DOMESTIC WATER DEMAND:
A CASE STUDY IN KLUANG, JOHOR

By

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PERMISSION TO USE

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Abstract

Demand for water is a vital issue in Malaysia as population growth, agricultural, and industrial development takes place. In addition, some states face problems of water shortage and stress because water use is already reaching maximum demand levels like Selangor state. In Johor, supply shortage is not a common problem faced by the water supply department, but as early steps it is essential for improving the security and resilience of our nation's drinking water and wastewater infrastructures. It was estimated a bout 40% of the world's population currently lives in water stressed areas. With a global population increase of three billion people predicted by 2050, water scarcity will soon become a matter of life or death. Economist, therefore have become interested in understanding the empirical nature of water demand for the accurate forecasting of water demand, pricing and in improving water resource planning and management. Significant actions should be taken to assess and reduce water loss and develop new security technologies to detect and monitor contaminants and prevent security breaches in water demand.

The purpose of this study is to examine the relationship between price and quantity and other relevant variables for water consumption in Kluang, Johor. One panel data regression between consumption and expenditure of water was estimated and the result indicates that price and quantity of water demanded have a positive relationship where increase in price will leads to increase in water use because the use of average price in this study. The regressions give the best result because it takes care of heterogeneity of individual in this analysis and the elasticities of price in range of 0.66 to 0.65 respectively. Furthermore, five different price and other variables specification regression models for a cross sectional analysis of a 335 samples of households, indicated that the price is significant at one percent level in all the regression in the models. The models explain more than 80 percent of the variation in the water use in the year 2012. The social and cultural practices were also found to affect the consumption patterns of the three major different ethnic groups in Malaysia. The Malay community in the sample was found to consume more water than the Chinese and Indian communities respectively.

Results of the study indicate that water pricing has a great potential of being an effective policy tool for water supply authorities. Price could be used to allocate and use water efficiently and could play a key role in the long run planning and conservation of water supplies. In this study, price variable is statistically significant at one percent level. This result shows that price charge for water will influence the total demand that have to be met by suppliers. The investments that have to be made by the authority will depend on the demand it has to fulfill. In addition, the demand is a function of price charged, a direct relationship between pricing policy and the scale of the investment is established. Thus, the water authority can make use of the simulated models to estimate the size of the facilities to be produced in order to make an efficient investment decision for future plan. The structured tariff mechanism was the most appropriate way to increase efficiency in the industry.

Abstrak

Permintaan air di Malaysia semakin penting kerana arus pertumbuhan penduduk, pertanian, dan pembangunan perindustrian yang semakin berkembang. Di samping itu, beberapa negeri menghadapi masalah kekurangan dan tekanan bekalan air yang serius seperti negeri Selangor. Di Johor, bekalan air yang diterima adalah mencukupi dan tidak serius, walaubagaimanapun, untuk membendung masalah ini langkah awal harus diambil meningkatkan keselamatan dan kualiti air minuman negara kita dan infrastruktur kumbahan air. Dianggarkan 40% daripada penduduk dunia kini hidup di kawasan yang mempunyai masalah tekanan air dan diramalkan pertambahan penduduk global tiga bilion orang pada tahun 2050 akan mengakibatkan kekurangan air yang amat serius untuk melangsungkan kelangsungan hidup di masa hadapan. Pakar ekonomi, berminat dalam memahami sifat empirikal permintaan air untuk meramalkan penggunaan air pada masa hadapan dan dalam penetapan harga juga ingin meningkatkan perancangan sumber air dan pengurusan yang efektif. Tindakan penting perlu diambil untuk menilai dan mengurangkan kehilangan air dan membangunkan teknologi keselamatan yang baru untuk mengesan dan memantau pencemaran dan mengelakkan pelanggaran peraturan keselamatan dalam permintaan air.

Kajian ini bertujuan untuk melihat hubungan diantara harga dan quantity serta pemboleh ubah lain dalam mempengaruhi permintaan air di Kluang, Johor. Teknik analisi panel data antara penggunaan dan perbelanjaan air dianggarkan dan hasilnya menunjukkan bahawa harga dan kuantiti air mempunyai hubungan yang positif di mana kenaikan harga akan membawa kepada peningkatan dalam penggunaan air kerana penggunaan harga purata dalam kajian ini. Regresi ini memberikan hasil yang terbaik kerana ia membendung masalah kepelbagaian individu dalam analisis ini. Keanjalan harga adalah 0.66-0.65 masing-masing. Tambahan pula, lima model yang berbeza telah di analisis dengan menggunakan 335 sampel isi rumah dan hasil kajian menunjukkan bahawa harga signifikan dan hampir semua regresi dalam model keseluruhan menerangkan lebih daripada 80 peratus daripada perubahan dalam penggunaan air pada tahun 2012. Gaya hidup sosial dan budaya juga didapati memberi kesan kepada corak penggunaan daripada tiga kumpulan utama yang berbeza etnik di Malaysia. Masyarakat Melayu dalam sampel itu didapati menggunakan air lebih benyak daripada masyarakat Cina dan India masing-masing.

Hasil kajian menunjukkan, harga air mempunyai potensi yang besar menjadi alat mengubal dasar yang berkesan bagi pihak berkuasa bekalan air. Harga boleh digunakan untuk memperuntukkan dan menggunakan air dengan cekap dan boleh memainkan peranan penting dalam perancangan jangka panjang dan pemuliharaan bekalan air. Dalam kajian ini, menunjukkan bahawa caj harga air akan mempengaruhi jumlah permintaan yang perlu dipenuhi oleh pembekal. Pelaburan yang perlu dibuat oleh pihak berkuasa yang akan bergantung kepada permintaan yang ia memenuhi. Pihak berkuasa air boleh menggunakan model simulasi untuk menyediakan kemudahan bagi membuat keputusan pelaburan yang cekap untuk rancangan masa depan. Mekanisme tarif berstruktur adalah cara yang paling sesuai untuk meningkatkan kecekapan dalam industri.

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Chapter 1

1.0 Introduction

Water, a word that is synonymous with life, is nature's free gift to the human race. It is very essence and the source of life thus no organisms can live without water. Importance of water to our earth seems to be unique among the other known celestial body. It has water, which covers over three fourths of its surface and constitutes 60 to 70 percent of living world. Water regenerates and is redistributed through evaporation, making it seem endlessly renewable.

However, just 1 percent of the world's water is usable to us, 2 percent is frozen in glaciers and polar ice caps and the rest 97 percent is salty sea water. The importance of water is always not appreciated. It takes a lot of effort to provide clean water to households.

Access to water is one of the pressing global issues of the 21st century. As our global population grows and becomes wealthier, the demand for water will greatly increase. At the same time, water availability and quality are also under growing stress from climate change, energy scarcity, land use decisions, and the requirements of industry and minerals processing. We will need to find better ways to both manage our current use of fresh water and configure it for the future, so as to be able to serve our growing populations and preserve stocks for future generations.

The world's 6.7 billion people consume about 4,500 km (4.5 teralitres) of freshwater annually, roughly 10% for domestic use, 70 percent for food production, and 20 percent for industrial purposes. This total represents less than five percent of that which is annually available through precipitation. The same is true of some traditional cultures with rice production. So while we face ever-growing demand for water on the one hand, we face severe supply constraints on the other. Research conducted by the World Resource Industries has found that 41 percent of the world's population or 2.3 billion people live in areas subject to frequent water shortages. These are defined as water stressed areas, where per capita water supply is below 1,700 m^3 (1,700,000 liters') per year (World Wildlife Fund Website).

Three significant factors impact negatively on the local availability of freshwater. Firstly, climate change induced glacier shrinkage is decreasing the availability of glacial water, threatening groundwater resources with salinization due to sea level rises, and endangering forests which store vast quantities of water, especially through increased wild-fires. Secondly, growing populations and rapid urbanization raise water demand due to higher consumption patterns. Thirdly, modern lifestyles promote activities such as high meat consumption that result in the use of large amounts of freshwater.

In Malaysia, we are blessed with an abundance of water resource with an average annual rainfall of 3 000 mm. It has been estimated that each of us enjoys a per capita renewable water of more than 5,000 m^3 per person per year. When compared to water resources available to people in many other countries where the per capita renewable water less than 1,000 m^3 per capita per year is not uncommon, the amount available to Malaysians is enormous. Yet, we are faced by water shortages and crises in many parts of the country. Obviously, the shortages and crises are not caused by having too little water to satisfy our needs. Rather, unsustainable management of water resources is the key issue.

We must re-think the way we use and manage water, and recognize the link between water and the natural environment. Sustainable water use is a possible solution and approaches such as Integrated Water Resources Management (IWRM) offers great potential as the way forward for ensuring the sustainability of our water resources. The scope of IWRM is wide and it emphasizes the integration of natural and human systems that include integration between the various components of water, and integration between water with the related land and environmental resources, and social and economic development. Sustainable water use through IWRM must happen at all levels and it needs to involve everyone from government agencies to private sector, NGOs, communities and individuals.

Table 1.1: *Raw Water Resource 2010-2011*

State	**2010 (MLD)**				**2011 (MLD)**			
	Direct Extraction from River	Storage Dams (Direct)	Ground Water	Total	Direct Extraction from River	Storage Dams (Direct)	Ground Water	Total
Johor	979 [r]	566	N/A	1,545 [r]	977	624	N/A	1,601
Kedah	1,277	15	N/A	1,292	1,328	13	N/A	1,342
Kelantan	226	N/A	150	377	239	N/A	164	403
Labuan	39	12	0.3	51	60	10	1	71
Melaka	298	214	N/A	512	312	216	N/A	528
N.Sembilan	466	374	N/A	840	543	344	N/A	886
Pulau Pinang	1,011	78	N/A	1,089	1,002	75	N/A	1,077
Pahang	1,035	N/A	28	1,063	1,051	N/A	29	1,080
Perak	884	447	N/A	1,331	878	476	N/A	1,354
Perlis	106	44	5	156	143	41	7	191
Sabah	707	272	19	998	710	275	22	1,006
Sarawak	1,006 [r]	109	0.4	1,115 [r]	1,003	116	0.30	1,119
Selangor	4,014	144	N/A	4,158	4,058	163	N/A	4,221
Terengganu	467 [r]	177 [r]	N/A	644 [r]	442	188	N/A	630
MALAYSIA	12,516 [r]	2,451 [r]	204	15,171 [r]	12,746	2,540	223	15,509

[r] = restated/revised

*** Million liters per day (MLD)**

Source: Malaysia Water Industry Guide 2012

1.1 Problem Statements

Major issues must be addressed to ensure sustainability of our water resources for now and in the future. They are:

i. **Over-emphasis on water supply management**

The water management system in Malaysia employs and depends heavily on the water supply management approach to cater to demand. This approach is unsustainable in the long run as water demand will eventually overtake water supply. The greater the demand, the more water has to be supplied so more structures like dams, water treatment plants and water distribution pipes need to be built. Where will it end? Supply and demand-side management has to be integrated. In addition, there is a need to look at water wastage and rates to change the appalling consumptive behavior of most Malaysians towards water.

ii. **High rates of water wastage**

Rates of water wastage in domestic, industrial and agricultural use are very high and this is unsustainable in the long term. Compared to other countries, Malaysia uses and wastes too much water.

iii. **High rates of Non-revenue Water (NRW)**

Rates of NRW in Malaysia are much too high with the national average being 40 percent. This equals a loss of 40 liters out of every 100 liters of treated water. If Malaysia can reduce the NRW losses to a minimum, the building of new dams could be delayed.

iv. **Low water rates**

Water rates in Malaysia are amongst the lowest in the world. This has not encouraged water conservation but instead led to water wastage and overuse, both of which undermine the sustainability of water.

In Malaysia, the demand for water has increased with the level of development. This has been a boon to Malaysians as the water that is necessary for drinking, cooking, personal hygiene and house cleaning has been made readily available to almost all the people through piped supply. However, in recent years the populace has become careless in the use of water. Although blessed with abundant rainfall, Malaysia's water demand has all but surpassed its natural supply. Average consumption per person in the home and at work has increased to an alarming level. Average consumption just at home now stands at about 226- 500 liters per person per day (LPD). This level of usage is far greater than many developing countries that have begun to mind how their water is used, who only use 60-150 liters per day (20 cubic meter per year).

The long-term water utility tariff model must take into account is accounting cost, social cost and sustainability cost. It is the target of many countries to set the tariff at full recovery of all these costs plus a margin. Water is a stable utility business and the margin cannot be high. Consideration must be given to the affordability of the consumers. As the economy grows, our income and corresponding affordability grow along and the tariff can be increased. It is imperative to appreciate that in a full recovery model, the cost recovery must be on the basis of an efficient and bloated cost to the consumers. For this, it is recommended that National Water Service Commission (SPAN) establish a regulatory accounting framework to shield off inefficient and bloated costs in tariff setting. The relevant costs and expenses submitted by the operators will have to be benchmarked and the related party transactions identified and transfer pricing set at arm's length. More importantly the demand aspects of water use have to be studied to manage water consumption on a sustainable basis.

1.2 Objectives:

In line with the issues raised above the objective of this study are:

i. To study the patterns of household water consumption in Kluang, Johor.

ii. To determine the price and income elasticity and other relevant variable elasticity's of demand for domestic water.

iii. To study consumers' behavior and awareness regarding water consumption.

1.3 Hypotheses:

The key hypotheses are:

Ho_1: Price of water has a significant impact on water consumption.

Ho_2: Income of consumer has a significant impact on water consumption.

Ho_3: Pricing policies can reduce the need for further investment in dams and reservoirs.

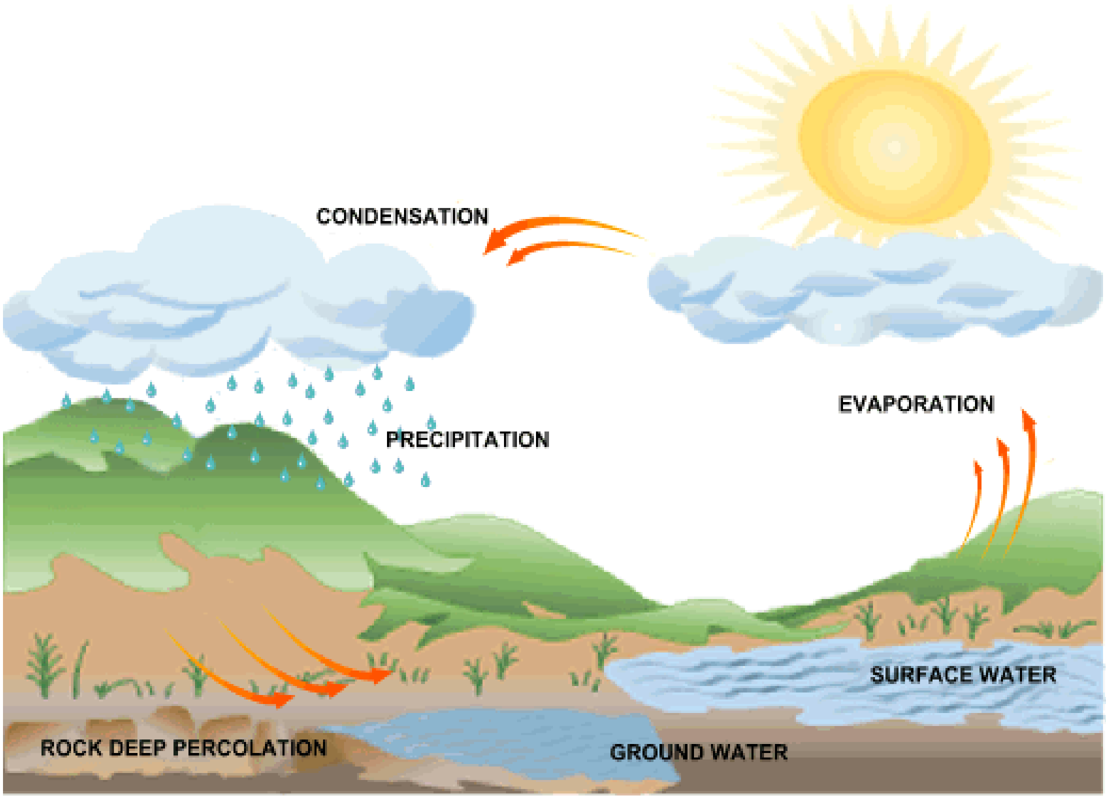
Chapter 2

2.0 Literature Review

2.1 Introduction

This chapter will provide a review of the literature on water demand, consumption and supply both locally and globally.

2.2 Water Cycle



(*Source: Syarikat Air Johor (SAJ) Website*)

Rarely have there been a raw water source that is suitable for domestic use, treatment process is normally required to exterminate all materials or elements that are not suitable for human consumption. In Johor, Malaysia an average daily household consumption is 5000 liters of water, where only five percent is used for consumption and food preparations while the remaining 95 percent is used for agricultural and industrial purpose.

In Malaysia, surface water is the main source of raw water. High rainfall flows into rivers, ponds, lakes or human made dams. Some of the rainfall is absorbed into the ground until it reaches a waterproof stone layer. This water can be obtained through wells or it can flow out as spring water in hill slopes. This water source is known as ground water.

2.3 Water Resources in Malaysia

Over the past 200 years, Malaysia has harnessed the abundant water resource for agriculture and water supply to industries and homes, where consumers have the convenience of running water at the turn of a tap. Wells have since been relegated to the past and collected water for cooking and drinking are a rarity. Water delivered by tankers, once not an uncommon sight, are now only contingency measures to tide over prolonged periods of drought and emergency.

The British laid down the foundation for piped water supply, shortly after they had set themselves up in Pulau Pinang, as their first base in Malaysia. When the population of new colony breached 10000, they drew up the first formal arrangement for water supply system in 1804. Convict labor was used to construct an aqueduct of bricks to transport clear stream water from the hills to town area. Earthen pipes were laid under the streets and water taken from them through tin pipes flow to homes. The water was untreated and was safe for consumption then. The brick in the aqueduct were often dislodged and was eventually replaced with a cast iron main in 1877.

This cast iron main is on record the first water main in Malaysia and traces of it can still be found in the Pulau Pinang water supply network. Sarawak was the next British colony to have water supply network starting with water mains in Kuching in 1887 to provide water to 8000 households. Kuala Lumpur was the next to have water at the turn of the tap, followed by Melaka in 1889 and the rest of Federated Malay States as they came under British colonial administration. Piped water was soon available to urban households and from standpipes throughout the country.

By early 1900s, water was no longer delivered untreated directly from the source to homes. Modern rapid filtration plants were only introduced in this country in the 1930s. The world historical development of water filtration can be traced back to the use of slow sand filters in 1829. However, it was the infamous lesson of the London Broad Street water well epidemic in early 1850s that slowed human disease was related to contamination from poor sanitation. After that event, there was an international movement to require all portable water to be filtered, generally using slow sand type filters.

Water began to be treated before distribution. This came about as a result of an international movement in developed nations that required the treatment of drinking water to prevent the outbreak of water-borne disease, such as cholera, typhoid and dysentery. As a British colony, Malaysia benefited from this development in water supply. It paved the way for water treatment engineers to design and construct filtration and water treatment plants. They were later replaced with slow sand filters with modern rapid gravity filtration plants, with rapid gravity filter, built in Air Itam in 1934 are still in service today. Disinfection technology using hypochlorite and later, gaseous chlorine made its appearance by 1915.

By 1939, households in the major towns of Malaya were well served with piped water. Many water installations, however, deteriorated from neglect during the war years of the Japanese occupation (1941-1945). Post war rehabilitation was slow and painful, with a shortage of treatment chemicals and demand overtaking supply. One of the most difficult supplies to operate then was the Kuala Lumpur supply, which had reached the limit of its capacity before the war and was now required to provide water to a swollen civilian population and heavy troop concentration. A number of small schemes were hastily implemented around Kuala Lumpur to meet the demand of the growing population.

By 1950, Malaysia had 100 treatment plants producing 195 million liters of water per day to supply a population of 1.15 million. Then, as now, water shortages were not uncommon, caused in by drought and rapid population growth. Demand for water increased sharply in the years after Independent in 1957, especially in the capital city of Kuala Lumpur, which was the focal point of the rural urban drift that occurred in the newly independent nation. To cope with rising demand, building the Klang Gates Dam and the Bukit Nanas Treatment Plant was put in hand and commissioned in 1959, ending a long period of water shortage and water rationing.

The Eight Malaysia Plan (2001-2005) projected water demand to increase by 5.4 percent per annum from 2001 to 2005. To ensure that there is ample supply to meet the nation's needs, the Federal Government allocated RM4 billion for water supply projects under the Eight Malaysia Plan. This is almost double the allocation under Seventh Malaysia Plan. The Eighth Malaysia plan also recommended Water Demand Management as a tool to stretch existing supplies and delay the development of large capital intensives projects. The asbestos cement pipes needed to be replaced to solve the challenges of water loss from leaking pipes.

Then, the 9th Malaysia Plan (2006-2010), under Ministry of Energy, Water and Communications a total of RM 8.1 billions was to be spent on water supply related projects of which RM2.7 billions will be for new water projects.

The 10th Malaysia Plan, a long-term strategy for water resource management underlined by the National Water Resources Policy (NWRP) will ensure efficient and effective management of the resource to cater to growing demands. Other measures include:

i. Expanding the implementation of the Integrated Water Resources Management and Integrated River Basin Management approaches in planning, managing, protecting and rehabilitating water resources and,

ii. A RM5 billion fund for flood mitigation programs and a restructuring of the water services industry, covering water supply and sewerage services, will also enter the final phase since its inception during the Eighth Malaysia Plan period. Some of the key focus areas:

- Full migration of state water operators to the new licensing regime will be completed. Upon migration, they will be governed by the Water Services Industry Act, 2006 and regulated by the National Water Services Commission.
- The phasing in of a tariff-setting mechanism to allow full recovery of costs to encourage sustained investments in upgrading and rehabilitating water treatment plants and distribution systems. The tariff increase will be segregated in bands based on consumption levels.
- National water supply coverage will increase from 93 per cent of population last year to 97 per cent in 2015.
- Sewerage services for households served by the grid and septic tanks will be extended from 28.8 million to 37.7 million. Some RM1.1 billion will be allocated to replace pipes and old meters to improve water quality and reduce losses in supply and,
- Parceling out the operations of centralized sewerage services to state water operating companies. An integrated tariff for both water and sewerage services will better capture the cost of service provision.

Table 2.1, a total of 63 water supply project have been approved under the Tenth Malaysia Plan by the Economic Planning Unit of the Prime Ministers' of Department. The approvals of these projects have been classified under the following programs categories:

Table 2.1: *A total of 63 water supply project have been approved under the Tenth Malaysia Plan*

No.	Programs	Project Quantity
1.	Construction/upgrading/renovation of existing and new water treatment plants and water distribution systems	34
2.	Programs controlling non-revenue water rate	17
3.	Development and maintenance of water resources	10
4.	Enhancement of efficiency and awareness in water services industry	2

Out of this total, 60 projects are already under way. They are in a preliminary stage such as appointment of consultant, designing, tender and procure mentor undergoing actual construction. Out of the said approved projects, this ministry has scrapped 3 projects. According to Table 2.2 the amount initially approved for the ceiling and allocation for the 10^{th} Malaysia Plan water supply development projects total RM1.594 billion and RM702.029 million respectively. The ceiling and allocation breakdown according to program is as follows:

Table 2.2: *The amount initially approved for the ceiling and allocation for the 10th Malaysia Plan*

No.	Programme	Project Quantity	Ceiling (RM) (million)	Allocation (RM) (million)
1.	Construction/ upgrading/ renovation of existing and new water treatment plants and water distribution system	34	905.970	383.398
2.	Program controlling non-revenue water rate	17	333.319	106.466
3.	Development and conservation of water resources	10	339.950	204.940
4.	Enhancement of efficiency and awareness in water services industry	2	15.500	7.225
TOTAL		**63**	**1594.739**	**702.029**

Note: figures for ceiling and allocation are inclusive for the 3 scrapped projects.

Sources: Water Supply Department

Table 2.3: *Total Length of Pipes in Malaysia 1983-2011*

Year	**Total Length of Pipes (km)**
1983	32,693
1984	34,302
1985	36,476
1986	39,681
1987	41,084
1988	43,643
1989	46,203
1990	48,762
1991	51,322
1992	53,881
1993	56,440
1994	59,609
1995	66,508
1996	67,484
1997	67,743
1998	68,131
1999	86,480
2000	87,090
2001	88,786
2002	90,544
2003	92,283
2004	94,668
2005	96,976
2006	105,513
2007	113,085
2008	118,580
2009	126,421
2010	127,994
2011	131,013

Source: Malaysia Water Industry Guide 2012

Table 2.4: *Total Length of Pipes by State in Malaysia 2010-2011*

Water Supply Entities	**Length of Pipes (km)**	
	2010	**2011**
Johor	19,191	19,824
Kedah	10,591 [r]	10,698
Kelantan	5,036	5,114
Labuan	484	809
Melaka	4,512	4,644
N.Sembilan	9,096	8,813
Pulau Pinang	3,981	4,052
Pahang	10,638	10,336
Perak	10,792	10,972
Perlis	1,814	1,838
Sabah	9,420 [r]	9,780
Sarawak	9,736 [r]	9,987
Selangor	25,427	25,927
Terengganu	7,305	8,219
MALAYSIA	**127,994**	**131,013**

[r] = restated/revised

km = kilometer

Source: Malaysia Water Industry Guide 2012

Notes:

i. Pahang Reduction in total length of pipes in 2011 was due to decommissioning of old pipes.

ii. N. Sembilan: Reduction in total length of pipes in 2011 was due to data being updated using GIS

2.4 Who manages water resources in Malaysia?

To manage the diverse issue and aspects in water provision, the federal and state governments have come to rely on the decentralization of responsibilities to various government agencies and later, to privatized entities. Malaysia's water industry structure is reflective of this, where both public and private service providers play an important role in the environmental, developmental, economic and operational aspects of water provision.

The structure of the industry comprises of various public and private service providers. Their roles and responsibilities are explained as follows:

2.4.1 <u>Federal Government</u>

Ministry of Energy, Water and Communications (MEWC)

Among the key functions of MEWC is the planning and implementation of water and sewerage infrastructure through the Water Service Department and the Sewerage Service Department. Additionally MEWC sets out the regulatory policies for SPAN in relation to the social, economic, consumer and technical aspects of the water and sewerage service industry.

Ministry of Finance (MOF)

MOF provides loans and grants for major capital investment in water supply and sewerage service developments undertaken by State service provider, or in the case of sewerage services by Indah Water Consortium.

Ministry of Health (MOH)

MOH plays a pivotal role in ensuring that the quality of water meets the national standards for drinking water as provided for in the National Guideline for Drinking Water Quality. MOH has also been leading The National Drinking Water Quality Surveillance Programme since 1983.

Ministry of Housing and Local Government (MHLG)

The Sewerage Service Department formerly under the MHLG was established in 1994 and took over the public sewerage system from 85 local authorities (except for Kelantan, Sabah, Sarawak, and Majlis Bandaraya Johor Bahru). Sewerage Service Department role include formalizing and implementing a programme to provide sewerage service, providing structural plans for the development of sewerage services, determining the minimum standards and specifications for sewerage system construction and installation, monitoring the enforcement of the Sewerage Service Act, issuing licenses to sewerage service contractors and ensuring their compliance with agreements.

Similarly, the water supply division formerly of the Public Works Department under the Ministry of Works is also now within the structure of Ministry of Energy, Water and Communications. The water supply Branch is involved in the implementation of inter-State water transfer projects and in providing consulting services on technical matters to water supply authorities, setting standards and criteria for design, operation and maintenance and standardization of water supply specifications.

Ministry of Natural Resource and Environment (MNRE)

As an agency under MNRE, the Department of Environment undertakes discharge regulation, setting and monitoring ambient river water quality standards and regulating new industrial development through environmental impact assessments as a means of monitoring and controlling activities and the discharge of effluents that would effect the water quality in rivers and water courses. The Department of Irrigation and Drainage is responsible for water resources, river and coastal works, urban drainage and flood mitigation.

National Water Service Commission (SPAN)

The SPAN Act was enforced by the Ministry of Energy, Water and Communications on 1st February 2007 and paved the way for establishment of the national water service commission or SPAN. SPAN was established to regulate the whole water service industry including sewerage service. Whilst the water catchment areas remain in the ownership of the respective States, any development affecting the water sources in the water catchment areas should take into account the needs of the water services providers, many of which are owned by the State Government.

This introduction of a centralized regulatory regime will greatly contribute towards improving efficiency and effectiveness in the water service industry. The presence of SPAN in the water service industry is to fulfill two main objectives:

- To support and provide an operating climate that is viable for operators to provide effective management of water and sewerage service.
- To protect the interest of consumers of the water and sewerage services in the country.

Water Asset Management Company (PAAB)

PAAB is an entity to rise affordable funding with the support of the federal government. PAAB will acquire water assets from the respective States including from IWK, Privatized entities that already own the water assets and new investment in water assets. PAAB also forms part of the Federal Government's efforts to restructure the water services industry in the country to achieve better efficiency and quality.

2.4.2 State Governments

Under the State Water Enactments, all States are responsible for public water supply covering development, operations and maintenance. In addition, the State's legislative power covers state works and water, including water supplies, rivers and canals. State Governments undertake regulation of abstractions and to varying degrees, monitor river water quality and development in water catchment areas.

State Public Works Department

Perlis, Kedah, Labuan and Sarawak except Kuching, Sibu, Miri, Bintulu and Limbang administer water supply through a State level Public Works Departments. This department also administers other services for infrastructure, such as roads, buildings and electrical works in the State.

State Water Supply Department

Pahang, Negeri Sembilan and Sabah have established a separate State owned water supply department to operate their water supply.

State Water Supply Board

Perak, Melaka, Kuching and Sibu in Sarawak operate their water supply through a State Water Supply Board. The body is considered to be more autonomous in their financial and administrative operations.

Regulatory Bodies

Regulatory bodies are formed in State where a previously State owned water supply department has been corporatized or privatized. The principle role of these regulatory bodies is regulating the water supply companies.

Water Supply Corporations or Companies

Water Supply Companies are essentially the corporatized entities of a State Water Supply Department. States that have water supply corporations or companies are:

- Kelantan
- Johor
- Pulau Pinang
- Terengganu
- Selangor
- Perak

2.4.3 Other Entities

Indah Water Konsortium Sdn. Bhd (IWK)

IWK is the privatized sewerage services provider established in 1993 as a privatized company that was awarded the concession to upgrade and operate sewerage systems that were previously under local authorities. In addition to operations and maintenance, IWK would also take charge of planning, design, construction and refurbishment of sewerage systems.

National Water Resource Council (NWRC)

There is a need to create inter-sectorial linkages between the physical, biological, economic and politic components. Established in 1998, NWRC was set up as a body responsible for the planning, development, regulation and management of water resources in country. Resolve water resource disputes between States, including establishment of a mechanism for agreeing terms. It's also managing on a national basis development and facilitates inter- State water transfers. Manage on a national basis to ensure long term sustainability of water supply and address the legal and other issues needed to facilitate increased use of inter basin and inter State water transfers.

World Wildlife Fund (WWF)

> Freshwater is perhaps the most crucial resource for humans and all other living creatures on earth. Sufficient clean water is essential for healthy living as well as the health of the environment. Our freshwater ecosystems continually face numerous threats and challenges. Recognizing this, WWF-Malaysia promotes the conservation, integrated management and sustainable use of the freshwater ecosystems.

Although the industry structure was not limited in its entirety, there are two major challenges associated with the water service structure. The self-regulation structure at the State level did not help to promote efficient and effective operations. Coupled with inability or the reluctance to revise tariff upwards for a long period of time, the State have to fund the operations and development of the water supply services, often from borrowings from the Federal Government.

There is a lack of co-ordination between the State-level and Federal-level Government, inter agencies, agency operator and agency-operator-consumer. This lack of centralized co-ordination has led to varied levels of industry performance across the State. The water services industry structure then allowed private operators to take on various parts of water services, but not all have met economic success in doing so. In turn, the main objective of creating an opportunity to raise funding for the construction, operation and maintenance of future water assets to achieve national development goals appeared to be at risk.

The problems of the water industry have been placed in "back waters". In the past, the problems are viewed as social challenges and never an economic challenge to be resolved. The problems are known and viewed as challenges to be resolved holistically. Going forward, the proposed industry model adopted in Malaysia aims to ensure a more holistic approach for the management of water services through an effective public-private partnership and the establishment of a socio economic regulatory body.

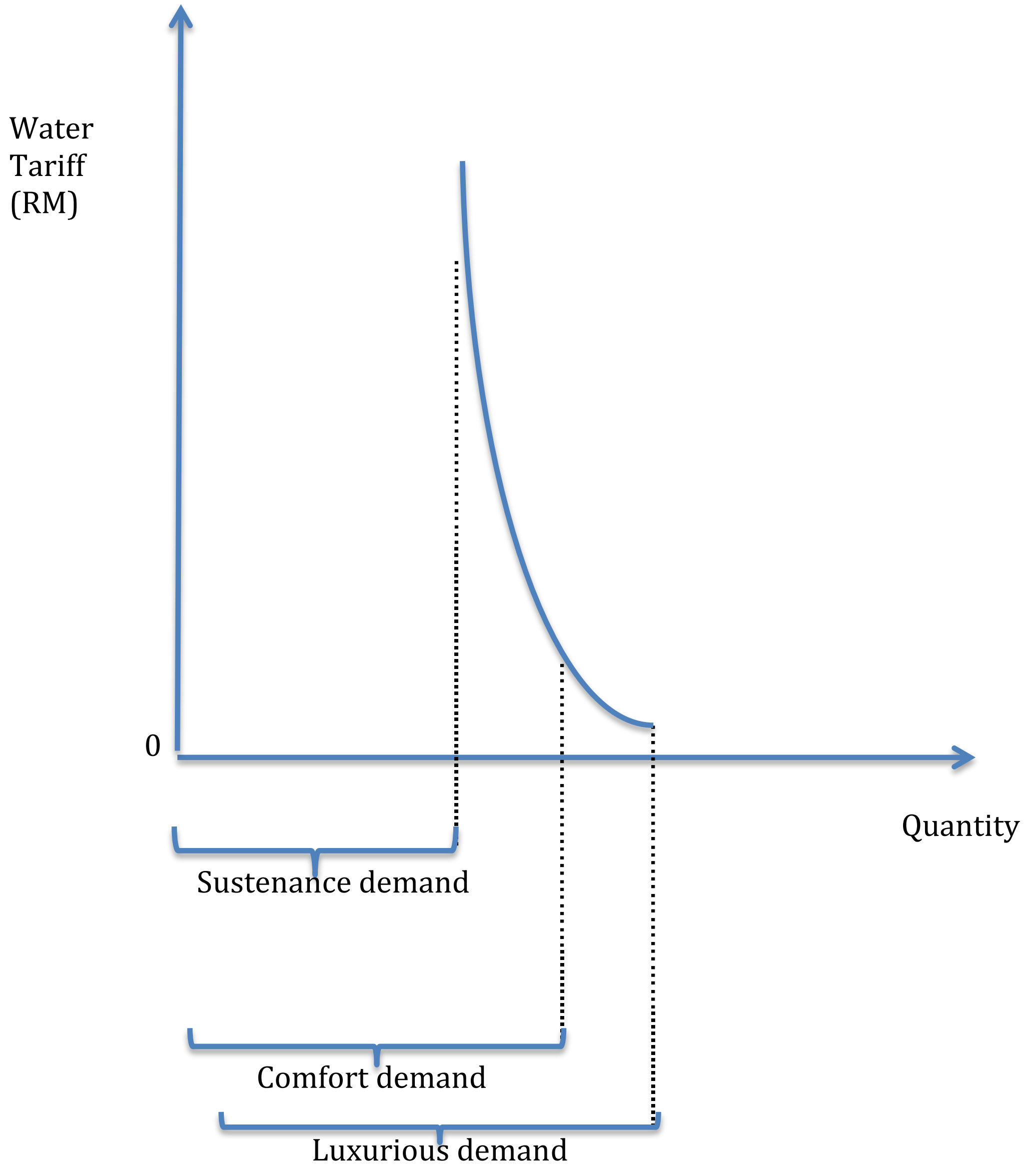
2.5 Demand for water

In Malaysia, the demand for water has increased with the level of development. This has been a boon to Malaysians as the water that is necessary for drinking, cooking, personal hygiene and house cleaning has been made readily available to almost all the people through piped supply. However, in recent years the populace has become careless in the use of water. Although blessed with abundant rainfall, Malaysia's water demand has all but surpassed its natural supply. Average consumption per person in the home and at work has increased to an alarming level. Average consumption just at home now stands at about 226 liters per person per day (LPD). This level of usage is far greater than many developed countries that have begun to mind how their water is used.

The long-term water utility tariff model must take into account is accounting cost, social cost and sustainability cost. It is the target of many countries to set the tariff at full recovery of all these costs plus a margin. Water is a stable utility business and the margin cannot be high. Consideration must be given to the affordability of the consumers. As the economy grows, our income and corresponding affordability grow along and the tariff can be increased. It is imperative to appreciate that in a full recovery model, the cost recovery must be on the basis of an efficient and bloated cost to the consumers. For this, it is recommended that SPAN establish a regulatory accounting framework to shield off inefficient and bloated costs in tariff setting. The relevant costs and expenses submitted by the operators will have to be benchmarked and related party transactions identified and transfer pricing set at arm's length.

Being an essential commodity for survival, the demand for water is relatively inelastic. Consumers will generally continue to consume the same water despite an increase in water charges. An incremental increase in water tariff has less than incremental decrease in the amount of water consumed. The inelastic demand for water is illustrate in Figure below:

Figure 2.1: *Inelastic Demand for Water*



Sources: Malaysia Water Association 2010

There is a certain amount of water that each consumer will continue to consume irrespective of the water tariff but within certain limits. If water tariff then reduces, the consumers are assuming to consume more to a level that they feel comfortable. Beyond that, the consumers will consume to wastage. Based on the demand curve above, water consumption did not reduce significantly if water tariff is increased. Whilst water is an essential commodity and the demand is inelastic, the government needs to fulfill Supply of water to all consumers including the rural consumers and affordable water tariff for the lower income group.

There is a growing debate that provision for water service should be charge on a full cost recovery basis. The challenge to the implementation of full cost recovery is the constraints on the ability and willingness to pay by the consumers. Demands for water have been increasing with urbanization from economic progress and population growth. However, the marginal costs of providing these services are increasing with rising environmental standards. Consumers' ability to pay is often much lower than full cost recovery, especially for the lower income groups.

Under the circumstances, the water tariff should continue to be distinguished between non-domestic usage and domestic consumption where the tariffs differ. However, the domestic tariff should be segregated into three progressive tariff bands based on the consumption level of each consumer. The increasing rate of tariff will also serve to encourage water conservation. The three-band tariff is consistent with the recommendation of the "Master Plan for the Development of Water Resources in Peninsular Malaysia 2000-2050, which recommended the following:

- Consumption up to 20 cubic meters per household per month (sustenance level) charged based on ability to pay by the lower income group.
- Consumption between 20-35 cubic meters per household per month (comfort level) charge based on ability to pay for average households
- Consumption in excess of 35 cubic meters per household per month (luxury level) charge based on trade tariff.

From the National Water Resources Study, domestic and industrial water demand for Peninsular Malaysia will increase three- fold from 9543 Mld (3483 million m^3/yr.) in 2000 to 31,628 Mld (11,543 million m^3/yr.) in 2050. By 2020, it is expected to increase by 2-fold. On a Peninsular Malaysia-wide basis, during periods of severe drought, the average natural or unregulated flows can barely meet the planned demand in 2050 of 31,628 Mld. Several dams form-impounding reservoirs have been identified for new source works required for augmentation of water supply over the next 50 years.

Table 2.5: *Domestic Tariff Ranking in 2012*

a) Water Rates (Domestic) 2012 for First $20m^3$

State	Last Tariff Review	Average Water Tariff (RM/m^3)	Ranking
PULAU PINANG	2011	0.22	1
KELANTAN	2001	0.40	2
PAHANG	1993	0.41	3
TERENGGANU	1997	0.42	4
PERLIS	1996	0.48	5
SARAWAK	1984	0.49	6
KEDAH	2011	0.50	7
PERAK	2006	0.50	7
SARAWAK[1]	2010	0.54	8
N.SEMBILAN	2011	0.55	9
SELANGOR	2006	0.57	10
JOHOR	2011	0.60	11
MELAKA	2011	0.60	11
SARAWAK[2]	1995	0.61	12
LABUAN	1982	0.90	13
SABAH	1982	0.90	13
NATIONAL AVERAGE		0.54	

b) Water Rates (Domestic) 2012 for First $35m^3$

State	Last Tariff Review	Average Water Tariff (RM/m^3)	Ranking
PULAU PINANG	2011	0.31	1
TERENGGANU	1997	0.52	2
KELANTAN	2001	0.55	3
SARAWAK [3]	1984	0.56	4
PERLIS	1996	0.57	5
PAHANG	1993	0.57	5
SARAWAK [2]	1995	0.61	6
SARAWAK [1]	1992	0.62	7
KEDAH	2011	0.67	8
N.SEMBILAN	2002	0.68	9
PERAK	2006	0.73	10
MELAKA	2011	0.75	11
SELANGOR	2006	0.77	12
LABUAN	1982	0.90	13
SABAH	1982	0.90	13
JOHOR	2011	1.05	14
NATIONAL AVERAGE		0.66	

Source: Malaysia Water Industry Guide 2012

Table 2.6: *Industry Tariff Ranking in 2012*

a) Water Rates (Industry) 2012 for First 80m^3

State	Last Tariff Review	Average Water Tariff (RM/m^3)	Ranking
SABAH	1982	0.90	**1**
LABUAN	1982	0.90	**1**
PULAU PINANG	2011	0.96	**2**
SARAWAK [1]	1992	1.03	**3**
SARAWAK [3]	1984	1.12	**4**
TERENGGANU	1997	1.15	**5**
SARAWAK [2]	1995	1.21	**6**
KELANTAN	2001	1.25	**7**
PERLIS	1996	1.30	**8**
KEDAH	2011	1.40	**9**
PAHANG	1983	1.45	**10**
N. SEMBILAN	2002	1.56	**11**
PERAK	2006	0.60	**12**
MELAKA	2011	0.67	**13**
SELANGOR	2006	2.27	**14**
JOHOR	2011	2.80	**15**
NATIONAL AVERAGE		1.33	

b) Water Rates (Industry) 2012 for First 500m^3

State	Last Tariff Review	Average Water Tariff (RM/m^3)	Ranking
SABAH	1982	0.90	**1**
LABUAN	1982	0.90	**1**
SARAWAK [1]	1992	1.06	**2**
TERENGGANU	1997	1.15	**3**
SARAWAK [3]	1984	1.19	**4**
PULAU PINANG	2011	1.19	**4**
SARAWAK [2]	1995	1.21	**5**
KELANTAN	2001	1.25	**6**
PERLIS	1996	1.30	**7**
KEDAH	1993	1.40	**8**
PAHANG	1983	1.45	**9**
N. SEMBILAN	2002	1.59	**10**
PERAK	2006	1.60	**11**
MELAKA	2011	1.80	**12**
SELANGOR	2006	2.27	**13**
JOHOR	2011	2.93	**14**
NATIONAL AVERAGE		1.36	

Source: Malaysia Water Industry Guide 2012

Sarawak[1] – Sibu, Kuching, Sri Aman, Limbang, Sarikei, Kapit, Miri
Sarawak[2] – Bintulu
Sarawak[3] – Other parts of Sarawak

There is a need to balance out the social obligations and the recovery of cost of supplying clean water to the consumers. The cost of water service should be fully recovered. As such, the long-term objective of the water tariff should be set to eventually fully recover the cost of water services. However, with the disparity of cost providing water services varying greatly between States, it would not be feasible to provide a common timeline towards full cost recovery.

The social aspect of tariff setting should not be just confined to looking after the needs of the poor, we must take into account the impact on the environment. The more water they're consume, the greater is the impact on the environment arising from sludge disposal as well as increase in waste water produced. Setting too low tariff does not help in conservation. For example, Pulau Pinang with the lowest domestic tariff consumes about 272 liters per capita per day (lcd), way in excess of the national average of about 185 (lcd). Setting a low tariff to meet the needs of the poorest segment of the society is unwise. The bulk of the subsidy goes to those who can afford to pay. There should be a direct rebate or subsidy to those in need.

Table on the next page shows Table 2.7: domestic water consumption by states in comparison to other selected countries and Table 2.8: overall water consumption 2010 and 2011 based on data in Malaysia Water Industry Guide 2012.

Table 2.7: *Domestic Consumption Per Capita Per Day 2009-2011*

State	**Domestic Consumption Per Capita Per Day (l/cap/d)**		
	2009	**2010**	**2011**
Johor	213	218 [r]	216
Kedah	231	222 [r]	226
Kelantan	137	145 [r]	137
Labuan	205	207	219
Melaka	225	231	233
N.Sembilan	215	223	227
Pulau Pinang	286	291	285
Pahang	183	175 [r]	186
Perak	222	228	230
Perlis	205	257	247
Sabah	106	85	107
Sarawak	134	188 [r]	188
Selangor	235	239	230
Terengganu	192	212 [r]	207
MALAYSIA	**210**	**209 [r]**	**210**

[r] = restated/revised

Source: Malaysia Water Industry Guide 2012

Table 2.8: *Water Consumption 2010-2011*

State	2010					2011				
	Domestic		Non Domestic		Total	Domestic		Non Domestic		Total
	MLD	%	MLD	%	MLD	MLD	%	MLD	%	MLD
Johor	730	70.5	306	29.5	1,036	738	69.6	323	30.4	1,061
Kedah	444[r]	67.6[r]	213[r]	32.4	657[r]	459	71.7	181	28.3	640
Kelantan	124	69.4	55	30.6	179	123	68.6	56	31.4	179
Labuan	19	50.5	18	495	37	21	50.6	20	49.4	41
Melaka	177	54.2	150	45.8	327	180	52.8	161	47.2	341
N.Sembilan	229	56.0	180	44.0	410	239	58.1	172	41.9	411
Pulau Pinang	468	59.8	315	40.2	783	459	59.2	317	40.8	776
Pahang	319[r]	73.9	113[r]	26.1	432	286	60.6	186	39.4	473
Perak	552	72.4	210	27.6	762	556	72.1	216	27.9	772
Perlis	63	87.7	9	12.3	72	62	84.6	11	15.4	73
Sabah	222	56.0	175	44.0	397	279	57.6	206	42.4	485
Sarawak	449[r]	58.1[r]	324[r]	41.9[r]	773[r]	431	57.3	321	42.7	752
Selangor	1,655	60.3	1,090	39.7	2,745	1,653	59.3	1,135	40.7	2,788
Terengganu	206	56.7	157	43.3	362	208	56.0	163	44.0	371
MALAYSIA	5,682	63.5	3,267	36.5	8,949	5,695	62.1	3,469	37.9	9,164

- *Data derived from upgraded billing system*

Source: Malaysia Water Industry Guide 2012

Notes:

i. Pahang: Total Consumption by Government Facilities in 2010 recategorised to non-domestic.

ii. Sarawak: Due to audited bill consumption of Kuching Water Board and Migration Billing System.

Overall, the total domestic water consumption is twice the amount of non-domestic consumption in Malaysia (Table 2.8). Such differences are even greater in some states e.g. Kedah, Perlis, Sabah, and Pulau Pinang. However, the average water consumption of non-domestic accounts is about three times the average water consumption of domestic accounts.

2.6 Non-Revenue Water (NRW)

Non-revenue water (NRW) is water that has been produced and is lost before it reaches to the customer. Losses can be real losses through leaks, sometimes also referred to as physical losses or apparent losses for example through theft or metering inaccuracies. High levels of NRW are detrimental to the financial viability of water utilities, as well to the quality of water itself. NRW is typically measured as the volume of water "lost" as a share of net water produced. However, it is sometimes also expressed as the volume of water lost per km of water distribution network per day.

2.6.1 Non-Revenue Water (Component)

a) Real Losses:

- Leak on pipe reticulation
- Leak on main pipes
- Water tank over flow

b) Commercial Losses:

- Unauthorized connection

Figure 2.2: *Water Leakage In Residential Area, Johor.*

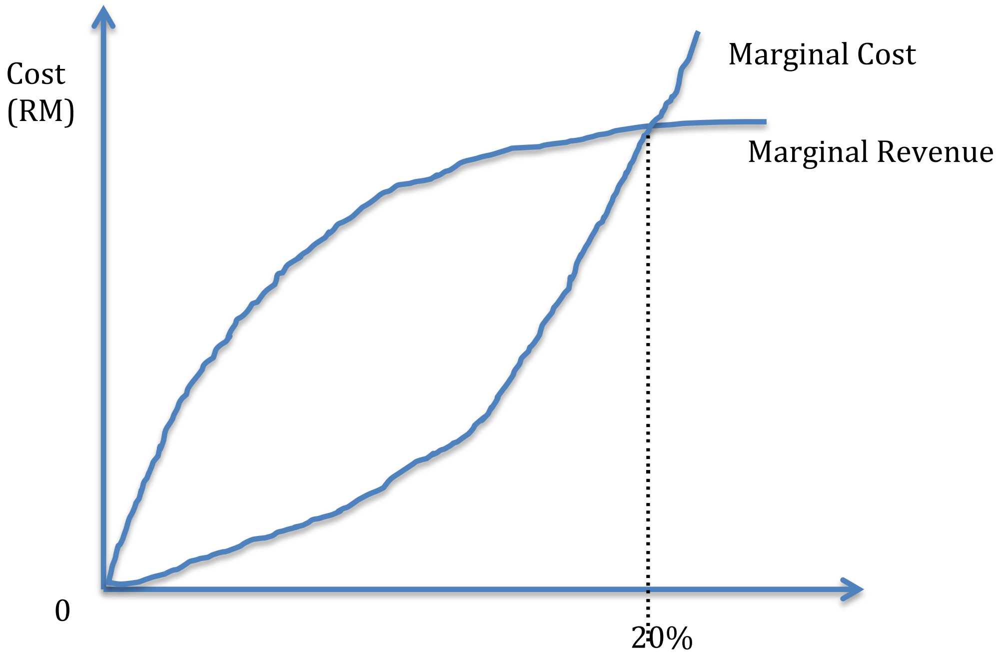
As part of the national water services activities, the government is now seriously looking on the Non-revenue water reduction works. According to Evaluation and Analysis of the various components of NRW losses (Prepared by IMA/AWWA) the components of NRW losses can be categorized Table 2.9 as below:

Table 2.9: *Water Balance*

<table>
<tr><td rowspan="10">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Water Consumption (Including Water Exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Loses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission & Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to Point of Customer Metering</td></tr>
</table>

There is a great need to address the issue of NRW, which is essential in making the proposed model sustainable. According to the World Bank, NRW costs about US$20 billion a year, of which developing countries account for more than US$9 billion. Currently, there is a proposal to target the reduction of NRW to 20%. There are various programs that are required to be implemented. As a start, it is best to examine the successful programed that Pulau Pinang has implemented. Pulau Pinang has managed to reduce the NRW to 19% in 2005 and planning to reduce it further to 15% by 2010. There are quick wins that NRW can be reduced at minimal cost initially. As the NRW is reduced further, greater effort and cost is required. There is a diminishing return on investment in addressing the NRW where by the marginal costs exceeds the marginal revenue as a figure 2.3 below:

Figure 2.3: *NRW where by the marginal costs exceeds the marginal revenue*



Source: Malaysia Water Industry Guide 2012

Table 2.10: *Non-Revenue Water (NRW) 2010-2011*

State	2010				2011			
	System Input Volume	Metered Billed Consumption	NRW	NRW (%)	System Input Volume	Metered Billed Consumption	NRW	NRW (%)
	(m^3 '000)				(m^3 '000)			
Johor	538,921	378,038	160,883	29.89	546,682	387,178	159,504	29.2
Kedah	435,492 [r]	239,684 [r]	188,019	44.9 [r]	447,444	233,764	213,680	47.8
Kelantan	137,494	65,427	72,066	52.41	147,048	65,213	81,835	55.6
Labuan	18,026	13,535	4,491	24.91	19,308	15,068	4,240	21.9
Melaka	161,552	119,515	42,037	26.02	166,037	124,426	41,611	25.1
N.Sembilan	264,228	149,539	114,690	43.41	270,731	150,107	120,623	44.6
Pulau Pinang	349,377	285,691	63,633	18.22	347,123	283,159	63,964	18.4
Pahang	352,587	157,625	194,962	55.29	393,938	172,587	221,351	56.2
Perak	394,377	278,239	116,138	29.44	404,759	281,734	123,025	30.4
Perlis	53,786	26,194	27,592	51.30	66,041	26,538	39,502	59.8
Sabah	339,881	144,955	194,927	57.53	361,000	177,173	183,827	50.9
Sarawak	397,728 [r]	282,251 [r]	120,806	29.0 [r]	395,324	274,604	120,720	30.5
Selangor	1,482,925	1,001,790	481,135	32.45	1,503,629	1,017,749	485,880	323
Terengganu	218,271	132,299	85,972	39.39	215,172	135,508	79,665	37.0
MALAYSIA	**5,144,593 [r]**	**3,274,657 [r]**	**1,867,350**	**36.4 [r]**	**5,284,235**	**3,344,808**	**1,939,427**	**36.7**

2.7 Water Demand Studies

Our existence depends on water, and it dictates the location and survival of civilizations. But few fully appreciate the role it plays in our lives and the amount that is truly required to feed us, and the implications this has for others. Globally, agriculture is the biggest user of fresh water. The Food and Agriculture Organization estimates farming accounts for 70 percent of global fresh water use. Irrigation will play a greater role in global food production in the coming decades. So as the world's population continues to grow, we will need to apply more efficient water management techniques. Demand for water has increased vastly over recent decades.

According to the World Meteorological Organization, global water consumption increased by six times between 1900 and 1995, which was more than double the rate of population growth. About 40 percent of the world's population currently lives in water stressed areas. With a global population increase of three billion people predicted by 2050, water scarcity will soon become a matter of life or death. The Economist newspaper reported in September 2008 that the bank JPMorgan believes that the five major food and beverage companies consume 575 billion liters of water a year between them, enough to satisfy the daily water needs of every person on the planet.

Adam Smith famously noted the distinction between market price and economic value in a passage in the Wealth of Nations describing the paradox of water and diamonds:

The word Value, it is to be observed, has two different meanings, and sometimes expresses the utility of some particular object, and sometimes the power of purchasing other goods, which the possession of that object conveys. The one may be called 'value in use'; the other, 'value in exchange'. The things that have the greatest value in use have frequently little or no value in exchange; and, on the contrary, those, which have the greatest value in exchange, have frequently little or no value in use. Nothing is more useful than water; but it will purchase scarce anything; scarce anything can be had in exchange for it. A diamond, on the contrary, has scarce any value in use but a very great quantity of other goods may frequently be had in exchange for it. (Book I, chapter IV).

Smith was using the comparison between water and diamonds to illustrate a distinction between two different meanings of "value". In fact, neither the distinction between the definitions of value nor the use of water to illustrate it was original with Smith. Two thousand years before Smith, Plato had observed that: "Only what is rare is valuable, and water, which is the best of all things ... is also the cheapest. In fact, Plato and Smith were both expressing a thought that had occurred to many other people over the ages, namely that the market price of an item need not reflect its true value. Market price reflects the fluctuating circumstance of daily life, whether the vagaries of supply (sudden scarcity, monopoly, etc.) or demand (temporary needs, changes in taste, fads and fashions), while the true value is something more basic, enduring, and stable.

For cases in which both supply and demand are disharmonic and seasonal, Riley and Scherer (1979) used a peak-load pricing for water. Three years later, Manning and Gallagher (1982) extended the model above and found that in the absence of storage capacity limits and direct costs of water, the price of water held in storage must rise at the rate of interest and that the effect of discounting is to cause a cycle in price of water. They observed that the Hoteling lemma regarding for the optimal price of an exhaustible resource available in a fixed quantity is just a limiting case of the kind of storage period and with no limit on the ability of storage capacity to carry this quantity over to the following periods.

A review of the academic literature reveals both a more sophisticated diagnosis of the problem and a more detailed prescription for addressing it. The literature clearly shows that public utilities in developing countries often serve only a fraction of the urban population, with the vast majority relying on alternate sources. Micro studies in urban areas such as Port-au-Prince (Haiti), Jakarta (Indonesia), and Onitsha (Nigeria) show also that the urban poor are disproportionately underserved poor households are almost never directly connected to the public utility, rely on vending systems, buy water by the bucket at very high unit prices, and hence consume very little water (Fass 1988, Whittington and others 1991, Crane 1994, World Bank 1994, 2003). Poor households often pay vendors several times the unit price paid by connected non-poor households to the utility, and they use only a fraction of the amount of water used by the connected. In many areas, water vending is no longer a fringe activity, and vending systems account for a large proportion of total water revenues. In Onitsha, for example, the water vending system collects 24 times as much revenue as the public utility during the dry season (Fass 1988, Whittington and others 1991, Crane 1994, World Bank 2003).

These findings strongly suggest that the widely used and well-intentioned public policy of keeping domestic water tariffs low is not working. According to the World Bank, this policy has resulted in massive and poorly targeted subsidization of service that has helped the rich but not the poor, has hurt the financial viability of utilities, and has led to deterioration in service quality, and consequently to low willingness to pay by users most communities are now caught in a low- price, low-quality equilibrium (World Bank Water Demand Research Team 1993).

Moreover, David Seckler (1998), It is important to emphasize that the prices which most users pay for water reflect, at best, its physical supply cost and not its scarcity value. Users pay for the capital and operating costs of the water supply infrastructure but, in the US and many other countries, there is no charge for the water per se. Water is owned by the state, and the right to use it is given away for free. Water is thus different from oil, coal, or other minerals for which the US government requires payment of a royalty to extract the resource. While some European countries, including England, France, Germany and Holland, do levy an abstraction charge for water, these charges tend to be in the nature of administrative fees and are not generally based on an assessment of the economic value of the water being withdrawn. Thus, in places where water is cheap, this is almost always because the infrastructure is inexpensive, or the water is being subsidized, rather than because water is especially abundant.

According to McCartney (1999) 321 cities had population in excess of 1 million and there were 15 megacities with populations of 10-20 million in 1995. He estimates that by 2025, about 56 percent of population will be urban and there will be more than 30 megacities. A recent UNESCO (2003) report indicates that at present 48% of the world's population lives in towns and cities; by 2030 the proportion will rise to about 60 percent (nearly 5 billion people). With this rapid increase in urbanization, it will be difficult for cities to meet the rising demand for freshwater with agriculture at the same time becoming increasingly dependent on irrigation. Rapid urban growth in developing countries puts tremendous pressure on their old and inadequate water supply systems.

Studied by Frederick (1999) water resources development around the world has taken different forms and directions since the dawn of civilization. Humans have long sought ways of reducing their vulnerability to irregular river flows and variable rainfall by moving, storing and redirecting natural waters. Early civilizations expanded in regions where rainfall and runoff could be easily and reliably tapped. He adds that the growth of cities required advances in civil engineering and hydrology as water supplies had to be brought from distant sources. In general, there are two classes of method for developing new sources of water supply where the traditional approach to construct wells, dams, reservoirs, canals and pumps over the years to collect, control and contain excess flows and to distribute water on demand during different periods. They help to change the world's varying water resources into reliable and controlled supplies. As a result, most water users take for granted that unrestricted quantities of freshwater are instantaneously available to them on demand.

Water shortage is becoming the greatest threat to food security, human health and natural ecosystems. Seckler (1999) points out there is an urgent need to focus the attention of professionals and policy makers on the problem of groundwater depletion and pollution, particularly in the more arid and semi-arid regions of the world like Asia and the Middle East. Moreover, these regions contain some of the major breadbaskets of the world such as the Punjab and the North China plain. Brooks (1999) identifies the origin of water stress stemming from three interacting crises:

- **Quantity**: the economic crisis - demands for freshwater exceed the naturally occurring, renewable supplies.
- **Quality**: the ecological crisis - much of the limited water is being polluted from growing volumes of human, industrial and agricultural wastes.
- **Equity**: the political crisis - the same water is desired simultaneously by different sectors within a single society or nation or by different countries wherever it flows (probably via a major river) through an international border.

Other than that, diverting water for irrigation in Central Asia has caused devastating effects. A notorious case is the Aral Sea. This has shrunk to a fraction of its original size and badly degraded in water quality. The latter has caused hundreds of thousands of people to suffer from anemia and other diseases due to the consumption of water saturated with salts and other chemicals coming from the cotton fields. (Serageldin, 2000).

According to Duda (2000), in developing and using water resources, priority has to be given to the satisfaction of basic needs and safeguarding of ecosystems. Beyond these requirements, water uses should be charged appropriately. Savenije

(2000), too, distinguished between primary water needs basic human needs such as drinking, cooking and hygiene and secondary need all other uses. The international consensus is that water for secondary purposes should be considered as an economic good, within which priorities in allocation should be based on socio-economic criteria, but could go as far as economic pricing.

Kundzewicz (2000) discusses the need for water resources management in terms of supply and demand. His conclusion is, firstly, that implementing intelligent water conservation and demand management programs, installing new efficient equipment and applying appropriate economic and institutional incentives to optimize water usage among competing groups, can largely avoid development of new sources of water supply. On the demand side, a variety of economic, administrative and community-based measures, he feels, can help conserve water immediately. He explains that while the links between population and freshwater resources are complex, there is no doubt that population growth increases the demand for freshwater. While new approaches to manage water supply and demand can help in the short term, reducing population growth is necessary to avoid a tragedy in the long term. There is an urgent need, he concludes, to slow population growth and to stabilize population size through family planning and reproductive health services. So Kundzewicz transforms the political crisis of Brooks into a political solution to the other crises, namely "rational" family planning.

Gleick (2000) indicates that there are five major drivers demanding a huge expansion of water resources in the 20th century is population growth, industrial development, and expansion of irrigated agriculture, massive urbanization and rising standards of living. The world population has grown from 1600 million to more than 6000 million over the last century. Land under irrigation increased from around 50 million hectares to over 267 million hectares. All these factors have led to more than six fold increase in freshwater withdrawals, from 580x109 m^3/yr. estimated for 1900 to 3700x109 m^3/yr. in 2000.

The increase in household water demand for example through an increase in garden watering and industrial water demand, due to climate change, is likely to be rather small, for examples less than five percent by the 2050s at selected locations (Mote et al., 1999; Downing et al., 2003). An indirect, but small, secondary effect would be increased electricity demand for the cooling of buildings, which would tend to increase water withdrawals for the cooling of thermal power plants. A statistical analysis of water use in New York City showed that daily per capita water use on days above 25°C increases by 11 liters/°C (roughly 2% of current daily per capita use) (Protopapas et al., 2000).

There are many ways that pricing mechanisms can be used to address scarce resources. Seagraves and Easter (1983) indicated that during seasonal shortages, higher marginal cost prices should be applied in order to recover fixed costs to ration all of the water during peak demand. In 2000, Johansson pointed out that many informal allocation systems had developed in the absence of prices or formal markets to address the scarcity. For example, Pakistan and India have been using the Warabandi system. Bali and Cape Verde have been using the Subaki system and the Entornador-Entornador system respectively.

In 2001, Griffin suggested a tariff structure for water that aims both at efficiency and revenue neutrality of water utility. He showed that water price should also include opportunity costs such as, user's marginal cost of water to take into account sacrifice of future uses of unrenowned groundwater supplies marginal value of raw water where, surface water and fully renewable ground water sources, in scarcity situations marginal capacity cost when water supplied with capacity installed is less than water demand.

All water sources are dependent on rainfall. Of the total average annual rainfall of about 320bcm for Peninsular Malaysia some 47 percent run off as surface flow and is available for use. The total annual demand is estimated to reach about 14bcm by 2020, which equates to 12 percent of the total water availability. However, water supply management and development in Malaysia is not centralized, but is managed on a state-by-state basis; and to cater for the differences in supply and demand inter state water transfer programmes have been implemented. To meet future requirements the National Water Resources Study (2000-2050), recommended 47 new dams and 3 new inter-state water projects among 62 water resource projects, including distribution systems (Dr. Ms Pillay, Ir. Tan Hoo, Keah Kwee Chu 2001)

To break out of this low-level equilibrium, World Bank experts contend, governments need to adopt a "demand-driven approach" in which utilities "deliver services that people want and for which they are willing to pay" (World Bank Water Demand Research Team 1993). There are two key ideas underlying the demand driven approach (Gulyani 2001). First, utilities can and should charge full costs for water and use the revenues to improve service and expand coverage that is, utilities should aim to move from a low price, low-quality service for all households to a high price, high-quality service for those who are willing to pay for it. Second, to do so, utilities and planners need to understand and respond to demand—quantity, price, and preferred service types and options in every community they intend to serve because demand is highly location-specific. In other words, by pricing the water right, effecting demand, and then responding to effective demand for water, governments and planners are well on their way to solving the problem.

The price of water or water tariff is the rate levied for the water supplied to consumers in order to develop sufficient revenues to provide for operation and maintenance and also for debt servicing. Water has traditionally been perceived as a public good that should be supplied free, or at a nominal price. But as the world's population increases drastically, the water is becoming more and more scare and its quality deteriorates due to rapid urbanization and industrialization. Hence, the cost of supplying potable water to consumers becomes much more higher and must be recovered from water charges. Therefore, tariffs must be designed so that at least operation and maintenance costs (preferably capital costs) can be recovered (Merrett, 2002).

Anything scarce and in demand commands a price where this is one of the basic principles of economics (Jones, 2003). Water is scare in some contexts (drought, degraded quality), so water pricing is increasingly seen as an acceptable instrument of public policy. The Organization for Economic Cooperation and Development (OECD) hypothesize that water should be treated as a product in the marketplace and discusses water pricing (Fujimoto and Tomosho, 2003).

In the UNESCO (2003) report, it is stated that a key component of non-structural approaches to water-resource management is a focus on using water more efficiently and reallocating more effectively among existing users. A general point made in the report is of considerable significance. It concludes that there is always great potential for better conservation and management, no matter how freshwater is used for agriculture, industry or municipalities. According to the report, water is wasted nearly everywhere and until actual scarcity impacts, most people will continue to take access to freshwater for granted. Low water prices have hampered the introduction of water saving technologies and contributed to its overuse. Developed countries show a wide range of variation in their water pricing, ranging from 0.4 $\$/m^3$ in Canada, 1.18 $\$/m^3$ in the UK, to 1.91 $\$/m^3$ in Germany.

Many non-climatic drivers affect freshwater resources at all scales, including the global scale (UN, 2003). Water resources, both in terms of quantity and quality, are critically influenced by human activity, including agriculture and land-use change, construction and management of reservoirs, pollutant emissions, and water and wastewater treatment. Water use is linked primarily to changes in population, food consumption including type of diet, economic policy including water pricing, technology, lifestyle and society’s views about the value of freshwater ecosystems. In order to assess the relationship between climate change and freshwater, it is necessary to consider how freshwater has been, and will be, affected by changes in these non-climatic drivers.

Water is differentiated by location, method of delivery, and extent of treatment, reliability, and other dimensions of quality. The costs of bringing water supplies to users differ greatly, so it can be expected the prices charged to the users also differ. There are different water prices, depending on the type of water service being provided, the decision being made, the revenue structure, or whether or not a water market is accessible to the water user. The correct definition of 'water price' should be: the charge or market price that would affect a rational water user's decisions concerning their pattern of water use, including quantities of water and water-related investments (Howe, 2005).

Water rate design depends on the objectives and these vary with circumstances. It is evident that there is no universal model (Garcia, 2005). The solutions have to be tailored for each case and be acceptable by the community. Thus, each water rate is unique and only applicable those users which the rate is designed for. They should not carelessly apply the same water pricing mechanisms to every country, but should develop different types of water pricing mechanisms according to the different backgrounds, such as geophysical or historical characteristics of each country.

The general principles underlying the present water tariffs in Malaysia include the Higher rated for higher consumption to discourage wastage, Cross-subsidy for domestic consumers by industrial consumers and a very low 'lifeline' rate to meet the 'ability to pay' criterion of the lower-income group to cover basic everyday need for domestic purposes (Cassey Lee, 2005). The incentives for efficient use of water are applied through the use of volumetric charges based on measured water use under an increasing block structure where block price rises with use rise. This approach is used for the water tariffs for residential homes (with the exception of Sabah which uses a flat rate). There are significant differences in the structure of residential water tariffs between the different states.

Studied by Scudder (2005) in developed countries, the number of dams is very likely to remain stable, and some dams will be decommissioned. With increased temporal runoff variability due to climate change, increased water storage behind dams may be beneficial, especially where annual runoff does not decrease significantly. Consideration of environmental flow requirements may lead to further modification of reservoir operations so that the human use of water resources might be restricted.

In his seminal article, Monteiro (2005) pointed out that determination of water price when facing capacity restrictions has been an issue of research for both water supply and other public utilities like electric power supply for which such decisions are generally studied together with the decisions to expand the system. Additionally, he found that peak-load pricing might postpone investment in system development in comparison with other more inefficient pricing schemes. According to Monteiro (2005), scarcity is a more recent apprehension than capacity restrictions, reflecting the fact that the common approach in rising water demand in the past was to extend the water supply system.

In Olmstead, Hanemann, Stavins (2007) Assumed that the four weeks of water demand they observe are representative of annual patterns, the total average annual household expenditure on water in this sample, including fixed charges, would be about $327. Household demographic data were collected by survey.

These include lot size, square footage of homes, number of bathrooms, and family size. Home age is also included in the water demand equation, and they expect that both very old and new homes may use less water than “middle aged” homes. They also control for the presence or absence of evaporative cooling, which substitutes water for electricity in air conditioning. They include a set of daily weather variables. Maximum daily temperature is represented by *maxt, weath* represents the moisture requirements of green lawns not met by precipitation, and *seas* is a dummy variable set equal to one during the arid (peak outdoor watering) season. Finally, the models include a set of dummy variables that represent the 11 urban areas included in the study.

Muyibi, Suleyman A. and Abdul Raufu Ambali (2008), Malaysia’s recent economic development has relied on a growing industrial sector, the expansion of irrigated agriculture, and an increasing urban population. This multidimensional growth is now placing a great deal of stress on water supplies. With approximately 22,000 cubic meters of water available to each person annually, Malaysia is not considered water stressed. However, pollution from industrial, agricultural, and domestic sources is a major source of concern. Rapid population growth has contributed to the increasing volume of domestic sewage discharged into rivers and drainage systems. Livestock breeding and indiscriminate use of pesticides has also negatively affected the quality of water supplies. Waste from rubber and palm oil factories continues to be a problem, although the adoption of effective treatment systems has reduced the volume of untreated waste from these industries in recent decades.

Ghazali Mohayidin (2009), Water demand and its production cost are changing over time and thus water authorities set various prices for different seasons. In summer, when weather is warm and dry, consumers' water demand increases and water authorities use higher prices to encourage consumers to decrease their water consumption. Using various rates in summer is the most effective method in comparison with the use of maximum rate in this season. While various seasonal prices reflect seasonal change of parsimony costs, rates could be strong motive for conservation, economical return and equality.

2.8 Household's Water Demand

The literature on residential water demand has expanded significantly in recent years in terms of scope and sophistication, as quantitative, regression based studies have illuminated many relationships while simultaneously identifying several new research questions. Firstly, the main findings on the determinants of residential water use are presented. Four types of explanatory variables are considered: socio-demographic characteristics, attitudinal factors, pricing policy measures, and non-pricing policy measures. The sub- section on socio-demographic characteristics also includes a discussion about weather variables, whenever applicable. Secondly, the results of the literature reviewed on the willingness-to-pay for water services are summarized.

Headley (1963), the impact of family income on residential water demand is studied on the basis of data from 14 cities in the San Francisco-Oakland metropolitan area. Income is the only variable included in the model as it is thought to be a good proxy for all those factors that induce consumers to demand more water for example dishwasher ownership, number of bathrooms. The relationship between the average percentage change in water purchase associated with a given percentage change in the median family income is estimated for 1950 and 1959. The results translate into income elasticity estimates of 1.49 and 1.24, respectively, suggesting that water consumption is very responsive to changes in income. In the analysis of the data over the ten-year period (1950 to 1959), the income elasticity estimate is much lower, although more plausible, with a weighted elasticity for the entire population reported at 0.19, suggesting that a 10% increase in income results in a 2% increase in water use. The study concludes that there is a significant positive relationship between family income and residential water consumption.

Another study by Wong (1972), the demand for municipal water is estimated with data from Chicago and nearby communities over the period from 1951 to 1961. Two analyses are carried out: a time-series analysis involving Chicago and 59 neighboring communities where cross- sectional analyses involving 103 public water supply systems. In the former analysis, average per-capita municipal water demand is expressed as a function of price per 1 000 gallons, average household income, and average summer temperature which in the latter analysis, temperature is excluded and sample communities are divided into four groups according to size. In both cases, income is found to be a statistically significant variable for Chicago in the time-series analysis and for the two largest groups of communities in the cross-sectional analysis. The time-series model provides a lower estimate of the income elasticity 0.2 for Chicago versus 0.48 in the cross-sectional model. However, income does not seem to have any significant impact on per-capita water consumption in suburban or small communities. Average summer temperature is significant in both suburban and urban centers.

In the study undertaken by Kuperan (1980) the impact of price has the great potential of being an effective policy tool by water authorities in the allocation and planning of water supplies. A cross sectional analysis of a stratified random sample of 101 household were used in the study and average income elasticity of demand for domestic water was calculated from linear and logarithmic linear equation. The price elasticity was found to be in the region of 0.08- 0.53. There was a positive relationship between income level of consumption and the price elasticity. Such a pricing system will offer both conservational and distributional advantages at a time when increasing water demands are putting pressure on existing water supplies. In areas where incomes are high, a rise in water price could help delay required capacity expansion and thus lower the long run average cost of water.

Remee Dass Annaniah (1985) studied show that price, income and other relevant explanatory variable elasticities can be used as an effective policy instrument by water authorities in the allocation and planning of water supplies. Water conserved through proper management and pricing policies for example by increasing block rates pricing would be much more cost effective than financing storage capacity expansion.

In Nieswiadomy and Molina (1989), the demand for water use is estimated based on micro data time-series (monthly) observations for the same group of consumers facing a decreasing block-rate pricing for the first half of the time series and an increasing block- rate schedule for the second half of the time series. Out of the 60 000 households living in the city of Denton, Texas, 101 consumers are randomly sampled, with their monthly water billing records obtained from the city's water department from 1976 to 1980, under a decreasing block-rate system, and from 1981 to 1985, under an increasing block-rate system. Only summer months are considered. Furthermore, the sample data are screened in such a way that the sample only includes houses with lawns and without swimming pools and owned by the same families over the entire time period. The model also includes income and weather as explanatory variables. Independently of the type of block-rate pricing scheme in place or of the estimation technique employed, households with higher incomes, bigger houses, and bigger lots are found to demand more water. Moreover, the effect of hotter temperatures on water consumption is significant and as expected positive.

They estimate the price elasticity of water demand with household level data, structurally modeling the piecewise-linear budget constraints imposed by increasing-block pricing. They develop a mathematical expression for the unconditional price elasticity of demand under increasing-block prices and compare conditional and unconditional elasticity analytically and empirically. They also test the hypothesis that price elasticity may depend on price structure, beyond technical differences in elasticity concepts. Due to the possibility of endogenous utility price structure choice, observed differences in elasticity across price structures may be due either to a behavioral response to price structure, or to underlying heterogeneity among water utility service areas.

Cheng Ming Yu (1996) found that the price variable is an efficient tool for managing the total demand that a water authority faces. To promote conservation in water consumption, increasing block rate structure is more preferable. According to Shin's perception price model by her was found that more frequent billing system should be adopted to achieve the conservation purpose.

Based on the analysis of billing records provided by Aurora Water, approximately 70-80 percent of deliveries in the utility's service area are to residential customers, with single- family homes accounting for the bulk of these deliveries. Stretching supplies to meet demands in Aurora has been a growing challenge for several decades, as rapid population growth, combined with limited opportunities to expand supply, have placed a premium on demand management. In this respect, Aurora is similar to cities across Colorado's Front Range and much of the southwestern United States (Nichols and Kenney, 2003).

Most of the attention was directed to seek for the best price mechanisms to regulate demand (Young, 2005, Campbell et al 2004, Green 2003, Nauges and Thomas, 2000, Winpenny, 1994). To ascertain the main drivers behind domestic water consumption or to make forecast for the short/medium term, econometric models have been widely proposed (Aghte and Billings, 1980, Campbell et al 1999, Dalhuisen et al 2002) using different sets of data, in time series, cross-sectional or panel data formats (Arbués et al. 2004, Dalhuisen et al. 2003, Martinez-Espineira, 2002). Water demand equations generally take a form where the quantity of water consumed is expressed as a function of price, income and a set of other factors. In the recent years, more and more variables have been incorporated into the models to the point that currently, the drivers of domestic water demand may be very varied (Nauges and Thomas, 2002).

Income importantly affects the responsiveness to price mechanism. Thus, while low-income families may not respond to price because they are using water mostly to fulfill basic needs, well-off individuals or households fail to respond because the price signal is not strong enough to curb their consumption (Renwick and Archibald 1998, Renwick and Green, 2000). The extreme case could be found where piped water supply is not available where slums area in Third World cities, rural poor regions, and so on. Water vendors sell pricey water to the citizens. This suggests that a conservation campaign based on price mechanisms may probably achieve larger reductions in domestic demand in lower income zones than in higher income communities (Hajispyrou et al 2002). Moreover household price responsiveness may not only vary depending on income but also it may vary seasonally, for example, increasing the responsiveness during summertime (Renwick and Green 2000).

Studies of residential water demand in industrialized countries have mostly concerned the measurement of price and income elasticities. In these countries almost all households have a link to the piped water network and tap water, generally of good quality is the primary source for all water uses. These characteristics permit a relatively straightforward estimation of the household water demand function. The chief methodological issue that has been extensively discussed in this literature is the nonlinearity of the pricing scheme, which may cause endogeneity bias at the estimation stage.

Analyses of household water demand in less developed countries (LCDs) first appeared in the work of White and others (1972), Katzman (1977), and Hubbell (1977) but remain limited even today. One reason for this lack of attention is that analyses of household water demand in LDCs are more difficult to do. This is mainly because conditions surrounding water access often vary across households, and this variability makes it almost impossible to base a comprehensive analysis of household water demand on secondary data from the water utility. Households often rely on a variety of water sources, including piped and non-piped sources with different characteristics and levels of services which are price, distance to the source, quality, reliability, and so on. Furthermore, many households in LDCs water is a heterogeneous good, which is not usually the case in industrialized countries (Mu 1990). Obtaining water from non tap sources outside the house involves collection costs that need to be taken into account to assess household behavior accurately.

In the study Céline Nauges and Dale Whittington (2010) have employed four principal strategies to obtain the information needed to investigate household water demand behavior in LDCs. First, well-designed household surveys can be used to complement existing data from public and private utilities. Second, households can be asked questions about how they would behave in hypothetical water use situations for example that studied by Whittington and others (1990), The World Bank Water Demand Research Team 1993 and Whittington and others (2002). Third, researchers can look to secondary markets such as housing to draw inferences about how households' value improved water services. Fourth, experimental methods (including randomized controlled trials) can be used to test how households behave in response to different water supply interventions (Kremer and others 2007, 2008).

This paper reviews the literature that uses data from utilities and household surveys to estimate household water demand functions, not papers that investigate water demand behavior based on stated preference techniques, revealed preference techniques, or experimental methods. They begin with an overview of three large groups of households in LDCs and discuss why water planners need somewhat different information about household water demand behavior to address the policy challenges each household group poses. Then they provide a brief overview of the literature on the estimation of water demand functions in industrialized countries because research based on data from LDCs has been informed by findings from this work. Methodologies developed to correct for price endogeneity under nonlinear pricing have in particular been applied in recent studies of household water demand functions in LDCs. (Celine Nauges and Dale Whittington 2010)

In almost all studies performed in industrialized countries, the residential water demand function is specified as a single equation linking (tap) water use (the dependent variable) to water price and a vector of demand shifters, which are household socioeconomic characteristics, housing features, climatologic variables, and others. In addition, to control for heterogeneity of preferences and other variables affecting water demand. A popular functional form is the double-log, which yields direct estimates of elasticities but constrains the elasticity to be constant. There are few discussions on the choice of functional form, except by Griffin and Chang (1991), who advocate more flexible forms such as the generalized Cobb-Douglas, and Gaudin and others (2001), who discuss the trade-off between simplicity and parsimony of parameters.

This single-equation modeling strategy implicitly assumes that there is no substitute available for water. Water quality and the reliability of the water supply service are generally not included in the single-equation model as controls because there is little variation in terms of service quality across households on the same distribution system. The focus instead has been on the estimation of price elasticity and the measurement of the impact of socioeconomic characteristics mainly income on the quantity of water used.

The main methodological issues relate to the choice of marginal or average price and to price endogeneity when households face a nonlinear pricing scheme such as an increasing or decreasing block pricing tariff structures. Although economic theory suggests the use of marginal price (the price of the last cubic meter), average price (computed as total bill divided by total consumption) has often been preferred.

Authors who use average price argue that households are rarely well informed about the tariff structure used by their local water utility and are thus more likely to react to adjustments in average price than in marginal price. Estimation of the residential water demand function when the pricing scheme is nonlinear has been the focus of numerous articles, including in the studied by Agthe et al 1986, Deller et al 1986, Nieswiadomy and Molina 1989, Hewitt and Hanemann 1995, Olmstead et al 2007.

In studies of household water demand functions in industrialized countries, data for the model estimation typically come from water utility records. An important advantage of relying on water utility records is that panel data on each household's water use are usually available. A disadvantage is that water utilities typically maintain little socioeconomic or demographic information on the households they serve. There is also little variation in potentially important covariates, such as the tariff structure itself and water quality and reliability.

Most studies find that household water demand is both price- and income-inelastic. Espey and others (1997) report an average own price elasticity of –0.51 from industrialized countries. Income elasticity has often been estimated in the range of 0.1–0.4. Other household characteristics like size and composition, housing characteristics (principal versus secondary residence; size of the lawn or garden, if any; stock of water-using appliances), and weather data are commonly acknowledged as determinants of water use in industrialized countries.

Chapter 3

3.0 Methodology

3.1 Introduction

This chapter, both the methods used in the collection and analysis of the data in the study will be explained in great detail. The areas covered in this chapter included methodology demand of water, household water demand, demand models, model of estimating household water demand, data collection where it covers the data collection procedures followed and the methods used to measure the variables in the study. This chapter ends with estimation techniques that have been used in this study.

3.2 The Study Area

This study was undertaken in Kluang, Johor to examine the consumption patterns and domestic households water demand in the city. Kluang with a population of 160,000, is the largest district of Johor state's. This town was selected as the study area because the water authorities Syarikat Air Johor (SAJ) undertook water tariff rates revision on 2011. Therefore, this will enable to study and observe the patterns of household water consumption and how consumers' response towards price changes in the area over those periods of time in Kluang, Johor. Other than that, the major reason was the area is the author's hometown. Therefore, greatly reduced the expenses and increased the ease of conducting the survey in a familiar place.

3.3 Data Collection

Using both primary and secondary data is preferred. Then, in this case study the data is about the consumption of water for certain random area in Kluang. The primary data was collected via standardized questionnaire and single interview of respondents. To minimize the bias and errors, the interviews were conducted with utmost care by the author herself. Hence, the secondary data was collected from the e-records of Johor Water Department (SAJ) where the data set consisted of water consumption figures of the individual households were obtained from the e-billing system of the SAJ water department. The author was also able to get assistance from water authorities (SAJ) in the early sampling and later secondary data collection stages of the study. All the data set from primary and secondary channel was then transferred to excel spreadsheet for ease of data regression process. Couple of weeks was taken to enter all the data with help of two friends to key in all the data.

3.4 Sampling procedure

The data set consists of a random sample of 335 households from the Kluang area. The sample size was determined that way because of to get a positive significant level in the result for this observation and the restraint of time and financial points of views. Data was collected from 19 housing area in Kluang where including urban and rural area and houses interviewed were chosen from 15-40 houses in the particular area low cost housing schemes, village, government servant quarters, housing estates. Specific codes and billing account number of respondents in primary data collection have been took, so it will be easy to trace all the information and figure on water consumption within 5 years where the water consumption in quantity (m^3) and prices that they paid every single month was taken from year 2008 until 2012.

3.5 The Questionnaire

A sample of questionnaire in the early stage was draw up by incorporating important and pertinent issues that bear upon the purpose of the study. A pre-test of 10 questionnaire was distribute to a group of lecturer to check the clearness, inclusiveness, effectiveness, and appropriateness of the questionnaire as well as the responses of the sample that have been analysis. Some adjustments were then have been made as a result of this pre-test and the final version of questionnaire was set up then. Some of the important questions found in the questionnaire are the households income per month, the households size, characterize of the housing type, and daily water usage in lawn area, cooking, wash and the most important things was to have a look on their monthly water bill to write down the billing account number to know about the quantity and price they used and consumed in SAJ consumer service e-billing system.

3.6 Conducting the Survey

Great effort was taken to explain wisely and clearly to the respondents about the purpose of the survey was conducted. This was to eliminate the fear of respondents that the enumerator was from the income tax department and politic interference because of the election that time. This ensured that the respondents would talk freely and willing to give truthful answers while interview process took place. The only sensitive question was that requiring respondent to state their households income per month. To minimize the error great effort was taken to emphasize that the information given by them will be confidential and just used for the research process only and some of the pay scales are common knowledge and can be expected when we know the occupation of the respondent and the households.

First of all, the respondents were asked about the households' income and the length of period that they have lived in that particular house. The interviews were conducted in the respondent's house that starts in the morning at 10.00am to 2.00pm and continued in evening at 4.00 to 7.00pm as the author had aimed to finish 30 respondents daily within 11 days. The author conducted the survey by herself to minimize data collection error. The survey was carrying out on the 29th Mac 2012 and ended on the 8th April 2012. For the whole survey, 3 samples were discarded, this was because their records is not found in the file that send to the author by SAJ authorities. Moreover, around 18 respondents will not had complete consumption data because they recently move to that houses, therefore the respondents past consumption was not available, however all the incomplete data is still have been used to data regression. This means that 335 out of the 338 respondents in the sampling list could be used in analysis where that is about 99 percent of the chosen sample. Finally, the survey was successful as it was carried out without difficulty and the respondents were very cooperative.

3.7 Variable Measurement and Framework of Analysis

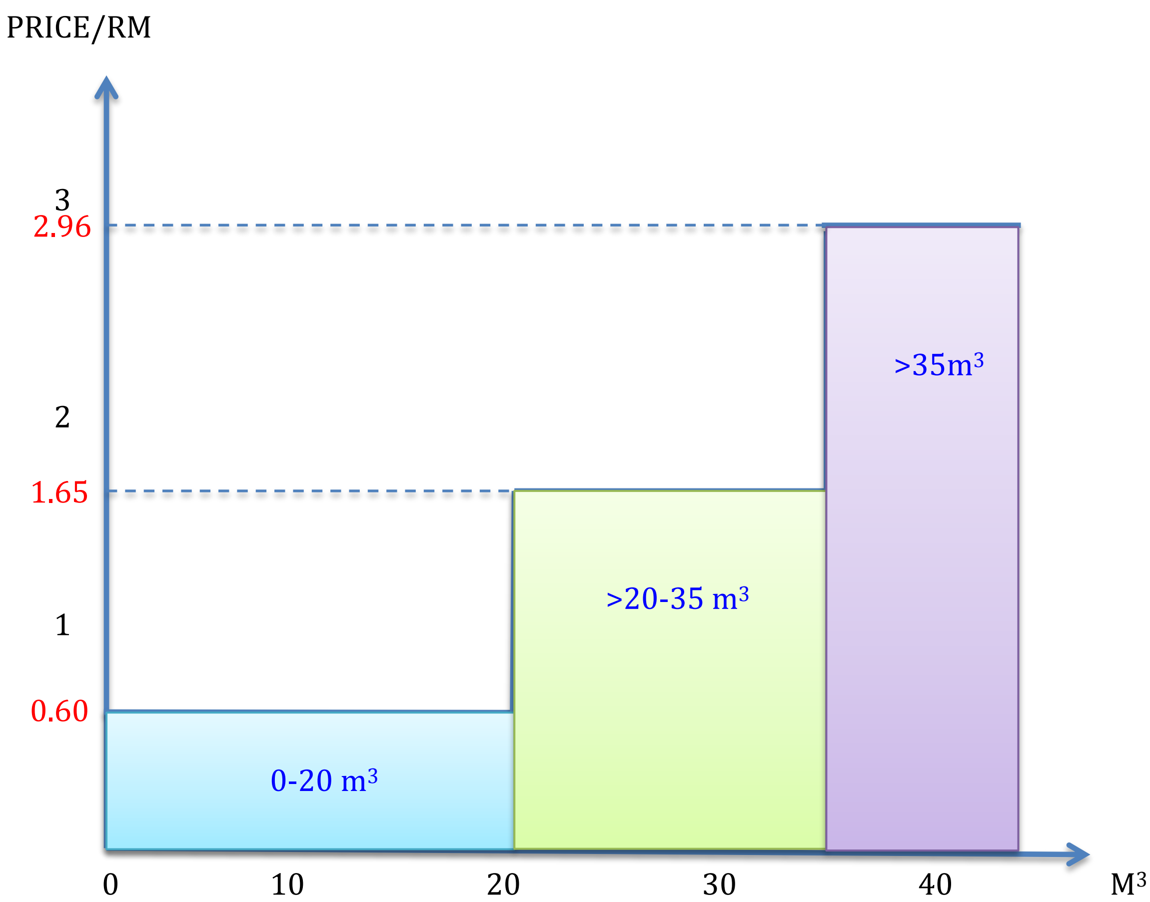
The main analytical tool in the study is double log linear via random effect and multiple regressions through both linear and logarithmic linear equations. The effects of income, price of consumption, household size, house characteristic and other variables such as lawn, water use in washing cloths, vehicles, and cooking at home on the demand for water among households of Kluang were examined using cross-sectional, time series and panel data. In the analysis it was assumed that different household units are homogeneous except for those variable explicit incorporated in the analysis. The relationship between consumption of water and the explanatory variables specified above was estimated by means of regression analysis. The regression variables were expressed both in per household and per capita terms in order to account for the possibilities of economics or diseconomies of scale in water consumption owing to the different in family size.

3.7.1 The Dependent Variable

The consumption of a commodity can be measured either by quantity or expenditure. If the product price paid per unit of the good purchased is the same good for all the consumers', than it is irrelevant whether quantity or expenditure is used as the dependent variable. In this study, even though water was a homogenous product but different consumers pay a different average price according to the quantity consumed per period. This is because the water utility charges a price based on increasing block rates. Therefore, in this study both expenditure and quantity measurements can be used for the dependent variable.

Price: the price of a goods and services is usually the most crucial factor that affecting quantity demanded. The types of price that have been used in this study are the average price (AP) and the actual price (P*). The average price can be calculated by dividing the total water bill with the number of month on a year.

Figure 3.1: ***Water Rates in Johor for The Domestic Supply: Residential Home***



Johor Water Department (SAJ) charges a price based on the increasing block rate. The minimum charge for water consumption was RM5.00. Flat rates charges on every consumption of water we can find through the figure 3.1 that explain clearly above.

Income: household income is one of the explanatory variables. It is includes income of the breadwinner of the household and income of others family members of the household who are directly involved in financing the expenses of the household unit. These other income of the member in the households contributes a large portion of their income for expenses especially in the case of poor families. Moreover, an adequate income is required to purchase this stuff, and because of the household's budget constraint, the amount of each item purchased will affect the availability of funds to purchase other stuff. Therefore, total household income is included as an explanatory variable in this study.

Household size: individuals in a household vary greatly in terms of age. It would therefore be inaccurate to incorporate in the regression equation the actual household size as one of the independent variables. This problem is taken care of in the study by estimating equivalents for water consumption and used it to estimate the household's size. In this study there family composition types are used, which are:

i. Children group, where includes family members who are less than 13 years old.
ii. Adolescent group includes family member who are between the ages 13-18 years old.

iii. Adult group includes family members who are greater than 18 years old.

House characteristic: house types whether there are terrace, semi-detached, apartments or flats, bungalow, condominium, orchard House, town house or others type of houses. The number of rooms, toilets, number of supply terminals, sinks, and bathroom also are used to see however the all these will affect the used/consumption of water or not.

Other variables: the other variables that influence water consumption are, ethnicity, religion, and sprinkling frequencies. This independent variables is fitted the regression to know whether it is affects household's water demands. The study also included numerous other variables such as ownership of vehicle and washing machine also the frequencies of washing the vehicles and used the washing machine as explanatory variables addition to income. All these variables are interrelated each other.

3.8 Demand Models

$$Q_{wc} = f\ (1,2,3,4,5,6,7)$$

Q = variables (water consumption or demand)

f = dependent variables

1= households quantity/size

2= price of water consumption in a year

3= total households income

4= technology

5 = environment factors

6 = house characteristic

7 = socioeconomic factors

8 = education level

3.9 The Regression Models

Multiple and double log regression models were estimated for household water demand in Kluang, Johor using cross-sectional, time series and panel data. Three models are examined in this study. One type of model uses the average price as the price variable. Double log regression was use random and fixed effect to test the model.

Three regression models were used to examine the impact of various independent variables on households water demand. First Model. This was done as follows:

$$\mathbf{C = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + Ui}$$

C = Average Household Water Consumption M^3 Per Year

β_0 = intercept,

X_1 = Ethnic

1 = Malays	or	1 = Chinese
0 = Otherwise		0 = Otherwise

X_2 = Religion

1 = Muslims	or	1 = Buddha
0 = Otherwise		0 = Otherwise

X_3 = Size Of Household determined by using all equivalents

X_4 = Total Household Income

X_5 = Type Of House

X_6 = Number Of Water Supply Terminals

X_7 = Frequencies Of Cooking

1 = Frequently

0 = Otherwise

X_8 = Average Price Per Year

X_9 = Frequencies Using Washing Machines per week

Ui = error term

Second Model:

$$C_{2012i} = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + Ui$$

C = Average Household Water Consumption M^3 Year 2012

β_0 = Intercept,

X_1 = Total Household Income

X_2 = Price of Water Consumption M^3 Year 2011

X_3 = Price of Water Consumption M^3 Year 2010

X_4 = Price of Water Consumption M^3 Year 2009

X_5 = Price of Water Consumption M^3 Year 2008

Ui = error term

Third Model (Panel Data):

$$\ln Q = \alpha + \ln P_x + Ui + \varepsilon i$$

ln Q = Quantity of Consumption

ln P_x = Price of Consumption

ui = unobserved individual heterogeneity

εi = error term

Chapter 4

4.0 Results and Discussion

4.1 Introduction

This chapter will present and interpret the summary of the results regression analysis carried out in the study. The choice of price variable that best fits the data are discussed first. This is followed by the OLS estimation of demand obtained from the regression of cross sectional data. The latter part of the chapter will discuss some policy repercussions according to the findings of the study in Kluang, Johor.

4.2 Descriptive Data Analysis

Whole 335 usable samples were collected from the study through personal interviews house by house in Kluang District that involve 19 residential areas. Majority of the respondents was Malay (35.82%) followed by Chinese (29.85%), Indian (28.36%) and Others (5.97%). Among all the respondents, most of them work in private sector around 41 percent, nine percent as a government servant, six percent as a businessman, 16 percent as a farmer and 28 percent otherwise. About three-quarter of the samples have two to four people in the household while one quarter have five to eight. Moreover, the average households size for the sample is 4.56 people per household. In run-of-the-mill, the respondents in this study consumed 26.09m^3 per month where the minimum consumption was 0m^3 and maximum 1003m^3 within 2008-2012. Furthermore, the lowest income earned by households in this study is RM 100 per month because some of the respondent is not working or retired. They receive monthly incentives from the welfare department. The highest income in the sample was RM8500. The mean of the income earned was RM2518.81. Water Consumption for the whole five years 2008 to 2012 was normally distributed as these figures:

Figure 4.1: *Average Consumption 2008 (M^3)*

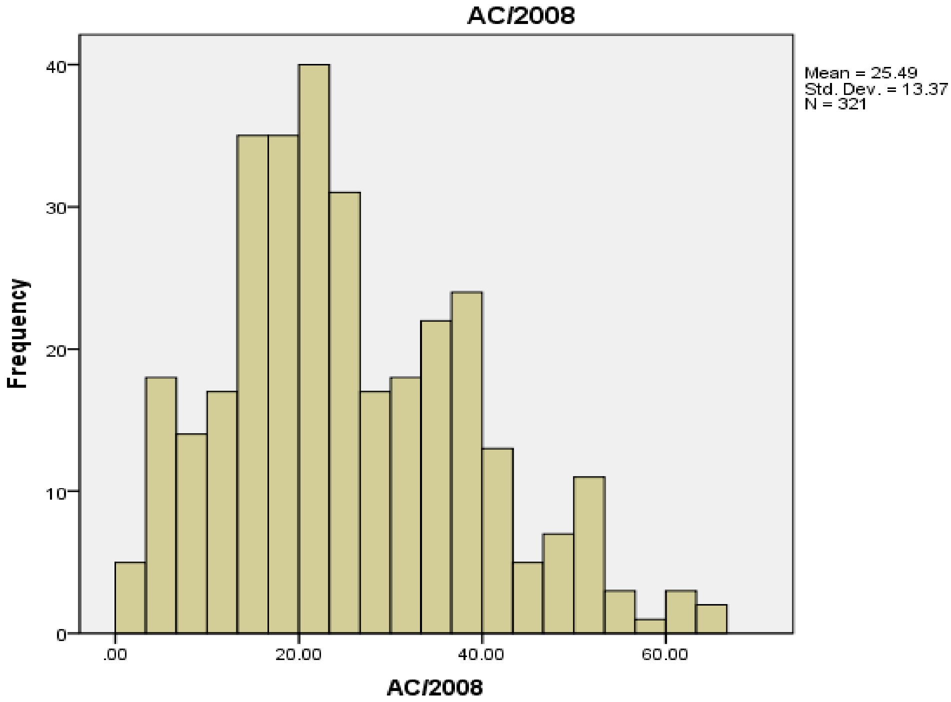


Figure 4.2: *Average Consumption 2009 (M^3)*

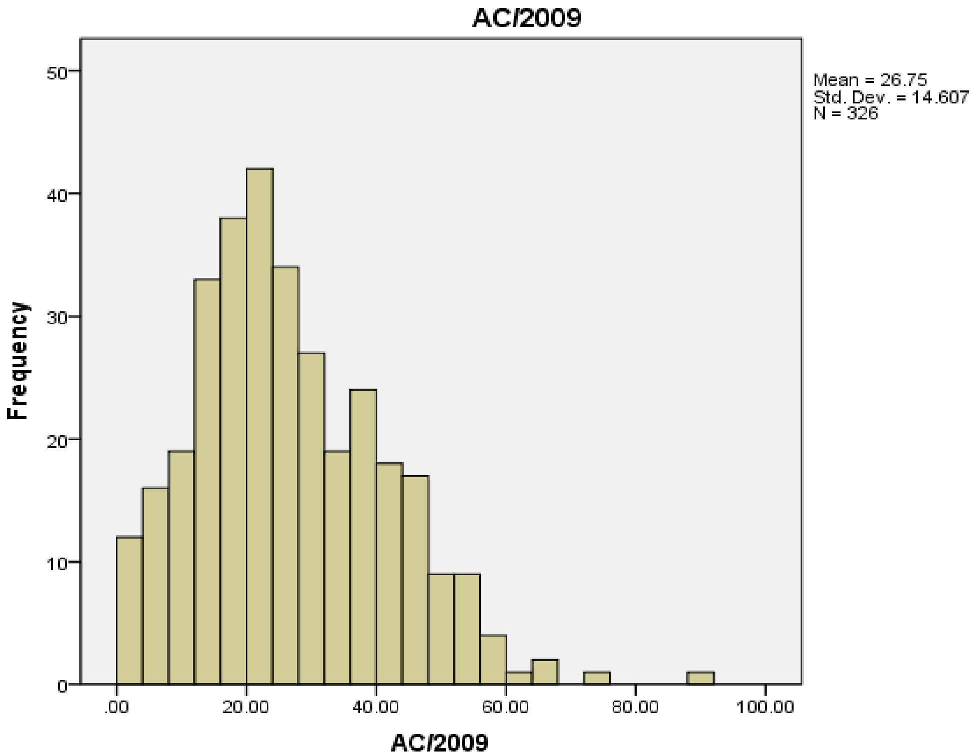


Figure 4.3: *Average Consumption 2010 (M^3)*

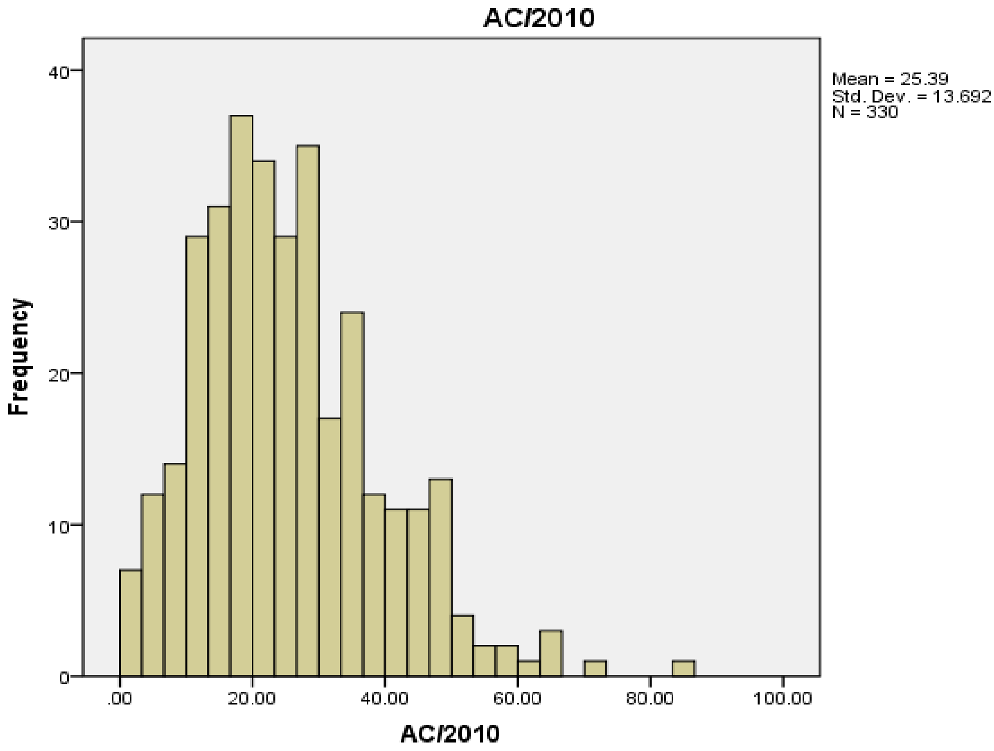


Figure 4.4: *Average Consumption 2011 (M^3)*

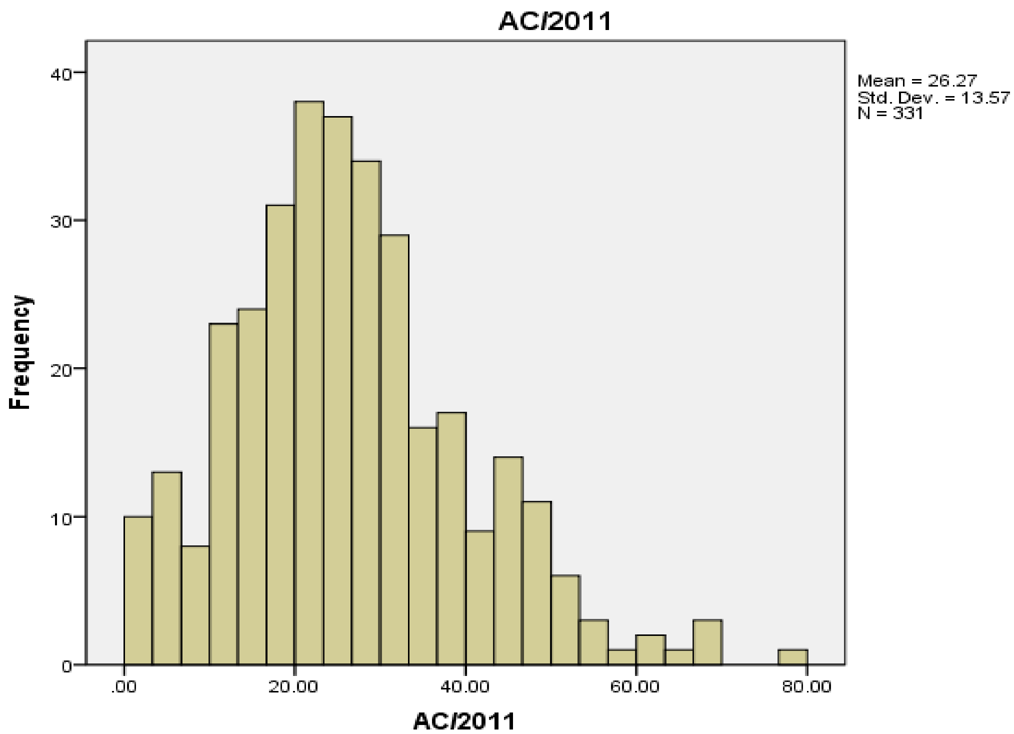


Figure 4.5: *Average Consumption 2012 (M^3)*

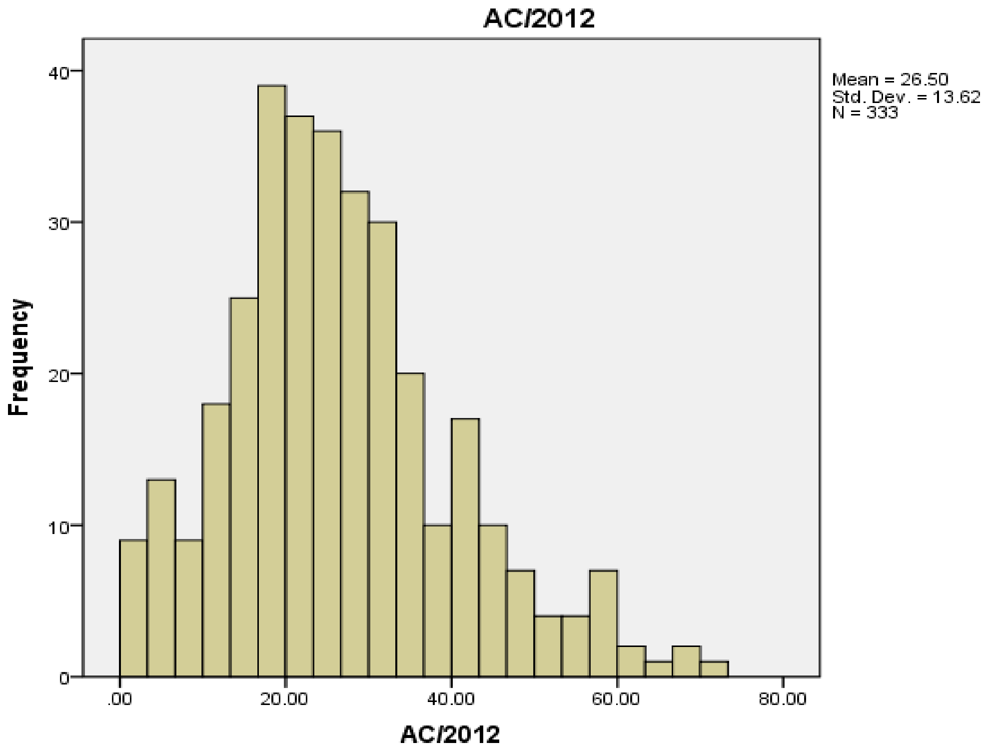


Table 4.1: *Classification of households According to their Respective Income*

Household Income per month	Income Classification	Sample Size
1. Less than RM1200	Lower Income Group	66
2. RM1200 – RM3500	Middle Income Group	202
3. RM4000 – RM8500	Upper Income Group	66

From the data collected, it was found that 86.57 percent of the respondents prefer to have smaller frequent accounts opposed to 13.43 percent who prefer to have larger less frequent accounts. All of the respondents responded positively towards price they have to pay for water consumption and 57 percent aware of the price they paid and 43 percent on the other hand. Only one respondent is still uses electric pump to supply the water from the well as a resource for daily water supply. About 10 percent of respondents from the observation used well water besides pipe water supply as a other source of water and 23.28 percent from survey used natural source of water such as rains water despite the availability of pipe water for their household water demand.

4.3 Consumers' awareness regarding the price of water

Table 4.2: *Consumers awareness of water price*

Household Income per month	Aware	%	Not Aware	%	Total
Lower Income Group **(RM0 - RM1200)**	20	26	56	74	76
Middle Income Group **(RM1200 – RM3500)**	95	50	95	50	191
Upper Income Group **(RM4000 – RM8500)**	31	45	38	55	68
Total	**146**	**44**	**189**	**56**	**335**

Consumers' consciousness of the price they paid for water is necessary if there is to be a reasonable response in quantity consumed to changes in the price of water. The application of the Marshallian price and quantity relationship to water will not be very meaningful if the consumers is not aware of the type rating system used by the water authority. Table 4.2 give the number of respondents according to income groups, who are aware and not of the price they paid for water.

It was discovered that, the entire sample about 56 percent of consumers were not aware of the price they paid for water. According to the table 4.2, there is strong relationship between income level and awareness of price paid. Hence, for the lower income group 74 percent of the consumers were not aware of the price they paid for water. Then, the upper income group only 38 percent was not aware of the price. The higher percentage (95 percent) of the middle-income group consumers are aware of the price paid for water.

Table 4.3: *Consumers awareness of water price by ethnic group*

Ethnic groups	Aware	%	Not Aware	%	Total
Malay	49	41	70	59	119
Chinese	40	40	60	60	100
Indian	48	50	48	50	96
Others	9	45	11	55	20
Total	**147**	**44**	**188**	**56**	**335**

When the differences in the awareness of the price was analyzed according to the different ethnic groups it was found that 70 percent, 60 percent, 50 percent and 55 percent of the Malay, Chinese, Indian and Others consumers correspondingly was not aware of the price they paid for water. A 10 percent level p – value test showed the differences in the awareness of the price among the four multiple ethnic groups to be not significant.

Consumers' preference for billing period, where consumers are not aware of the price, they will respond to every time they received the bills at the end of each billing period and paid the bills monthly. In, Kluang, Johor they used increased block rates for certain M^3 they used, but consumers are not responsive to the amount they pay. They just pay every month's bill but do not realize the quantity per unit that is paid.

Consumers' preference for larger less frequent accounts or smaller more frequent accounts was also analyzed according to the multiple income and ethnic groups. Table 4.4 gives the type of accounts preferred by the consumers in the different income groups and table 4.5 gives the type of accounts preferred according to ethnics group.

Table 4.4: *Type of accounts preferred according to income groups*

Household Income per month	**Larger Frequent Accounts**	**%**	**Smaller Frequent Accounts**	**%**	**Total**
Lower Income Group **(RM0 - RM1200)**	8	11	67	89	75
Middle Income Group **(RM1200 – RM3500)**	30	16	162	84	192
Upper Income Group **(RM4000 – RM8500)**	8	12	60	88	68
Total	**46**	**14**	**289**	**86**	**335**

About 86 percent of the consumers preferred smaller and more frequent accounts for example monthly billing. The preference is significantly different for the different income groups. Almost all the consumers in the lower, middle and upper income group respectively prefer smaller and more frequent accounts. This difference in the preference for smaller or larger accounts among the different income groups is significant at one percent level p- value test.

Table 4.5: *Type of accounts preferred according to ethnics groups*

Ethnic groups	Larger Frequent Accounts	%	Smaller Frequent Accounts	%	Total
Malay	16	13	103	87	119
Chinese	7	7	94	93	100
Indian	19	20	76	80	96
Others	2	10	18	90	20
Total	**147**	**44**	**188**	**56**	**335**

On analyzing the preference for larger or smaller accounts according to ethnic groups it was found that 87 percent, 93 percent, 80 percent and 90 percent of the Malays, Chinese, Indians and Others ethnics respectively more prefer smaller and more frequent accounts. This difference in preferences according to ethnic groups however was not significant at the 10 percent level p - value test.

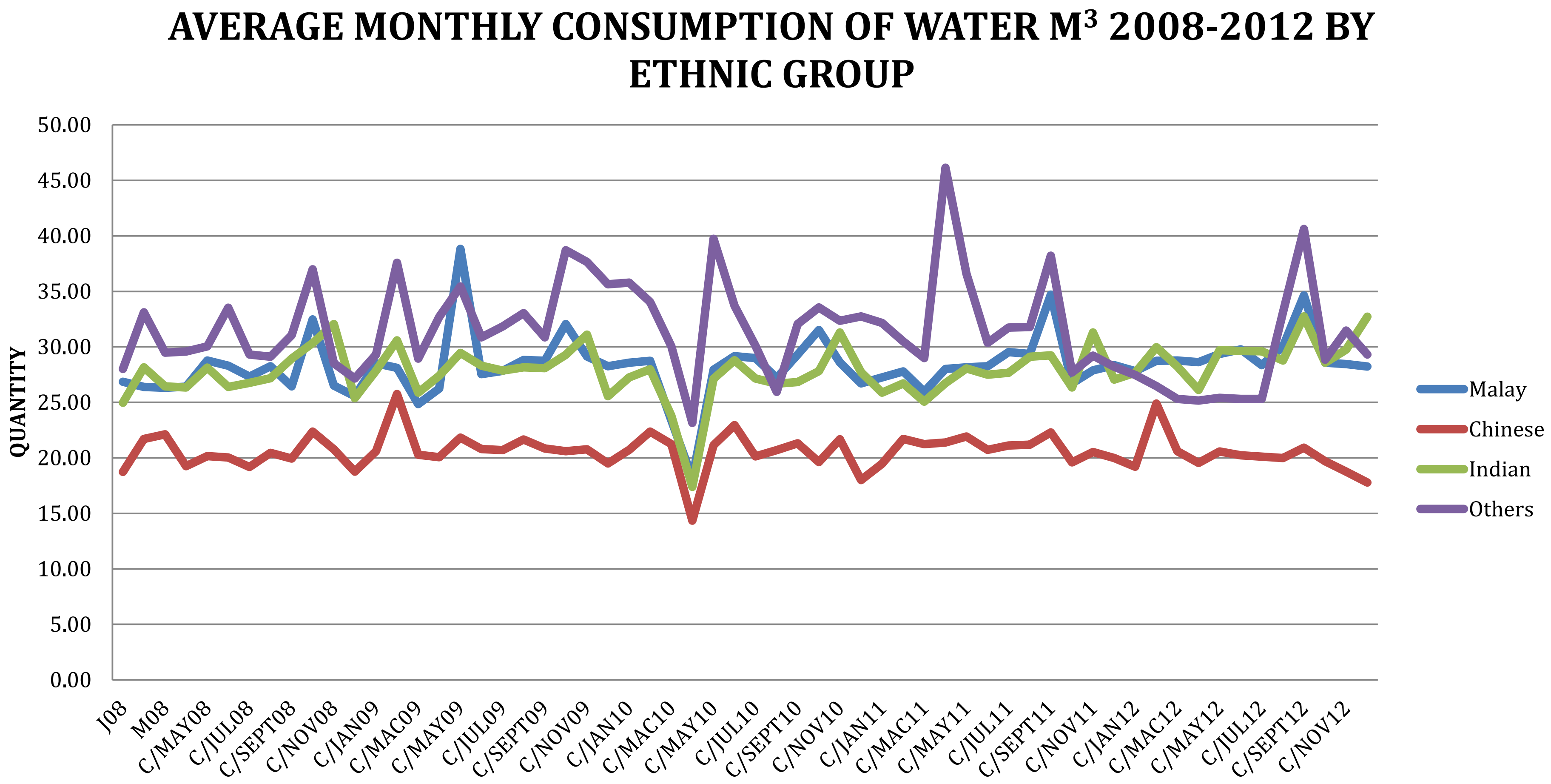
The implication of the consumers' lack of knowledge of price and preference for small and more frequent accounts is that most respondents have no knowledge of average expenditure, that is total expenditure divided by consumption per unit time. Therefore, small but more frequent billing for example monthly payment could be used as a device to reduce water consumption. The fact that, most of the households in this survey choose to used small but more frequent accounts than on the other hand.

4.4 Patterns and trends of the water consumption and price 2008-2012

Figure 4.6 and 4.7 shows the monthly per capita water consumption for all the samples between ethnic groups. The households monthly consumption and expenditure is obtained by e-billing system from the billing authorize. The Malay households in the sample are 119, Chinese 100, Indian 96 and Others 20. The trend shows a seasonal pattern with peak consumption during the month of August and November for each year. There is a significant different in the water consumption of the multiple ethnic groups. On average the Chinese have a lower consumption than the Malays and Indians.

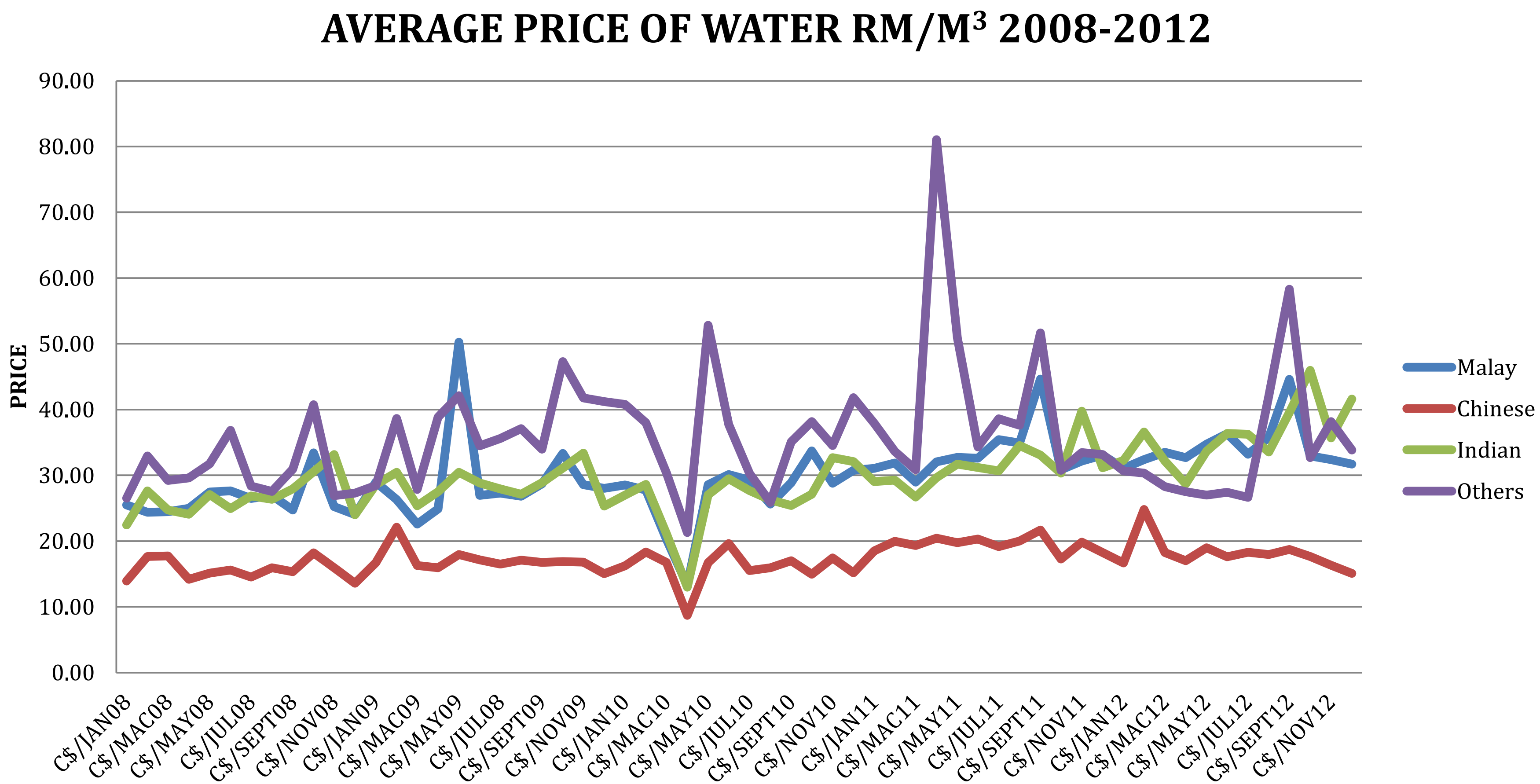
The consumption of water was low in March 2010 as it is the rainy season on that month, almost every year on March water consumption is lower because consumers use less water during the rainy season. On the other hand, the increase in consumption in the peak month like end of year and New Year is because of festivals like Christmas, Chinese New Year, school holidays and cultural practices where more water is used during those periods.

Figure 4.6: *Consumption of Water M^3 2008-2012 by Ethnic group*



Sources: Survey Data

Figure 4.7: *Average Price of Water RM/M³ 2008-2012 by Ethnic group*



Sources: Survey Data

4.5 Regression Analysis of Water Demand Studies

In this section, the measurement and estimation results of the different components of the models system are presented.

Model 1

$$\mathbf{AC_{2012i} = \beta_{0i} + \beta_1 AP_{2012i} + \beta_2 AP_{2011i} + \beta_4 DMALAY_i + \beta_5 DCHINESE_i + \beta_6 TYHOUSE_i + \beta_7 DFCOOK_i + \beta_8 NHH_i + \beta_9 THHINC_i + \beta_{10} NSUPTER_i + \varepsilon_i + u_i}$$

Where,

i	=	observation (1, 2, 3, 4, 5……..335)
AC_{2012i}	=	the quantity of household water consumption in M^3 per year 2012
β_{0i}	=	the intercept
AP_{2012i}	=	average price of the year 2012
AP_{2011i}	=	average price of the year 2011
$DMALAY_i$	=	Ethnic (Dummy for Malay)
		1 = Malays 0 = Otherwise
$DCHINESE_i$	=	Ethnic (Dummy for Chinese)
		1 = Chinese 0 = Otherwise
$TYHOUSE_i$	=	Type of the House
		1 = Bungalow 0 = Otherwise
$DFCOOK_i$	=	Dummy for Frequently Cook
NHH_i	=	Total Number of peoples in the House

$THHINC_i$ = Total Households' Income

$NSUPTER_i$ = Number of Supply Terminal

The estimated multiple regression for Model 1:

AC_{2012} = 10.38 + 0.3355AP_{2012} + 0.1023AP_{2011} + 1.336DMALAY

(t = 20.46***) (6.03***) (1.90*)

– 0.960DCHINESE – 0.399TYHOUSE +

(-1.28) (-3.07***)

1.523DFCOOK + 0.564NHH – 0.000353THHINC +

(2.30**) (3.60***) (-1.61*)

0.281NSUPTER + ε_i + u_i

(1.56)

R^2 = 0.870 **F = 238.65** **N = 330**

*** significant at 0.01 level
** significant at 0.05 level
* significant at 0.10 level

The adjusted R square of 0.87 for the multiple regression function in Model 1 explains 87 percent of the variation in the water use by year 2012. The price of the water in this study where average price does not have expected sign but has a positive sign, which indicate an increase in water use, will lead to increase in average price, ceteris paribus. The result is inconsistent with previous studies done by David and Ganapathi (1986) and Ming Yu (1996). Indeed, as cited by Joseph and Welch

(1982), many empirical studies of the demand for water under declining block rates using average price have been conducted but few have produced results consistent with traditional demand theory. They explained this, in part by pointing out that when average price is define ex post as the ratio of total expenditure to quantity of consumed, a positive dependence between quantity and price tends to be established which reflects nothing more than an arithmetic relationship.

In this study, average Price of 2012 and the lag year 2011 is statistically significant at one percent level; this means the price of water in year 2012 still influences the consumption of water in the lag year 2011 as theory of consumption that our economy variable have a momentum and should depends on previous value (Gujarati, 2003). Furthermore, type of the house, the frequency of cooking, and number of people in a household is significant at one percent level, the more frequent the household used to cook at home and bigger the family size the more the quantity of water they will consume. Moreover, DMALAY, total households' income and number of supply terminal were statistically significant at 10 percent level and have positive relationship where it is shown when one percent of supply terminal increase, consumption of water will lead to increase of 28.11 percent of water use.

Model 2:

In this section, the measurement and estimation results of the different number of households' equivalents which are below 13 years, between 13-18 years and more than 18 years old. These are components of the models system presented.

AC2012 = 10.592 + 0.341AP2012 + 0.100AP2011 + 1.199DMALAY

(t = 20.12***) (5.86***) (1.67*)

- 0940DCHINESE – 0.398TYHOUSE +1.618DFCOOK

(-1.25) (-3.05***) (2.43***)

+ 0.635NHHlt13 + 0.916NHH1318 + 0.311NHHgt18

(2.67***) (2.80***) (1.36)

- 0.000334THHINC + 0.308NSUPTER + $\boldsymbol{\varepsilon_i}$ **+** $\mathbf{u_i}$

(-1.52) (1.70*)

R^2 = 0.871 **F = 195.94** **N = 330**

*** significant at 0.01 level (1%)
** significant at 0.05 level (5%)
* significant at 0.10 level (10%)

Prob > F = 0.0000 shows significant where at least one of the variable and it is non-zero will explain the independent variables. Average price of 2012, lag year price 2011, dummy for Malay, type of house, number of households below 13 years and between 13- 18 years old showed statistically significant at 1 percent level. Likewise, the number of supply terminals is significant at five percent and dummy for Chinese ethnic is not significant and has negative relationship with the consumption. The R square of 0.871 explains 87.10 percent of the water consumption in 2012.

In all the regression equation, the number of persons in a households and the level of water use have been shown to be important water demand shifters. In this study, household size is positively related to water consumption. Previous research was also indicated that the larger the number of persons in a household will contribute to a larger water use by Kuperan (1980) and Cheng Ming Yu (1996). An increase in the household size by the addition of an adult to the household will lead to increase in water usage by not less than 31 percent.

Whilst, the number of supply terminals has a significant influence on water consumption. This indicates that an additional of one percent of water supply terminal in a households will leads to increase in water consumption by 35 percent. This can be explained by the fact that the tendency to conserve or use less water is smaller when one has the freedom to use the tap as long as one likes without someone waiting for his or her to turn to use it (Kuperan 1980). Besides, chances of water leakages are also higher when they are a larger number of water supply terminals. Houses that had large number of water supply terminals were also the houses that had flush latrines. Flush latrines tend to use more water than other kinds of toilet system such as bucket.

Model 3: Consumption patterns of different ethnic groups

The consumption levels of different ethnic groups are not similar because of different social and cultural practices. The linear regression model used to account for the consumption levels of the multiple ethnic groups is as follows:

i. Malay Households:

AC2012 = 9.058 + 0.337AP2012 + 0.100AP2011 – 0.376TYHOUSE +

(t = 20.70***) (5.90***) (-2.89***)

1.625DFCOOK + 0.482NHH – 0.000380THHINC +

(2.52***) (2.98***) (-1.76*)

0.294NSUPTER + 0.210FWASH + 1.851DMALAY + ε_i

(1.63*) (1.67*) (2.95***)

R^2 = 0.868 **F = 239.63** **N = 330**

*** significant at 0.01 level (1%)
** significant at 0.05 level (5%)
* significant at 0.10 level (10%)

Based on the regression result above, the R-squared is 0.868 which means 86.8 percent of the variation in the total consumption of water for 2012 is explained by the independent variables. However, since the p - value for F – test is 0.000 and show significant level of one percent, this indicates there is a linear relationship between the consumption of water 2012 and all the independent variables. Therefore, the OLS multiple regression line fits the data statistically and the overall equation is significant. It shows that, out of nine independent variables, six are significant at one percent level and the rest three are significant at 10 percent level.

The constant value is 9.06, which means the value of all the independent variables is 0, the total water consumption 2012 was 9.06M^3, ceteris paribus. This value is unlikely to occur since the value of all independent variables will never become 0. All the variable has a positive relationship with water consumption except for type of the house and total households income where it show one percent an increase in both variable will lead to decrease in water use respectively -0.376 and -0.000380 but both of the variable was significant at one percent and 10 percent level. This is maybe because one percent increase in households' income will lead to decrease 0.038 percent in water use. This is probably due to the fact that the higher the wage rate the more awareness of the importance of water consumption in households, where we can think logically that higher income group are usually educated group and they are aware of the nature resource that they are used together.

ii. Chinese Households:

AC2012 = 10.48 + 0.334AP2012 + 0.100AP2011 – 0.315TYHOUSE +

(t = 20.35***) (5.85***) (-2.51***)

1.044DFCOOK + 0.514NHH – 0.000351THHINC +

(1.63*) (3.17***) (-1.60)

0.263NSUPTER + 0.218FWASH - 1.763DCHINESE + $\boldsymbol{\varepsilon_i}$

(1.46) (1.72*) (-2.63*)

R^2 = 0.870 F = 238.11 N = 330

*** significant at 0.01 level (1%)
** significant at 0.05 level (5%)
* significant at 0.10 level (10%)

According to result above for Chinese ethnic group, average price of 2012 and 2011, numbers of households' size as measure by all the equivalents are statistically significant at one percent level. Although income was found to be significant in most of the studies before, it is not significant at 5 percent in this study for Chinese ethnic group. The R square for regression estimates are high where 87 percent the variation on consumption of water is explained by the independent variables.

DCHINESE variable has a negative relationship with the consumption of water. The coefficient value is -1.763, which mean that with one percent increases in Chinese ethnic will leads to decrease in consumption of water by 17.63 percent.

However, there are six variables significant out of nine in this regression. The total households income and type of house have negative relationship with the consumption of water and others are positive.

iii. Indian Households:

$$\mathbf{AC2012 = 9.85 + 0.338AP2012 + 0.104AP2011 - 0.251TYHOUSE +}$$
$$(t = 20.34^{***}) \quad (6.03^{**}) \quad (-1.98^{**})$$
$$\mathbf{1.282DFCOOK + 0.524NHH - 0.000466THHINC +}$$
$$(1.91^{*}) \quad (3.19^{***}) \quad (-2.14^{**})$$
$$\mathbf{0.262NSUPTER + 0.1768FWASH - 0.025DINDIAN + \varepsilon_i}$$
$$(1.44) \quad (1.38) \quad (-0.04)$$

R^2 = 0.867 **F = 232.34** **N = 330**

*** significant at 0.01 level (1%)
** significant at 0.05 level (5%)
* significant at 0.10 level (10%)

The R square in this function was explained more than 80 percent of the variation in water use for Indian ethnic group. Only number of supply terminals, frequency of washing and DINDIAN are not significant but has positive relationships with quantity of water consume in 2012. One percent increases in price of water quantity, water consumption will lead to increase 33.86 percent in 2012 and 10.39 percent in 2011, *ceteris paribus*.

In all the regression equations, the number of persons in a household and the level of water use have been shown to be important water demand shifters. In this study, household size is positively related to water consumption. Previous research has also indicated that the larger the number of people in a household it will contribute to a larger water use, ceteris paribus (Kuperan 1980; Remee Dass 1985; and Ming Yu 1996). Malay household is significant at five percent level and they tend to use more water than other ethnic group as shown in the result above. Certain social and cultural practices of these ethnic groups could be used to explain the different consumption levels. Rituals like doing ablutions before prayers, morning baths and frequent house washing are common among the Malays and Indians. Almost all the regression have a negative relationship between type of house, it is maybe because the size of the house and household size is differ, where the house is big but the households size is small, so, water demanded is lower than others.

The income variable is not significant in certain of the regression equations that are consistent with the finding carried out by Ming Yu (1996). Despite average price are significant at one percent level in all the regression equations and have a positive relation with quantity of water use, where increase in average water price will leads to increase in water use. Overall, the results show that R^2 is more than 80 percent and it is represent all the variables and the model provide a good fit.

4.6 Detection of Heteroskedasticity Problem for Model 1, 2, 3(i), 3(ii) and 3(iii)

The entire regression model that stated above had heteroskedasticity problem, but no multicollinearity problem (see Appendix C). Table 4.6 below indicates the detection of the heteroskedasticity problem.

Table 4.6: *Detection of Heteroskedasticity Problem for Model*

Model	**Chi Square**	**P-value**
Model 1	**178.16**	**0.0000**
Model 2	**214.27**	**0.0000**
Model 3 (i)	**177.74**	**0.0000**
Model 3 (ii)	**177.33**	**0.0000**
Model 3 (iii)	**184.62**	**0.0000**

Since the p – value for all the Breusch-Pagan/ Cook –Weisberg and White test for heteroskedasticity is almost 0, this means that the heteroskedasticity problem exists in the model because it shown significant. Thus, robust standard errors seem to be a more common and popular method for dealing with issues of heteroskedasticity. Then, all the models will be regressed again by using that method to solve the problem.

Table 4.7: *Model 1 (robust)*

	Coefficient	Std Error	t- ratio	p-value	
const	10.38673	1.095103	9.48	0.000	***
AC_2012	0.3354974	0.0537475	6.24	0.000	***
AC_2011	0.1023132	0.0464937	2.20	0.028	**
DMALAY	1.336254	0.7150681	1.87	0.063	*
DCHINESE	-0.9606594	0.6946616	-1.38	0.168	
TYHOUSE	-0.3997996	0.1382896	-2.89	0.004	***
DFCOOK	1.522768	0.6881195	2.21	0.028	**
NHH	0.5638276	0.136362	4.13	0.000	***
THHINC	-0.0003525	0.0002042	-1.73	0.085	*
NSUPTER	0.2811457	0.1833429	1.53	0.126	

R^2 = 0.870 **F = 128.59** **N = 330**

Table 4.8: *Model 2 (robust)*

	Coefficient	Std Error	t- ratio	p-value	
const	10.59222	1.080811	9.80	0.000	***
AC_2012	0.3406848	0.0513229	6.64	0.000	***
AC_2011	0.1000531	0.0451485	2.22	0.027	**
DMALAY	1.199644	0.7319794	1.64	0.102	*
DCHINESE	-0.9398538	0.6885251	-1.37	0.173	
TYHOUSE	-0.3976263	0.1392925	-2.85	0.005	***
DFCOOK	1.617573	0.6890596	2.35	0.020	**
NHH 13	0.6346385	0.2295064	2.77	0.006	***
NHH1318	0.915791	0.262225	3.49	0.001	***
NHH1318	0.310732	0.2045627	1.52	0.130	
THHINC	-0.0003335	0.0001996	-1.67	0.096	
NSUPTER	0.3074547	0.1867809	1.65	0.081	*

R^2 = 0.871 **F = 108.25** **N = 330**

Model 3: Consumption patterns of different ethnic groups (robust)

Table 4.9 (i): *Malay Households*

	Coefficient	Std Error	t- ratio	p-value	
Const	9.057951	1.168184	7.75	0.000	***
AC_2012	0.3371001	0.0532446	6.33	0.000	***
AC_2011	0.1003768	0.0455625	2.20	0.028	**
TYHOUSE	-0.3757568	0.1388995	-2.71	0.007	***
DFCOOK	1.625102	0.6757155	2.41	0.017	**
NHH	0.4823931	0.1410734	3.42	0.001	***
THHINC	-0.0003799	0.0002013	-1.89	0.060	*
NSUPTER	0.2942195	0.1865299	1.58	0.116	
FWASH	0.2104069	0.1281138	1.64	0.102	*
DMALAY	1.850625	0.6921907	2.67	0.008	*

R^2 = 0.870 **F = 137.39** **N = 330**

Table 4.9 (ii): *Chinese Households*

	Coefficient	Std Error	t- ratio	p-value	
Const	10.47472	1.094274	9.57	0.000	***
AC_2012	0.334007	0.0552093	6.05	0.000	***
AC_2011	0.0998757	0.04758	2.10	0.037	**
TYHOUSE	-0.3151825	0.1282164	-2.46	0.014	**
DFCOOK	1.043869	0.6660523	1.57	0.118	
NHH	0.5142065	0.1426046	3.61	0.000	***
THHINC	-0.000351	0.0002065	-1.70	0.090	*
NSUPTER	0.2633984	0.1802851	1.46	0.145	
FWASH	0.2176826	0.1316508	1.65	0.099	*
DCHINESE	-1.762479	0.6846439	-2.57	0.010	***

R^2 = 0.870 **F = 117.73** **N = 330**

Table 4.9 (iii): *Indian Households*

	Coefficient	Std Error	t- ratio	p-value	
Const	9.851129	1.159604	8.50	0.000	***
AC_2012	0.3386391	0.0553468	6.12	0.000	***
AC_2011	0.10385	0.0484783	2.14	0.033	**
TYHOUSE	-0.2509484	0.1305156	-1.92	0.055	**
DFCOOK	1.282446	0.6881954	1.86	0.063	*
NHH	0.5238551	0.1427794	3.67	0.000	***
THHINC	-0.0004662	0.0002141	-2.18	0.030	**
NSUPTER	0.2617484	0.1844006	1.42	0.157	
FWASH	0.1759136	0.1293361	1.36	0.175	
DINDIAN	0.0253488	0.6004073	0.37	0.966	

R^2 = 0.867 **F = 122.08** **N = 330**

*** significant at 0.01 level
** significant at 0.05 level
* significant at 0.10 level

Comparing the results with the earlier regression, note that none of the coefficient and R square estimates changed, but the standard errors and hence the t values are a little different. Had there been more heteroskedasticity in these data, we would have probably seen bigger changes, so there is no bigger changes that can seen above. As for Model 1, variable average price 2011 become significant at 5 percent level and one percent level for model 2. Then, model 3 (ii) total households income level become significant at 10 percent level but still has negative relationship with the water consumption 2012. In short, the variable is still having significant impact after the heteroskedasticity and on the other hand some of the result is insignificant.

4.7 The Price Elasticity's using Panel Data Analysis

The model estimated below is based on pooled regression analyses, which are subjected to unobserved individual heterogeneity. In this study, the data access is limited of information where it could be use to estimated Random Effect and Fixed Effect model that able to control individual heterogeneity problem. The panel data information confides only the quantity of consumption and the expenditure of water.

Model 4:

$$\ln Q = \alpha + \ln P_x + u_i + \varepsilon_i$$

where,

ln Q = Natural log of Quantity Water Consumption

ln P = Natural log of Price Water Consumption

ui = unobserved individual heterogeneity

εi = error term

```
. tsset  res time1
       panel variable:  res (unbalanced)
        time variable:  time1, 1 to 60
```

In this case 'res' represent entities or the panel (i) in this study was residents and time1 represent time variable (t) 1 to 60 is represent years that starts from 1 Jan 2008 until 31 Dec 2012 for every month. The note (unbalance) refers whether to the facts that all respondents' incomplete data, if for example, do not have data for one year then the data is unbalanced. Ideally, in the study would want to have a balanced dataset but this is not always the case, however we can still run the model.

Fixed Effect

The fixed-effects model controls for all time invariant differences between the individuals, so the estimated coefficients of the fixed-effects models cannot be biased because of omitted time-invariant characteristics like culture, religion, gender, race and others.

Random Effect

The rationale behind random effects model is that, unlike the fixed effects model, the variation across entities is assumed to be random and uncorrelated with the predictor or independent variables included in the model:

“...The crucial distinction between fixed and random effects is whether the unobserved individual effect embodies elements that are correlated with the regressors in the model, not whether these effects are stochastic or not” [Green, 2008, p.183]

Table 4.10: *Panel Data result*

Effects	**Models**	**Std. Error**	**P - value**	**R^2**
Fixed	Lc = 1.169 + 0.6656Lcp	0.0035	0.000***	0.647
Random	Lc = 1.152 + 0.6670Lcp	0.0035	0.000***	0.647

Total number of cases or observation was 19266 and 336 total number of groups or entities. Based on the regression, probability chi squares equal to 0.0000, for both fixed and random effects is strongly good and all the coefficients in the model are different than zero, its significant within the variables is significant and it can explain the dependent variables. R^2 = within shows 0.647 for both effect, the 64.7 percent in the Lc that is explained by the time variation in Lcp. As Corr (u_i,x)=0 this means that, random effect model, assume that the unobserved effect ai, is uncorrelated with each independent variables. Probability chi-square is a test (F) to see whether the entire coefficient in the model is different than 0.

The value of probability chi-square is less than 0, which mean this data is significant. Two tails p-value test the hypothesis that each coefficient is different from 0. To reject this, the p-value has to be lower than 0.05. Based on the two tails p-value, the value for Lcp is 0.000 that means the variable Lc has a significant influence on Lcp because the values are less than 0.05 at 95% confidence interval. The coefficient for Lcp is positive for both analysis, which mean one percent increase in Lc, Lcp will increase by 1.169 in fixed effect model and one percent increase in Lc, Lcp will increase by 1.152 in random effect model. The value of corr variance is equal to 0, which mean the dependent variables are uncorrelated with the unobserved effect. To compare between fixed effect and random effect, we used Hausmann test to identify which method is better.

Hausmann Test

```
. hausman fixed
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed          .          Difference          S.E.
-------------+----------------------------------------------------------------
         Lcp |    .6655039       .66708       -.0015761        .0007119
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg
    Test:  Ho:  difference in coefficients not systematic
                  chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        4.90
                Prob>chi2 =      0.0268
```

Reject ho and it is better to use fixed effect. In this test Probe > chi2= 0.0268, below than 0.05 so, it is show significant, so, fixed effect is more appropriate than random effect statistically.

Chapter 5

5.0 Summary and Conclusion

5.1 Overview

This chapter will present the summary of the major findings of the study. The implication of the findings for water management policy will also be discussed in this section. The limitation of the study and recommendations for further research are covered in the last section of the chapter.

5.2 A summary and the major findings of the study

Demand for water is a vital issue in Malaysia as population growth, agricultural, and industrial development takes place. In addition, some states face problems of water shortage and stress because water used is already reaching maximum demands like Selangor state. In Johor, supply shortage is not a common problem faced by water supply department, but for early steps it is essential for improving the security and resilience of our nation's drinking water and wastewater infrastructures. Significant actions should be taken to assess and reduce water loss and develop new security technologies to detect and monitor contaminants and prevent security breaches in water demand.

The purpose of this study was to examine the relationship between price and quantity where price in this case is significant in water consumption in this study. In theory, increase in price will lead to a decrease in consumption but in this study are found that increase in price leads to an increase in quantity. This is because in this study the price used in the regression is the average price. Thenceforth, the more water is consumed the average price is getting lower, when average price less people consume water more.

$$AP = \frac{TP}{Q} = AP\downarrow$$

When total price (TP) of water consumption divided with the quantity of water consumed, value of average price will decrease. In this study, average price and the quantity of consumption have positive relationship, means when average price (AP) increase quantity demanded also increases resulting in the positive relationship.

Regression analysis was used as a tool to analyze data obtained in the study. The cross sectional regression using the five different models where used to see the differences between ethnic and households equivalents. A model using panel data is used to estimate the price. The price elasticity was 0.66 using average price, so a one percent increase in average price, can expect 0.66 changes in consumption. The entire cross sectional regression analysis function in the whole model was able to explain more than 80 percent of the variation in the water use for year 2012.

Furthermore, all the other variables that explain the demand of water are households' size, number of supply terminals in the house, frequency of cooking and total household income. On the demographic side, households' size has the strongest impact on water demand. The study also indicated that economics of scale are present in water consumption. Besides, an ethnic difference does have a significant impact on water consumption, among the Malay, Chinese and Indian ethnic groups, this study showed that the Malay and Indian group's consume more water than Chinese. This finding is not contrary to our expectations that certain social and cultural practices influence the consumption patterns of different ethnic groups.

Previous study undertaken by Shin (1985) due to price perception model, found that consumers respond more to average than marginal price because the price perception parameter, K is approximately equal to 1 (K= 0.638). However, studies from Ming Yu (1996) showed that marginal price approach provides the best-fit model to estimate the domestic water demand. Shin study implies that the use of average price is also appropriate for the study of water demand. The sign obtained for average price is however positive and this contradicted, basic price theory and thus findings requires further analysis.

5.3 Policy Implications

To meet the demand for water in this era of globalization that have a high development and growth, more large dams are proposed as a key solution for future water demand. Dams are hardly the only way to meet demand for water, whether it's new demand due to population growth or to adjust to altered precipitation or runoff patterns resulting from climate change. The first step in fighting a new dam is to insist that a reasonable assessment of demand for water is made available. Without knowledge of how much water is needed, discussion of tools to meet demand is premature. Any credible demand assessment should assume future implementation of significant conservation and efficiency measures. Once demand is nailed down, citizens should call for a thorough assessment of supply options to meet that demand. (WWF Global 2012)

The demands for domestic water following the conventional demand theory in general depends on the size of population, income, house characteristic, and the price of water. The growth of population, per capita income, the increase in price and the corresponding elasticities will lead to a growth in the demand. Hereafter, reliable estimates of price elasticities of demand are essential for good planning in resource development projects involving large capital expenditure. The result of this study can be used when forecasting and designing capacity for residential water system. The effect of changes in price upon demand and revenue, ceteris paribus, should be considered before expensive construction, which may impose a price rise is undertaken. In addition, price elasticity in this study is found to be inelastic, water suppliers may increase total revenue from residential users by increasing the price.

This action itself would decrease the quantity consumed and militate against the need for an expansion of facilities. However, if a decrease in water use is achieved, real price increase must be significant and obvious to the consuming public.

Water pricing has a great potential of being an effective policy tool for water supply authorities. Price could be used to allocate and use water efficiently and could play a key role in the long run planning and conservation of water supplies. In this study, price variable is statistically significant at one percent level. This result shows that price charge for water will influence the total demand that have to met by suppliers. The investments that have to be made by the authority will depend on the demand it has to fulfill. In addition, the demand is a function of price charged, a direct relationship between pricing policy and the scale of the investment is established. Thus, the water authority can make use of the simulated models to estimate the size of the facilities to be produced in order to make an efficient investment decision for future plan. The structured tariff mechanism was the most appropriate way to increase efficiency in the industry.

There is an indication that consumers' awareness of price and the rate structure could increase their response towards changes in price. The finding that a large percentage of the consumers are not aware of the price because of the lower price rates in Malaysia. So, it would benefit any community to educate this people and they can recognize the enormous costs involved in meeting short-term desire for large rate of consumption. If the price tool is not able to deal with the problem, then rationing may be necessary for every household for daily usage.

5.4 Limitations of the study

The time series regression cannot be estimated in depth because the data obtained from the Syarikat Air Johor Holdings (SAJH) just covered five years that begun from 2008 to 2012, a much longer period of study would be useful in estimating the long run if want to do time series regression such as 10 years and above. Besides, The panel data most of the variables other than expenditure on water in the regression inconstant over time, so the variable that can be use in this regression is just the consumption of water and the expenditure only.

Nevertheless, the number of samples that have been used in this study is not enough, means the sample size is small relative to the actual number of consumers in the area of study done. Thus, it was appropriate if at least a few thousand samples that show 5 percent of the whole population in Kluang, Johor to really indicates the whole demand of the water in this district. Since the sample in this study was only 335 respondents, this cannot be a best representation of the population of Kluang, Johor. Moreover, the comparison of this study between region or state should also be done, so that a clearer picture of demand for water can be seen.

In this study just average price was used to estimate the relationship between price and quantity of water demanded while the marginal price of the water consumption is unavailable and it cannot be measured due to the lack of the information from the authorized billing system. Other factors such as public education is not included in the model and may play an important role in determining the demand for domestic water.

5.5 Recommendation for future studies

Water demand studies should vary from region to region and the result may possibly have different effects in different region of this country. Therefore a separate study should be taken and factors reflecting local demand determinants must be embedded in the appropriate regionalized model. It would be useful if the full information about the demographic, geographical and sociological background of the region can be obtained before the survey is carried out.

The role of conservation of quantity and quality of water supplied for domestic use and whether the consumers are satisfied in terms of service provided and the quality of water provided should also be studied.

5.6 Conclusion

Water is the vital resource to support all forms of life on earth it seems like oxygen for every human being. It is essential for the well being of our civilization and is the essential element for growth and development as well as the basic requirement for the health of the world's environment. Since there is an imbalance between availability and demand, careful management is essential. The summary of the world population and the anticipated growth rate will occur in the less developed countries – where the need for water is the greatest and the current supply is limited. It is important to recognize that careless use and contamination of the water that is available is widespread. In some regions of the world, life is threatened by the imbalance between the demands and available supplies of water so we must use water wisely by managing demand more effectively and using appropriate pricing mechanism to reduce water wastage.

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