purpose dams.

The issue of water scarcity is global. By 2025, two-thirds of the global population could confront water stress (FAO "Hot issues : water security 2012) – the vast majority would be in Asia. While Asian freshwater resources have remained the same, its population has grown from nearly 1.5 billion in 1950 to 4.2 billion by end of 2011 or 60 percent of the world's total (UNDP 2011). Asia's rivers, lakes and aquifers give it, per capita, barely one tenth the water of South America or Australia and New Zealand, less than one-fourth of North America and nearly one-third of Europe (FAO IRWR 2011). Yet the world's fastest-growing demand for water for food and industrial production and water supply is also in Asia.

The decision lies on whether developing Asian nations would have the capacity to emulate many of the advanced countries to build large dams in order to strengthen the high capita storage capacity needed for human development and economic growth. China, as the fast growing developing country, and second largest economy in world, has embarked on construction of many large dams. In the case of Malaysia it is interesting to note that based on computation of the total storage volume of 86,763 million m^3 and the current population of 29 million, the per capita storage is 2,992 m^3 when compared to Australia's 4,600 m^3 and North America's 6,000 m^3.

Environmental and Social Conditions of Sustainability

Where large quantities of water are needed for potable and/or industrial water supply, irrigation, energy and flood control, multipurpose dams have proven to be the best solution. Once these dams are completed, they become an integral part of the environment. It is essential that environmental assessments be made to identify potential impact by the project. From social aspects, public involvement early in the project planning process also allows the affected people not only to better understand the project but plan for and obtain assistance for real estate acquisition and resettlement. It is an acceptable practice that people who have to be resettled must have a better quality of life than they have before and also better facilities. All necessary expenses for such settlement practices should be included in the project cost.

Central to issues on the development of dams in Malaysia is the effect it has on water resources lies on inadequate environmental and social consideration when planning of the project. Perhaps if the planning and study period is spread over a reasonably longer period of at least five years or more before the project is started, most issues of concern would be scrutinized and agreed to everybody's satisfaction and adverse impacts reduced to absolute minimum.

The environmental impact of dams are wide ranging and can be briefly summarized as follows:

i. Habitat fragmentation within dammed rivers;
ii. Downstream habitat effects caused by altered flows, such as loss of floodplains, riparian zones, and adjacent wetlands and deterioration and loss of river deltas and ocean estuaries;
iii. Deterioration of irrigated terrestrial environments and associated surface waters;
iv. Reduction of river flows, leading to reduced water quality because of dilution problems for point and non-point sources of pollution;
v. Genetic isolation of species as a result of habitat fragmentation;
vi. Changes in ecosystem-level processes such as nutrient cycling and primary productivity;
vii. Contamination of food webs, and
viii. Increase in greenhouse gas emissions.

One example of note is the Three Gorges Dam in China. Constructed in 2006, the dam was completed and became functional by July 2012. The environmental impacts are certainly worth noting when considering the benefits of considerable hydroelectric power (22,500MW). The first impact is the water pollution created the submergence of hundreds of factories, mines and waste dumps, and the presence of massive industrial centres upstream. Second, erosion of the reservoir and downstream riverbanks is causing landslides, and treating one of the world's biggest fisheries in the East China Sea. Third, the weight of the reservoir's water has many scientist concerned over reservoir-induced seismicity. Finally, crisis have also argued that the project may have exacerbated recent droughts by withholding critical water supply to downstream users and ecosystems, and through the creation of a microclimate by its giant reservoir. In 2011, China's highest government body for the first time officially acknowledged the "urgent problems" of the Three Gorges Dam.

Equally of major concern in the resettlement of people from the area to be inundated as reservoirs. Some form of resettlement programme has to be drawn up during the planning and study period. In Malaysia, many of the programmes have either been unsuccessful or met with implementation problems. For instance, many Orang Asli communities have been provided with alternative housing which is built of concrete structures in land areas that are void of forest vegetation. Such housing are unsuitable for the Orang Asli who are used to living in wooden houses among tall trees.

To quote actual examples of dams that have been built in Malaysia and some of their effects on the environment and communities, two dams are cited, namely Sg. Selangor dam in Hulu Selangor and Kelau Dam in Pahang.

For the Sg. Selangor Dam, because the project was in Selangor where public is more vocal and more aware of environmental issues, there was much protests from various NGO groups during the early stages of the project. Now, some 12 years after the implementation of the dam, the actual outcome of some of the earlier major concerns can be summarized as follows:

- Relocation of about 340 Orang Asli in Kg. Gerachi and Kg. Peretak – in this case there was emphasis placed on providing the Orang Asli communities with suitable housing which was designed to be of wooden structure, more like kampong houses. There are nevertheless still issues in the implementation programme due to inadequate follow up on their livelihood, schooling programme for the children, etc.
- Impact on firefly colonies in Kg. Kuantan located at the river mouth about 80 km downstream of the dam – this was one of the key issues of concern of the Sg. Selangor dam. The Malaysian Nature Society had been monitoring the firefly colonies after the dam was constructed and their finding was that the colonies have been dwindling. However, this may not be completely due to the dam project along since there are also other activities at the estuary areas that could be affecting the mangrove ecosystem.

In the case of the Kelau Dam project in Pahang, the dam construction is currently ongoing. The main issue relating to this project is again the resettlement of Orang Asli communities affecting about 110 people. The resettlement package for the Orang Asli includes concrete houses, 5 acres of oil palm areas and monetary compensation for 4 years. This is part of Government's "Program Pembasmian Rakyat Termiskin", (PPRT) programme. There are already problems with the execution of the resettlement programme; the oil palm areas are poorly managed, the houses are in areas that are completely cleared of vegetation, the drainage systems for the housing area have already collapsed, and there is no waste collection provided for the settlement area.

As a result some of the Orang Asli families have moved back to near where they used to live before.

Resettlement programme must involve educational proposals and new activities such as crafts or other cottage industries to be developed.

Effective Governance of Water Resources Management

Another main issue of concern is the confusion over responsibility for governance. "Many countries still have multiple agencies with responsibilities for water. This often leads to ineffective planning and utilization of available resources, including water, human and financial resources. I cannot think of a country in the region that would not benefit from a long hard look at the institutional arrangement for water planning and management". (Makin ADB).

Management of water resources is a state responsibility in Malaysia and of late, a number of states has instituted some form of arrangement for improvement to water resources and water demand management with a varying degree of success. The state of Selangor, with the formation of Lembaga Urus Air Selangor (LUAS), has for sometime established a system of governance, which would be a suitable model for other states to adopt. Among the responsibilities are:

- The conservation, replenishment and supply of water
- The beneficial use of water
- determining and recording the actual availability of water resources within the state,
- protection of water from pollution and the improvement of its quality
- equitable distribution of water by allocating the rightful use of water to users for different purposes broadly based on the principle of IWRM
- protection of the environment

At the National level, there has yet to be an effective Advisory Mechanism on efficient Water Resources Management across the whole range of users based on IWRM principles. The users are irrigated agriculture, potable water supply and sewerage, hydropower, flood management, environment, fisheries, transport and others. This mechanism, among others, can provide guidance and advice on policy matters, human resources training, research and development and investments on capital and operational works.

A good example, for reference, is the way the Council of Australian Governments (COAG) water reform is being made to work in Australia. The role of COAG is to initiate, develop and monitor the implementation of policy reforms that are of national significance and which require cooperative action by Australian governments (State Governments).

The responsibility in water resources management lies with the State Governments. Water resources can become a National Issue when shortages in supply are widespread throughout or some parts of the country. In such a case, the role of the Federal Government, represented by a Mechanism, becomes important to provide coordination among the states and setting direction to overcome any issues and problems of national importance. This Mechanism should preferably be independent, sector-neutral and high level. With the formation of this mechanism, important issues of dam safety can be addressed, through legislation and applied uniformly throughout the country.

General issue of concern in management

- To change from Supply to Demand Management
- From Sectorial to IWRM
- Federal-State coordination
- Inter-state coordination
- Inter-Ministry coordination
- Public Participation
- Driving Business Development and Wealth Creation
- Driving Science, Technology and Innovation (STI)

Specific Issues of Concern

- Water security and, consequently, food security are important concerns which need to be carefully balanced with the likely negative social and environmental impacts they can cause.
- Dam safety – the need to have legislation in the provision of dams to ensure that dams are properly and adequately designed, maintained and regularly inspected by providing standard practices including rules and regulations
- Moving towards a more inclusive approach to tackling water pollution issues has long been recognized as a positive step : but turning this into a practical reality requires social evidence for what works well at catchment scale.
- Launching of water certification standard (eg.UK-based Carbon Trust) – a Water Standard to help drive the move to resource-efficient economy, requiring to produce at least two years of data abstraction.
- Promoting close linkages among the sectors, such as, water and energy. Water is not only essential for large-scale electricity consumption and production but also the water sector is a major consumer of electrical power.
- Promoting the provision of multi-purpose dams as a mean to manage demands on use of water in the overall water resources management.

Summary of Conclusion

- The main issue of concern facing Malaysia is scarcity in freshwater resources. At the moment, this is being experienced in the five states of Perlis, Kedah, Penang, Selangor and Melaka. There are normally large bodies of water downstream of rivers which are severely polluted. The situation may become serious with the imminent impact of climate change. For a long time in the past, provision of dams and storages has been given priority in solving water shortages and has played an important part in water sources regulation in the states concerned. Some amount of recycling has also been adopted for irrigated areas.
- Reservoirs impounded by the dams inundate extensive areas of forest and fertile lands permanently and cause adverse effect to flows in the river regimes. The initial issue before the construction of the dam is to satisfy the environmentalist and social activists that any adverse effect will be minimized. At planning stage, sufficient time should be allowed (5 years or more) for reconnaissance work identifying suitable sites for dams. At the later stage when the dams are in operation, the dam owners are obligated to ensure that the river flows are kept to at least, the normal flows before dams make their appearance. The dam owners are to ensure that dam safety units are set up for the regular monitoring and surveillance functions. Safety review by independent and properly qualified engineers is strongly recommended.

- Malaysia needs a mechanism at the highest national level to provide an independent, sector-neutral effective leadership and drive in water resources management. There is also need for private sector participation, principally as stakeholders, if water resources management is to be successful.

4.0 MAXIMIZING SUSTAINABILITY IN THE CONSTRUCTION AND OPERATION OF DAMS

Introduction

Despite efforts to achieve Integrated Catchment Management, it is conceivable that dams will be required in the future to meet societal needs. If this is the case, what process can be followed to ensure that the most sustainable outcome is achieved when considering the vast array of technical, environmental, social and economic challenges that exist with a new or existing dam project?.

The emphasis on sustainability has relevance in Malaysia considering the challenges involved in siting a dam. There are numerous issues to contend with and past experiences of dam building in the country have often faced difficulties related to community resettlement and environmental degradation. Whilst there are existing regulations in place to assess the sustainability implications of a dam (i.e. Environmental Impact Assessment), these could be enhanced with the latest developments in current dam building practice. This next section briefly sets out a process of determining the most sustainable outcome for hydropower projects.

The Hydropower Sustainability Assessment Protocol (HSAP)

Developed by the International Hydropower Association (IHA) and launched in 2011, the Hydropower Sustainability Assessment Protocol (HSAP) is a sustainability assessment framework for hydropower development and operation. It enables the production of a sustainability profile for a project through the assessment of performance within important sustainability topics. Sustainability in this context refers to aspects related to the environment, society, economy, technical and integrative aspects. While HSAP is focused towards hydropower projects, the process of site selection, engineering design and project operation has relevance in determining suitable sites for dams in Malaysia. Table 4.1 provides an overview of the sustainability criteria and Figure 4.1 shows an example of the scoring 'spider diagram'.

HSAP is an evidence-based objective assessment of a project's performance, prepared by an accredited assessor applicable to all stages of hydropower development in all global contexts. Therefore, it is plausible that the HSAP could be integrated into Malaysia's current EIA processes to help site areas for dams that will limit the environmental, social and economic upheaval. Furthermore, the preparation of HSAP involved participation of leading NGOs including WWF, The Nature Conservancy, and Transparency International. NGO participation provides further legitimacy and helps to ensure all aspects of sustainability are being properly examined.

The Application of HSAP

A wide application of the Protocol is desired by the IHA and they argue it should be applied in a collaborative way, to ensure the best availability of information and points of view. The development and evaluation of a hydropower project will involve many actors with different roles and responsibilities. It is recognized that both development and operation may involve public entities, private companies or combined partnerships, and responsibilities may change as the project progresses through its life cycle.

In sum, HSAP provides developers and relevant stakeholders (i.e. government agencies, non-governmental, community groups) with a necessary tool kit so that they are asking the right sustainability questions across a number of topics. If these stakeholders are unsure of the most suitable site for dams between a number of different sites, the HSAP provides them with a way to determine the most sustainable and in which areas they need to augment poorly performing aspects of the project.

Potential application of HSAP in Malaysia

Any future application of HSAP in Malaysia could be undertaken alongside the current regulatory framework for dam selection and associated environmental and social assessments, including the Environmental Impact Assessment (or EIA). The current regulations relating to Environmental Impact Assessment is stipulated under the Section 34A Environmental Quality Act 1974, Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987. Dam projects are Prescribed Activities under three categories:

i. Schedule 3 – Drainage and Irrigation: (a) construction of dams and man-made lakes and artificial enlargement of lakes with surface areas of 200 hectares or more.
ii. Schedule 13 – Power Generation and Transmission: (b) dams and hydro-electric power schemes with either of both

Table 4.1: Sustainability criteria for dam builders as prescribed in the HSAP

TECHNICAL	ENVIRONMENTAL	SOCIAL	FINANCIAL AND ECONOMIC	INTEGRATIVE
Siting and Design	Downstream flows	Project affected communities and livelihoods	Economic viability	Downstream need and strategic fit
Hydrological Resource	Erosion and sedimentation	Resettlement	Financial viability	Communications and consultation
Reservoir planning, filling and management	Water quality	Indigenous people	Project benefits	Governance
Infrastructure safety	Biodiversity and invasive species	Cultural heritage	Procurement	Integrated project management
Asset reliability and efficiency	Waste, noise and air quality	Public health		Environmental and social issues management

Source: International Hydropower Association

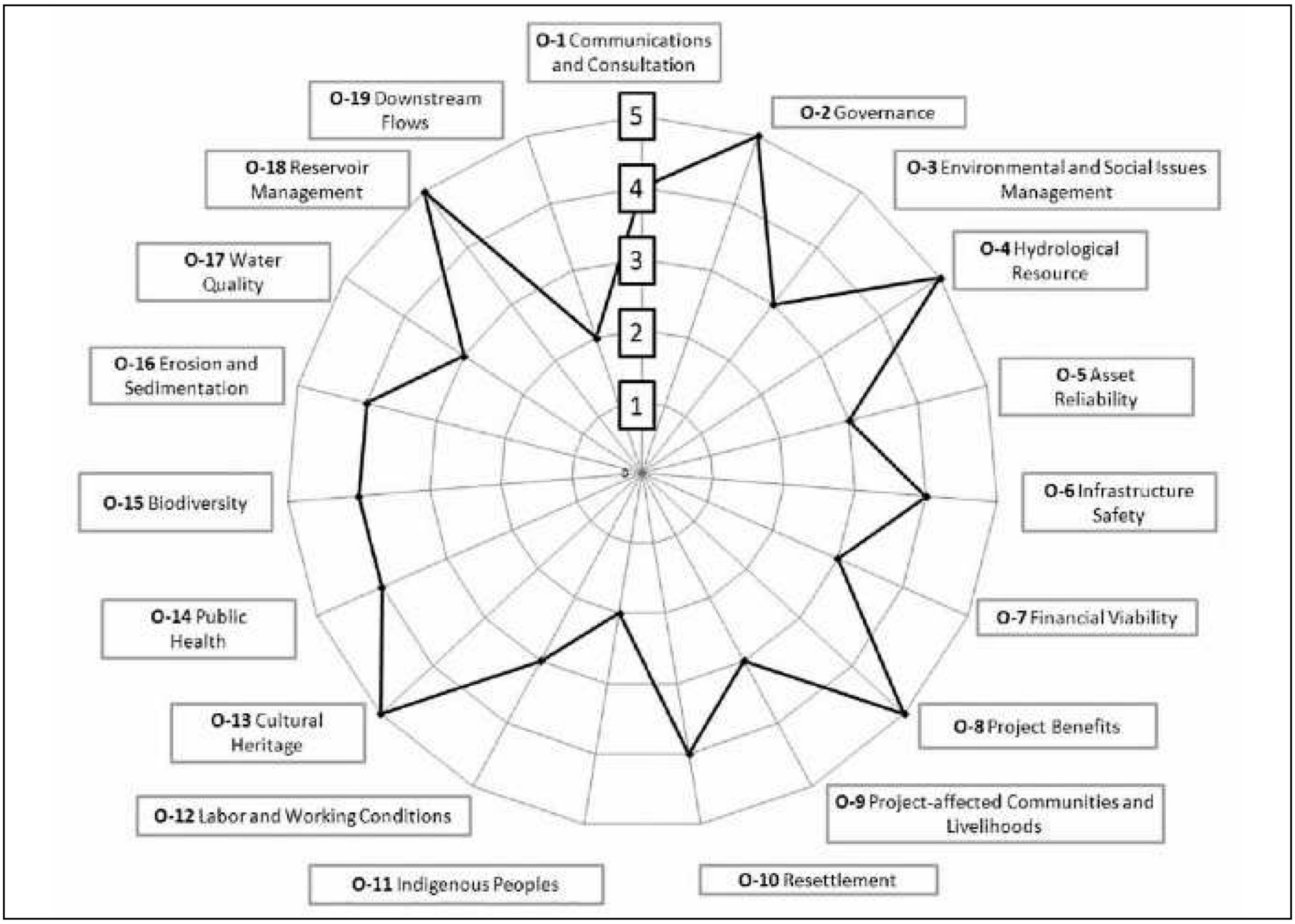


Figure 4.1: Example of a scoring 'spider diagram' for an individual dam

Source: International Hydropower Association

of the following:- (i) dams over 15 metres high and ancillary structures covering a total area in excess of 40 hectares and (ii) reservoirs with a surface area in excess of 400 hectares.

iii. Schedule 19 – Water Supply: (a) construction of dams or impounding reservoirs with a surface area of 200 hectares or more.

The Hydropower Sustainability Assessment Protocol (HSAP) appears to be a good tool for site selection exercise whereby environmental, social and economic factors are included in the decision to site a dam. The HSAP would be most appropriate to be used during the masterplanning stage when preliminary investigations are made to identify sites for dams. For instance, for water supply dams, the water resources masterplan studies identify dam sites which are recommended to be gazetted for the purpose. The HSAP tool could be used for such studies.

In Malaysia, the EIA process usually takes place once the dam site has already been identified and using the HSAP at this stage is almost too late for a change in the site. The EIA identifies the impacts and make recommendations to mitigate the impacts, which is more a corrective rather than a preventive means of minimizing environmental and social issues. In most cases, the EIA is conducted in tandem with the engineering design and at this stage, the project proponent (usually the government authorities) is already quite committed to the implementation of the project and would have already invested time and cost.

Having said that, recently the DOE has included an additional step in the EIA process which is the requirement to conduct a Preliminary Site Assessment (PSA) and submit the PSA to the DOE before embarking on the full EIA study. The HSAP process could be a useful tool in the PSA stage. However, the PSA process is a fairly simplistic assessment without involving the participation of an independent expert and auditor which is the concept of the HSAP.

The HSAP could provide a more comprehensive assessment of potential sustainability impacts than the PSA and, moreover, if successfully adhered to, provides the developer with a certification standard of international standing.

5.0 FUTURE OUTLOOK OF TOMORROW'S DAMS TO ACHIEVE SUSTAINABLE TARGET

Introduction

For a long time dams have been the most obvious option in meeting development objectives. Over the past 5,000 years, more than 50,000 large dams have been completed. Throughout history of the world, dams and reservoirs have been used successfully in collecting, storing and managing water needed to sustain civilization.

Construction of dams gathers momentum since 1900s when more than 60% of the dams have been built as shown in Figure 5.1. Most of the construction has taken place in industrialized countries where need for water grows tremendously beyond the basic needs in food production, drinking water supply

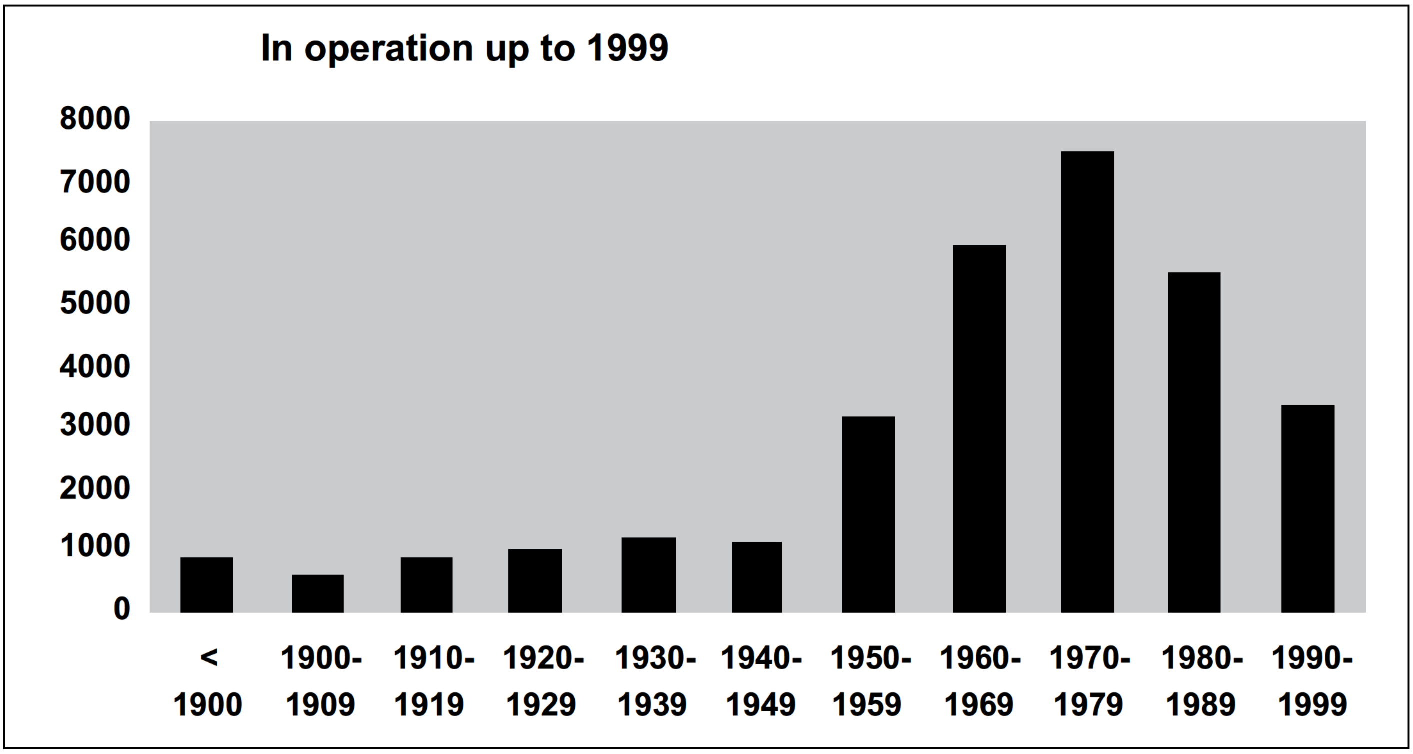


Figure 5.1

Source: Dams and Reservoirs, Societies and Environment in the 21st Century (22 ICOLD International Conference 2006)

and flood control measures. The era of intensive development in industrialized or developed countries calls for massive energy requirement which relies a lot of energy provided by hydroelectric generation. More than 80% of the world reservoirs storage is used for hydropower.

However, over the past three decades there has been a dramatic decline in dam investment in industrialized or developed countries. This is possibly due to stabilization in demand for water and energy in developed countries and also resiting of some heavy industries to developing countries possessing extensive energy potentials like hydroelectric power.

The present total storage is about 6,800 km^3 (billion m^3) and is estimated to increase by 2,500 km^3, i.e. around 40% up to 2050. A further increase of 1,000 or 1,500 km^3 after 2050 is likely, as shown in Table 5.1.

The probable huge increase in oil costs, the likely premiums to clean energy may provide impetus to building more hydroelectric dams in large countries like China, India, Brazil, Russia and Congo.

Before 1970, for dams as for other human activities, there was little concern for the environment. For now, the possibility to build dams is made more difficult in view of actions of some opponents. Critics to large hydraulic structures, particularly to large dams often argue that economic and social development can also be achieved without them. It is the intention in this presentation to address this issue based on available alternative options which can be used. The two main environmental drawbacks of dams are large impounded areas and, in some cases, the withdrawal of most of the river water throughout the year. Besides studying the possible alternative options to large dams, the dissemination of fair and balanced information on the benefits of the dams and the management of these drawbacks are thus essential.

Table 5.1

YEAR	2000	2050	2100
a) Irrigation, water supply,dry season releases, flood mitigation, part for hydropower (50%)	1200	2400	3000
b) Hydropower alone	3000	3600	4000
c) Siltated storage and unsiltated dead storage	2600	3500	4000
Total	**6800**	**9500**	**11000**

Source: Dams and Reservoirs, Societies and Environment in the 21st Century (22nd ICOLD International Conference, 2006)

Dam Development in Developed Countries

Most developed countries turned to large dams to help them in their industrialization development to meet escalating water, energy and other demands from the 1930s to the 1970s. Compared to the rest of the world, they had a headstart in dam building and this reached a peak in the 1970s when 7000 dams were constructed as seen in Figure 5.1. On average two or three new large dams were commissioned each day somewhere in the world. The water that is stored and regulated by dams and reservoirs produces irreplaceable water resources and apart from water and energy demands, also brings benefits to flood mitigation, river navigation, recreation, tourism and the environment. Globally, this represents 30% of the world's available water resources which reaches the end users. However over the past three decades there has been a dramatic decline in dam investment in developed countries.

Over this same period, partly due to pressure from anti dam movement, the world is looking for a balance between the benefits and the environment for water resources projects. The challenge for the future will be the utilization of dams in conjunction with the climate, environment and land use as part of social and economic development goals, crucial to achieving sustainable and inclusive growth of which natural aquatic ecosystems are considered as an integral part.

Dam Development in Developing Countries

Many developing countries started building large dams after World War II and are still building more in order to meet the increasing water and energy demands for now and the future. As shown in Figure 5.2, the top five dam-building countries account for more than three quarters of all large dams worldwide, with approximately two-thirds of the world's existing large dams found in developing countries. Being late starters in dam building, inevitably, they face the full force of anti-dam movement of the world which became active after 1970s.

Among developing countries, Malaysia has to date constructed 69 large dams, of which 66 were constructed after World War II and has plan to build 73 more by 2050 (Review of NWRS 2012 and other reports). About 95% of the reservoir storage is used for hydropower.

Malaysia has undertaken ten Five-Year Economic Development Plans (EDP) successfully and has ensured that there is sufficient quantity of water supply for development in agriculture, domestic and industrial uses. For the same period, storages were provided for hydro-electric generation. Timely commissioning of dams under the various stages of the EDP has assisted in the stability in the supply of water resources for the economic development and water security of the country. It is a credit to the country that Malaysia has maintained water security at all time with the continued implementation of EDP. This is crucial in achieving sustainable and inclusive growth.

Adverse Impacts of Dam

Worldwide, dams have been accepted as an important means of meeting perceived needs for water and energy services and as long-term, strategic investments with the ability to deliver multiple benefits. Some of these benefits include job creation, creating income from export earnings by selling cash crops or processed products. In many cases an unacceptable and often unnecessary price has been paid to secure those benefits especially in social and environmental terms.

The generic nature of the impacts of large dams on ecosystems, biodiversity and downstream livelihoods is increasingly well known. Increased attention is now given to avoidance or minimization of ecological impacts. A number of developed countries, particularly in the USA, ecosystem restoration is being implemented as a result of the decommissioning of dams.

It is possible that impacts of large dams have yet to reach a serious level in Malaysia. The question is what about what may unfold in the future if more dams are built. Perhaps lessons can be learnt from China, which along with India is now building most of the large dams among developing countries. Can developing countries like Malaysia manage sufficiently well without dam?

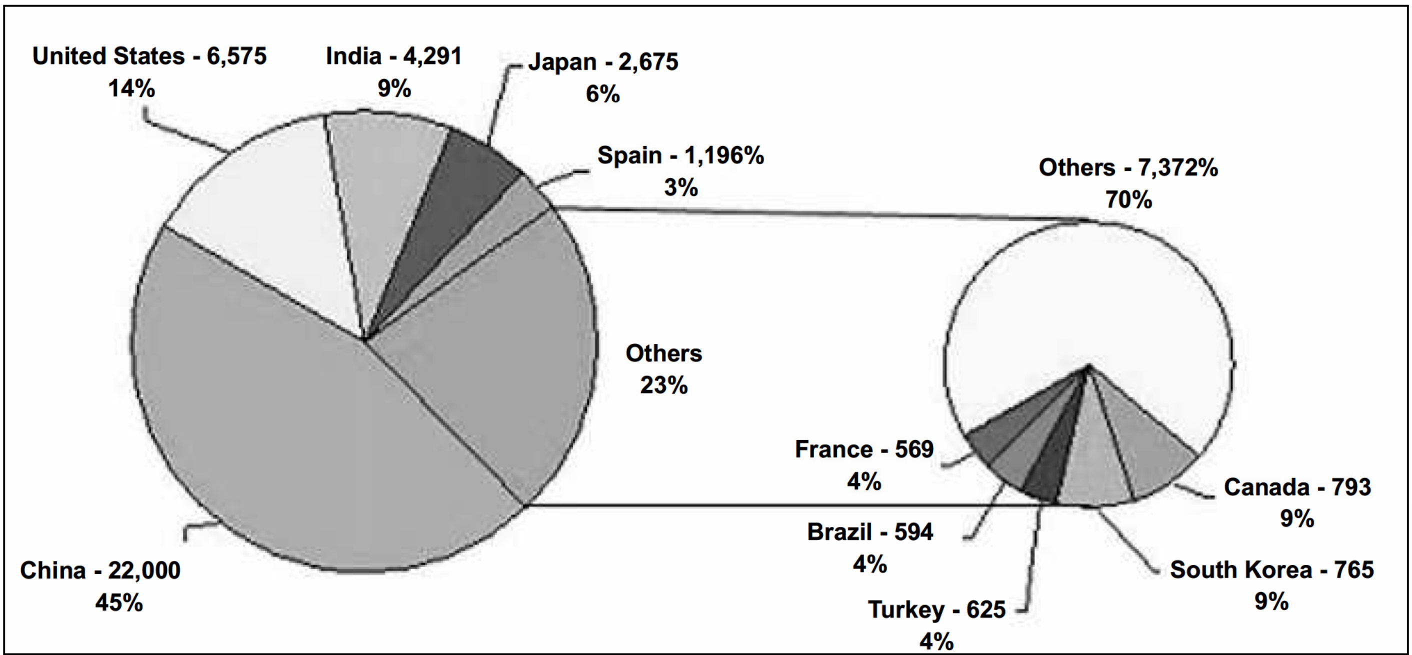


Figure 5.2: World population of dams, by country

Source: World Commission on Dams (WCD) estimates, based on ICOLD and Other sources

Other Options to Dam Building

Opponents of large dams contend that better, cheaper, more benign options for meeting water and energy needs exist and have been frequently ignored. Dams have often been selected over other options that may meet water or energy goals at lower cost or that may offer development benefits that are more sustainable and more equitable.

For Malaysia, several options to dam building for water and energy resources development to meet sustainable energy, water and food needs currently exist as shown in Figure 5.3.

- **Stakeholder Engagement:** Promoting IWRM is now widely accepted internationally as central to effective management of water resources. Although accepted by the Government for adoption more than 20 years ago, the results have not been satisfactory. Getting all parties to be involved in an integrated manner in water management can assist in solving major water problems like keeping clean (to acceptable standards) large bodies of water in rivers and lakes and maintaining them in good conditions, for use.

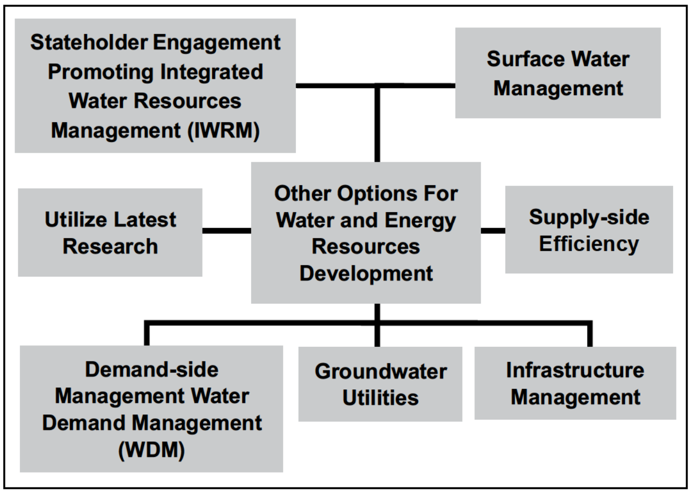


Figure 5.3: Other Options for Water and Energy Resources Development

- **Surface Water Management:** Improve the management of surface water in order to utilize this resource more effectively, including improving the surface water quality and tackling pollution. This includes examining how best to manage current surface water sources through the legislative and regulatory frameworks. The diesel oil spill into Sungai Selangor in August 2013 is a case in point: the incident reveals a breakdown in the enforcement and monitoring of polluting industries in the Malaysian urban context.
- **Supply-side efficiency:** This can include inter-basin transfers, recycling and reuse of water and new supply alternatives like renewable energy options. Where practicable, there should be provision in raising of existing dams to store more water instead of planning for more dams. As far as possible, more existing dams should be converted and used as multi-purpose dams.
- **Infrastructure Management:** Manage existing infrastructure to minimize water losses, such as reducing non-revenue water (NRW) from illegal connections and damaged pipelines. Malaysia treats approximately 14,000 mega litres a day in 2011: however, nearly 37% does not reach consumers (Malaysian Water Industry Guide 2012). In contrast, neighbouring Singapore reports an NRW value of just at 4.6% (Asian Green Index, 2011). This issue highlights not only the considerable waste of water but the waste of energy and chemicals required for the treatment process.
- **Groundwater Utilization:** Determine the opportunities for groundwater extraction, including critical research to derive the extent of sources and treatment technologies required.
- **Water Demand Management (WDM):** Implementation water demand management strategies to reduce the need for water. Such techniques include education of water users to minimize their consumption and encourage installation of water efficient technologies (i.e. half flush on toilets, push taps). This can be supported by considering the economies of water supply, including revisions of the current water tariff. Examples of water demand management in action include programmes in the Murray-Darling Basin, a water scarce region in Southeast Australia. Here, an integrated programme was devised to support better use across the major industrial and agricultural user groups, as well as including a plan for residential users too.
- **Utilize Latest Research:** Recent developments in the field of 'water footprint' to allow a better understanding of the extent of our water quality and quantitative impacts related to water production and consumption. Determining a 'water footprint' for the Malaysian Water Industry as a whole may help to justify more sustainable strategies and approaches.

All these alternative options are not easily implemented but if successfully put in use can question the wisdom in building more dams. But can this happen?

Some of the alternative options make economic sense and merit special attention listed as follows:

► Demand-side management (WDM)
Options for water supply hinge on demand-side management (WDM) in reducing usage and wastage and efficient distribution and accounting for water supplied to end users

In the case of potable water supply, any reduction in per capita usage means saving in water usage and reducing wastage. Correspondingly, a better management in water distribution can cut down on water losses considerably. As an example, Table 5.2 indicatively shows a potential saving of at least 1600 Mld in potable water supply in 2020 in Peninsular Malaysia assuming a 15% reduction in per capita demand and a 6% reduction in losses.

In the case of agricultural water usage, particularly paddy cultivation, a small reduction in water usage can free a considerable amount of water for other end users, like domestic and industrial supplies and for environment and recreational benefits.

Efforts to develop varieties that require less water is currently on going. In the mean time, efforts to increase irrigation efficiency has to be stepped up. As an example, as shown in Table 5.3, the total paddy crop water requirement for the MADA Granary is 0.011 MCM/ha for the main season and 0.013 MCM/ha for the off season. Thus the total crop water requirement is equivalent to 0.024 MCM/ha/year. Rainfall provides 52% (0.0125 MCM/ha) of the total water needs and the remaining 48% (0.0115 MCM/ha) is from non-rainfall sources namely the dams (32%), rivers (10%) and re-use (6%). With a total area of 96,558 ha, then the total crop water requirement is 2,317 MCM/year. Since 52% of this amount 1,205 MCM is from rainfall and the remaining

48% or 1,112 MCM has to be from irrigation. Presently, MADA irrigation system is reported to be operating at 70% irrigation efficiency. This means that the irrigation supply to produce rice here is 1,588 MCM/year. If irrigation efficiency is raised to 75% (an on-going effort), then the total irrigation supply would be 1,483 MCM/year, a reduction of 105 MCM/year. This is equivalent to a relief of 288 MLD for the water supply industry.

Assuming a domestic and industrial consumption rate of 250 litres/day/capita, this savings from irrigation could satisfy water supply requirements for about 1.2 million population. Estimating that the populations of Kedah, Perlis and Pulau Pinang now are nearly 2.3, 0.7 and 1.7 million (2015) respectively or a total of 4.7 million, this saving in irrigation represents nearly 25% of the water supply requirements of the population in the three northern states.

► Supply-side management in efficient inter-basin water transfer
Inter-basin water transfers have solved a number of vital water shortage cases in Peninsular Malaysia in recent years. The most notable completed project in the transfer of water from the Sg. Muar to Melaka to meet the shortfall in potable water supply in 1991. Catchment water transfers have been known to take place in hydroelectric generation. One example is in the Cameron Highland Scheme, where augmentation of water supply comes from upper reaches of Sg. Kelantan at Sg. Plauur to Ringlet completed in 1963. It is possible that such similar schemes may take place in the future, particularly, the transfer of water from existing dams in water rich states to recipient's states needing water.

► Regulating reuse and recycling of water, potentially, as augmented supply to available water resources. One of the greatest opportunities for water reuse is to supplement or replace the potable water or freshwater demands of industries and other commercial uses. The industry is the second largest market for water supply after agriculture, accounting for around 25% of global demand. The milestone in the development of safe water reuse practices are as seen in Figure 5.4 and are based on the advances in waste water treatment with the technological break through in of membrane filtration. In developed countries an important new concept in water reuse is the 'fit-to-purpose' approach which entails the production of recycled water of a quality that suits the end users. Figure 5.5 (Asano 2002; Lazarova *et al*., 2013) shows the sequence treatment and reuse for the main categories of water reuse. Water reclamation and purification technologies exist to produce pure water of almost any quality desired, including purified water of quality equal to or higher than drinking water (IWA Lazarova *et al.,* 2013). In Malaysia, this potential supply should be closely studied with particular reference to treated effluent discharges in built-up areas in Selangor, Kuala Lumpur, Putrajaya, Johor and Penang where there is scarcity of unregulated water resources (Review of NWRS 2000-2050). The total potential augmentation from treated wastewater effluent is estimated to be about 14% of total water demand for these states as shown in Table 5.4. (Using data from Malaysian Water Industry Guide (MWIG 2012).

Similarly, if focus is given to Selangor, Kuala Lumpur and Putrajaya, the total potential augmentation from treated biomass effluent is estimated to be 24.5% of total water demands as shown in Table 5.5.

Large commercial and industrial complexes are known to have their own recycling systems to meet their own requirements for non-potable water usage for washroom facilities, cleaning purposes and landscape work. In some cases, with further treatment, the water has been used for potable purposes. It is understood that the first large scale recycling system is planned for TRX (Tun Razak Exchange in Kuala Lumpur) with a capacity of 14 Mld.

► Renewable Energy (RE) Options
Due prominence is now given to usage of renewable sources

Table 5.2: Reduction in per capita consumption and water losses

YEAR 2020	
Projected Potable Water Demand (MId) For Malaysia	18,618 MId
a) Per capita demand Assuming 50% as domestic and 15% reduction in per capita demand	9,309 MId
For Peninsular Malaysia	8, 046 MId
Correspondingly reduction in per capita demand	1, 123 MId
b) Water losses Assuming 50% as domestic and 6% reduction in losses	9,309 MId
For Peninsular Malaysia	8,046 MId
and 6% reduction in losses	483 MId
TOTAL (a) + (b)	1,606 MId

Source: Demand Projection: Review of NWRS (2000-2050)

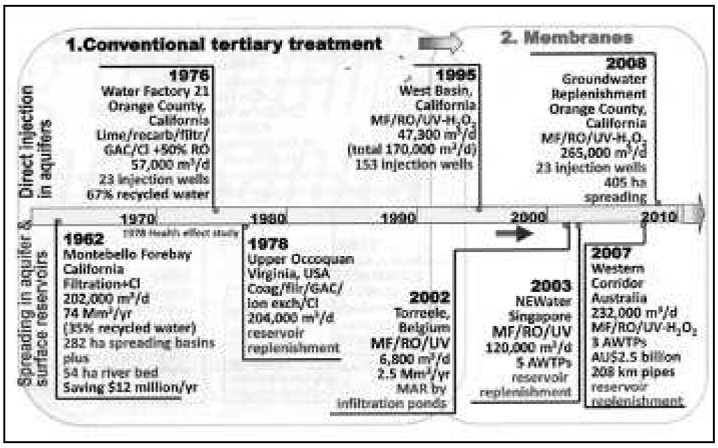
Table 5.3: Irrigation water saving through efficiency improvement

POTENTIAL WATER SAVINGS IN IRRIGATION (AN ILLUSTRATION) – THE MADA GRANARY	
A. Estimated Total Paddy Crop Water Requirement	
a) Main Season	0.011 MCM/ha
b) Off-Season	0.013 MCM/ha
c) Total Annual	0.024 MCM/ha
B. Total MADA Granary Area	96,558 ha
C. Total Annual Crop Water Requirement (A(c) x B)	2,317 MCM
D. Sources of Water	
a) Rainfall (52% x C)	1,205 MCM/yr
b) Non-Rainfall (48% x C)	1,112 MCM/yr
E. Irrigation Supply	
a) Present Irrigation Efficiency	70%
b) Thus Irrigation Supply (D(b)/E(a))	1,588 MCM/yr
F. Potential Savings	
a) Increasing Irrigation Efficiency to	75%
b) Irrigation Supply (D(b)/F(a))	1,483 MCM/yr
c) Irrigation Supply Savings (E(b)-F(b))	105 MCM/yr

Table 5.4: Potential for water supply augmentation by recycling of wastewater in Selangor, Putrajaya, Kuala Lumpur, Johor and Penang

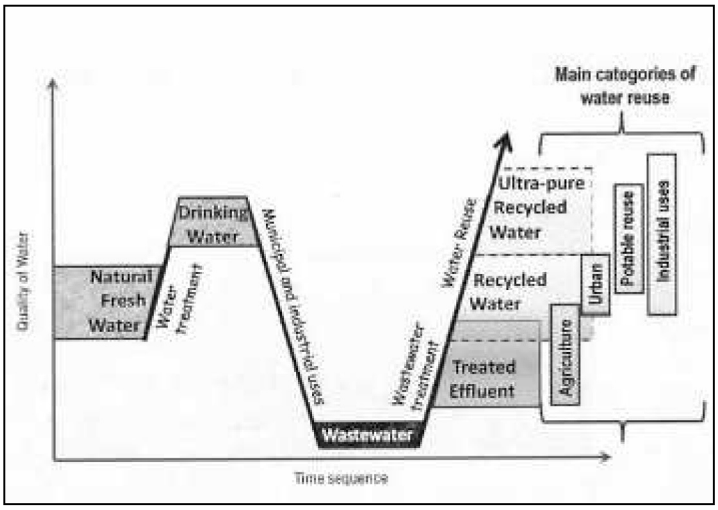
2020	
Total estimated effluent from Regional Plants (2011)	1151 Mld
Total potable water demand in the region	8046 Mld
Percentage of water recycled	14%

Source: Potable water demand – Review of NWRS (2000-2050Treated Effluent – MWIG 2012



Source: International Water Association (IWA) Water 21 August 2013

Figure 5.4: Milestones in indirect potable water reuse with selected connected projects



Source: International Water Association (IWA) Water 21 – August 2013

Figure 5.5

Table 5.5: Potential for water supply augmentation by recycling of wastewater in Selangor, KL and Putrajaya

YEAR 2020	
Total estimated potable water demand for Selangor, KL and Putrajaya	4896 Mld
Total estimated effluent water available for recycling (source IWK estimated)	1200 Mld
Percentage of water recycled	24.5%

Source: Potable water demand – Review of NWRS (2000-2050Treated Effluent – MWIG 2012

of energy (RE). In the Five-Fuel Diversification Policy (2001), RE is incorporated as the fifth fuel, the other four being oil, hydro, gas and coal (Malaysia Energy Outlook 2010-2030, EPU.).

Under the Renewable Energy Act 2011, there are only four technologies applicable for Feed-in Tariff (FiT) portfolio, which are biomass, biogas, solar photovoltaic and small hydro. It is reported that the Sustainable Energy Development Authority Malaysia (Seda) is considering the inclusion of wind as another renewable resource in the RE Scheme. Seda together with Energy, Green Technology and Water Ministry is on a mission to increase RE sources, which will not only address carbon reduction, but can indirectly assist in providing alternative options to building dams.

Energy provided by RE is green and clean and with strong Government participation the mission will receive encouraging public support. The scheme is in the early stages of development in Malaysia. Electricity generation RE by Public Licences by region in 2011 is as shown in Table 5.6.

► The River Revitalisation Program

The Four River Restoration Project to restore the four major rivers in South Korea is one of the most recent schemes implemented to provide water security, flood control, ecosystem vitablity and small-scale hydropower.

The project sets on exemplary case of strong determination and accomplishment in recent time in this part of the world to resolve deficiencies in drinking water and water for industrial and agricultural uses. The Korean Government spends US$18.3 billion over 3 years (2009-2012) on the project. The project also improves the water quality of the rivers to an average of grade 2. The project scopes and effects are seen on Table 5. 7.

In Malaysia, the Klang River Rehabilitation Programme is currently on-going. Perhaps the whole stretch of the river would be rehabilitated or "cleaned-up" in the future to resolve deficiencies in domestic and industrial water and also for environment and renewable benefits.

Summary of Conclusions

It is apparent that there is a future in the provision of RE and the implementation of green technology as both are strongly supported by the Government and with public-sector participation. In both cases, intensive efforts are being undertaken to provide alternative options to production of energy via RE and reduction and saving in usage of electricity by application of green technology.

There is as yet to be an effective effort in all-round reduction in water usage and consumption in the Water Industry and production of additional water sources, like recycling of biomass effluent and rehabilitation of rivers to a scale which constitutes a sizeable figure in water use and consumption.

Any remarkable success in these areas will no doubt influence decisions on dam building of the future.

6.0 CONCLUDING THOUGHTS

On balance, there is still good ground to justify more dam construction in Malaysia but this must be preceded by in-depth study and detailed planning at least five to ten years or even more before any project is started with most issues of concern scrutinized and agreed to everybody's satisfaction and adverse impacts reduced to absolute minimum. It is important, therefore, that an Integrated River Basin Management Plan (IRBM) be completed before implementation of large structures, like dams.

Dams should be made more attractive to the people and people must be seen to benefit from large projects like dams. Dams should not only be seen as benefiting from industry's point of view but should also address rights of the people especially those affected by land acquisition and resettlement. This can be achieved by following an internationally respected standard for

Table 5.6: Electricity Generation (RE) by Public Licences in 2011

Region	Type of Prime Mover	Installed Capacity (MW)	Unit Generated (MWh)
Peninsular Malaysia	Land Fill Gas	2.00	5,613
	Mini Hydro	45.98	38,780
	Solar	0.80	666
	Palm Oil Mill Effluent (POME)	2.00	2,030
	Subtotal	48.78	47,089
Sabah	Palm Shell & Empty Fruit Bunch (EFB)	35.20	165,425
	Wood Waste	10.00	4
	Mini Hydro	17.34	47,841
	Palm Oil Waste	14.00	69,483
	Subtotal	76.54	282,753
Sarawak	Mini Hydro	6.00	7,021
	Solar	0.02	15
	Subtotal	6.02	7,036
Grand Total		131.3	336,879

Source: National Energy Balance 2011- Suruhanjaya Tenaga

Table 5.7: The Four-River Restoration Project, South Korea

Project Scope & Effects			Unit Generated (MWh)
Flood Control	Dregging: 450 million m^3 Detentions: 5 places Reinforcing dilapidated leeves: 784km	→	Lowering flood water levels (2-4m)
Water Security	Movable weirs: 16 Dams: 2 Elevating agricultural reservoir banks: 96	→	Secure 1.3 billion m^3 of water
Water Quality Improvement	Sewage treatment facilities: 1,281 Total-phosphorus treatment facilities: 233	→	Swimmable water 76% → 86%
Ecological Restoration	Ecological wetlands: 118 million m^2 Fish-ways: 33 sites	→	Improve natural ecology & promote eco-tourism
Waterfront Development	Bicycle paths: 1,757km Tourist attraction sites: 36	→	Better quality of life

Source: The River Revitalization of Korea

dam design, building and operation, such as the Hydropower Sustainability Assessment Framework as described in section 4.

Dams need not be the only solution in preparing for the future in water security but it is a good option when viewed in terms of risks involved in future global climate change impacts which is uncertain. What is certain are the observed, abnormal climate-related events in recent years of increased variability of rainfall resulting in historic floods and droughts in many places around the world.

What should a responsible and pro-active government do to prepare for water resource investment of the future to avoid water security risks and where could dams play any useful role? This is a very important and vital area where there need to be close cooperation between states and between states and the national government with coordination provided by a mechanism at the highest federal level.

Addressing The Need For Future Dams

Developing countries, like Malaysia, may still need to build large dams for development in the future (possibly up to 2050) for the following reasons:

First:

The uncertainty in 'human-induced' climate change situation and consequently extreme climatic conditions may render river flows in many parts of the country to be unstable and unreliable at unpredictable time for irrigated agriculture, domestic and industrial supplies.

Second:

Demand for electrical energy is large and it appears unlikely that RE can be substantially produced in the future to replace oil, gas and coal. Nuclear Power is an option which has yet to be accepted for use.

Third:

Paddy irrigation in granary areas needs a large volume of water and, at the moment, supply from river sources can be unstable throughout the year, except regulated by strategic reserves in dams like the MADA Scheme. Furthermore, with increase in energy cost, pumped paddy irrigation scheme, like the Kemubu Agricultural Development Authority (KADA) Scheme, will be expensive to maintain and operate.

Fourth:

Hydroelectric scheme is expected to be promoted because it is RE, source of clean energy and green.

Fifth:

As the country transforms into a developed nation, the water management approach will also have to transform in tandem. This is the change from Supply-side Management to meet the basic needs of a developing country, to that of Water Demand Management, a characteristic of a developed Nation that makes best use of available infrastructure and water. However, it will still take sometime to achieve a mature and stable environment to complete that transformation and achieving high levels of water security is a critical element in this process. Thus for now, the prudent strategy would be to continue planning for dams as a component of total water resources management plan for the future.

Sixth:

Recovery of additional source of water for use as industrial water or other non-potable uses can be substantial from recycling of treated biomass effluent. For developed areas in Selangor, Kuala Lumpur and Putrajaya, for example, there is potential to make use of this facility up to 25% of their total water demand in 2020. The volume is substantial and is likely to increase in the future and, therefore, is also worth implementing for economic reason. However, the will to proceed appears, so far, to be not so forthcoming.

Seventh:

Unless there is firm commitment by the Government to invest on rehabilitation and cleaning the large bodies of water, like rivers and lakes, to enable large extra volumes of water to the available for use, strategic storage in dams remains a solution for security of supply.

Eights:

The Water Industry needs strong leadership at the highest national level in Water Resources Management to ensure integrated management at Federal and State levels. Among the objectives is to possibly change the lifestyle of the people: use less water, reduce wastage and cut down on losses – a necessary feature of a developed country status. Unless this is achieved, the fundamental demand of services the dam provides will not be reduced.

Finally, with the increase of freshwater scarcity and energy cost, the strong links between water and energy are becoming increasingly obvious. The 'Water-Energy-Nexus' has become an increasingly important concept in recent times; it recognizes that energy and water are intrinsically linked and should be considered together as opposed to independently. Energy drives every element of the water cycle, while water is necessary for energy production. The effects of climate change and global warming reinforce the need for a holistic approach to the management of energy and water into an integrated system.

This holistic approach has not effectively taken place, at the moment, in Malaysia. While a lot of focus has been given to energy with the creation of government agencies SEDA (for RE) and GreenTech Malaysia (for green technology/climate change) nothing much has been done for water. It is timely, therefore, that a national mechanism be set up at the highest level to assist and coordinate water bodies at federal and state levels in all-round reduction in water usage and consumption and production of additional water sources, like recycling of biomass effluent and rehabilitation of rivers to a scale which constitutes a sizeable figure in water use and consumption. At the same time, this national mechanism could assist in setting up a "Government Commission on Dams" for enforcement of dam safety in Malaysia.

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