Water Resources, Population Growth, and the Environment in Malaysia: An Overview

Zuraini Anang, University Malaysia Terengganu, Malaysia
Noorhaslinda Kulub Abdul Rashid, University Malaysia Terengganu, Malaysia
Azlina Abd. Aziz, University Malaysia Terengganu, Malaysia
Roseliza Mat Alipiah, University Malaysia Terengganu, Malaysia

The European Conference on Sustainability, Energy & the Environment 2018
Official Conference Proceedings

Abstract
Water is the basic need for life as well as the essential input for industries. The increasing population and urbanization leads to the highly demand of water consumption which contributes to water scarcity among residential and industrial usage. Water stress is the most crucial environmental challenges experiencing in many nations around the globe. Beside, water shortage an increase to the population would also bring industrialization and urbanization which causes environmental problems which directly affects the quality of the water supply. Population growth have a significant effect on environment in order to meet the sustainable development. This paper reviews and analyse on the trends in water resources, population growth and environment pattern in order to understand the key issues and challenges faces for water resource development in Malaysia. Furthermore, it attempt to examine the linkages between the population, water consumption and environment. The article finally discusses the importance of improving and enhancing existing policies of water resources in order to conserve the nature while promoting sustainable economic growth.

Keywords: Water consumption, Population growth, Environment, Sustainable development

Introduction

There can be no life without potable water. This need is threatened by increasing population growth which places pressure on water demand for domestic, industrial, and municipal uses. Most if not all industries require water not least of which is agriculture and energy. The most water scarce or stressed areas are typically those with few water resources, high population densities, and high population growth rates (UN, 2007). Population growth means that there is less water per person and those areas with the highest populations and high levels of industry often suffer from the highest levels of water stress and scarcity.

Given the above, cities are particularly vulnerable to water stress and shortages, particularly given that they often undergo continuous urban development resulting in increased water demand (Dash, 2013). From 1950 to 2016, the population living in urban centres grew significantly from 30% to 54.5% (UN, 2016). With this growth trajectory, it is estimated that by 2050, 66% of the global population (roughly 6.2 billion people) will reside in urban areas (UN, 2015). Africa and Asia are two rapidly growing regions. China (additional 292 million urban residents), India (additional 404 million urban residents) and Nigeria (additional 212 million urban residents) will likely account for 37% growth of the world's urban population by 2050 (UN, 2015). The mass migration to cities means has resulted in a near six-fold increase in global water consumption in cities, which is twice the rate of population growth (Guinness and Walpole, 2012).

Malaysia's water is nearly entirely derived from surface water resources such as rivers and reservoirs at 98% (Second National Communication (NC2), Malaysia 2011). The remaining 2% is sourced from groundwater. Malaysia spends most of its valuable water on irrigation, and industrial and domestic purposes (Economic Planning Unit, 2006). As for its non-consumptive uses of water, Malaysia uses it predominantly for hydropower, navigation and recreational activities.

With economic and population growth, the demand for water to sustain life and industries is also rising. This demand is highest for agriculture. In Malaysia, this demand was 54% of the nation's total demand for water in 2010 (Economic Planning Unit, 2010).

In Malaysia, the demand for water is not equal across all states and areas. Some areas suffer from water scarcity while other places have an overabundance of water. In 1998, an El Nino related drought caused severe water stress in Kedah and Penang, and water rationing in Kuala Lumpur and Petaling Jaya for many months, while other states were relatively unaffected.

Malaysia's weather has also become rather unpredictable in recent years with an increasing frequency in dry spells and water crises in Peninsular Malaysia, particularly Malacca and Selangor, and some parts of East Malaysia. For example, the 2002 drought destroyed thousands of hectares of paddy in Perlis and caused water stress in many areas of the country (Chan, 2009).

With this overview of the state of water in Malaysia, this paper reviews and analyses the trends in water resources, population growth and environmental patterns in order

to understand the key issues and challenges facing water resource development in Malaysia. Furthermore, it examines the linkages between the population, water consumption and environment. The article concludes by discussing the importance of improving and enhancing existing water resources policies to conserve nature while promoting sustainable economic growth.

Materials and Methods

This study reviews the current state of water resources in Malaysia based on a review of full-text journal articles, reports, and conference proceedings sources from both electronic and non-electronic databases. In addition, the websites of organisations that have researched or address this issue were referred to for related documents and reports. Only documents written in English were considered.

Water Resources

Malaysia is a country with abundant water resources. Groundwater accounts for 90% of the freshwater resources. The renewable water resources are 630 billion m^3 - the summation of surface runoff and groundwater recharge. This translates into an annual average water availability of about 28,400 m^3 per capita. The water resources in Malaysia are summarised in Table 1.

Table 1: Water Resources in Malaysia

Annual rainfall	990 billion m^3
Surface runoff	566 billion m^3
Evapotranspiration	360 billion m^3
Groundwater recharge	64 billion m^3
Surface artificial storage (dams)	25 billion m^3
Groundwater storage (aquifers)	5 000 billion m^3

Source: National Water Resources Study (1982) and Malaysia Water Industry Report (1998)

Streams and rivers with and without impounding reservoirs contribute 98% of total water used in Malaysia. Groundwater contributes the remainder. River flow regimes are irregular and to secure safe yield from surface water sources, storage facilities were constructed. The main reason for the lack of groundwater use in the country is the easy availability of surface water resources; there are over 150 river systems in Malaysia (Abdullah and Mohamed, 1998). The most important source of raw water is direct extraction from rivers, with approximately two-thirds of raw water supply in Malaysia (Table 2) being obtained in this way. It is followed by storage dam and groundwater in the less-developed states of Sabah and Kelantan.

Table 2: Raw Water Resources (2016)

Water Supply Entities	Direct Extraction from River	Storage Dams (Direct)	Ground Water	Total
	Million Litre Per Year (MLD)			
Johor	1,072	664	n.a	1,737
Kedah	1,449	22	n.a	1,471
Kelantan	287	n.a	214	501
F.T. Labuan	69	4	0.0	74
Melaka	424	312	n.a	737
N. Sembilan	489	408	n.a	897
Pulau Pinang	1,064	91	n.a	1,155
Pahang	1,170	31	7	1,208
Perak	1,031	361	n.a	1,393
Perlis	186	71	4	260
Sabah	836	355	30	1,221
Sarawak	1,207	122	n.a	1,328
Selangor	4,661	427	n.a	5,088
Terengganu	485	197	n.a	682
MALAYSIA	**14,431**	**3,065**	**254**	**17,750**

Notes:
1. Volume of raw water extracted may vary for each year due to:

a. Treated water supply and demand

b. Commissioning of new WTPs

c. Upgrading of available WTPs

d. Other environmental factors including weather and pollution

Source: Malaysia Water Industry Guide (2017)

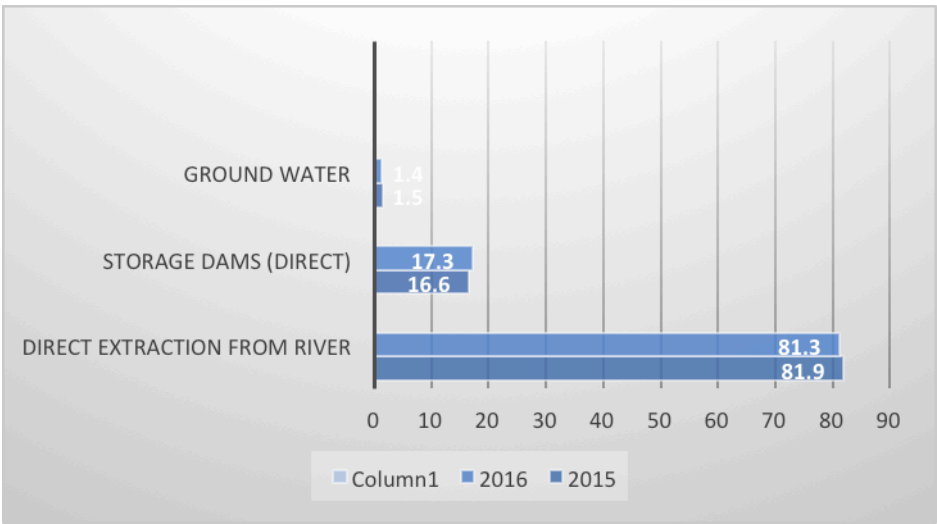

Figure 1: Proportion of Raw Water Resources 2015-2016
Source: Malaysia Water Industry Guide (2017)

Water Supply and Water Coverage

As of 2016, 95.7% of the population was served with clean and treated water supply, rising from 95.5% in 2015. Most states recorded 100% coverage in urban areas - the only exception being Kelantan at 61.7% as stated in Table 3. As a less-developed state, it does not have the financial capacity to improve water supply coverage.

Table 3: Percentage of Urban & Rural Population Served, 2015-2016

Water Supply Entities	% Population Served 2015			% Population Served 2016		
	Urban	Rural	State	Urban	Rural	State
Johor	100	99.5	99.8	100	99.5	99.8
Kedah	100	96.5	198.3	100	96.5	98.3
Kelantan	61.5	66.4	64.0	61.7	67.7	64.7
F.T. Labuan	100	100	100	100	100	100
Melaka	100	100	100	100	100	100
N. Sembilan	100	99.8	99.9	100	99.8	99.9
Pulau Pinang	100	99.7	99.9	100	99.7	99.9
Pahang	100	96.0	98.0	100	96.0	98.0
Perak	100	99.2	99.6	100	99.2	99.6
Perlis	100	99.0	99.5	100	99.0	99.5
Sabah	99.8	76.0	87.9	99.8	79.0	89.4
Sarawak	99.8	78.0	94.2	99.8	80.4	94.5
Selangor	100	99.5	99.8	100	99.5	99.8
Terengganu	99.1	92.9	96.0	99.1	92.9	96.0
National Average	**97.2**	**93.0**	**95.5**	**97.2**	**93.5**	**95.7**

Notes:
The percentage of coverage in Kelantan is low because other alternative sources are used although there is accessibility.

Source: Malaysia Water Industry Guide (2017)

Table 4: Non-Revenue Water (NRW) 2015-2016

State	2015				2016			
	System Input Volume	Billed Authorised Consumption	NRW	NRW (%)	System Input Volume	Billed Authorised Consumption	NRW	NRW (%)
	MLD				MLD			
Johor	1,702	1,266	436	**25.6**	1,737	1,286	450	**25.9**
Kedah	1,316	702	614	**46.7**	1,362	725	637	**46.7**
Kelantan	454	231	222	**49.0**	471	238	232	**49.4**
F.T. Labuan	71	49	22	**30.9**	72	50	22	**30.5**
Melaka	481	388	93	**19.3**	500	405	95	**19.0**
N. Sembilan	757	493	264	**34.8**	773	520	253	**32.7**
Pulau Pinang	1,014	813	202	**19.9**	1,054	827	227	**21.5**
Pahang	1,128	532	596	**52.8**	1,111	579	532	**47.9**
Perak	1,260	878	382	**30.3**	1,318	916	402	**30.5**
Perlis	220	96	124	**56.3**	243	96	148	**60.7**
Sabah	1,229	552	677	**55.1**	1,221	586	634	**52.0**
Sarawak	1,268	846	423	**33.3**	1,328	850	479	**36.0**
Selangor	4,675	3,178	1,497	**32.0**	4,807	3,260	1,547	**32.2**
Terengganu	621	428	192	**31.0**	628	440	189	**30.0**
MALAYSIA	**16,195**	**10,452**	**5,743**	**35.5**	**16,625**	**10,779**	**5,846**	**35.2**

Source: Malaysia Water Industry Guide (2017)

Despite efforts to improve management of water supply and its distribution, the rate of non-revenue water (NRW) declined from 35.5% in 2015 to 35.2% in 2016. This is due to the effective enforcement and faster replacement of pipes, as well as efficient of district metering zones to monitor water pressure and detect burst pipes. However, the NRW rate was highest in Perlis at 60.7% and Sabah at 52%.

Table 5: Water Treatment Plants Design Capacity and Production (1981-2016)

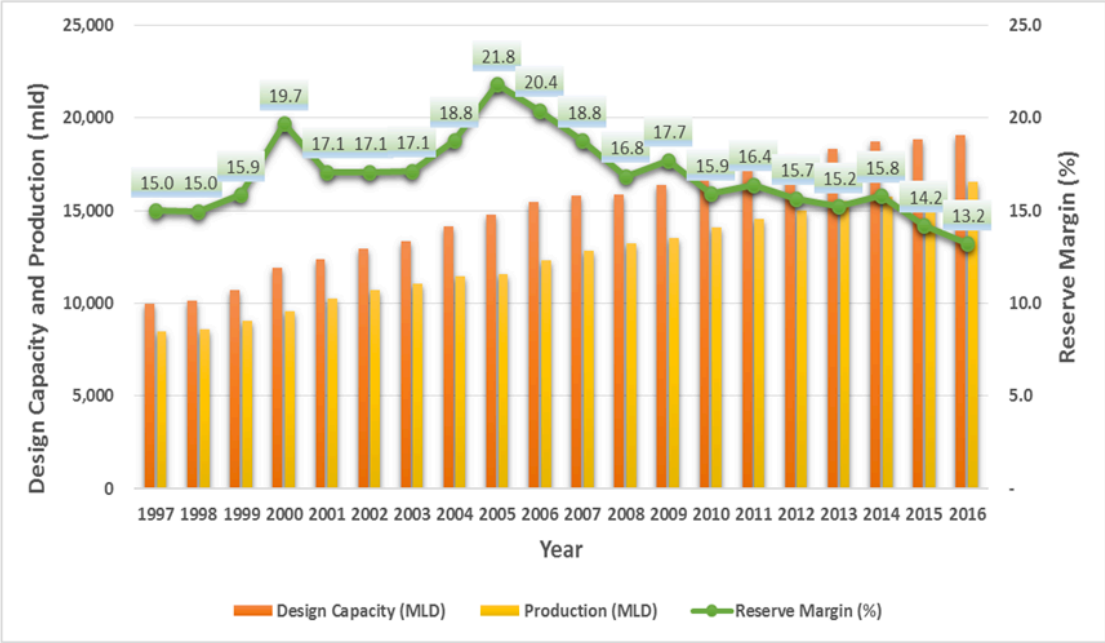

Table 6: Water Treatment Plants Design Capacity and Production 2015-2016

State	2015				2016			
	No. of WTPS	WTPs Design Capacity	Production	Reserve margin (%)	No. of WTPS	WTPs Design Capacity	Production	Reserve margin (%)
		MLD				MLD		
Johor	44	1,986	1,619	**18.5**	44	1,986	1,661	**16.4**
Kedah	36	1,308	1,315	**0.0**	36	1,308	1,361	**0.0**
Kelantan	35	500	454	**9.2**	35	500	471	**5.8**
F.T. Labuan	6	101	73	**27.6**	6	101	72	**29.2**
Melaka	9	639	519	**18.8**	9	639	510	**20.1**
N. Sembilan	23	994	752	**24.4**	23	1,000	779	**22.1**
Pulau Pinang	9	1,479	1,014	**31.4**	9	1,599	1,054	**34.1**
Pahang	76	1,414	1,129	**20.1**	76	1,414	1,111	**21.4**
Perak	46	1,816	1,289	**29.0**	46	1,846	1,317	**28.7**
Perlis	4	233	220	**5.6**	4	233	230	**1.0**
Sabah	73	1,304	1,229	**5.8**	73	1,304	1,221	**6.4**
Sarawak	93	1,609	1,268	**21.1**	93	1,675	1,328	**20.7**
Selangor	34	4,606	4,675	**0.0**	34	4,606	4,807	**0.0**
Terengganu	12	846	603	**28.7**	12	846	616	**27.2**
MALAYSIA	**500**	**18,835**	**16,159**	**14.2**	**500**	**19,056**	**16,536**	**13.2**

Source: Malaysia Water Industry Guide 2017

Malaysia has built 24 new water treatment plants and an additional 38 plants were upgraded. This has increased its production capacity to 16,536 million litres per day. These initiatives have expanded the coverage of clean and treated water networks and ensured the security of supply.

Overview of Water Demand in Malaysia

Water consumption is divided into domestic and non-domestic. Domestic water use refers to water used for indoor and outdoor household purposes such as drinking,

preparing food, bathing, washing clothes and dishes, brushing your teeth, and watering the yard and garden. Non-domestic consumption refers to industrial, commercial, and public uses of water such as shops, offices, schools, and hospitals, among others. The levels of industrial consumption depend on the intended output and resource technology. The industrial consumption is commonly expressed in litres per unit of product or raw material. Table 7 presents the proportion of water consumption. The percentage of domestic consumption increased from 6,378 mld (2015) to 6,495 mld (2016) whereas for non-domestic consumption also increased from 4,074 mld (2015) to 4,242 mld (2016).

Table 7: Total Volume and Proportion of Water Consumption 2015-2016

State	2015					2016				
	Domestic		Non-Domestic		TOTAL	Domestic		Non-Domestic		TOTAL
	MLD	%	MLD	%		MLD	%	MLD	%	
Johor	811	64.1	455[r]	35.9	1,266[r]	773	60.1	513	39.9	1,286
Kedah	511	72.8	191	27.2	702	525	72.4	200	27.6	725
Kelantan	159	68.6	73	31.4	232	163	68.3	76	31.7	239
F.T. Labuan	17	35.2	32	64.8	49	17	34.1	33	65.9	50
Melaka	202	52.0	186	48.0	388	206	50.8	199	49.2	405
N. Sembilan	276	55.9	217	44.1	493	287	55.2	233	44.8	520
Pulau Pinang	483	59.5	329	40.5	812	492	59.5	335	40.5	827
Pahang	309	58.2	223	41.8	532	342	59.0	238	41.0	580
Perak	628	71.5	250	28.5	878	655	71.4	262	28.6	917
Perlis	81	84.2	15	15.8	96	82	85.4	14	14.6	96
Sabah	315	57.1	237	42.9	552	335	57.1	252	42.9	587
Sarawak	478	56.5	368	43.5	846	474	55.7	376	44.3	850
Selangor	1,862	58.6	1,316	41.4	3,178	1,883	58.5	1,336	41.5	3,219
Terengganu	246	57.5	182	42.5	428	264	60.0	176	40.0	440
MALAYSIA	**6,378**	**61.0**	**4,074**	**38.9**	**10,452**	**6,495**	**60.5**	**4,242**	**39.5**	**10,737**

Source: Malaysia Water Industry Guide 2017

Based on National Water Resource Study 2000-2050 the water demand for domestic consumer will be increased from 2000 till 2050, respectively 2,029 million m^3 to 5,904 million m^3. The total volume also rises from 10,833 million m^3 to 17,675 million m^3 (Table 8).

Table 8: Water Demand for Peninsular Malaysia (Million m^3/yr)

Demand*	**1998**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Domestic	1,833	2,029	2,987	3,862	4,606	5,251	5,904
Industry	1,260	1,454	2,592	3,561	4,330	5,016	5,639
Both	3,093	3,483	5,578	7,423	8,936	10,267	11,543
Irrigation	7,350	7,350	6,517	6,517	6,517	6,132	6,132
Total	**10,443**	**10,833**	**12,095**	**13,940**	**15,068**	**16,399**	**17,675**

*Include losses

Source: National Water Resource Study 2000-2050

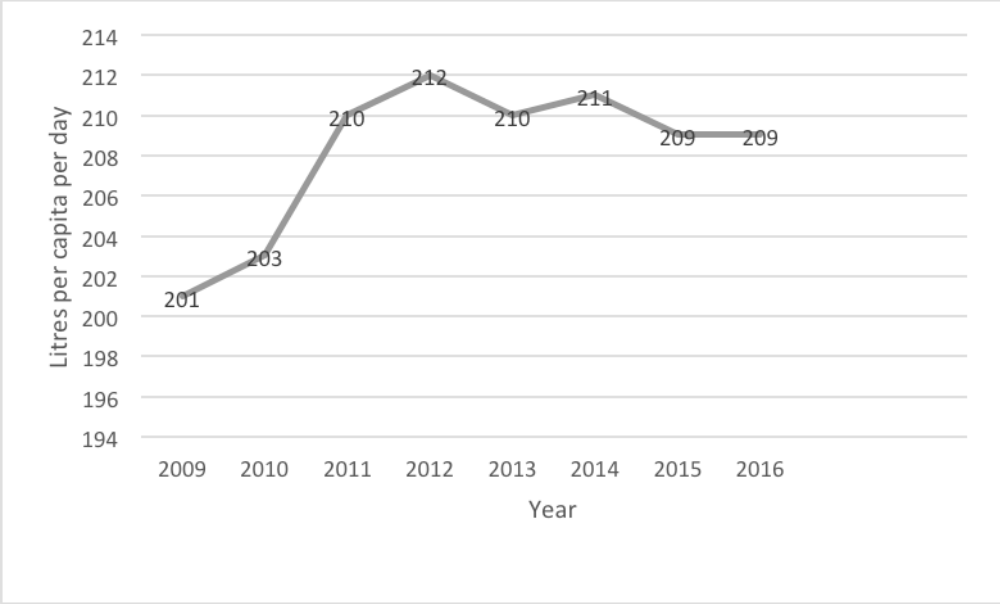

Figure 2: Domestic Consumption Per Capita Per Day in Malaysia (2009 - 2016)
Source: Malaysia Water Industry Guide 2017

The average domestic water consumption (DWC) is 285 litres per capita per day compared to the average of 36 Asia countries at appropriately 165 litres and a United Nation (UN) guideline of 160 litres per capita per day.

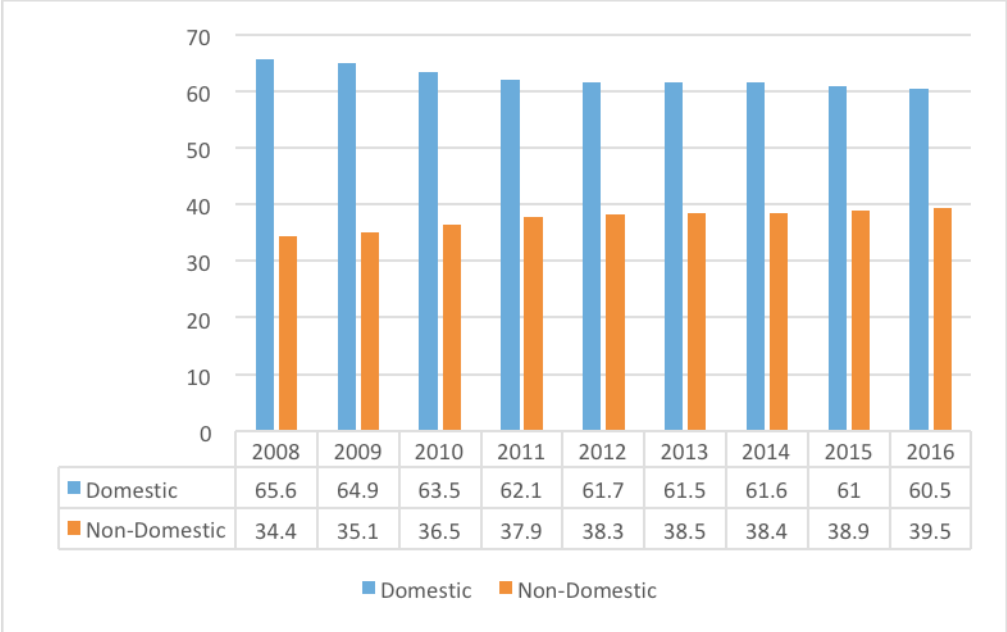

Figure 3: Total Volume of Water Consumption 2008 - 2016
Source: Malaysia Water Industry Guide 2017

Determinants of Water Demand

Numerous factors impact on the demand for water. The most influential factors are climatic such as rainfall, temperature and evaporation rates and population related such as population growth, population density, water price as well as socio demographics (Slavíková et al., 2012; Duarte et al., 2013). Household characteristics

(Syme et al., 2004), water availability and conservation (Davies et al., 2014), and pricing and policies (Jorgensen et al., 2009) are also major determinants of water usage.

Syme et al. (2004) found that outdoor water consumption and use behaviour concentrated in watering gardens, cleaning and swimming pool, and that these practices were shaped by climate, income, lifestyle and water conservation practices. Regarding indoor use, it was determined by household appliances and water conservation practices (Gregory and Di Leo, 2003).

Different cities use water differently. Indian and Palestinian cities modify their practices based on water supply capacity (Andey and Kelkar, 2009). In northern Nigeria, precipitation brought about by seasonal changes determine consumption practices (Nyong and Kanaroglou, 2001). In Hong Kong and Beijing, the national gross domestic product (GDP) is highly related to increases in the rate of base water use (Zhang et al., 2013). In California, water price (WP), water appliances and water-saving subsidies are the main factors associated with water consumption (Renwick and Archibald, 1998).

In total, there are 15 major determinants of water demand consisting of climatic factors (two variables), water tariffs, socioeconomic factors (seven variables), water appliances (two variables), and water supply and conservation factors (three variables).

Sustainable Development of Water Resources

The world is facing unprecedented challenges in water resources management. Water is essential for life because humans cannot live without water for more than several days. In Malaysia, the government promotes holistic development by implementing proactive policies and strategies at different levels starting from the 7th Malaysia Plan onwards.

Barrier (2004) revealed growth is negatively affected by the government's appropriation of output to supply water but positively influenced by the contribution of increased water use to capital productivity, leading to an inverted U relationship between economic growth and the rate of water utilisation. The majority of economies continue to use fresh water to support growth, while others suffering from high levels of water scarcity could see their economic growth suffer due to the inability to sustain industry.

Given recent climatic and environmental trends, the world is anticipating a significant rise in water scarcity. This is confounded further by the ongoing rise in global production and consumerism (Vörösmarty et al., 2000).

It is necessary to model the relationship between water use and economic growth by determining the economic value of water. Despite changing water capacity leaning towards the privatisation of water, water continues to be perceived as a government-provided non-excludable good subject to congestion.
Barro (1990) and Barro and Sala-I-Martin (1992) argued that modelling the influence of water utilisation on economic growth helps form a growth model that includes

publicly provided goods that are subject to congestion as a productive input for private producers in an economy.

In China, Fang et al. (2006) investigated the relationship between water scarcity and growth by examining the impact of intersectoral and interregional water allocations on growth.

Hossein et al. (2012) presented evidence supporting the hypothesised inverted U relationship between economic growth and the rate of water use across countries. The result suggests that current rates of freshwater utilisation in the vast majority of countries are not yet constraining economic growth.

These studies underscore the importance of water for economic growth. In other words, development cannot be continued without water. Hence, the water resource needs to be developed and managed sustainably to ensure the social, economic and environmental development for the current and future generations. As a result, Sustainable Development Indicators (SDI) for water have been introduced to monitor the water sustainability.

Population and Water in Malaysia

Malaysia's current population is 32.04 million. An increase in the population leads to higher demand for water supply in residential, industrial and agriculture sectors.

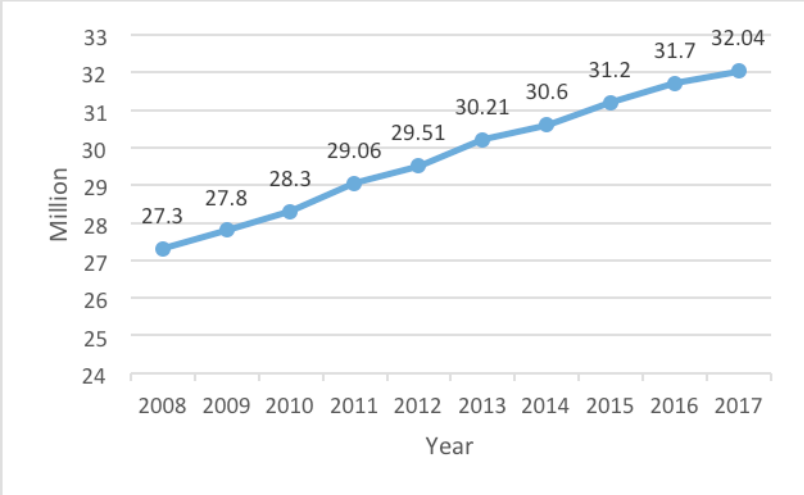

Figure 4: Population Growth in Malaysia (2008 - 2017)
Source: Department of Statistic Malaysia

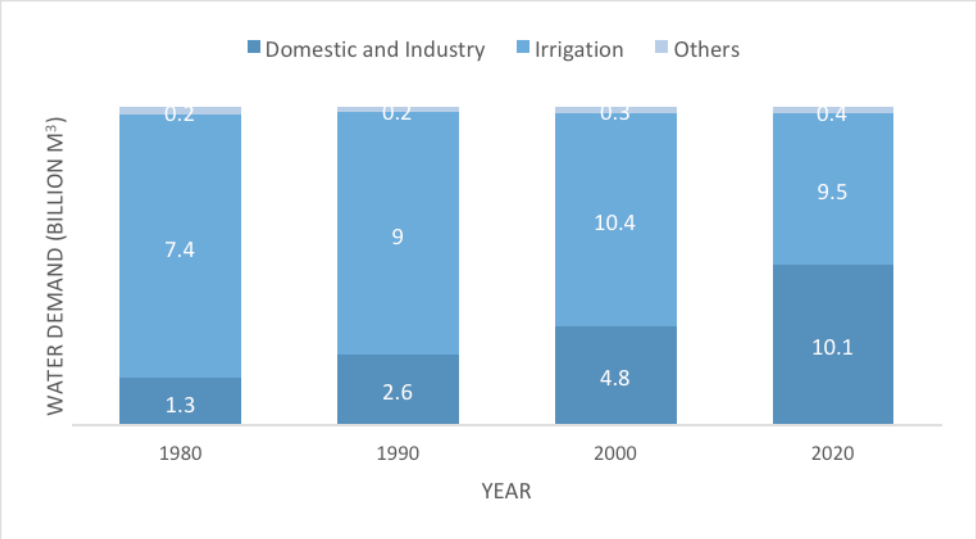

Figure 5: Water Demand for Different Sector in Malaysia (1980-2020)
Source: EPU (Economic Planning Unit) 2006. The Ninth Malaysian Plan (2006-2010). Prime Minister's Department, Putrajaya, Kuala Lumpur, Malaysia

Figure 5 shows the demand for water in different sectors in Malaysia from 1980 to 2020. The total demand for water in the country was 8.9 billion m^3 in 1980. Usage of water for irrigation accounted for 83% of the total water usage in 1980. The demand for water increased to 11.8 billion m3 in 1990 for agricultural, industrial and domestic purposes. It was found that agricultural sector constituted the highest portion (76%) of the total water usage in 1990. The water distributed in the agricultural sector was used for irrigation of eight large paddy granary schemes and 924 smaller schemes, which combined a total area of 340,000 hectares 10. Water demand had steadily increased to 15.5 billion m^3 in 2000. As usual, the agricultural sector comprised the greatest portion (67%) of the total water usage while the demand for water in the industrial and domestic sector increased nearly two-fold during the 2000s.

The industrial and domestic sectors use water predominantly for hydropower, navigation and recreational activities. Between 1980 and 2000, Malaysian dedicated most of its water resources to the agriculture sector. The domestic and industrial sector also recorded increased water demand of approximately 12% annually over the same period. This was spurred by a growing population and economic growth. It is anticipated that Malaysia's demand for water would reach 20 billion m^3 by the year 2020. A national agenda to industrialise and boost economic growth means that the industrial demand for water is projected to constitute nearly 51% of the total water demand by 2020.
In conclusion, as the population grows, the demand for water mounts and pressure on finite water resources intensifies. Climate change, which is also closely tied to population growth, will also lead to greater pressures on the availability of water resources.

Impact on the Environment

Population Impact on Future Water Quality

More people means more demand for water. It also entails the possibility of greater waste and pollution which threaten the water supply further. Malaysia suffers from high levels of pollution which have affected its water resources significantly.

As reported by Department of Environment in Figure 5, of state of the rivers of473 rivers monitored for water quality, 244 (52%) were clean, 186 (39%) were slightly contaminated, and 43 (9%) were infected.

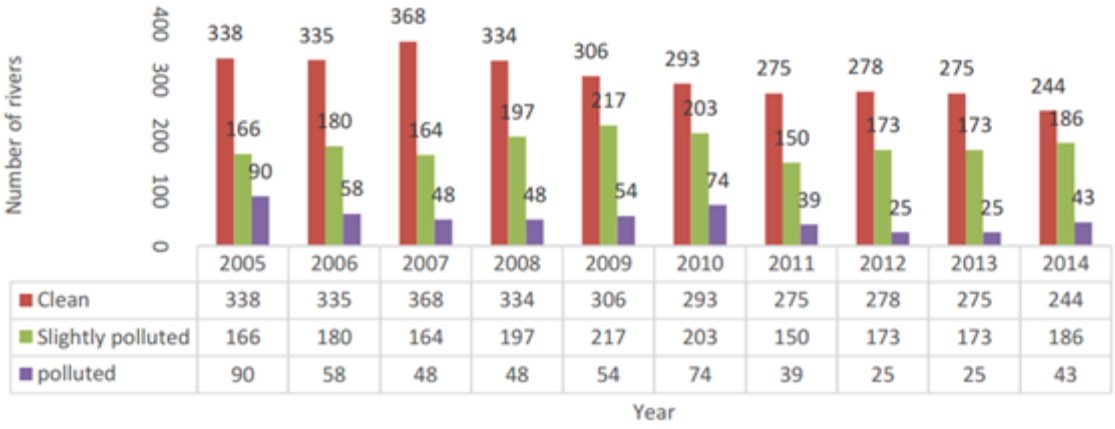

Figure 6: River Water Quality Trend in Malaysia

Issues and Challenges of Water Resources in Malaysia

Malaysia is a developing country with a growing population, particularly in urban centres due to rural-urban migration and growing urbanisation. It has strained the government's ability to meet infrastructure and service needs and provide the environmental conditions required for better living. This includes water treatment facilities overwhelmed by the population which has direct and immediate consequences for health and the environment.

The increased demand for increasingly limited water supply has created competition for water resources. The obvious answer to the problem is to build more dams which are costly financially and environmentally. Furthermore, the practicable limit of surface water resources development has been reached in some regions of high demand, and it has become necessary to consider inter-basin and interstate surface water transfer schemes.

Floods are natural phenomena that can be exacerbated by poor development policies and practices. The high rate of sedimentation in the rivers has adversely affected their drainage capacity, leading to more frequent floods in downstream areas and more intense flooding. Flash floods in urban areas are becoming more frequent as a result of the runoff from industries and residential areas.

In Malaysia, an estimated 29 000 km^2 or 9% percent of the total land area is flood-prone, affecting some 12% of the population. The average annual flood damage was estimated at RM100 million in 1980. This figure is significantly higher nowadays due to the urban sprawl and development.

Floods cannot be controlled effectively. Nevertheless, mitigation measures can be put in place to reduce its impact and cost financially and environmentally. Besides the construction of dams and reservoirs and the improvement of river systems, measures to increase infiltration and to store the excess water in small ponds and retention basins are being promoted. The Department of Irrigation and Drainage is leading these efforts. Public utilities such as water supply, sewerage, and urban drainage and flood mitigation are also helpful.

The main determinants of water pollution are domestic and industrial sewage, effluent from palm oil mills, rubber factories and animal husbandry. Mining operations, housing and road development, logging and clearing of forest are major causes of high concentrations of suspended sediments in the rivers. In several urban and industrial areas, organic pollution of water has resulted in environmental problems and adversely affected aquatic life. In addition to organic wastes, rivers remain a convenient means of solid waste disposal. A major portion of household refuse which is not collected, burnt or buried finds its way into drains and rivers. In the Klang Valley, an estimated 80 tonnes of waste ends up in the river system every day. River water quality and pollution control need to be addressed urgently since 98% of the total water originates from rivers. Almost all of the investments in water-related infrastructure depend on reasonable river water quality.

Malaysians are highly inefficient in their use of water. Despite its significant agriculture, it has a rather inefficient open irrigation system which takes advantage of flooding. The cost of irrigating farmland is relatively cheap leading people to be careless in their use of water. There is also a high proportion of unaccounted-for water in urban water supply systems, as one-quarter to one-third of the domestic and industrial water is lost before it reaches the consumers. This is partly due to poor infrastructure leading to leaks in addition to illegal activities. Such a state has led the authorities to focus on improving water efficiency more so than securing additional water resources.

Malaysia's growth means that standards of living have improved. Water shortages are improving environmental and conservation awareness. Nevertheless, higher standards of living mean that the demand continues to place growing pressure on the water supply, despite awareness. This challenge is being addressed through a focus on improving efficiency in water processing and consumption.

According to Chan (2003), there are major issues that must be addressed to ensure sustainability of water resources for now and in the future. In Malaysia, the water management system depends on the water supply management approach to cater for demand. This approach is not sustainable due to the fact that will exceed the water supply in the long run. It means that when demand increases, water supplied will rise as well, and more infrastructure like dams, water treatment plants and pipes for water supply distribution should be built. The comprehensive approach is required to ensure the sustainable water resource and integrated supply and demand-side management needed. Also, to change the consumptive behaviour of Malaysians to use water wisely.

Rates of water wastage are very high compared to other countries in the domestic, industrial and agriculture sectors. As reported by United Nations, Malaysia's national

average for per capita water use per day was 287 litres in 2001 compared with 165 litres per capita water use per day in the average of Asian countries. Moreover, rates of NRW are too high, approximately with a national average of 37.70%. If this could be reduced, Malaysia would have sufficient water supply with no need to build new dams.

Additionally, water catchments have been gazetted and protected by the government. If not, it will be exposed to development which is affecting the environment and water resources. Changing climates and weather also affect the water resources. For instance, in 1997/98, there Malaysia suffered a water crisis caused by El Nino. This situation should be taken into account in planning water resources development.

Malaysia has the lowest water prices in the world. Due to this low price, customers over-use water and are not encouraged to take water conservation measures. The process of reviewing the water rates should be transparent and involve professional and public participation to achieve water sustainability. About 68.2% of total water consumption is for agriculture purpose. However, irrigation efficiency is 50% at best in the larger irrigation schemes and less than 40% in the smaller ones. The government needs to encourage the water recycling and sustainable agriculture practices. Finally, due to serious problems of water pollution, the cost of treating polluted waters is very high and negatively impacts on the sustainability of water resources.

Conclusions and Policy Implications

Malaysia is rich in water resources. Its increasing population means higher water demand. Climate change also contributes to water shortage, particularly in the dry season. Currently, the water providers have been regulated by SPAN which is one regulatory body, uniform legislation, uniform legislation and rules, uniform tariff-setting principles and procedures, standard key performance indicators (KPIs), standard operating procedures, and standard product certification procedures will be implemented. Additionally, the framework on water services reform includes the federal government, state governments, the National Water Resource Council (NWRC), the National Water Services Commission and the Water Asset Management Company (WAMCo).

Moreover, the aims of restructuring the framework of water industry services are to ensure a high level of efficiency of services and operation; to upgrade water quality and ensure continuous and sufficient supply; to reduce non-revenue water (NRW); to relieve the state water operator's financial burden; and to develop a progressive and effective water services industry. In other words, it is to promote sustainable and holistic water supplies and sewerage services in the best interest of consumers and the environment as well as addressing funding requirements for infrastructure development.

References

Abbasinejad, Hossein, Gudarzi Farahani, Yazdan (2012). Water and economic growth in OPEC Country (Approach in the Government Management of Resources Operational), Procedia, *Social and Behavioral Sciences, 31*, 297 - 303.

Andey, S.P., Kelkar, P.S., (2009). Influence of intermittent and continuous modes of water supply on domestic water consumption. *Water Resource Management 23 (12),* 2555e2566. Available at: un.org/en/development/desa/population/publications/pdf/ urbanization/the_worlds_cities_in_2016_data_booklet.pdf. (Accessed 1 June 2017).

Barbier, E. B. (2004). Water and economic growth, *The Economic Record*, Vol. 80, No. 248, 1-16

Barro, R.J. (1990), Government spending in a simple model of endogenous growth. *Journal of Political Economy, 98*, S103-S124.

Barro, R.J. and Sala-I-Martin, X. (1992). Public finance in models of economic growth. *Review of Economic Studies, 59*, 645-61.

Chan, N. W. (2009). Issues and challenges in water governance in Malaysia. *Iran Journal of Environmental Health Science and Engineering 6* (3):143-152.

Chan, N.W. (2003). NGOs and community participation in water management in Malaysia. Paper presented at the *National Dialog on Effective Water Governance in Malaysia, 29-30 September 2003, Kuala Lumpur*. Organised by Malaysian Water Partnership (MyWP) and Drainage & Irrigation Department Malaysia.

Dash, D.K., (2013). 22 of India's 32 big cities face water crisis. The times of India, New Delhi, India. Available at: timesofindia.indiatimes.com/india/22-of-Indias-32-big-cities-face-water-crisis/articleshow/22426076.cms. (Accessed 1 June 2018).

Davies, K., Doolan, C., van den Honert, R., Shi, R., (2014). Water-saving impacts of smart meter technology: An empirical 5 year, whole-of-community study in Sydney, Australia. *Water Resour. Res. 50* (9), 7348-7358.

Duarte, R., Pinilla, V., Serrano, A., (2013). Is there an environmental kuznets curve for water use? A panel smooth transition regression approach. *Economic Model. 31*, 518-527.

EPU (Economic Planning Unit) (2006). The ninth Malaysian plan (2006-2010). Prime Minister's Department, Putrajaya, Kuala Lumpur, Malaysia, 53 p.

EPU (Economic Planning Unit) (2010). The ninth Malaysian plan (2011-2015). Prime Minister's Department, Putrajaya, Kuala Lumpur, Malaysia, 429 p.

Gregory, G.D., Di Leo, M., (2003). Repeated behavior and environmental psychology: The role of personal involvement and habit formation in explaining water consumption 1. *Journal Application Social Psychology. 33*, 1261-1296.

Guinness, P., Walpole, B. (2012). Environmental systems and societies for the IB Diploma. Cambridge University Press, Cambridge, the United Kingdom.

Initial National Communication (INC), Malaysia (2000). The report submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Ministry of Science, Technology and the Environment, Putra Jaya, Malaysia; July 2000, pp. 5-6.

Jorgensen, B., Graymore, M., O'Toole, K., (2009). Household water use behavior: An integrated model. *J. Environ. Manage. 91* (1)*,* 227-236.

Keizrul Abdullah and Azuhan Mohamed. (1998) Water - A situation appraisal and possible actions at the community level. Seminar on local communities and the environment II, Environmental Protection Society of Malaysia, Petaling Jaya, Malaysia

Malaysia Water Industry Guide, (2017). Malaysian Water Association in with collaboration with Ministry of Energy, Green Technology and Water (KETTHA) and National Water Service Commission (SPAN).

Nyong, A.O., Kanaroglou, P.S., (2001). A survey of household domestic water-use patterns in rural semi-arid Nigeria. *J. Arid. Environ. 49* (2), 387-400.

Renwick, M.E., Archibald, S.O., (1998). Demand side management policies for residential water use: Who bears the conservation burden? *Land Econ. 74*, 343-360.

Second National Communication (NC2), Malaysia (2011). The report submitted to the United Nations framework convention on climate change (UNFCCC). Ministry of Natural Resources and Environment (NRE), Putra Jaya, Malaysia. Available at: http://www.nc2.nre.gov.my, pp. 1-145.

Slavíkov_a, L., Malý, V., Rost, M., Petru_zela, L., Voj_a_cek, O., (2012). Impacts of climate variables on residential water consumption in the Czech Republic. *Water Resource Management 27* (2), 365-379

Syme, G.J., Shao, Q., Po, M., Campbell, E., (2004). Predicting and understanding home garden *Water Use Landscape Urban Planning 68*, 121-128

UN (the United Nations), (2007). World Urbanization Prospects The 2007 Revision. United Nations, New York. Available at: un.org/esa/population/publications/ wup2007/2007WUP_Highlights_web.pdf. (Accessed 1 June 2018)

UN (the United Nations), (2015). World Urbanization Prospects: The 2014 Revision. United Nations, New York. Available at: esa.un.org/unpd/wup/Publications/ Files/WUP2014 Highlights.pdf. (Accessed 1 June 2018).

UN (the United Nations), (2016). The world's cities in 2016. New York, United Nations.

United Nations (UN)-Water and food and agriculture organization of the United Nations (FAO). (2007). *Coping with Water Scarcity: Challenge of the Twenty-First Century*. New York, NY: UN-Water and FAO

Vörösmarty, C.J., Green, P., Salisbury, J. and Lammers, R.B. (2000), Global water resources: Vulnerability from climate change and population growth, *Science*, 289 (14 July): 284-288.

Xiangming Fang, Terry L. Roe and Rodney B.W. Smith (2006). Water shortages, water allocation and economic growth: The case of China, Paper presented at the 10th Joint Conference on Food, Agriculture and the Environment, Duluth, Minnesota, August 27-30

Zhang, D., Ni, G., Cong, Z., Chen, T., Zhang, T. (2013). Statistical interpretation of the daily variation of urban water consumption in Beijing, China. *Hydrology Science Journal 59* (1), 181-192.

Contact email: zura@umt.edu.my