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# Natural Resource Management and Environmental Security in Southeast Asia: Case Study of Clean Water Supplies in Singapore

**Kog Yue Choong**

**Institute of Defence and Strategic Studies**
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***With Compliments***

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## ABSTRACT

The concept of environmental security in Southeast Asia has assumed greater urgency in recent years. The Southeast Asian environmental crisis has long been a matter of concern at the regional level-- long before the onset of economic crisis. Decades of rapid industrialisation and urbanisation without effective environmental management programmes have led to environmental degradation. Most countries have been grappling to clean up their major rivers, despoiled by industries and households using them as waste dumps in the absence of adequate infrastructure to treat wastes and dispose of them. On a bilateral basis, the question of trade or the sharing of resources such as water is a potential source of tension between countries such as Malaysia, Singapore and potentially, Indonesia. Since Singapore buys water from only one Malaysian State it has long been a source of irritation for the Malaysian people and its political leadership. If Southeast Asia is now part of a globalising world, the ownership and management of natural resources remain strictly a national concern. Environmental studies have highlighted however, that with globalisation, cities and affluent countries have ecological footprints, which are many times the sizes of the territories that they occupy. The need for trade and for sharing resources among nation-states in the region will grow over time. With diminishing supplies of such resources and contestation over them for even domestic needs, tensions are likely to grow not only within countries but also at the regional level. Unless the region as a whole adopts and effectively enforces common environmental standards, the problem could emerge as a potential source of conflict. The paper proposes to consider regional efforts which have been made to reach a common understanding about the management of natural resources and the setting of environmental standards. Environmental problems can threaten a nation's security and economy -- not only at national but regional levels as well. This paper intends to issues of clean water supplies.


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Professor Kog Yue Choong is the President of East West Engineering Consultants, Deputy Chairman of the Council of the National University of Singapore, and a member of the Design Advisory Committee of the Urban Redevelopment Authority, Singapore. His firm has undertaken various development projects in Singapore, Myanmar, Maldives, China and Vietnam and winning prestigious awards such as the Architectural Heritage Award from the Urban Redevelopment Authority, Singapore and the "Tourism for Tomorrow" Award for Environmental Conservation from British Airways. He has been a guest speaker in conferences and a judge in various competitions.

# NATURAL RESOURCE MANAGEMENT AND ENVIRONMENTAL SECURITY IN SOUTHEAST ASIA: A CASE STUDY OF CLEAN WATER SUPPLIES TO SINGAPORE

## Introduction

The Southeast Asian environmental crisis was of concern long before the onset of Asian economic crisis. Decades of rapid industrialisation and urbanisation without effective environmental management programmes led to environmental degradation only partially reflected in the deforestation and flood problems which have beset Southeast Asian countries. Air and water quality standards have deteriorated. Most countries have been grappling with problems cleaning up their major rivers which have been despoiled by industries and households using them as waste dumps in the absence of adequate infrastructure to properly treat and dispose of waste.

Transboundary pollution caused by forest fires in Indonesia has been one source of irritation to her neighbours in the region. This has been highlighted by the fact that pollution has been a main cause of the downturn in the region's tourism industry. This pollution problem joins traditional environmental concerns shared by countries in the region such as marine pollution arising from the growth of sea traffic along shared sea lanes such as the Straits of Malacca.

Even though Southeast Asia is now a major player in the global economy, the ownership and management of natural resources remains strictly a national concern. Environmental studies have shown that cities and affluent countries have ecological footprints which are many times the size of the territories that they occupy. It would require resources from an area many times the size of Singapore to produce the food, water, energy and other resources needed to sustain its people and economy.

On a bilateral basis, the question of trade or the sharing of resources such as water is a source of tension between countries such as Malaysia and Singapore and potentially, Indonesia. The need for trade and for the sharing of resources among nation-states in the region will grow rather than decrease over time. With diminishing supplies of such resources and contestation over them for even domestic needs, tensions are likely to grow not only within countries but also

at the regional level. The securing of sufficient water supplies for Singapore to run its economy and for domestic use has been a source of irritation for the Malaysian people and its political leadership since Singapore buys water from one Malaysian state. Given rising needs and the inadequacy of the authorities in meeting such needs in Malaysia, Singapore is likely to be the target of growing resentment among Malaysians. This will be accentuated by the growing awareness of income differences between Malaysia and Singapore. Things usually come to a head when bilateral relations are going through a bad patch or when domestic problems in Malaysia arise from water shortages and rationing during periodic droughts.

Great differences exist among national incomes in the region. This can sometimes lead to circumstances in which pollutive industries move from richer to poorer countries because of their different environmental standards. Fortunately, the problem has not been serious, judging by evidence from studies that have been done. However, there have been incidents which suggest that unless the region as a whole adopts and effectively enforces common environmental standards, the likelihood of the problem emerging as a potential source of conflict and tension will remain.

This paper proposes to consider cases of shared natural resources and other environmental issues in the region which have and potentially will pose threats to regional security. A major area for study will be water supplies to Singapore. These supplies will have to be considered in the context of the rapidity of pollution of sources as well as the inadequacy of infrastructure to provide for the needs of the population for clean drinking water in many of the countries of Southeast Asia.

## Impending Water Shortages

Water literally gives life not only to organisms but to economies as well. The health of humans and ecosystems depend on water, as does the production of goods and services. Because water is critical to human survival, the fate of nations often depends on a particular country's access to water. The World Bank has estimated that one billion people have poor access to clean water and the number will rise to 2.5 billion, about one person in three, by the year 2025 unless governments begin spending more on their water supply systems.

It has been estimated that supplying water to people and companies is a $700 billion a year industry. That is 40% of the size of the oil sector and one third larger than the global pharmaceutical sector (Tully 2000). About 97% of the world's water is sea water, 2% is locked up in the polar ice caps and underground reservoirs and the remaining 1% is fresh water available for human use. Mankind already uses more than half of this amount and is projected by 2025 to need three times the amount of fresh water that is currently available. As a comparison, from 1940 to 1990, withdrawals of fresh water from rivers, lakes, reservoirs, underground aquifers and other sources increased by more than a factor of four (Shiklomanov 1993).

It has also been estimated that farming in Asia consumes more than 80 per cent of fresh water drawn from streams, rivers, reservoirs and underground lakes (WMO 1997). Irrigated rice, in particular, is a heavy consumer of water. It consumes 7,650 m3/ha as compared to wheat, which consumes only 4,000 m3/ha (Spurgeon 2000). This is partly because farmers in developing countries continue to waste water by their diffuse irrigation methods (ST 21 Aug 2000). A major fear is that water shortages will affect China's food self-sufficiency. If China is forced to turn to the global grain market to meet shortfalls in food output then world grain prices will be raised. This will in turn aggravate social and political instability in many Third World countries.

In addition, there are also problems concerning mismanagement of the water resources such as reports which state that unaccounted for water in the Selangor and in the Federal Territory is as high as 35% (ST 19 Aug 2000) and about 50% in Buenos Aires before privatisation (Tully 2000). The results have been increased pressure on fresh water resources in most regions of the world and a lack of adequate supplies in some localities.

In Asia where water has always been regarded as an abundant resource, per capita availability declined by 40-60% between 1955 and 1990 (Spurgeon 2000). The looming water crisis is the most severe environmental problem in many parts of Asia today. Asia has the lowest per capita availability of freshwater in the world, with Central and parts of Southeast Asia already well above the threshold of "high water-stress" conditions, which occurs when the ratio of use to availability exceed 40%. Indeed, some countries in Central Asia are already using 90% of their available freshwater resources. In South Asia, the use of available freshwater resources will soon reach 50%, while in northern portions of China and Mongolia, they have reached 25%. Many other parts of Asia will suffer the same fate during the next 25 years. China and India, which will

have populations of 1.5 and 1.4 billion respectively by 2025, will encounter serious water shortages within the first quarter of the new century. Currently, it is estimated that Asian industry swallows some ten percent of the region's fresh water (WMO 1997). Consequently, acute water shortage will limit economic growth and industrial expansion (ADB 2000).

The supply of fresh water in a region is limited by the dynamics of the hydrological cycle. This means that the renewable supply is an important constraint to the sustainable use of water within a particular region. Apart from human use, water is also needed to sustain natural ecosystems found in wetlands, rivers, and the coastal waters into which they flow. Pumping water from underground aquifers faster than they can be recharged or diverting so much water from wetlands or rivers that freshwater ecosystems fail are clearly unsustainable practices. Despite this, examples of unsustainable water use can be found in virtually every region. For example, the depletion of aquifers in parts of the Middle East, India and Southeast Asia. Other examples are the diversion of river water from the dying Aral Sea in Kazakhstan and Uzbekistan. Excessive withdrawals are causing intrusions of sea water into deltas and coastal aquifers in China and Vietnam, as well as the uncontrolled flow of sewage and fertiliser runoff is hastening eutrophication in some temperate and tropical lakes and many coastal seas. In Thailand, the rapid lowering of the water table due to excessive extraction of ground water has caused the shallow aquifers in Bangkok to become contaminated with sea water. The over withdrawal of ground water reserves has also caused land subsidence in cities such as Bangkok and Jakarta. In Bangkok, for instance, land has subsided in some places by 0.5-0.6 metres over the last 20-25 years, a situation which has aggravated the city's flood problems (ESCAP 1995). In countries like Bangladesh, salinity and sedimentation are occurring largely as a result of upstream water withdrawal. In India and Pakistan, water tables are falling at rates of two to three metres a year. India is using its underground water reserves twice as fast as they are being replenished. The flow of the Ganges and other important waterways is much reduced compared with only a few years ago. Hundreds of lakes are at historically low levels. India's plight has been heightened this year by its worst summer water shortage this century, causing severe hardship for at least 50 million peasants.

When rain falls in Asia it usually arrives in torrents over a short period, usually during a single monsoon that lasts from four to six months. The rest of the year is almost dry. As a result, much of the runoff simply flows into the ocean as waste while at the same time eroding uplands, sometimes catastrophically. The monsoons, furthermore, are often erratic so that in many

countries, floods and seasonal water shortages occur concurrently. In several parts of the world, including Asia, water demands are fast approaching the limits of resources. According to the International Water Management Institute, one third of the world's population will experience severe water shortages by 2025. The warning signs are everywhere. Malaysia suffered critical water shortages which prompted water rationing for the 1.8 million people of the Klang Valley in 1998 because of drought. Satellite photographs show that the entire north of China is drying out. China's Yellow River ran dry and did not reach the sea for 226 days in 1997. The water table under much of the North China Plain, a region responsible for nearly 40% of China's grain production, had fallen by an average of nearly 1.5 metres over the last five years (Brown and Halweil 1998). The Chinese Academy of Science estimated that economic losses caused by water shortages in cities across the North China Plain ran as high as US$ 24 billion in 1997 or 3% of the GDP (FEER 2000).

Several additional factors contribute to the potential for regional water shortages by limiting the available supply. Among the most serious is water pollution from a wide variety of industrial, municipal and agricultural sources. Water has contributed most to the 'Green Revolution', which brought about the growth in rice production in Asia during the past 30 years. But this expansion has occurred at a cost to the environment. A proportion of the chemicals applied as fertiliser and as pest and weed control pollutes rivers and lakes through runoff and into groundwater from leaching.

A recent investigation by Cambodian and United Nation officials has found traces of arsenic in 9 % of drinking water samples collected in 13 of the nation's 24 provinces, prompting concerns that too much pesticide run off had entered Cambodia's drinking water during recent years (ST, 19 Aug 2000). A recent survey of more than 700 mainland rivers in China found that close to half were significantly polluted, with one in ten considered undrinkable. The culprit: industrial waste. Now, toxins such as DDT are being detected in fish and other marine life in the South China Sea (Asiaweek, 18 Aug 2000). Water pollution adds enormously to existing problems of local and regional water scarcity by removing large volumes of water from the available supply. Although there has been significant progress in controlling water pollution in many developed nations over the past three decades, pollution has continued to rise in most developing nations. This poses a threat to human health and to the health of aquatic ecosystems in these nations. One factor is the rapidly growing and industrialising cities of the developing world, where pollution control is still in its infancy and domestic sewage and industrial effluents

have left many urban rivers and groundwater sources heavily contaminated. The widening shadow of pollution around major cities has important implications for urban development, exacerbating the already difficult task of extending basic water and sanitation services to the urban poor. Much of the water in Southeast Asia is polluted because of a lack of waste water disposal, adequate sanitation and proper management of sewage. The problem of pathogenic pollution is quite severe in Southeast Asia. Pathogens generally come from domestic sewage that is discharged untreated into watercourses. 54% of the lakes in Southeast Asia are found to suffer from eutrophication problems (UNEP 1994). The region inland water bodies are also affected by the presence of pathogenic agents. Many rivers carry enhanced nutrient and pollutant loads as a result of changes in land use, industrialisation and urbanisation. Discharge of mine tailings and development of industrial areas with direct discharge of pollutants into neighbouring river systems has resulted in hot spots of heavy metal pollution throughout the region.

Another trend aggravating water shortages is global warming. 1998 was the hottest year on record with some of the most extreme weather in history. Indonesian forest fires emit more greenhouse gas than does the whole of European industry. A global panel that studies climate change predicts a 1.5 degree –3 degree Celsius rise in temperatures in the 21st century. Global warming could lead to reduced water supplies because of consequential changes to the world climate. A NASA study found that each year global warming melts Greenland ice equal to 4.5 trillion litres of water, as well as contributing to a 23 cm rise in sea level over the last century (ST 24 Jul 2000). Scientists have predicted that within 50 years the ice cap stretching from the North Pole will disappear every summer. As it stands, the coverage of the Arctic sea ice has already declined by 6% since 1978, and the average thickness of the remaining ice sheet has declined from 3.1 m in the 1950s to 1.8 m today, a loss of 42% (ST, 24 Jul 2000). The thick ice that has for ages covered the Arctic Ocean at the pole has turned to water and an ice free patch of ocean about two kms wide has opened at the very top of the world. From Spitsbergen, Norway to the Pole, there were miles of unusually thin ice and intermittent open water (Sunday Times, 20 Aug 2000). Subsequent examination of satellite images revealed a body of water about 15 km long and five km wide near the pole. The remaining ice was also badly fractured. It is known that the average Arctic temperature in winter has risen by about six degrees C over the last 30 years and Northern Hemisphere sea ice has been melting at a rate of about 15% per decade (ST, 1 Sep 2000). The evidence of global warning is everywhere and its implications extremely worrisome. There are fears that some of the current fresh water supplies such as lakes and reservoirs will be

submerged by rising sea water levels. This will in turn reduce the fresh water supply available for human use.

According to most paleoclimatologists, the last 140 years was one of the most anomalously wet periods in the last 4000 years (Davis 2000). If this is true, then less rainfall and more frequent droughts can be expected once the anomalously wet period ends and the world's fresh water supply situation turns very bleak.

Many believe that water promises to be to the 21st century what oil was to the 20th century: the one precious commodity that determines the wealth of nations. As a result, water will replace oil in the 21st century as the major source of geopolitical tension. Some also believe that the way a country handles its water problems could determine the difference between greatness and decline. Those nations that keep their waterworks in superb working order and still operate them at the lowest cost will have a competitive edge (Tully 2000).

**Fresh Water Supplies as a Regional and National Security Issue**

Water scarcity is not only the single greatest threat to human health; the environment and the global food supply--it may spark violent conflicts within Asia and in other regions as well. Communities upstream of river basins and those downstream often find themselves in collision. Where scarcities loom, cities and farms are beginning to compete for available water. This will intensify the countless skirmishes already happening periodically. In China, for example, there were recent clashes in Henan province where hundreds of villages were involved in fighting over control of disputed water catchment area (ST 21 Aug 2000). Recently, northern China experienced the worst drought in decades (ST 2000). This drought dried up rivers and drained reservoirs, forcing more than 100 cities in northern China to implement strict water rationing. The drought sparked social unrest as farmers protested against water rationing. In some villages, farmers rioted over rationed supplies and higher prices. Thousands of villagers in Shandong clashed with police after officials cut off the water they had used for irrigating drought-plagued fields. More than 100 people were hurt and a police officer was killed during mayhem in Anqiu village. The conflict started when government engineers were mobilised to block streams leaking water from the nearby Mushan reservoir. Fights broke out after 300 police were dispatched to quell the protests of 5,000 villagers.

There are many examples illustrating the importance of water supplies to the regional security in various parts of the world. The bulk of the water supply for Israel, Jordan, Lebanon and Syria comes from the River Jordan and the River Yarmuk. In the 1967 Middle East War, Israel occupied the Golan Heights, enabling them to control the Jordan River and its watershed, pre-empting Syrian and Jordanian plans to cut off the water supply to Israel. Israel has had to secure a reliable water supply since ancient times by elaborate projects, such as King Hezekiah's secret tunnel to the pool of Siloam in Jerusalem, to ensure that the city could survive while it was under siege (Keller 1980). Currently, Israel depends on the West Bank for 25% of its supplies (Engelman and LeRoy 1993). As far as the Israelis are concerned, the return of the West Bank in any peace settlement in the Middle East is closely related to the resolution of the water rights of the River Jordan and the use of groundwater from aquifers for the water supply to Israel. In every Middle East War during the past 40-50 years, both sides always pursued the destruction of the water supply system and the fresh water sources of their opponent as one of the important strategic targets. Therefore, water resources are not only vital for the livelihood of the people but are also crucial for national security in the Middle East. Countries in the Middle East have always regarded water resources as a military strategic resource. Many believe that if the water issues of the Middle East are not resolved satisfactorily after the resolution of all other issues, then the region will remain explosive (Riyah 1985, Schmida 1985).

Egypt, Ethiopia and Sudan are among the ten most water-stressed countries in the world. They are some of the countries which the River Nile flows through, making it the major water supply for these countries. Ethiopia and Sudan were the first two countries to confront Egypt on the use of water in the River Nile. In 1991, Egypt objected strongly to the agreement between Sudan and Ethiopia to extract water from the River Nile to meet their water needs, fearing that it would adversely affect the downstream flow into Egypt. Because of the Egyptian objection, as well as other technical and internal political reasons, the plan was not implemented. Nevertheless, with the rapid population growth and the increasing water demand for agriculture, the risk for conflict, including military clashes, among countries affected will be greater.

India and Bangladesh are squabbling over water rights to the Ganges. Even though Bangladesh gained independence from Pakistan in 1971, it was only in 1996 that India and Bangladesh signed a 30-year agreement on the allocation of the water resource of the Ganges. There are 114 Indian cities located upstream discharging untreated sewage into the Ganges and as a result, adversely affecting the water quality downstream in Bangladesh. Of course

Bangladesh is extremely concerned and this is another of the many unresolved issues between them. The possibility of conflict between India and Bangladesh because of the disagreement on the various problems related to the use of the water resource of the Ganges still exists.

Pakistan's main water supply is from the River Indus, River Sutlej, River Ravi, River Chenab and River Jhelum, which all originate in Kashmir. For many years Pakistan has objected to the Indian plan of building dams upstream, fearing that the downstream flow will be drastically reduced as is the case with the Ganges. Consequently, India's dam building plan has remained an important issue to be resolved diplomatically between the two countries. If this issue is not resolved satisfactorily between them, then it will certainly add more fuel to the already strained relationship between the two countries.

From the preceding discussions, it is apparent that in most countries, the water supply is linked to the supply of food, which in turn is largely dependent on irrigation rather than rain. Therefore, water supply is important for food security, especially so in the future because of population and economic growth, pollution and global warming. However, Singapore with only 1% of its total area under agriculture (Singapore 1999) is an exception as the bulk of its food demands are met by imports from neighbouring countries and elsewhere. Nevertheless, water supply is a crucial aspect of Singapore's national security, and is included as part of Singapore's civil defence strategy. The fact that the lack of water was a key factor which hastened the fall of Singapore to the Japanese serves as a painful reminder of how crucial water supply is to the security of the city-state. When the British blew up the causeway in anticipation of an invasion from the north, they inevitably severed the water mains from Johor as well (Simson 1970). Water supply will continue to be a crucial aspect of Singapore's national security in the future, not only militarily but also economically. Even though the Malaysian government guaranteed Singapore's water supply in a Separation Agreement deposited in the United Nations, the Singapore Armed Forces will move into Johor, forcibly if need be, to restore water supply to Singapore if the guarantee is breached (Lee 2000).

Johor now depends largely on a supply of treated water from Singapore. This is the result of the Water Agreements between Singapore and Malaysia in which Johor sells raw water to Singapore at three cents per 1,000 gallons and buys treated water back for 50 cents per 1000 gallons. Obviously, this arrangement is not acceptable to Malaysia, judging from the recent Malaysian Cabinet's decision approving $318 million for the construction of a water treatment

plant in Johor. In one year when the plant is completed, Johor will have its own water supply (ST 19 Aug 2000). Singapore has depended on Johor to meet her water needs for the last 68 years and is likely to be dependent on Malaysia for future increased water demands. It must be recognised that demand for water within Malaysia is also increasing because of population and economic growth. For example, in Selangor and the Federal Territory, water consumption is expected to increase to 3,500 million litres a day in 2003, 4,000 million litres a day in 2010 and 5,000 million litres a day in 2020 (ST 19 Aug 2000). At the same time, pollution, mismanagement and urbanisation have reduced the usable water resources in Malaysia. What are the security implications for Singapore as it continues this reliance on Malaysia for an important part of her water supply? Will the control of water give Singapore's neighbours a certain power over Singapore and leave the smaller country in a weaker position in any deal or conflict? This can be best understood by a review of the water supply and demand in Singapore, especially on how Singapore has managed her limited water resources and the growth of the water demand. And finally, how Singapore plans to meet her future demands for water.

## Review of Singapore Water Supply and Demand

Between 1963 and 1999 the population of Singapore increased from 1.8 million to 3.9 million. In the same period, per capita consumption more than doubled from 154 litres per person per day to 327 litres per person per day. Consequently, water consumption increased 4.7 times from 273,912 m3 per day to 1,276,000 m3 per day. Clearly the increase in water consumption in the past 36 years has out-paced population growth. Factors such as the larger economy and higher standards of living have influenced the increase in Singapore's water consumption. Table 1 shows the water sales for the period 1960 to 1999. Roughly, sale of water to homes makes up about half of all water consumed and water for industrial and commercial use makes up most of the remaining water sold.

Table 1 Water consumption in Singapore, 1960-1999
(in thousand $m^3$)

| Year | Domestic | Shipping | Commerce/ industry | Government | Total annual consumption |
|---|---|---|---|---|---|
| 1960 | 40,786.9 | n.a. | 21,697.6 | 36,997.2 | 99,481.7 |
| 1970 | 71,024.0 | 2,276.9 | 35,718.3 | 43,923.6 | 152,942.8 |
| 1980 | 113,478.0 | 3,347.0 | 75,991.3 | 23,750.0 | 216,566.3 |
| 1990 | 177,343.3 | 2,914.4 | 113,148.6 | 29,391.8 | 322,798.1 |
| 1999 | 234,638.4 | 1,997.2 | 175,345.6 | 27,701.1 | 439,682.3 |

Source: Department of Statistics (Singapore)

According to Postel (1993), countries with less than 1,000 m3 per person per year of water resources can be considered 'water stressed', in other words with insufficient resources to meet their needs. Such water stress indexes must be interpreted cautiously. They do not necessarily imply a future shortage of available water, since that depends on actual usage patterns and on the efficiency with which water is used and even reused. Burundi, for example, is potentially a water-stressed country according to the water stress index, but it uses little water for irrigation at present and so has abundant supplies for other purposes. Moreover, efficient management and modern technology can stretch even scarce water supplies much further. Israel, for example, supports its population, its growing industrial base, and intensive irrigation with less than 500 m3 per person per year (Engelman and LeRoy 1993). Table 2 shows the water resources of each of the ASEAN countries. Though comparatively well endowed with water resources, only a part of the renewable water resources can be extracted and used, owing to the high variability of stream flow between low water and flood seasons, the inaccessibility of some watercourses, and the lack of storage sites on many catchments (ESCAP 1995). Using this criterion, Singapore ranks alongside the Middle Eastern countries to be among the worst eight in Asia and the only country in ASEAN considered water stressed due to insufficient resources. The government commissioned a study of the use of groundwater in the late 1940s. White (1952) reported that there was a potential supply of three million gallon per day (13,600 m3 per day) from wells in the Bedok Valley. However, subsequent studies by the Public Utilities Board (PUB) found that the yield of groundwater from the Old Alluvium in the Bedok Valley is very limited (Chou 1972). Therefore it has been recognised that it is not possible for Singapore to be self sufficient in water supply competitively and that Singapore has to depend on Johor, one of the states in West Malaysia nearest to Singapore, for substantial share of her water needs.

Table 2 Water resources of Asean countries

| Country | Annual Internal Renewable Resources ($km^3$) | Annual Withdrawals ($km^3$) | Annual Per Capita Internal Renewable Water Resources $m^3$ | Annual Withdrawals As Percentage of Water Resources | Annual Per Capita Ground-water Withdrawal $m^3$ | 1999 GNP Per Capita (US$) | Population (millions) |
|---|---|---|---|---|---|---|---|
| Cambodia | 88.10 | 0.52 | 8,195 | 1 | - | 300 | 11.0 |
| Indonesia | 2,530.00 | 16.59 | 12,251 | 1 | - | 1,110 | 209.4 |
| Laos | 270.00 | 0.99 | 50,392 | 0 | - | 400 | 5.4 |
| Malaysia | 456.00 | 9.42 | 21,259 | 2 | - | 4,530 | 23.0 |
| Myanmar | 1,082.00 | 3.96 | 22,719 | 0 | - | - | 48.9 |
| Philippines | 323.00 | 29.50 | 4,476 | 9 | 82.8 | 1,200 | 75.8 |
| Singapore | 0.60 | 0.19 | 172 | 32 | - | 32,810 | 3.9 |
| Thailand | 110.00 | 31.90 | 1,845 | 29 | 15.0 | 2,740 | 62.6 |
| Vietnam | 376.00 | 28.90 | 4,827 | 8 | - | 310 | 80.3 |

Source: World Resources Institute 1998; The Little Data Book, World Bank 1999, Asiaweek 2000

Singapore recognised the importance of managing water demands very early and has encouraged its population to reduce their water consumption by various measures. These measures can be classified as: (1) education/persuasion; (2) fiscal incentives and (3) legislative and administrative control. Since 1962, the PUB has periodically organised national campaigns to save water. Correct pricing of water has been touted as the best policy to ensure its proper use. Current pricing levels in most countries are far too low to cut down on wastage (ADB 2000, Winpenny 1994). On the other hand, if prices of water are raised too much, there may be protests and even riots. For instance, Cochabamba, Bolivia's third largest city, decided to raise water rates to pay for an improvement project after privatisation. Waves of protesters attacked soldiers and blocked roads and the city was forced to cancel the project (Tully, 2000). Moreover, too high a water rate may undermine Singapore's competitiveness in attracting wafer plants which require large quantities of water. Since 1973, the PUB has utilised a stepped tariff system for domestic users of water (Wong, 1993). The non- domestic users are charged a flat rate so as not to discriminate against industries that naturally consume more water (Hansard, 12 May 1991). The Economic Expansion Incentives Act (Chap. 86) was amended in 1984 to allow for a 50 per cent investment allowance for industrial consumer to undertake projects which reduce the consumption of potable water. In 1991, a water conservation tax was levied on water consumption over 20 m3 for domestic users and at a flat rate for non-domestic consumers. The tax rates were subsequently raised in the following years. Since June 1997, the government announced that water tariffs and the conservation tax would be restructured and raised over four annual increments until 1 July 2000 so that all households pay the same rate for water as non-domestic consumers, other than shipping (ST, 27 Feb 1999). The Public Utilities (Water Supply) Regulations under the Public Utilities Act and the code of practice for water services allow the PUB to ensure that the water supply systems in operation are of high quality and that leakage of the systems is minimised. They also enable the PUB to require mandatory water conservation measures to be implemented. Despite the implementation of all these measures, Singapore's consumption of water continued to grow at a rate faster than its population growth rate. Nevertheless, the water demand would certainly be much higher if not for the implementation of these measures.

When Raffles landed in Singapore in 1819, water from inland streams and wells was sufficient to maintain the 150 or so inhabitants on the island. As Singapore grew as a port of call, there was an urgent need for water to be supplied to ships which called at Singapore. A small

reservoir was constructed on Fort Canning by 1822 to supply water to ships. The population in 1850 had grown to over 50,000, creating a desperate need. A donation of $13,000 by philanthropist Tan Kim Seng, in 1857, heralded the start of Singapore's piped water supply. Work then began on the construction of an earth dam to impound water at the MacRitchie Reservoir, then known as the Thomson Road Reservoir. Municipal water supplies in Singapore began in 1867 with the completion of the construction of the embankment. Between 1874 and 1878, two pumping stations were built at MacKenzie Road and Mount Emily to improve water pressure and ensure a continued water supply to the city. The MacRitchie dam was enlarged between 1890 and 1894 and again at the turn of the century, moving the dam to its present location and raising it by 1.5 metres. Water was still in short supply with dry spells occurring in 1877, 1885 and 1895. Pearl's Hill Service Reservoir was built between 1903 and 1905, and the Lower Pierce Reservoir was completed by 1912. During World War I, investigations began into new water sources and works on Seletar Reservoir began after the war.

Meanwhile the population had risen to more than 400,000 by 1920 and the colonial authorities began looking towards Johor as a possible source of water. The Gunong Pulai Scheme was eventually selected and an agreement was signed in 1924 with the Sultan of Johor for the use of this water. The Gunong Pulai and Pontian Reservoirs and treatment works at Gunong Pulai were operational by 1932, and steel pipes were laid to carry the water to the Pearl's Hill Service Reservoir. In 1926, a steam pumping station was built to turn the Woodleigh installation into a pumping system. And by 1928, the Fort Canning Reservoir was in operation. Between 1937 and 1941, Gunong Pulai's treatment capacity was doubled. A second pipeline was laid to Johor Bahru. A subsidiary reservoir, Pulai I, feeding Pontian Reservoir was also completed. Seletar Reservoir was enlarged in 1940 and a pumping station was built there to transfer raw water from this reservoir to the Pierce Reservoir.

The water supply system fell into disrepair during the Japanese occupation in World War II (1942-1945). As the population grew, there was a need to find new sources of water. The state of emergency between 1948-1960 also made it difficult to maintain the system because Gunong Pulai and Pontian Reservoirs were in the heart of the communist territory (Water Department Annual Report 1956). Plans to develop the Johor River Scheme were interrupted by the outbreak of World War II and the Malayan Communist insurgency in Malaya. A new water supply had to be found and Tebrau River, which was in a safe area and closer to Johor Bahru, was selected.

The Sungei Tebrau Scheme, which commenced before the war, was completed in 1953 and a new 1,600 mm pipeline was laid through the causeway to Singapore.

To provide adequate storage, the Murnane Service Reservoir was completed in 1956, followed by the Jalan Eunos Service Reservoir in 1959. The droughts of September 1961 to January 1962 and April 1963 to February 1964 made Singaporeans more aware of the precarious situation of their water supply. In 1961 and 1962, agreements were made with the Johor state government for the supply of water to Singapore. These agreements are still in force. The Public Utilities Board (PUB) was constituted by the Public Utilities Ordinance in May 1963 to take over the responsibility of providing water, electricity and piped gas by the former city council. The Skudai River Scheme was operational in August 1964 and the Johor River Scheme in 1967 went some way towards relieving water shortages. In 1969, Seletar Reservoir, renamed Upper Seletar Reservoir in 1992, was enlarged by more than 35 times (PUB 1997) and the Woodleigh Waterworks was expanded to cope with the increased volume of water.

Between 1983-87, Skudai and Johor River Waterworks were extended. The Skudai and Kota Tinggi waterworks were extended in 1987 and a 2,000 mm diameter submarine pipeline was laid between Johor Water Works and Singapore. The Linggui Reservoir Project commenced in 1988 and was completed in June 1993. A new Water Agreement was signed with the Johor State Government of the Linggui Dam. The agreement provides for Johor to supply Singapore with additional treated water in excess of the present entitlement of 250 million gallons of water a day from the Johor River.

Most of Singapore's water supply capacity was developed by the PUB since independence in 1965. This includes the damming of seven rivers and the creation of Southeast Asia's first storm water collection system. In 1975, the Upper Pierce Scheme was completed and water from this reservoir was treated at Chestnut Avenue Waterworks. In the same year, the Kranji/Pandan Scheme was completed and water from these two reservoirs was treated at the Choa Chu Kang Waterworks. Between 1976 and 1979, piped water was brought to Pulau Tekong with the construction of an impounding reservoir, a service reservoir, waterworks and a water supply network on the island. Works on the Western Catchments Scheme started in 1977 and was completed in 1981. It involves the damming of four rivers – Murai, Poyan, Sarimbun and Tengeh – and converting them into reservoirs. Consequently, the treatment capacity of Choa Chu Kang Waterworks was also enlarged at the same time. The last surface water source, Sungei

Seletar/Bedok Water Scheme, was completed in 1986. It involved constructing a dam across the mouth of the Sungei Seletar to form Sungei Seletar Reservoir, renamed Lower Seletar Reservoir in 1992, and converting the Bedok sand quarry site into the Bedok Reservoir and the construction of the Bedok Waterworks. It also involved constructing eight storm water collection ponds at Yishun, Tampines, Bedok and Yan Kit. Capital expenditure between 1963 and 1993 amounted to a total of S$1.9 billion (PUB Annual Reports).

In 1966, the Jurong Industrial Water treatment plant was commissioned and began to supply industrial water to Jurong. This water is reclaimed from treated sewerage effluent and while of sufficiently high quality for industrial use, is not potable. Nevertheless, this has helped to ease pressure on potable water supply in Singapore. Industrial water now represents about two percent of all water consumed in Singapore.

The pollution of Singapore's water resources was especially acute in the sixties and seventies. About half of the 110 millions gallons (500,000 m3) of water consumed each day was discharged into open drains (Chen 1973). A large number of streams were badly polluted by decayed organic matter and were considered "dead conduits" without any apparent plant or aquatic life (Johnson 1976). Since then Singapore has embarked on a comprehensive programme to clean up the rivers and to ensure that all sources of pollution are connected to the sewerage system or are treated before discharging into public water courses. This has been achieved mainly through education and campaigns, extension of the sewerage system, provision of water closets in all homes, phasing out of pig farming and by legislative and administrative control. The latter is effected through the Water Pollution Control and Drainage Act, Trade Effluent Regulations, and the various codes of practice for surface runoff and sewerage to ensure that all new developments comply with the required pollution control standards and the quality of the discharge into the water courses.

The Bedok and Lower Seletar Scheme is a good model for Singapore to develop in the remaining catchment areas. The scheme collects surface runoff from parts of north-eastern and eastern Singapore, namely the newly urbanised areas of Ang Mo Kio, Bedok, Tampines and Yishun New Towns and the area north-west of Changi International Airport. It then transfers the flow to storage reservoirs in Bedok and Lower Seletar. The unique feature, which sets this scheme apart from earlier ones, is the utilisation of untapped urban runoff from residential areas as main source of raw water. The design of the scheme required co-ordination within various

ministries and organisations including the Housing and Development Board (HDB), the Ministry of the Environment (ENV) and the Planning Department to exclude industries and pollutive land users and to create a drainage system to drain urban runoff into suitable collection points. Other measures such as the covering of drains and gutters around HDB blocks, the grading of HDB void decks to discharge into the sewage system and the implementation of various pollution control measures on construction sites were implemented so that water in these catchments would not be excessively polluted. Only runoff from larger storms is collected, as it tends to have a lower level of pollutants. This is effected through an automatic monitoring system which only collects water when the volume of the runoff is sufficiently large. Since its commissioning in 1986, the scheme has proven itself capable of delivering raw water comparable in quality to raw water obtained from upland reservoirs with a largely forested catchment (Lee and Nazarudeen 1996). Since then, newer urban stormwater pond collection stations have been implemented or are being planned in the northern and north-western parts of Singapore to replace existing stream abstraction stations affected by urbanisation arising from public housing developments. One unique facility is being built under the flyover of an expressway interchange to utilise the land space which otherwise would be of limited use. The PUB is also designing a covered type of stormwater pond at another location, the first of its kind, in order that the land above this functional type of concrete pond can be used for other purposes such as school football fields and basketball courts (Lim and Lim 1997).

Because of limited water resources and increasing water demands, the PUB reduced its unaccounted for water (UFW) by implementing various upgrading programmes and water conservation measures. As a result of their efforts, the UFW in Singapore has reduced from 10.6% in 1989 to 6.2% in 1995 (Ng et al 1997).

Singapore has now reached a point where around half its total land area is harnessed for water resources (Lim and Lim 1997). Singaporeans consume some 1.2 million m3 of water daily. Close to half, or about 680,000 m3, comes from water catchment areas, such as the island's 14 reservoirs, and storm water collection ponds in HDB new towns. The rest comes from Johor (ST 4 May 1998). The total storage capacity for reservoirs in Singapore and in Johor presently is estimated to be 142x106 m3 and 787.5x106 m3 respectively (Yap 1994). This capacity is enough for about two years supply at current levels of consumption. This means that strategically there is about two years for Singapore to work out a solution to any water supply problem should a water crisis develop. However, if for some reason the water stored in the reservoirs in Johor is

no longer available for use by Singaporeans, there is only about four months time available for Singapore to sort out the problem with the Malaysian government.

In 1987, then Prime Minister Lee Kuan Yew announced that Singapore was looking into the possibility of tapping water from Indonesia (Business Times 7-8 Oct 1989). Following this, an agreement "on economic co-operation in the framework of the development of the Riau Province" was signed on 28 Aug 1990. Under this agreement, Singapore and Indonesia agreed to co-operate on the sourcing, supply and distribution of water to Singapore". This agreement also includes co-operation over trade, tourism, investment, infra-structural and spatial development, industry, capital and banking. (Government Gazette, Treatises Supplement No.1, 1990). In 1991, a Water Agreement signed with the Indonesian Government provides for the supply of 1,000 million gallons of water a day from sources in the Province of Riau in Indonesia.

Also planned is a project to tap the water resources of the Sungei Kampar catchment in West Sumatra (ST, 30 Jan 1993). The Sungei Kampar project is described as a project to provide water to the Riau province. This suggests that water for Singapore would have its place as part of a much larger plan to build up the regional economy. The Bintan project marks the beginning of a new era in the development of new water projects. While previously the PUB has managed the construction and development of water resource projects alone, the Bintan scheme will be built and managed by PUB's subsidiary company, Singapore Utilities International (SUI). Two joint venture companies were created in 1992 for the purpose of developing a supply of water from Bintan and to supply water to Bintan and the neighbouring Riau islands (PUB Annual Report 1992). However, the pace of the progress for these developments has been very slow and it has come to a halt because of the political uncertainty in Indonesia after the financial crisis. At this point in time, there is no certainty that it will proceed in the near future because of the political situation in Indonesia.

There are several countries sharing water resources with their neighbours. This is because their rivers and ground water basins transcend national boundaries. Therefore, neighbouring countries of the water resource have a natural "right" to the resource. Such "rights" are recognised in international law and form the basis for countries to negotiate should disputes on the use of shared water resource arise. Singapore's situation is unique in that the water resources in Malaysia, and hopefully in Indonesia in the near future, are being shared with Singapore even though Singapore does not share river or ground water basins with her neighbours. While we

presently enjoy relatively friendly relationships with our ASEAN neighbours, this cannot be always guaranteed. It is desirable for Singapore to have some measure of independence regarding a resource as important as water.

Singapore could have three desalination plants by 2011 and these could produce enough to replace the water supplied under Singapore's first water agreement with Malaysia, which expires in 2011 (ST 4 May 1998). The first such plant will be operational by the year 2005 with a capacity of 136,000 m3 (30 million gallons) a day (ST 3 Jan 2000). At the same time, Singapore is also experimenting with the use of water reclaimed from treated sewerage effluent to produce potable water by erecting a S$10 millions pilot plant in the Bedok Sewage Treatment Works which will be operational in 2001.

Under the 1961 and 1962 Johor River Water Agreements, which expire in 2011 and 2061 respectively, Singapore pays RM 0.03 per 4,500 litres of raw water, while Johor buys back some of the processed water at RM 0.50 per 4,500 litres (Pereira 1998). The Singapore government claims that Singapore is subsidising Johor to the tune of RM29 million a year by selling it treated water at a reduced rate. It also noted that Johor is voluntarily buying an average of 37 million gallons of treated water per day from Singapore, more than double the amount of 15 million gallons of water that it has a right to (Sunday Times, 6 Sep 1998). Singapore officials met their counterparts in Malaysia to discuss a new 100 year water agreement after 2061. Singapore officials have requested 350 million gallons a day of raw water and 400 million gallons a day of treated water to be supplied by Johor and Pahang to meet its projected demand of 950 million gallons a day for a population of seven million 160 years from now. This request for water beyond 2061 is, however, contingent on Malaysia satisfying its own needs first. The Malaysian officials are prepared to supply Singapore the same volume of 350 million gallons a day and have asked Singapore to source for water elsewhere, perhaps Indonesia, or to build desalination plants to meet its additional water demands. This is because Malaysia cannot commit itself to a quantum in view of the uncertainty of its own situation in 150 years time. In addition, Pahang's resources are earmarked for an inter-state water transfer following the 1998 water crisis in the Klang Valley. The Malaysians have also accused Singapore of profiteering in the resale of water (Singh and Zulfakarin 1999). Malaysian officials recognise that water is an emotional issue for both countries. What makes water a particularly emotive issue among the Malaysian states is that some states suffer from chronic water shortages while others enjoy water surpluses. In March 1990, water rationing was imposed in the northern regions of Johor while water flowed from

reservoirs in Johor managed by the PUB to Singapore. Critics have pointed out that this implies that the Johor government seemed to put Singaporean needs before those of the state (ST 10 April 1990). Malacca faced a water crisis in 1991 with water rationing being imposed throughout the state. Malaysians living in Malacca were incensed that while they had to endure the inconvenience of water rationing, water continued to flow across to Singapore. Eventually, a National Water Council was set up to allow for sharing of water resources between various states (ST, 12 June 1992). Future water talks between Singapore and Malaysia will only be held closer to the expiry period of the two agreements (Pereira, 31 Aug 1998). Bilateral ties between Singapore and Malaysia were jolted occasionally by "some irritants" over the last few years. A Malay Malaysian claimed that most Malay Malaysian's thoughts and perceptions on what Singapore has done to incur Malaysian hatred are: (i) support by Singapore newspapers, and therefore the Singapore government, for the Anwar issue; (ii) sabotaging, through Clob, Malaysia's economic situation by short-selling activities; (iii) unwillingness to lend to Malaysia when it was in dire straits; (iv) high interest rates in Singapore banks, including Maybank, during the Asian crisis; (v) timing of the CIQ (Customs, immigration, quarantine) issue. Overall, he claimed that it made the Malay Malaysians feel there was a very serious and co-ordinated effort to bring down the Mahathir government and to slow Malaysia's rapid movement towards achieving their Vision of 2020 (Sunday Times, 20 February 2000). If this is indeed the prevailing sentiment of the average Malay Malaysian, then it will be very difficult for Singapore to continue to rely on Malaysia for a supply of water when the existing water agreement expires in 2061. Even more difficult will be for Singapore to secure from Malaysia an additional 400,000 m3 per day of water to meet her eventual demand for a population of seven million.

There has also been some unhappiness expressed in Indonesia over the selling of water to Singapore on the grounds of ecological damage to an identified reservoir area and Singapore's "exploitation" of Indonesia (ST, 29 June 1991 and 1 December 1993). Singapore is small and with limited resources but remarkably successful. Singapore has relied on the goodwill of her neighbours for water, labour, natural resources, and trade. Inevitably Singapore's success may have led to envy and resentment from certain sectors of the Malaysian and Indonesian populations because of historical reasons. The Growth Triangle represents "a new horizon of ample opportunity to improve the standard of living for (the Indonesian) people" (ST, 29 June 1991). By being an active partner in the growth triangle, Singapore can then legitimately stake a claim to the resources of the region. Singapore's present practice of tying water resource

agreements with other joint developments in Malaysia and Indonesia is a pragmatic attempt at promoting inter-state interdependence.

On the other hand, Singapore is in practice managing water resources in foreign territory in order to draw water from Malaysia and Indonesia. However, accepted state practice does not allow Singapore to directly intervene in the management of the catchments in Malaysia and Indonesia. The quality of the water is controlled by environmental policies and enforcement practices of the territory in which the water catchments are located. Therefore, pollution control in these catchments becomes a regional concern, and skilful diplomatic handling of the pollution problem which implicitly recognises the sovereignty over the territory is required to resolve these issues. At times, it may be necessary to close down the treatment plant as the closure of Skudai Water Treatment Works in 1991 while the problem is being resolved.

Singapore has been fortunate in that the government has enabled the country to prosper despite the lack of any significant natural resources. Singapore has also been successful in being able to provide a safe and reliable supply of water to her entire population. This is possible only because Singapore's water resources have for many years been supplemented substantially from Johor, as evidenced by the preceding discussion. While Malaysia's supply of water to Singapore is a testimony to good international co-operation and friendship, this relationship has not always been smooth. It must also be pointed out that both of the water supply agreements were concluded before Singapore gained full independence, while Singapore was still under British rule. There is a risk that the Malaysian government will decline to continue supplying water to Singapore if this is in conflict with their own interests--even when the relationship with Singapore has been cordial. The same is true for the Indonesian government. This was amply demonstrated in the episode involving the initial Concorde flight from Singapore. The inaugural Singapore Airlines-British Airways Concorde flight from London to Singapore and back on 10 Dec 1977 did not take place even though it was fully booked because Malaysia refused to grant permission for the supersonic jet to fly its skies. The inaugural flight was saved when Indonesia gave permission for the Concorde to re-route over its air space after an eleventh hour meeting. But this was only for a short while. Indonesia withdrew permission for the Concorde to fly over its skies a week after the Singapore-British joint service commenced. It was only a year later, after numerous talks, that Malaysia and Indonesia gave the green light for the Concorde (ST, 27 Jul 2000).

## Conclusion and Recommendations

It is clear that despite the implementation of a good water resource management in Singapore it is difficult for Singapore to be self sufficient in meeting her water needs competitively because of its small size and limited water resources. Even though substantial resources have been invested in Singapore since independence to secure as much of a domestic water supply as possible, Singapore continues to rely on Malaysia (and probably Indonesia in the future) to supplement her present water resources and to meet future water needs. This raises serious questions about Singapore's dependency on her neighbours for so vital and strategic a resource. Malaysian and Indonesian water consumption will likely increase because of pressure from population and economic growth. Mismanagement of the water supply system and pollution problems caused by the agricultural sector, industrialisation and urbanisation in the two countries will reduce substantially the surplus water for supply to Singapore. Therefore, there is a compelling need to reduce the level of dependency for the sake of Singapore's security and relationships with her neighbours. Recognising that nations with lower cost water resources will have a competitive advantage in this century, the options available for Singapore to meet her future water needs are discussed as follows. Several options have to be pursued simultaneously to ensure redundancies and safeguard the interests of Singapore due to the strategic importance of water to the security of Singapore.

The first option is to increase the water supply locally by desalination and reclaiming water from treated sewage effluent. The potential for water reclamation and reuse in Singapore is great as 80-85 per cent of the water supplied by the PUB is discharged into the sewage after use (Tay et al, 1994). This means that more than 800,000 m3 of municipal waste is available for reclamation each day. There are various methods currently available for desalination of sea water and the two universities in Singapore are actively involved in research to help reduce the cost of desalinated water. If Singapore succeeds in pioneering a desalination method to produce potable water at a cost that is comparable to the present treatment costs, then Singapore will be able to achieve self sufficiency in water supply and need not rely on neighbouring countries to supplement her water needs. Even if this is not possible, it is strategically important that a few desalination plants be put in operation so that expertise on the operation of these plants can be built up and put to good use whenever the need arises. At the same time, the model of Bedok/Lower Seletar scheme of collecting surface runoff from urbanised areas should be duplicated in other remaining areas so that the land area harnessed for water resources can be

increased further beyond the present level of about 50%. This infrastructure will be developed and operationally ready but won't need to be operated at full capacity if other cheaper sources of water supply are available. In addition, the storage capacity of reservoirs within Singapore should be increased whenever possible to increase the time available to work out a solution in the event of the non-availability of water stored in reservoirs in Johor. In this regard, the use of underground space for storing water should be pursued further. The UFW should be lowered further by the PUB by redoubling its efforts. Ultimately, this is the fallback position when Singapore is negotiating with Malaysia and Indonesia.

The second option is to further manage water demand in Singapore. While it is inevitable that future water demand will be increased because of continued population and economic growth, the rate of increase can continue to be moderated by education and persuasion, fiscal incentives and disincentives and by administrative and legislative control. Another water management measure that can be implemented is to identify economical usages that are appropriate for the more pollutive surface runoffs that are not being collected by the storm collection system currently or treated trade effluent from sewerage treatment works. At worst, this should be a contingency plan to be activated as and when the need arises.

The third option is to resolve as soon as possible the issue of securing more water from Malaysia after 2061. The recent visit to Malaysia by Senior Minister Lee Kuan Yew is an important step in this direction and the response from the Malaysian Government seems to be favourable (ST, 19 Aug 2000 and 26 Aug 2000). Despite the risk of being dependent on Malaysia for part of Singapore's water supply and the occasional hiccup in their relationship, this is still one of the most cost effective sources of water supply. For the last 68 years, this option has worked well for Singapore and Malaysia is also a politically more stable country when compared to Indonesia.

The fourth option is to expedite the installation of a water supply system under the Water Agreement with Indonesia as and when possible. Strategically, this serves as a backup plan to the Water Agreements with Malaysia.

The fifth option is for Singapore to explore the feasibility of securing water from water rich countries in Southeast Asia like Papua New Guinea and Laos. Very large water tankers can be used to transport water back to Singapore just like oil is being transported from the Middle

East to other countries. In the twenty first century, water may become a commodity like oil, which can be bought on the international market. If this is a possibility, then it will be advantageous for Singapore to secure necessary agreements with those water rich countries to help establish Singapore as an important water trading hub of the world in the near future.

One key question is how self sufficient Singapore needs to be and how much water in terms of storage and catchments is needed to meet Singapore's emergency needs. From the security viewpoint, Singapore must be totally self sufficient in a water crisis. Therefore, the water supply system including water catchments to meet Singapore's water needs minus wastage must be in place and operationally ready. From the economic competitiveness viewpoint, a 'least cost' water supply system must be relied upon to ensure Singapore's competitiveness. The water supply system in operation must therefore be a balance of the above two considerations. The storage within Singapore of only about four months of the current water consumption is too low and should be increased to the equivalent of one year's supply -- this will enable a smooth transition to the totally self sufficient water supply system and the sorting out of any teething problems. Underground storage appears to offer a feasible alternative in achieving this objective. Notwithstanding the above, Singapore must maintain a political environment in Southeast Asia that enables future generations to share in the water resources of her neighbours.

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